DISPOSABLE VERSUS REPROCESSED HOSPITAL SUPPLIES

BY

HAROLD E. SMALLEY

⌐AND OTHERS¬

VOLUME 1

PROJECTS B-158, B-178, B-203, B-216, B-245

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Tentative Plans for
A Study of Hospital Cost Systems

January 1959

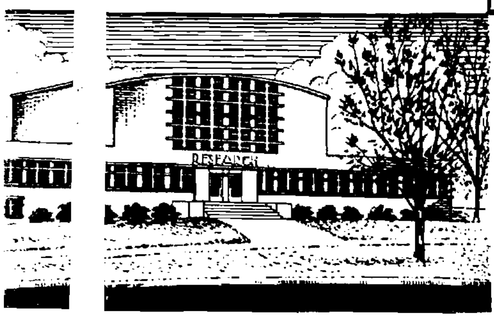
"Disposable versus Reprocessed Hospital Supplies"

USPHS GRANT #GN-5968

BULLETIN NO. 1

by

Harold E. Smalley
Principal Investigator



Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia

DISPOSABLE VERSUS REPROCESSED HOSPITAL SUPPLIES

Tentative Plans for
A Study of Hospital Cost Systems

by
Harold E. Smalley, Ph.D.
Principal Investigator

and

An Interdisciplinary Research Team

BULLETIN NO. 1

This investigation is supported by a three-year research grant, GN-5968, from the Division of General Medical Sciences and the Division of Nursing Resources of the United States Public Health Service.

January 1959

T A B L E   O F   C O N T E N T S

I. SUMMARY

The specific aim of this project is to develop a practical decision system for determining the relative economic feasibility of disposable and reprocessed supply items for hospitals. This study constitutes the first phase of an investigation of alternatives and their relation to hospital costs. It is organized in the Georgia Institute of Technology through the Engineering Experiment Station and is being conducted in cooperation with Emory University Medical Center and hospitals in the Atlanta area. The approach to the overall investigation is divided into four parts:

1. Determine the cost factors which govern the two types of supply items.
2. Determine the relationship of cost factors to the two types of supply items.
3. Determine a hypothetical decision system.
4. Test the hypothetical decision system through evaluation and revise system as required.

A continuation study, while not being a part of the immediate study, will be devoted to an investigation of extensions of the decision system for possible application to other procurable supply items. This will be followed by an investigation of extensions of the decision system for possible application to the procurement of other resources, such as materials, equipment, and labor, and to other broad management decisions involving choices between alternatives.

II. TENTATIVE PLANS

A. SPECIFIC AIMS

To develop a practical decision system for determining the relative economic feasibility of disposable and reprocessed supply items for hospitals.

This study constitutes the first phase of an investigation of alternatives and their relation to hospital costs. This investigation is one of the several research programs by the principal investigator in the application of industrial engineering principles and practices to the health field. This study is part of a methods improvement program attempting to achieve a maximization of the quality-cost ratio for hospitals. The program is based upon an interdisciplinary approach utilizing research, education, and consultation in cooperation with Emory University Medical Center, the Georgia Hospital Association, and other organizations of health-oriented people.

B. ORGANIZATION

The project is organized under the direction of the principal investigator and is being conducted by him and an interdisciplinary research team. This team includes an industrial engineer, an economist-accountant, a nurse, a psychologist, various consultants, and several graduate students. The National Advisory Committee and the Local Steering Committee are organized to advise on planning and evaluation. Names of Staff Members and Committee Members are listed below.

C. ASSUMPTIONS

The following assumptions are made in this study:

1. An investigation of alternatives and their relation to hospital costs is best approached by an analysis of the <u>specific</u> as a means of promoting understanding of the <u>general</u>.
2. Decisions should be based upon an objective comparison of alternatives.
3. Cost factors[1] exist and can be segregated, identified, and measured.
4. There is a relation between cost factors and a measure upon which alternative decisions can be made.

D. APPROACH

The approach to this project will be as follows:

1. <u>Determine the cost factors which govern the two types of supply items</u>. Compute unit cost of using and processing each of several reprocessed supply items in a few specific hospital situations.

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[1] Cost factors are considered to be those interacting elements of a total fiscal structure that contribute to bring about the outlay or expenditure of resources.

a. Select one supply item, such as conventional reprocessed syringe.

b. Compute unit labor cost.

(1) Determine a representative method of processing.

(2) Measure total work content by time studies.

c. Compute unit material cost.

(1) Compile original cost of supply item.

(2) Determine productive life by experimentation, records, etc.

d. Compute unit overhead cost.

(1) Compile costs which vary as a function of the passage of time and which are attributable to the reprocessing of supply items.

e. Devise and compute intangible cost factors.

f. Compute a measure for appraising this specific alternative.

g. Repeat Steps (a) through (f) for other reprocessed items.

h. Analyze examples to determine nature of interacting cost factors and their effect upon derived measures.

2. Compute unit cost of using each of several disposable supply items in a few specific hospital situations.

a. Select one supply item, such as the disposable syringe.

b. Make a survey of prices charged hospitals.

(1) Compute unit procurement cost.

c. Compute unit costs for using supply item, e.g., labor, material, overhead, and intangibles.

d. Repeat Steps (a) through (c) for other disposable items.

e. Compute a measure for appraising this specific alternative.

f. Analyze examples to determine nature of interacting cost factors and their effect upon derived measures.

3. Analyze cost accounts of a selected sample of hospitals.

a. Determine the kinds of accounting methods employed.

b. Determine the extent to which cost accounting is used.

c. Collect cost data pertinent to supply items.

d. If collected cost data are too gross:

(1) Build cost factors from gross costs by analysis and synthesis, using electronic computer or other devices, or

(2) Collect actual cost data specifically for this project, using temporary cost accounting system in each hospital in order to obtain cost factors.

e. Analyze this data to determine nature of interacting cost factors and their effect upon derived measures.

4. Compare results of approaches 1, 2, and 3 cited above, and develop a composite list of the cost factors which govern the two types of supply items.

(It is estimated that this will conclude the first year of the total study. The second year will be devoted to the following work:)

E. SECOND YEAR

5. <u>Determine the relationship of cost factors to the two types of supply items</u>.

a. Determine intercorrelations among cost factors.

b. Determine correlations between specific cost factors and measures upon which alternative decisions can be made.

c. Test all correlations for statistical reliability and for validity.

d. Establish relative worth of each cost factor appearing in the composite list.

6. <u>Determine a hypothetical decision system</u>.

a. Construct a mathematical model involving the selection measure as a function of all cost factors.

(1) Use sample of hospitals for various kinds of disposable and reprocessed supply items.

(2) Develop standard model.

b. Reduce this theoretical model to a practical model by deleting insignificant cost factors.

c. Convert this practical model into a useful administrative tool, such as:

(1) Nomogram

(2) Multi-variable table

(3) Arithmetic system

(It is estimated that this will conclude the second year of the total study. The third year will be devoted to the following work:)

F. THIRD YEAR

7. Test the hypothetical decision system through evaluation, and revise system as required.

   a. Select a sample of hospitals of varying size and type and of several different combinations of the cost factors.

   b. Using decision system developed, predict results which would be obtained by use of various reprocessed items in the sample of hospitals.

   c. Analyze actual pertinent costs accrued by use of reprocessed items.

   d. Evaluate validity of the decision system by comparing results from Steps b and c above.

   e. Redesign decision system as and if required to improve predictability.

   f. Using decision system developed, predict results which would be obtained by use of various disposable items in the sample of hospitals.

   g. Have several hospitals introduce the use of several disposable items.

   h. Analyze actual pertinent costs accrued by use of disposable items.

   i. Evaluate validity of the decision system by comparing results from Steps f and h above.

   j. Redesign decision system as and if required to improve predictability.

   k. If decision system is redesigned in Step j, re-evaluate.

(It is estimated that this will conclude the third year and will satisfy the specific aims of this study.)

G. CONTINUATION STUDY

A continuation study, while not being a part of the immediate study, will be devoted to an investigation of extensions of the decision system for possible application to other supply items. This will be followed by an investigation of extensions of the decision system for possible application to other resources, such as materials, equipment, and labor, and to management decisions involving choices between alternatives.

III. SIGNIFICANCE OF THIS RESEARCH

We are beginning to see pre-processed and disposable items of all sorts in our daily lives. Items such as disposable napkins, paper cups, facial tissues, foodstuff packaging, and other disposables have become commonplace. Part of the stimulus for this innovation has come from consideration of convenience. Private enterprise, profit-motivated business is beginning to realize the value of disposable items as a means of reducing labor costs. The economies inherent in mass production factory operation are being capitalized upon by a substitution of specialized labor in the factory for diversified, highly skilled labor at the point of consumption.

The health industry is beginning to use disposable items in increasing volume, e.g., the disposable enema and the disposable syringe. Of course, other disposable items such as napkins, cups, pads, and gauze have been used for some time. There is reason to suspect that economies can be effected through an increased use of disposables without adversely affecting quality of patient care or quality of hospital services rendered. Unfortunately, most hospitals do not have industrial engineers nor good cost accounting systems which could provide definitive information upon which the hospital administration can make objective decisions as regards the alternatives of disposables versus reprocessed items.

It is the overall purpose of this study to devise, test, and perfect a system for use by the hospital administration in making decisions with respect to these types of supply items. A practical decision system will enable hospitals to substitute objective policy guides for hunches, tradition, bias, and precedent. Such a system might well be extended to hospital supply items other than disposables and reprocessed. It might be modified or expanded for application to the procurement of other resources such as materials, equipment, and labor, and to management decisions generally which involve choices between alternatives. If such a decision system can be developed, it would be a significant step forward in facilitating the maximization of the quality-cost ratio of providing hospital services.

IV. FACILITIES AVAILABLE

Facilities include those of the Georgia Institute of Technology, including resources of the School of Industrial Engineering, the Engineering Experiment Station, and the Rich Electronic Computer Center; Emory University Medical Center, including University Hospital, the School of Nursing, and the Graduate Program in Hospital Administration; and a selected sample of hospitals in the Atlanta area.

V. PROJECT STAFF

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PROCEEDINGS

of

NATIONAL ADVISORY COMMITTEE MEETING

May 16, 1959

"Disposable versus Reprocessed Hospital Supplies"

USPHS GRANT #GN-5968

D.J.

Edited by:

Harold E. Smalley
Principal Investigator

Engineering Experiment Station

Georgia Institute of Technology

Bulletin No. 2.

Atlanta, Georgia

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G E O R G I A   I N S T I T U T E   O F   T E C H N O L O G Y
ATLANTA, GEORGIA

Engineering Experiment Station Project #B-158

NATIONAL ADVISORY COMMITTEE MEETING

Atlanta Biltmore Hotel

May 16, 1959

Edited by:

Harold E. Smalley
Principal Investigator

This investigation is supported in part by a research grant (GN-5968: "Disposable versus Reprocessed Hospital Supplies") from the Division of General Medical Sciences and the Division of Nursing Resources of the United States Public Health Service.

Bulletin No. 2.

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P R O C E E D I N G S

I. Morning Session - 10:00 a.m.

NATIONAL ADVISORY COMMITTEE:

Present	Absent
Dr. Richard A. Dudek	Dr. Lillian M. Gilbreth
Dr. Daniel Howland	Dr. Ruth P. Kuehn
Dr. Hugo V. Hullerman	
Mr. Matthew F. McNulty, Jr.	

PROJECT STAFF:

Dr. Harold E. Smalley

Dr. Joseph J. Moder, Jr.

Mr. Thomas L. Newberry, Jr.

Mr. Isaac Ifrach

OTHERS:

Dr. A. D. J. Emerzian

Mr. Harold O. Duncan

Introduction

Smalley: This is the first meeting of the National Advisory committee of the USPHS Project, "Disposable versus Reprocessed Hospital Supplies". One of the reasons for this morning meeting is to bring this group up to date on the Project so that, when we meet this afternoon with the Local Steering Committee, we will all be at about the same point. The local group is more aware of what's going on as they have met several times since the Project was instituted. We will start by giving you some background for the Project.

Background

This Project was an outgrowth of the Management Engineering Program at the University of Pitt burgh. As a result of the Hospital Bed Project and other programs in the Vice Chancellor's Office at Pitt, the present Project was structured. Some interest was expressed in this Cost Study by the PHS. We applied for and were given a grant while still at Pitt. Dr. Dudek and I, and most of the others on the Bed Project team, left Pitt last summer and it was decided at the time to leave the Hospital Bed Project at Pitt but to move the Cost Project, "Disposable vs. Reprocessed Hospital Supplies", to Georgia Tech.

Last summer we applied to the USPHS to permit us to pursue the Cost Study at Ga. Tech through the Engineering Experiment Station, in cooperation with Emory University Medical Center. We had a PHS site visit in August of last year. On January 1, 1959, the Project grant was made effective. Since the grant was made effective in the middle of an academic year, it has caused us to defer, to some extent, the organization of the team; but I thought I might outline for you how we conceive the team to be organized and to report progress in organizing the team.

Organization

First, under PHS regulations, it is necessary that a principal investigator be designated. Indeed, grants are made to individuals though the funds are held by an institution. The expenditure of funds is controlled by the prevailing regulations of the institution. I will be serving as principal investigator throughout the Project and will be devoting about 25% of my time to the Project. The Project is to be organized much the same as our Project at Pitt, namely, with an interdisciplinary team approach with a sufficient number of full-time people who regard this Project as their principal and first responsibility. They may do a few other activities that are compatible with the Project, perhaps teaching, an operational project here and there, or working a bit on some other research; but their principal responsibility will be to the Project.

We conceive that the group will be led by a team leader who will assume more or less the same functions as those of Dr. Dudek at Pitt on the Hospital Bed Project. This person would be largely responsible for the day-to-day pursuit of the objectives of the Project. We have not appointed a person to this position. We are trying to get Dr. Emerzian interested in it. Some of you have met him and he will be along soon. If Dr. Emerzian is willing to come with us, we are in hopes he can join us by the first of July, certainly by the first of September. If Dr. Emerzian is not able to join us, then we will have to continue to look for suitable candidates. We have an ad in the Journal of Industrial Engineering which has turned up a few leads but I am about to come to the conclusion that we will have to pry someone loose from existing work.

We plan to have, also, a full-time research nurse on the Project. This afternoon, perhaps Miss Graves, of Emory, will be able to report to us on an interview which I arranged for her with a Maj. Owen, who is retiring in June from the Army Nurse Corps. Maj. Owen's record is very good and, if Miss Graves' reaction to her is favorable, we will appoint her as the full-time, health-oriented team member.

Mr. Newberry, who is with us today, will be appointed as half-time engineer on the Project. Mr. Newberry has his Master's degree from Ga. Tech and is now in our new Ph.D. Program, working toward his doctorate. Later today we will hear something of his part in terms of trying to coordinate his dissertation objectives with the objectives of this Project.

We have yet to decide to what extent we will need a psychologist on the team, as to whether we need a full-time psychologist, a half-time psychologist, or a psychologist in a consultant role. This is one of the ways in which we would like to "pick your brains". Once we have reviewed the objectives, we need to know how we can best integrate psychological resources required.

We have, at present, three Master's candidates in I.E., who are interested in working on the Project and doing their theses on some phase of the project. We anticipate that there will be others, perhaps some from Emory's School of Nursing or Emory's Program in Hospital Administration, who would be interested in taking an area of the Project in which they might do their Master's theses.

We have a Project secretary, who is delving through the "red tape" of the Experiment Station and the PHS, trying to make it easier for us to do the things we have to do, by taking care of some of the routine matters.

Miss Graves, Director of Nursing, at Emory, is our nursing service consultant on the Project and she will be of tremendous help, particularly in our liaison with Emory University Hospital and later when we do our clinical studies and evaluations. Dr. Moder, who is with us today, is our consultant on methodology Dr. Moder is Professor of I. E. at Ga. Tech. We look to him for guidance and suggestions throughout but particularly in those phases of designing experiments, planning the overall approach and evaluation. Professor Evelyn Rowe, of Emory's School of Nursing, will be our consultant in Nursing Education. Dr. Mary Margaret Williams, of Emory, is our consultant in Nursing Research. We look to these two ladies for liaison in any student work on the Project that may be done in Emory's School of Nursing. If it works the way it did in Pittsburgh, there could be class projects, special problem work, and theses. We anticipate that we will need other consultants; for example, in operations research, hospital finance and purchasing, and perhaps others. Our aim here is to utilize these consultants when needed and when available to provide resources to round out the team.

All of you have probably noted the names of the members of this National Advisory Committee. Dr. Dudek, Dr. Howland, Dr. Hullerman, and Mr. McNulty are here. Mrs. Gilbreth could not come as she is out of the country at the present time. She has promised to come in and consult with us in the fall. Mrs. Kuehn had planned to come until last evening. I got a wire from her, stating that she could not make it, and she sent her apologies.

On our Local Steering Committee we have Mr. Duncan, who is with the Veterans Administration and to whom we would look, particularly, for hospital administration aspects. Since he has a tremendously large area of responsibility in hospital administration, we think that this could be a valuable resource for us. And we are certainly happy to have him with us this morning. Also on the Local Committee is Dean Ada Fort, of the School of Nursing at Emory. Dr. Williams will serve in her stead next year since Dean Fort will be on leave. Other members are Miss Helen Graves, Director of Nursing at Emory University; Colonel Frank F. Groseclose, Director of the School of Industrial Engineering at Ga. Tech and also a member of the Research Advisory Committee for the Experiment Station; Mr. Burwell Humphrey, Administrator of Emory University Hospital; Mr. Roger Klein, Director of the program in Hospital Administration at Emory; Dr. Edward Loveland, Assoc. Professor of Psychology at Ga. Tech; Dr. Moder, whom I referred to earlier; and Dr. Rocker Staton, who represents the Dean's Office at Georgia Tech. We look to Dr. Loveland to serve as a consultant to us or as a part-time team member; but if he is unable to do this, perhaps he can suggest someone else who might. This afternoon we hope that he will have some ideas for us. Dr. Staton is also a valuable resource for us because he did his Doctoral Dissertation in a hospital area while at Johns Hopkins. I wonder if you have any questions or comments on the background or the organization of the Project.

(Dr. Emerzian was introduced.)

Discussion

Dr. Howland: I guess you know about Harold Davidson by now and his O.R. background. He might be the one you could get interested in helping out. I learned this morning that Earl Alluisi, a psychologist, will be joining the staff at Emory.

He came from Ohio State and has considerable interest in systems research. He did work at the Aviation Psychology lab in experimental designs, etc. He worked at the Army Medical Lab at Fort Knox on Human Engineering problems. Good background.

Smalley: That's a good suggestion and we'll follow it up. Let's call Ed Loveland's attention to this man this afternoon. We do have valuable resources in the I. E. School; we have a large, diversified staff, and certainly Davidson is one possibility.

Hullerman: I'd be interested in understanding a little better the scope of the Project. My question revolves mostly around the word "procurement". How far into obtaining and putting into use do you intend for this study to go? I know that these grants allow a great deal of flexibility in changing direction; but, at this point, how far into use of material will it carry us?

Smalley: I would say, Dr. Hullerman, this is still open. We have no fixed ideas about specifics but we had thought up to this point that what we would want to do for sure would be to determine the cost factors themselves. (See Page 2 of the Summary.) That is, what factors are there which have an effect upon the decisions that you make with respect to using reprocessed versus disposable items? We thought that if we could begin to identify these, define them, and measure them in some way, this would be our first step. Then we thought that we would determine which of these seem to be significant and which extraneous.

Hullerman: In procuring, do you mean the cost of obtaining an item, like a syringe, up to the point where the nurse actually injects the needle?

Smalley: I would say the total cost.

Hullerman: Do you mean the cycle of use for the needle? The question is, do you take a needle up to the time that it is to be used or do you include also the using of the needle?

Smalley: If I understand your question clearly, it would be the total cost, including the use of the needle.

Hullerman: I think this is an important question and I think that we would be much better off if we had the whole cycle involved, rather than the procuring of it ready for use.

Dudek: This was the intention because in any "make or buy" situation, the total cycle is involved.

Smalley: This same problem was encountered in this other project. It's not enough to get the best hospital equipment in the world into the patient's area if it is not used or not used properly. I am convinced that, unless you consider the whole cycle, as you put it, you don't really have the whole cost picture and by cost I would hasten to add that we are thinking of not only monetary cost, or its equivalent, but some of the non-monetary factors.

Emerzian: I think that you would have to consider the components of the cycle. My suspicions are that you are going to discover the components, when expressed in terms of cost, are going to vary from hospital to hospital. There are certain activities associated with procurement which could vary from hospital to hospital. As to the procurement itself, that is, from the time the order is placed to the time that the article is secured in the hospital, some point or other would have to be defined and this could vary from hospital to hospital, which may or may not be significant, I don't know. This would be something which you would have to discover later when you drop out the insignificant variables.

Dudek: This Project might draw heavily on what Dan and his crew are doing at Ohio State. If he's trying to set up the system of the hospital, if they are actually describing the system, you may have a big step toward trying to define all these variables.

Emerzian: Is this an analog of a hospital that's being done?

Smalley: It may not be possible but, to clear up this question, perhaps Dr. Howland could give us a thumbnail sketch of his project.

Ohio State Project.

Howland: The title of our project is, "The Development of a Methodology for the Evaluation of Patient Care". This interest arose as the function of doing straightforward Industrial Engineering studies in the Hospital. And our original assumption was that you could write some sort of multiple regression equation for patient care and this would be given to us by the hospital; and if we could then say, "Well, this is the contribution of the physical plant and this is the contribution of somebody else"- . It didn't take long, about two days I guess, to find out this just isn't so.

After about two or three years of trying to get some kind of a picture of this "beast", we have come up with a diagram as follows. And this is what I mean by a theory, a crude one, a very primitive theory. It's a theory in the sense that it is an organization or classification scheme, not in the sense of a theory in physical science, like $f = ma$. But it's a place to start as an administrative guide to pigeonhole our work and also as a sort of a directing device. We say that the hospital model, or analog, looks like this:

$$E = f(x_i, y_j)$$

Where E is our overall criterion measure of effectiveness.

Now, in the O.R. business, this is usually taken to be cost and taken to be measurable and you optimize this in some sense or maximize or minimize it, or something. And in this situation, we don't think this is possible. We take this to be patient care, which is unmeasurable. The nicest description I have found of it is Dr. Dunn's notion of the general level of wellness which includes sociological, physiological, and economic, and you name it. This is the good, the true, and the beautiful. That sounds fine but we can't do anything with it. So, we say that this takes care of patient care, nobody can argue with this because nobody can get their mitts on it. The hospital, as a system, performs a function, which is the following.

This, by the way, works out for all the projects which we have. We say that it does the following jobs. It has a selection function which is a filtering action, if you like, getting objects into the system. Once It's got them, it performs a service function which is providing medical care and nursing care, housekeeping care, etc. In order for this to continue in time, it has a logistic function, you have to be supplied. Then, on top of all this, you have a control function which is the collection of data about what is going on, the statement of what you want and sort of a "servo" notion of minimizing the difference of the error between these.

Now we are backing off to the point where we are looking for criteria for each of these. For the selection function, in admissions, for example, we can take criteria such as time lag in getting patient from front door to bed. My wife works as a volunteer in a Columbus hospital in the admission office. She comes home after her day in the hospital and we sit down and have a long list of critical incidents. It seems to us that the real problem in getting a patient into the bed is that the admission office and nursing service look at the same physical bed but they don't conceptualize it as the same thing. It's the same piece of hardware but they are really talking about different things. And what's needed is some information transmission and understanding about what everybody's talking about.

The service criteria. We are assuming that the medical staff knows what they are doing and we are assuming that the hospital system should be geared to give them that they ask for. We are not getting into medical audit. So we have adopted, with their advice, some criteria such as medication errors, number of "consults", and a long list of these, presumed to be good practice of medicine.

Then "Supply". We are trying to work in the blood bank, principally because this was thought to be the toughest and because it cuts across many departments within the hospital.

This control thing is the whole business of record keeping, information transmission, etc. These men are the dependent variables of the hospital, acting as a system, and we are trying to get measurable behavior criteria for how these things get done. Now we say that this overall global goal is some function of the way these things get accomplished or not accomplished. And we further say that the function relating accomplishment of these tasks to optimize this overall global goal, at this stage in the development of the art, cannot be done rationally, mathematically, or in any formal fashion.

This is what the manager with responsibility and assistance does by guessing and, as a function of what he knows and what he can find out. This is management judgment, if you like, and this is research activity here. And what we can do for him as a research group is to spell out and measure how these things are getting performed. We have found that managers in other situations can do an awful lot better with this kind of information than they can do without it. Well, this then is the dependent variable of the whole system.

Over here you have the three classes of resources over which the hospital system has some control that it uses to get these things done. The first class is what we call the plant. This includes the architectural details of the hospital, the fact that per diem cost is some function of the floor plan. If you have one kind of hospital floor plan, you can expect one sort of cost and another floor plan, something else. So, we are interested in the equipment that they have available.

We talk about the general resource of staff. In starting out, we assume that the staffing variable of most importance in this case is the status relationship among serving personnel. We have a sociological group working on this. These guys were extremely lucky two years ago in being able to get a class of interns who had just entered the hospital and who were then assigned to each service for a matter of several weeks, and then as far as we can see, completely randomly scattered around. We followed these guys and got their reactions to the various services and the various services' reaction to them. We followed this up to the point where everybody was getting a little tired of talking to us, answering the same questions about different services; so we got out before we got thrown out. We were able to get some extremely good dope on these birds and we had some of them in all services. So we sort of had this design handed to us, with no designing on our part.

The characteristic of the patient that we are most interested in, again this is just a judgment that we think is important, is the information capability of the patient, what he knows about his disease, what he's told, how he's told it, and so on. We picked diabetes because this is fairly "clean". We've had tremendous cooperation with the medical staff on this. We've had a full-time psychologist working on it who has lived in the hospital and made friends with the medical staff. He shares information with them and they are allowing him to do the "N.M.P.I." for diabetics. Now this is quite an accomplishment because this is something you just don't do in two minutes. It means that everybody's got to really put out to get it done. And we had a decision to make here, whether we should try a shotgun approach and just see what would fall out or pick a neat hypothesis and test it. We thought the first plan should be shotgun, we just didn't know enough and we weren't able to find anybody else who did, to zero in anything very specifically. So they're working on this information-handling capacity, if you like.

What we've done, then, is try to get some hard criteria for task performance of the system and relate this to the dimensions of the plant, the patient and the staff that the hospital has available to it.

We have had lots of difficulty with our multi-disciplinary functions. You have to make a decision: either you have people working for you who are competent in many disciplines, so that each member of the team is in a sense a team in itself, or you have people who are really from different disciplines and they work more or less independently on the variables that are of interest to them. We have adopted the latter course decause it seems to me that if you do the former, you are almost forced to reduce everybody to the rank of amateur in everybody else's dimensions; and nobody lives long enough to keep up with hiw own field, much less two or three others.

So we have a sociologist working here and we can't even understand their language. They talk about the left-hand side and the right-hand side and I think this means dependent and independent variables. I was confused about which is left and which is right. They're starting on another study in the Tuberculosis Hospital on alienation, which I was interested to find out about. I think this a construct that an Industrial Engineer would never dream up in a million years but they're off with it. The thing I'm saying here is that these guys are going ahead and behaving like sociologists and they've done some things that horrify me; but if this is what sociologists do, I just clutch my ulcer and let them go. The same with the psychologist; the same with the engineer.

The interdisciplinary business comes primarily at the planning level. Sociologists are interested in a patient variable, alienation. And the patient group, the psychologists, are interested in status variables, namely, the status in terms of how socio-economic status or education or something or other, effects their ability to handle information about themselves and their disease. But these tie-ins come about after the fact, we didn't plan them, we didn't know enough. The same thing is working across here. Very briefly this is what we're up to.

Hullerman: Could you explain the equation you put on the board.

Howland: (Explains mathematical model.) This is the standard O. R. model and if this is a reasonable model for what you are doing, you can't do better. However, my point is that, in a problem of the size and complexity of the hospital, this just doesn't work. Either, to get this measurable criteria, you go so far down the scale that your problems are trivial, or you have to make so many simplifying assumptions to use it, that it's no good. So, you go then to this other "beast" where, you say, this is your "distal" (unmeasurable) criteria. This is the part of the end of the rainbow that you never quite get your hands on. It's something you can agree on but you can't find. This is a function of task performance. Now then, you say, task performance is in turn a function of the resources that you have. Well, this makes sense. Let's say we are talking about the selection task. Certainly the way people are admitted to the hospital depends on the physical plant of the hospital. Whether to take a broad jump, whether it's a mental hospital or a general hospital, depends on the staff. You might have a pediatric hospital as opposed to a general hospital, depends on the patient. Columbus is continually getting into difficulty because parents bring children to the University Hospital, which does not have a pediatric service, and they're told to go to Children's Hospital; and then there's a great big "whoop-de-doo" in the paper, "Hospital turns away bleeding child", and then the dean has to go down and talk to the Legislature. Each one of these tasks depends on everything. Then you break these out and you say each of these is some function which is a function of many other variables, e.g., physical plant layout, equipment, supplies, whatever. And you take the staff and their functions of status, social characteristics, etc. You have this fantastically complicated mess but all you're doing initially is lay out your dimensions for your variables; then what we've done is get general agreement on these variables and then we've said O. K., status, everybody thinks this is important. Let's find a guy who knows how to study status. And we get him and we talk to him and away he goes, and he's cranking out stuff about status. We're not trying to make an engineer out of him, we're not trying to make a psychologist out of him, we're trying to run him at full throttle as a sociologist. And I think this/~~a~~is trade-off you make in this interdisciplinary team business; "run" them as "within discipline" experts or as "between discipline" amateurs, in a sense. I don't think you can do both.

Smalley: In that connection, Dick, this does not differ substantially from our experience in Pittsburgh, where we had several disciplines and we found that really the way to get it done is to let the psychologists work in this area and let the engineers work here and let the nurse work here, and hope for some cross-fertilization.

Dudek: Yes, actually, Dan, we found the same thing because we would get to talking, then we would say, "Well, let's attack this problem first." Well, the psychologist has his idea and maybe it was more psychological than anything else; and we couldn't understand what he was trying to do and we would try to. We were amateurs operating in this area. So, finally we just decided, "O. K., this is your baby. Go ahead and we'll work over here because we know this."

Howland: Well, there seems to be sort of folklore about interdisciplinary groups being together. I think this is for the birds. I don't think it works too good and I don't think you have to have this as a requirement. Get a good sociologist in and if he's a bear, O. K., he's a bear.

Smalley: What about their value in design of the overall approach and in the evaluation? Is that where you find them working as a team, if at all?

Howland: Yes. When we started, as I pointed out, we started with this simple minor regression notion and this whole thing has evolved out of our work on this project. This is an after-the-fact kind of thing. We're now using this. Every time we start a new project, we do this first; and we get agreement before we start. The only thing we started with, initially, was the notion that there were sociological factors, physical factors, and psychological factors; and that there were staff, patient and plant. Now we sort of got some guys who didn't know what they were doing any more than we did, and they started off. But I think this device which has evolved is a pretty useful one for keeping things on the track, once you have it. As I say, we now have all our projects set up like this. It's a dandy gimmick for a bookkeeping device, if nothing else, and I think there's a lot more to it, as we learn more. It seems to me that there are a lot of general things you can get out of these variables, general measurement scales, general ways of handling them; and then you can talk about specifics for specific kinds of systems.

Smalley: Have you encountered yet any need for determining the degree to which the patient is dependent upon those who care for him?

Howland: Oh, well, not specifically. This, I think is, if I understand the word, which ties in with this alienation business.

Smalley: I was wondering if it hadn't already come to your attention. I think the work on the Patient Profile that we started at Pitt, and which is continuing, conceivably should be of some value in that respect.

Hullerman: Are the things you are measuring "independent"?

Howland: Well, no.

Hullerman: The equipment is X, etc.?

Howland: Yes, you are right.

Hullerman: In order to get any change in a procedure, you have to have an organization. It may be substantially different from what we have here as the result of what you find out there. Where is that shown in your formula?

Howland: This formula, in a sense, specifies the organization, not in any organization chart sense but in a behavioral sense. This may be completely different from the organization chart. It seems to me that the next step after you've gotten this is to, if you believe in organization charts, crank one around that will reflect this behavioral organization.

You have a strange situation here. It seems to me that a lot of the considerations of organization that people are trying to use in the hospital stem from military organizations, e.g., "span of control". The objectives of a military organization are diametrically opposed to this kind of organization. In a military organization, you want to be sure that the guy can do at least what he's supposed to do. If he can do something else on top of this, it's his tough luck. In the hospital, it seems to me, what you want to do is take advantage of everything you can possibly get out of a man or out of a research team. And what this leads you to is <u>status inversions</u>, where in one situation a man may be a high status member of the group, where in another situation he's not. And this is where you run up against difficulties with the formal organization chart. You get this same situation in the airline. The pilot in the air is in command of the ship and nobody tells him what to do. On the ground, he's way down at the bottom of the pile. He may be going to school, he may be doing all kinds of different things inbetween.

Cost Study Discussion

Hullerman: In reviewing this outline, I was trying to stack it up against a feeling I have which I think very well may be the case with many a hospital. Everything we've read, for example, about the advantages costwise, not service-wise, for the use of disposables, comes up with a cost of so much if you do it this way. Now, there's very little that I have heard about to indicate that this is not in reality an increase in the cost of operations, because there's no evidence that anything else is cut out. Now, where in this do you get into the elimination of a past system, from a cost standpoint, not a service standpoint?

Howland: Now there is nothing in this about cost at this point; this is behavior. Now this brings up another point. It seems to me that cost is a pretty high level abstraction which you assign to some kind of behavior, and it's also my feeling that you first have to nail down behavior, then you do the cost assignment. For example, in a study we did with a motor freight firm, the maintenance people were keeping cost records on maintenance and this didn't tell them the first thing about what was happening to the tires or batteries or generators, or anything else. The reason for keeping cost records was that the maintenance superintendent was a graduate of a business college and this was all he knew how to keep. And we were trying to get failure data from this group and they had no way of collecting it; they didn't know what to do with it if they did. It took us almost three years to have this switch from cost to behavior data made. It was finally made by the president who went down bodily and took these cost records out of the file and threw them into the incinerator. Then they had to do it our way because they didn't have anything else. But the cost data just didn't tell them anything.

McNulty: This organization chart that you say may have evolved from this work, you would field test a great deal of this. Your behavior patterns in Columbus, Ohio, might be a lot different than the sociological concept in Birmingham, Alabama.

Howland: That's exactly right. And it seems to me that, if you can look at the behavior and get some clues about how to specify dimensions and measure them, it's up to the individual hospital "to smoke Viceroys" or whatever it is and to be "thinking men". For example, in Columbus, we have a children's hospital which has, I understand, gone from being just so-so to extremely good because of one M. D. in the thing, who had vision and drive and did things. There's no place in this for him but what we are betting on is that there are certain behaviors that have to get accomplished in any hospital, from a field hospital where you're operating in the mud up to your ankles, to the most modern, glorious thing in the world. But certain basic things that have to be done, then the problem for the individual hospital is given: you know what these are, and given: you know how to measure performance of these, how do you use what you have to do. So you are flexible on an individual basis, as far as accomplishment is concerned. And this is where the organizational chart for any individual hospital comes in.

Accomplishment:

Smalley: Dan, let me ask you this. I wrote a "cloud-gazing" expression over here, premising that accomplishment is some function of the ratio of results to costs. The numerator there, M and Q, stands for the magnitude and quality of yield from the system. And C_m and C_n represent the so-called monetary and non-monetary consumption of resources. Am I right in presuming that your efforts have been directed thus far in dealing with the numerator only? And when you talk about behavior patterns, you're talking about results, you haven't considered the consumption of resources at all?

Howland: Not in the cost sense. We talked about consumption of blood in pints but we did not attempt to do this in dollars.

Smalley: Only as a measure of activity though, is that right? You were interested in the consumption of blood because this measures how much or how well something's being done?

Howland: Right. We take as a criterion of blood bank performance, if they can meet the demands for the amount and the quality (or type) of blood that the surgical service asks for.

Smalley: Now, in trying to tie that in with the question Dr. Hullerman posed, I was wondering if he was interested in, for example, something you do to change the numerator, undoubtedly will have an effect in the denominator. It might simply add to the cost and not eliminate anything in the process. It's this old matter of "paper savings". Do you really accomplish it? Even in a non-monetary sense, do you really save it?

Hullerman: I am very interested in the Study because I think it gets us down from some very general stories to something rather useful. Could we have a complete transcription of what's going on here so that we could study it before the next meeting?

Smalley: We certainly will make that available to you.

Patient Care:

Duncan: In your basic approach, when you broke down patient care in certain task areas and one of them was service, did you find that some of the variables involved in the non-measurability of the global concept of patient care showed up in this service area here?

Howland: Yes, when we do it this way, we assume that this global measure is some function which we don't think we can get our hands on; of service but not just service, all the rest of it is done, too.

Duncan: This is an area where it does show up and the one where you will have difficulty?

Howland: Yes.

Dudek: This massive problem has to start in this way. This is how Hal and I really conceptualized this study. We were going to make some of these assumptions that you have to make, to see if we could come up with something practical for right now, and then start from there, you see; because we felt that this was a rather important thing from talking to some administrators. But you need these kinds of studies, too, these basic ones. This was going to start in this way but we hoped to end up in something practical, even though there would have to be many of these assumptions made in order to get it down. What we had hoped was to test them and see if these assumptions would hold fairly well in general. To make it usable, but not necessarily accurate nor completely correct or sound in theory.

Phantom Savings:

Emerzian: I think that you have put your finger, Dr. Hullerman, on a very important point, one that I've heard several times; and I am not certain that this project is going to be able to give you the answer to it. But there is a difference between labor saved and the value of labor saved. Let's assume that you are able to put in a disposal supply item and may reduce the total activity of a function by three or four hours a day. You translate this into cost. Does this mean any effect upon my payroll? And I say to you, I don't know. This depends upon you. I don't know your conditions.

Hullerman: Yes, but in this study of Harold's here, I am wondering whether it actually reduces the cost of a function in some way in fact. In other words, you get way down in the organization and system of operation to make this cost reduction.

Dudek: I think it does in this sense, in the way Joe brought it out. But this time, that we can show you on paper, as Hal just referred to, paper cost, but as far as the hospital goes, it may just be idle time. Because nobody did anything with this time and, therefore, the overall costs were not affected at all. But this is really a management function. We have no way of saying, once we get this cost, you have to do it this way, you have to fire a person, or you have to transfer time, or you have to add another job, in order to save this money. We can just show that you have this potential. Then, from there on, it's in the hands of the administrator, the management man. This same operation goes on in industry. Many industries have good I. E. Departments but they don't use this information; so, in effect, they are just giving I. E. lip service because they would never utilize any of the costs that were put on paper.

Local Analysis:

Emerzian: As I look at this thing, I think that what's going to happen here is that out of this Project certain information will be derived. Each hospital should have a resident engineer who will interpret the information which is given but put into it the local variables and then make his local analysis. I don't think that this study can give you the local analysis, the local application. We need trained people in the hospital to take this information which we have and apply it to their own situation.

"Everyone": This is always true.

Emerzian: This is true to us but, as I talk to hospital administrators, I have the feeling that a lot of them are discouraged with this "ivory tower stuff". They don't have time to read it and, if they could read it, they wouldn't understand it anyway. What they're looking for is something which they can understand and apply.

Howland: They're looking for a "kit" and there isn't any; there never will be unless we have just one hospital.

Emerzian: We have an educational problem on our hands, I would say.

Smalley: This Project need not be that pessimistic. We're not just going to be an ivory tower on this and we're probably not going to be as theoretical as Dan is obliged to be in his by virtue of the scope of his work. We will give them a practical tool but it is not a panacea, not a general model in which you put in the number of beds, the size of the staff, and the local price index and grind out an answer.

Emerzian: This project will be as successful as the extent to which it gives the person on the spot all the tools necessary to solve his "make or buy" problems.

Specific to General:

Dudek: What we were going to do was to investigate a specific and see if we get to the general.

Howland: We started this way, too, with needle packaging. I was unhappy with the fact that these little studies were done as Master's theses. We would go back three weeks later and find things had not been followed through. So we were struck with the fact that if you really want to make any changes. you've got to hit it at a higher level. And, as I say, our first great disappointment was to find that the hospital didn't have any measure of patient care. So we have been forced into greater and greater abstraction in order to make any sense out of this.

Case Studies:

Hullerman: In this study, you were starting with determining methodology and in reaching a decision; that was the first step. But, also, you're going to get into the application of some of these things in hospitals. Let's recognize that no hospital can be told how to organize itself. But, if the study itself will give some attention to what actually happened in reductions of cost, if any, and how those were brought about, I think it might be helpful, if any can be brought about. If we could show that either it did or did not effect redistribution of personnel, and how it would be a help.

Emerzian: You want some case studies of actual applications.

McNulty: A by-product, maybe.

Smalley: There is a distinction here between testing the model and case applications. Undoubtedly, testing the model will be a part of the Project, as Joe indicates. We're looking at the third year as being the time when we do this. But I believe from your question here, you're looking for more than that the model held up well in this situation, or it didn't here.

Hullerman: I wouldn't take out any criterion judgment but you have come up with a number of things, presumably a more efficient way, a better method of determining cost. But what happened in the hospital over and beyond that when these things were put in? Take the syringe, for example. You're reaching a method as to how you're going to decide the difference between cost, is that right?

McNulty: Procurement cost?

Hullerman: Cycle cost, really.

Smalley: Total cost?

McNulty: Including usable cost? I thought, Dr. Hullerman, you were going to get to some of the things that I was concerned about, cost in terms of personnel, cost in terms of morale, cost in terms of patient satisfaction. Are we getting into all of this? You used procurement throughout, so I took it to mean that we're talking of a purchasable and disposable cost, as opposed to a cost of satisfaction, if you will.

Hullerman: No, I'm staying away from the cost of satisfaction or better service. Suppose that you find from this study, with a method that's acceptable, that the cost of furnishing a syringe is "x" cents by the disposable method and "y" cents, which is higher by the reprocessing method. The hospital puts this in but, actually, the hospital is increasing its total operating cost unless it also cuts out some "y" cost somewhere. Right?

Emerzian: Only if they're monetary costs.

Dudek: Suppose that some kind of study is done to determine that patient satisfaction goes up this much if you use a disposable rather than a reprocessed syringe. It feels nicer, and patient satisfaction goes up. And then cost factors are assigned to this. How it's going to be assigned, of course, is a big question. If you, as an administrator, decide to take this disposable because, for the same price, you've gotten more patient satisfaction, and that's what you want, then you've saved some money; but you haven't saved it on the profit and loss statement.

Types of Costs:

Hullerman: Well, that's goodwill; and that sort of thing we are not interested in here. You've got to find the dollars with which to run the hospital. While they are related to goodwill, it's pretty hard to establish the relationship. In the cost of the "x" method, the disposable as against the reprocessed, if the study were to indicate that this did or did not happen, that the hospital was able, on direct cost, to put this in and increase its budget or whether it was able to accomplish something else and, if so, how. I think this is of significance to anybody reading the report. It would be to me.

Smalley: In other words, you're not interested in any phantom savings; you're interested in knowing if it saved any dollars.

Hullerman: Of course we're interested in phantom savings but you can't take both of them "aboard". You can't take them to Blue Cross.

Dudek: I think what you're driving at is that this model should be constructed in two ways:

(1) Only with real cost, those costs that will appear on the profit and loss statement, for a comparison, and

(2) With "unmeasurable" (phantom) costs.

Hullerman: I think this comes back to a feeling on my part, a great mistrust in ever using the idea of avoidable costs or intangible benefits. Let's recognize them but you can't measure them. They're important, they're vital, but they're meaningless.

Smalley: Let me draw an analogy between this and the inventory control problem we're having in industrial engineering. If your company runs out of something and has to tell a customer, "Sorry, we don't have it", you lose the profit you would have earned on the item that you didn't sell. In addition, you lose something by virtue of the goodwill you have lost; or the fact that he may go to your competitor next time. We have a difficulty measuring these things. To the same extent, we have a difficulty measuring this. What we can do, and the dodge we often take is, what will it cost you to increase the probability from, say 0.30 to 0.90 that you will not turn a customer away. Then let the decision maker decide for himself on that basis whether it's worth the extra cost to avoid this loss of goodwill. Now I think there's a parallel here. We can pose to a decision maker: "Well, this is what it will cost you to achieve these intangible benefits over here, over what it would cost you without them. Now, are you willing to buy that much of these intangibles?"

Hullerman: You have two ways in which to present a problem, a budget, or a service that you want to add: One is, what does it mean in good hard dollars? And the other is, what does it mean in terms of what is more important in the long run, your degree of service, your patient satisfaction, and this kind of thing. But you have to make a choice from year to year. Which one of the new expenses is going to help your patient satisfaction, efficiency of service? And if the study would do something to show whether or not there were any dollar differences, up or down. I don't care for any judgment on it, just the facts. Did this hospital add to its cost or didn't it? This would make a more predictable and usable report for the hospital.

Dudek: In a sense, this makes your study a little simpler.

Emerzian: I think this whole study's quite complex. For example, I read this case yesterday. I don't know what the supply item was, but it was something they put down into a person's stomach. They take it out and clean it occasionally. Someone came along with a disposable item made of plastic material. I think it cost more than the item we process. But, in the opinion of the medical staff, patient comfort would be increased if you used the disposable item. A disposable item costs the hospital more money (real money) but the hospital increased the cost for that particular charge for that particular service by "x" amount. In other words, the hospital made a value judgment here to the patient, saying, "Now, we think that this has less discomfort than the other item, therefore, we will charge you $15.00 more."

Hullerman: What bearing does that have on this study?

Emerzian: I'm saying here that the administrative decision which came about from information which we might give to the hospital administrator, is unpredictable in terms of what they might do with that information. Here you have some feeling that patient satisfaction was increased, therefore, price was increased.

Hullerman: You're mixing up income and cost here. This is another factor in the situation. I think this can be a very important and helpful study; but the hospital, whenever it adds $15.00 to the charge to the patient, it automatically is adding to its rates. And its got to go to Blue Cross on costs, not on rates. On rates, its got to go to the public and say, "We've got a $40.00 instead of a $35.00 bill"; so that it's always under pressure. I'm not minimizing the significance of patient satisfaction or public relations but we do have some reports showing the relative costs of disposable as against reprocessed items. Even if I personally knew that these costs, when put into use, would be more and that there was no real prospect on the basis of what any other hospitals have done, of saving that cost, you could still do it but, at least, you would know where you stood on it. If this study could give the picture of what happens, it would be more helpful.

Moder: Are you concerned about the fact that a lot of this reprocessing might be in the classof deferrable work? If you took away some of this deferrable work, this would just create more idle time or, perhaps, you would have some idle time which you can use for this deferrable work.

Hullerman: The hospitals are so understaffed already that the time is used somewhere else, but you haven't any choice if you don't know these things.

Emerzian: We're doing economic study on a Coulter counter. The Coulter counter gives you a greater accuracy and reliability, so they tell me. The Coulter counter is more expensive. What we hope to be able to tell people is that, for one per cent increase in accuracy, it's going to cost you so much, for two per cent so much.

Hullerman: I just signed a requisition for a Coulter counter that will cost about $3500.00. We will not get any more for the patient, really, than what we already have. We are not deficient in equipment to do what needs to be done now but we buy it. Why? Well, there are certain pressures back of this purchase. One is that Children's is a research institution and this refinement that you're talking about will have some value in the research work which is large in hematology there, very large. The other reason is, all the laboratory director's friends are getting Coulter counters. You've got a good deal with your director and the Coulter counter is cheaper in the long run, probably, than going out and trying to find a new director and all the reconstitutional laboratory that goes on. You've got to give them a little ground here and there and this happens to be one in which, management wise, means quite a bit to him. Certainly there are special funds we can't use for operations then we can put into what's in the semi-research light. So there are choices I know, and this is what I would like to have this study bring out, which other studies haven't: That it doesn't mean a cent in savings in the operation of the hospital. It means a lot more satisfaction.

Duncan: We say "patient satisfaction"; we are really talking about something larger, quality of care, of which the basic satisfaction is a part but not necessarily an integral part of.

Hullerman: I've personally studied on personnel usage, etc., where they show how they save manpower, man hours per time period and, in spite of all this, the costs keep going up. I think costs will keep going up in spite of what anybody does. But if this thing can specify one part of it, this will be a great service. I don't think you should kid yourself or anybody else that you're going to save operating cost, and I don't think you will.

McNulty: This discussion today is interesting to me. We are talking about the end product of what we are sitting here to contemplate, I imagine, but I would like to make just one comment on that. I seem to sense here a feeling that administrators are simple people, therefore, we should get out a simple report. I am sort of opposed to this (even if true). I do make the point that I would like cost in this but I would also like to see many other factors included in it; and I'd keep emphasizing satisfaction wherever else you will. The Coulter counter is, perhaps, a poor analogy but I can see that some cost factors even in its utilization, in the sense that, if you didn't sign the requisition, the morale, the behavior pattern that Dan mentioned would decline to such an extent that it might be a wise investment in terms of cost savings. Eventually, if all of this gentleman's collegues start using it and they talk at their union meetings of results in terms of the Coulter counter. this places him at a disadvantage and we can't overemphasize that.

Hullerman: Is this the decision for determining the relative economic feasibility of procuring?

Smalley: I would have two comments for that. One is that I imagine that the connotation to be attached to procuring is a more general one than writing a requisition for it and paying for it when it gets there. The other is that I see the objectives being rewritten as we begin to structure this. For example, at the moment, as a result of this discussion this morning, I see two, at least two avenues, a fork in the road here. We can take all of these intangible things, being fashionable about getting the latest thing and satisfying the desires of the people, to being able to say they have it at conventions; or having them use something that is not quite as obnoxious as something else. Lumping all of this and pricing it for the administrator and saying, "All right, Mr. Administrator, subjectively make your own evaluation as to whether or not these intangible advantages are worthwhile. I will price it for you to tell you what it costs you, if you decide on this course of action." We could do it that way, or we could try to open up that area and build a model that would assist him in evaluating his alternatives. I am not certain now whether or not we should concentrate on this second one or not. I think that is the area in which you say, Joe, that this is a complicated problem.

"Everyone": It is.

Hullerman: It may be said that some hospital is leading the field, or some hospitals have, why don't we? We have competition in the picture. The doctors say, "We've got the finest instruments in the world", or "We don't have". After all, there are hundreds of factors that you might measure in this area of the value of doing things a different way. But the study here is on cost, all the first points, especially the first three. This study constitutes the first phase in an investigation of alternatives and their relation to hospital costs.

Kinds of Models:

Dudek: Well, but now, costs were used very generally, meaning that we would try to evaluate some of these things you just mentioned. How much is it worth to us to lead in the field? Let's put a cost factor on it. However, I think, maybe, the procedure would be to do this in two stages. A model that considers only those real costs and then another one to consider all these so-called intangibles, such that you could see first, that is what our real cost, savings, or expense would be. And these would take into account the using of the items, whether it takes longer to use the disposable or less time, whether it costs more; all the real dollar costs. Then, in the second model, you would add all these other variables to it, to see - sure our cost went up but, in essence, it went down because our patient satisfaction went up this much. Our staff satisfaction went up this much. Therefore, our morale is going up this much. It is worth it to us to raise our costs to obtain this intangible savings. But the administrator of the hospital would have to make this decision. Then he would have both costs. You could get a savings out of it, but it reduces morale a little, or it is not quite as nice for the patient; but it does save us money. Then when you add the rest of this model, for patient satisfaction, etc., it would be worth while.

Hullerman: If you are going to lump it into one study, if you are going to duplicate what is already on the market to an extent, except as to the methodology of reaching a decision, you can't measure these things, your report isn't going to be believed. This is a matter for judgment in the institution. We need something that will be read and believed.

Smalley: Are you suggesting that we build a model, dealing with these so-called non-monetary factors, or that we not build a model for them?

Hullerman: Oh, I think it would be wonderful to build a model if you can live that long.

Smalley: You think, by all means do the other whether you get to intangibles or not?

Hullerman: That is right.

Dudek: Do the practical one first, get a practical model.

Howland: Get the model you can get.

Hullerman: The point is that if you put these together, you are not going to get something that is nearly as useful, I think, as if you can separate the tangible, the thing that people can't question, from the intangible, the thing they can question. Is this reasonable?

Smalley: It's very reasonable. My question is, should we try to do these things concurrently, or should we try to do them sequentially?

Howland: If you don't concentrate on the real cost, you could fritter away so much of your resources. Patient satisfaction is a "will-o-the-wisp" thing. You've got to start with something.

Practical Aspects:

Emerzian: You have a wonderful opportunity here, Harold, of finding out what the people who would use this information want. As I understand it, the people who are on the right-hand side of the table here are potential users of this information. Is this a fair assumption?

Someone: Yes.

Emerzian: Well, here we have a wonderful opportunity. Now, you tell us, gentlemen, how should we do this in order to make it practical for you? Is that a fair question, sir?

Hullerman: I would answer it this way. Somebody else would answer it another way. It is practical if I can know the out-of-pocket, the cost involved in a disposal versus a reprocessed item through its cycle. This would be helpful. It would be helpful to me if I could know whether the dollars I have to provide at the end of the year are greater or less, whichever way I go. It would be helpful to me to know what actually happened with other hospital budgets, if they did save any money, which I seriously question. What did they do in reorganization, not to tell any other hospital what to do, but what they did. It is an idea, a lead. Thirdly, what did the hospital gain in the intangible area, and who said it gained? I mean, if you take something off of nursing or central supply, of course, they have gained. And there is a lot of gain - but who said so? What did you measure to find out how real this was, or whether it was real in one small segment of the hospital. These things would make such a study quite useful because I would expect, year after year, quarter after quarter, to go to the Board and say, "We can do it this way." Now, I will give you an example. We are going to put in a hostess program of some size and we are already running more of a deficit than we can stand. This is not going to save the hospital a penny on its budget, it is going to add to the budget. But, we elected to do it because the returns are so great in the intangible areas in which we feel a great lack. But I can go to the Board and say, "This is going to cost "X" thousands of dollars and we are not going to take in a penny of it." But they understand it and if, as a result of this "high-in-the-sky" area which some of the other disposal studies take us into, I think you've got something that is worthwhile.

Smalley: Mr. Duncan, as a potential good customer of disposable manufactured items, what would sway you in a decision as to whether to bring in a disposable item or whether to use the reprocessed type? Would it be this dollar and cent business largely, or would it be the intangibles, or some combination? How would you come to that decision?

Duncan: I would endorse much of what Dr. Hullerman said. But I wouldn't be looking forward to a tangible savings which would detract from my operating expenses. I mean that I have a smaller budget next year, but rather which could be converted to time. In other words, in this practical measurement of cost, the employees' time, which we spoke of a moment ago as being idle time, I would not look at it in that way. We seem to feel that there are so many things we should be doing that we can't be doing already, that this would enable us to divert that employee to something else which would result in a better product, a better patient care product. So, we would be as much interested in improving the value of our product as we would in reducing the cost of it. But it would be a mixture, how fine it would be, there would be some decision making elements, which we would have to make in each local situation.

Hullerman: I agree with him on this. I don't think that use of dollars of the budget is the most important thing. But what did the hospital actually do with these people? Now, we have an example in a hospital in which they took the Dietary Service out of the Nursing Department but nobody could tell me what the nurses did when this large load of work was taken off of them.

Smalley: This is what I have been referring to as "phantom savings". That is, it's savings on paper only. Unless you are able to do what you say, divert them to better care or divert them to other activities, then it obeys Parkinson's Law. But, you're optimistic that Parkinson's Law will not come into effect and you will be able to use this time productively, either by increasing the quality or doing some things that you are not now doing.

Duncan: This is up to management. We can't come out with something which is fool-proof and which, without thought, is going to prove this; but we can give a tool, a resource to management which somebody is going to have to insist on his using, and which will result in ultimately much good.

Hullerman: Wouldn't it be worthwhile even if we just knew that some hospitals did something with this.

Duncan: Oh, yes, as a matter of fact, we would require a reporting.

Hullerman: But nobody can tell us what they should do.

Duncan: No, I agree.

Dudek: Would this be a fair way of stating this a little differently. What you are after is something that will quantify as much of the data as possible to reduce your intangible judgment as low as possible? In other words, we can't eliminate this administrator. He is still going to have to make a decision somewhere along the line.

Duncan: He's still going to have to think, a little.

Dudek: But if we could give him a model that reduces as much of the data down to some objective value, dollars and cents or time saved, or something of this nature, then the follow-up, the hereafter would be plain. Now let's try it in some hospitals and what do they do with it? What did that hospital administrator actually find out? That he saved time or money but not necessarily reduce the budget; but put these people over here and they are doing their job that wasn't done before?

Hullerman: As a separate research project, I would like to see a methodology for determining how an administrator would know what was done with the extra time.

Smalley: Matt, what would loom large in your mind, in making the decision?

McNulty: Well, I don't know. I am hesitant to react like a laboratory director that wants the Coulter counter. But I would have more of a balance between costs and what I might nebulously describe as "other things". I would be very interested in the report as to whether it would give me any methodology by which I might make an application to some analyses that I would like. I would be interested in the cost, but I would also be interested in various factors of the cost, which I presume would be in there, and that is: What does this mean in terms of additional warehousing and what does it mean in terms of all of the logistics of the situation, as opposed to those logistics I now have? It is my off-hand guess that there is probably a very large logistic problem involved, the warehousing and things of that type. In addition, I would want to know and this is where I would bring in the balance, what did the users think of this? It is fine if it comes out at fifteen cents or it's 0.5 mills less, but I would also like to be sure that, concurrent with the knowledge, if I get the fact that if it is a syringe and none of the nurses liked it and all of the patients felt that it was the blunt end of a fountain pen into their - - -. These things would be important to me. And I kept mentioning this, probably to the point of paranoia; but I think that, concurrent with cost, should be: What is the utilization factor in terms of satisfaction, employee satisfaction, patient satisfaction, I don't know, there may be a Board satisfaction, all sorts of satisfaction. I would want more of a balance in these than what I perceived in listening to what Dr. Hullerman said.

Emerzian: And in frustrations?

McNulty: Yes.

Hullerman: I want those things but I think that if they dilute the more tangible, they are less useful.

Dudek: Well, this is what I think: We are going to have to do it in two pieces.

Smalley: It is impossible to tell now whether this would end as one great big complicated formula or an encyclopedia that you went through. It is an operational problem with us on the team as to which way it is more feasible to get at it but we are interested in what you see our target would be.

McNulty: I would say a word. I wasn't trying to be facetious before when I mentioned the simple recipient and the simple report. I think that every profession, every occupation, has its simple level, if you will, and I don't think any report should be geared to that simple level. I think we should recognize it and try to contemplate ways of dealing with it. But I don't think we should gear everything we are doing to the simple level. I don't know whether I am making the point or not. I understand it myself but I don't suppose I can say it as well as I would like to. But if there is the administrator in "Squedunk" and he understands only a plus b equals c, I don't think we should get out a report that says a plus b equals c; because I think we would lose a great deal in doing it.

Howland: I agree with that but, on the other hand, you also run into the problem of getting a chance to do it at all. And this is what we have been up against. Some guy comes to us, looking for a methods engineering kit and we dump this in his lap.

Duncan: But couldn't you say, now, we can look in this direction and head out. And then, to the extent that we can do it, fine; to the extent that we can't do it, we would use what we could come up with.

Howland: This is another trade-off you make, along with the scope and the neatness of your model. You make a trade-off between assumptions and data collection-analysis. The question is how can you live with assumptions? For Pete's sake, do it! It's only when your assumptions get you into more cost in researching than finding out what is going on that you go into research.

Precision:

Emerzian: That's an interesting plan. I think some establishment of the level of precision should be made. In other words, is the answer that you want, in terms of money that you save, or is your conclusion one of whether you will adopt it or not? I think there is a big difference in precision between these two. In one case, we are just "in the ball park" or "out of the ball park". In the other case, you may be "in the left field" or "right field" or "at second base".

Dudek: In other words, you are going to take the job of making the decision away from the administrator in one case.

Emerzian: As much as possible. If these conditions exist in his hospital, he should do thus and so.

Dudek: That's another question that can be bandied about quite a bit.

Emerzian: I think that the gentlemen here on our right (administrators) are the only people who can answer this question for us.

Tangibles vs. Intangibles:

Hullerman: Harold, we were talking about a method in determining a practical decision system, aren't you?

Smalley: That is right.

Hullerman: And this we need. I don't see why the formula has to be too simple as long as it identifies the tangible vs. intangible areas. We need a system for determining the cost factors, the tangible ones. We also need a system for determining how we value the intangibles. This is important because we don't know how now.

Decisions:

Smalley: This depends on what you find. I can conceive of findings taking the form: If you come out in this area, you buy the disposables;*if you come out in this area, you have got to weigh in your mind these parameters of the model which do not indicate a clear cut course of action and, as Dick indicated, this area of ignorance has not been sufficiently reduced to make a precise judgment. If you are on this side of the fence, you go this way; if on the other side, the other. I am not sure, until you get into it, whether it would take this form or whether you would come out with some sort of index. It would be up to the administrator to interpret this index, or whether it would be a formula.

Economic Feasibility:

Hullerman: Even in dealing with requests that come from different elements of the hospital, medical staff, nursing, etc., any system that would help us to evaluate the patient satisfaction, the departmental satisfaction, the number of people in the department satisfied, we could use a formula for this. It would help a great deal. I think it might be identified separately, although there might be an overall formula. From the things that actually affect the dollar, this would prove helpful. But this brings back the fact that you are not really talking about the relative economic feasibility, unless this word "economic" is a very, very widely interpreted word, are you?

Smalley: No. I would agree that the way it is worded, the emphasis is upon dollars and cents. But I would be highly disappointed if it ended up without considering some of these things that Mr. McNulty has mentioned. Indeed, as we have conceived it and as we have explained it to others, we would certainly be concerned with these other factors.

Hullerman: Then you come out with a formula for helping us to reach a decision as to what value should be placed upon it?

Smalley: Yes.

Intangibles:

Hullerman: Aren't you back, then, into F?

Smalley: No, I don't think you are.

Howland: I disagree. I think when you get into values, you're strictly in the "F business". Value, as I would think of it, is a hypothetical construct to explain some kind of behavior; this isn't something you measure.

Smalley: Well, that is the reason I say it depends on whether or not you attempt to explain the intangibles. I think you can recognize their existence and price them for the administrator and describe some of their characteristics. I am not looking for or hopeful enough to expect an explanatory model of the non-monetary. I had just as soon try to avoid that. I would fully expect to have some sort of descriptive model of what is happening in this non-monetary area. And then go ahead and price it for the manager.

Howland: Well, the pricing is where the values come in. This is the assigning of the cost to whatever it is - behavior.

Dudek: Well, I think that he means that, when he wants to price, each one of these will have to be evaluated and say, "Now then, in certain situations, these are the things that it will affect, the amount that you will assign to this value". And this cannot be a certain amount (C) in all cases. These are the considerations you give to this C for the local situation. You assign a value here and here, on more or less of a point system; and you can add it up. And there is your C. But the C for this certain intangible in Birmingham may be different than the C in Detroit for that same variable.

Howland: O. K., then they are pumping in their own valve system.

Dudek: Right, and I say these are the values we found. And give them a guide to make this value judgment.

Smalley: This is getting closer to what Mr. McNulty said about not giving them the answer, necessarily, but giving them something to work with so he can find his answer.

Dudek: Right, and I think this is what you meant when you said, yes, you will try and give him a value for this intangible; but he is going to have to find it. All you are doing is giving him really a procedure to find it by.

Smalley: Gentlemen, we have reached the hour of lunch and I don't want to cut this off in any sense but I think we ought to go on in to lunch and resume at the afternoon session. I am sure we will come back to this point several times today.

II. <u>LUNCHEON MEETING:</u> 12:00 Noon

Welcoming by:

Colonel F. Groseclose, Director of School of Industrial Engineering

Mr. Burwell W. Humphrey, Administrator, Emory University Hospital

Dr. Harold E. Smalley, Principal Investigator

Dr. Wyatt C. Whitley, Chief, Chemical Sciences Division, Engineering Experiment Station, Georgia Tech.

III. Afternoon Session - 2:00 p.m.

NATIONAL ADVISORY COMMITTEE

Dr. Richard A. Dudek
Dr. Daniel Howland
Dr. Hugo V. Hullerman
Mr. Matthew F. McNulty, Jr.

LOCAL STEERING COMMITTEE

Mr. Harold O. Duncan
Dean Ada Fort
Miss Helen G. Graves
Colonel Frank F. Groseclose
Mr. Burwell W. Humphrey
Dr. Edward H. Loveland
Dr. Joseph J. Moder, Jr.
Dr. Rocker T. Staton

Absent: Mr. Roger Klein

PROJECT STAFF

Dr. Harold E. Smalley
Mr. Thomas L. Newberry, Jr.
Mr. Isaac Ifrach
Miss Montyne Floyd
Mr. Edward W. Davis
Mr. Joseph B. Talbird

OTHERS

Dr. Harold O. Davidson
Dr. A. D. Joseph Emerzian
Mr. Glenn M. Hogan
Mr. Richard Miller
Dr. Mary M. Williams

Introduction:

Smalley: This is the afternoon session of the joint meeting of the National Advisory Committee and the Local Steering Committee for the U. S. Public Health Service Project, Disposable vs. Reprocessed Hospital Supplies. I would like to welcome Committee Members, certain Project Staff Members, and guests.

This morning, we had a meeting of the National Group and certain members of the Staff. We tried to bring the National Group up-to-date on the Project. An attempt was made to give a background for the Project, how it came to be, where we are now, how we are organizing the Project, the roles played by the various Committees, the way the Project is set up at Georgia Tech, and the types of co-operation we have with Emory University Medical Center. Then we talked about some of the issues in the research. I won't attempt to summarize all of those, I expect that some of the same questions will come out this afternoon. I have a feeling that we did establish some direction in which the research might very well go, and some notion as to what our target should be. Special emphasis was placed upon whether this eventual decision model would take the form of a practical system or something highly theoretical. In addition to the team that will be pursuing this Project on a full-time basis, there will be some consultants and also some graduate students. We have already established some liaison with manufacturers of hospital supplies. We haven't yet decided to what extent we want to use them, but these manufacturers are quire interested and we have been supplied with a tremendous quantity of disposable enemas and syringes and all imaginable disposable items. All of this is interesting and it gives us some better idea as to what is on the market, but we don't see quite yet how we are going to use these.

I was thinking that we should remind you that the outline of the Project, which has been sent to you through the mail, is more crystal-ball gazing as to what might be done than it is a firm intention on our part. Indeed, since the full-time Staff has not been appointed as yet, and we definitely want the Staff to participate in decisions as to the directions in which the Project shall go, we are purposely not trying to set out any rigid pattern at this moment.

One of the main purposes of this meeting today is to get your ideas as to the directions in which you think the research out to go, the points of emphasis, how we can take advantage of knowledge that is already available, how we can take advantage of sources that are available.

Staff:

We are in hope that the Staff will be appointed and on the job by the first of September at the latest, perhaps it can be an accomplished fact before that time. I indicated this morning that I am devoting a quarter of my time to the Project, more or less; Mr. Newberry will be half time on the Project beginning July 1; Mr. Ifrach, Mr. Talbert, and Mr. Davis, three Master's students at Georgia Tech, will be graduate research assistants. There may be other graduate assistants; and we hope to have one or more students from Emory, in Nursing or in Hospital Administration. We hope to have a psychologist, either full-time or part-time on the team, or as a consultant. There may be other disciplines involved that we may want to use on a consultative basis. In all probability, besides the consultants we already have identified, namely, Miss Graves in Nursing Service, Dr. Moder in Methodology, Mrs. Rowe in Nursing Education, Dr. Williams in Nursing Research, we probably will want to bring in people in operations research, hospital finance, purchasing, and perhaps other areas.

Project Outline:

One of the things that I thought we might do this afternoon is to look at the outline and refresh ourselves on what it is we are setting out to accomplish, realizing that we have a tremendous amount of freedom, by virtue of the terms of the grant under which this work is to be done. If we see other fruitful areas, we can explore them. If we see tangents which develop as a result of some preliminary work, we can explore those. If we want to modify our objectives substantially, we can do this. So long as we accomplish in the end the overall objectives, namely, to shed more light upon this matter of whether hospitals should make or buy, whether hospitals should purchase items from the outside which it uses and throws away, on the one hand, or whether it should make an investment in an item which has a prolonged life over which you amortize the cost. I do think we have tremendous latitude and our objective here today is to pick your brains, if you will, in terms of how we can best exploit this opportunity we have.

Now, please refer to the outline which you have. This outline was prepared two years ago. We have learned a lot since then. We have had a lot of ideas since then but we thought that, before we revise it drastically, we would come to a more definite decision as to the direction in which we would go. Generally speaking, we were setting out to develop a practical decision system for determining the relative economic feasibility of procuring disposable and reprocessed items for hospitals.

In this morning's session, it was pointed out that the term, "procuring", may be misleading because we are certainly interested in more than just writing the requisition and receiving the item. We are interested in the overall cost, both monetary and non-monetary. We are interested in a complete cycle of what happens to a supply item.

When we talk cost, we are talking both monetary and non-monetary. This point was discussed at length this morning. I am not sure I can draw a consenses of just what the group felt this morning but, at least, there were these possibilities: We could emphasize the practical aspect, to give the administrator or supervisor a way of determining which course of action is likely to be better from a monetary point of view. This would pretty much leave the non-monetary aspect unexplored. Or we could build two models, one of the practical, monetary, dollar type and another for the non-monetary, the intangible types of cost involved. Or we could attempt to build a decision system to incorporate both of these complexes of variables. Also, there was some thought about a descriptive model of some of the non-monetary factors. This would simply tell the decision-maker that these are some of the things to worry about. Another possibility is to cost two alternative courses of action, A and B, involving different levels of intangibles. If you feel that patient care is being improved by going from A to B, this is what it will cost you. It is up to you to decide whether it is worth it to you or not, as opposed to a system whereby you would attempt to build in as parameters the relative value of the intangibles. I would hope that, this afternoon, some more light will be thrown on that.

We can see this Project in various stages: To determine what cost factors are at work that govern these decisions. To determine something about the relationship among and between these factors. To determine a hypothetical decision system which conceivably would include not only the significant but, perhaps, some of the insignificant and even somewhat extraneous cost factors. To go through some procedure by which these could be tested. This testing, I think, might very well be done in a clinical situation and in, perhaps, one hospital and, perhaps, in many different kinds of hospitals. We see, as an outgrowth of this, once decision models have been built, that this could have certain extensions to other types of management decisions, such as whether to buy paper cups or use glasses in the cafeteria, whether to use linens that are reprocessed in the laundry or to buy disposable linens. And eventually extending this into the procurement of equipment, perhaps even labor. Should you have your own cafeteria or should you have your meals catered? Should you have your own laundry or should you go out and buy or rent linens? And these sorts of decisions. So we see it as a "kick-off" for many other types of decision models.

I wonder if there are any questions on our objective? Are there any questions or comments with respect to the outline itself, with regard to the general objectives we are shooting for?

Graduate Students:

One of the ways in which we plan to bring resources to bear upon the problem is by encouraging graduates in student research, in areas that are either a part of the Project or are closely allied with the Project. By closely allied, I mean that literature searches might be the same, methods of investigation might be similar, or most importantly, results of these might be useful to pursuing certain phases of this Project. We anticipate that a number of such people will be interested. I have asked three of our graduate assistants to be here today. One of the things I want them to do is to tell you what thinking they have done so far in this area. I must apologize, really, for putting them on the spot this way, because they have only been thinking about this a few days, literally. Indeed, two of them are not on the payroll yet! It is a bit unfair but I wanted to take advantage of this opportunity to have them throw out a few ideas to you and then, maybe, you could ask them some questions or make some suggestions to them that would stimulate their thinking further as to what kinds of things they might get into. So, with that qualification and with my apologies, I would like to call on Mr.Talbird first and let him tell you what he's been thinking about with respect to research in this area.

Talbird: I started thinking in this area in terms of my particular interest in industrial engineering. One of the things I have been most interested in is inventory and inventory control. I started with this and started to thinking how can I use this in thinking about the hospital? One of the first questions that came to my mind that might need answering was, what would be the difference in the total amount of money invested in supplies at any one time. I thought that I might be able to find some answers to this problem with using inventory theory, not overall, but just looking at two or three types of items, at once, and comparing what you have invested in one type of supplies and what you have invested in using the other type of supplies at one particular time. Further than this, I haven't done an awful lot of thinking, as Dr. Smalley said. There hasn't been a lot of time and this is about as far as I have gotten in my thinking.

Smalley: This ties in with something you, Mr. McNulty, said this morning about, as an administrator, you might be interested, among other things, as to what effect widespread use of disposables would have upon, say, warehouse area or storage area. Conceivably Mr. Talbird's ideas would tie in with this. I was wondering if you had any reaction to his area of interest in that regard?

McNulty: Only, maybe, one of satisfaction. I do think that any study we do in this area that deals with disposables - we were talking of unit price this morning, or we were talking of costing, and we finally, I think, evolved monetary costing. In so doing, I think we may be relating cost to unit price and unit price might be determined by volume purchase, which in some settings you might not be able to do by such techniques as drop shipments and so on, you might have to do by pure warehousing. And also, on the nursing units, what sort of warehousing problems would you have that could be calculated in the cost? I was trying to raise also, should the calculated, I think one of the gentlemen said this morning, "in the frustrations", I was calling them "satisfactions" up until now but am leaning toward the term, "frustrations".

Smalley: I wonder if there are any other observations or suggestions you may have for Mr. Talbird in his area of interest?

Hullerman: I would like to suggest that he take a look at these factors that would be involved, such as the addition of personnel as well as space for processing the use of disposables, I mean for handling on a disposable basis. And, also, what about the disappearance of items on the ward units?

Volume of Manufacture:

Smalley: At Pittsburgh, in trying to encourage the use of certain time-saving devices, the question arose, how much of the present price of these items is attributable to the relatively low volume? If the manufacturers could increase substantially the volume of manufacture in response to some increase in demand on the part of the hospitals, this inherent economy might very well be passed on in the form of a lower price. And if mass purchasing by hospitals could accompany this, conceivably this could reduce unit cost additionally.

Hogan: Automation in industry might be tied in better to disposables than to custom-built articles.

Smalley: I think that one of the basic principles we are dealing here with is that labor is cheaper and more efficient at the point of manufacture than at the point of consumption, though I am not sure what the pitfalls may be in going far in that direction. Joe, did you have a question?

Inventory:

Emerzian: Yes, I think that this is very fascinating work on inventory. I would like to encourage Mr. Talbird to take a problem where there is interdependence of operations with inventory size. I'm thinking in terms of pipettes, and people have to use pipettes. Now, if your inventory is too low, too small, technicians may have to wait before they can use a pipette. If your inventory is too small, it means that you can't obtain economies in washing pipettes because you are working with a very small lot size. As a matter of fact. in one laboratory, we tripled the inventory of pipettes to avoid approximately forty minutes of "wait" time on the part of technicians. In many cases, they would grab a dirty pipette and go in and wash it. We also reduced the wash room force by one person per day. So, I think it is intriguing when you have an interrelationship of operations. We have several people dependent upon the quantity of a particular supply item.

Hullerman: I think that hospitals will be willing to go along with an increased cost if it were to be expected that when enough hospitals did this, thr unit cost would go down. And I presume that it would. This could be a factor in the widespread use of the new system.

Emerzian: I haven't seen a hospital administrator act as quickly as he did in this case. Pipettes were in there in about two days.

Hullerman: Well, I was talking to Beck and Dickenson three or four years ago, and they said, well, the cost is this now but if enough hospitals would get together, the unit cost would go down eventually. But this is two or three years from now, not practical now. But is this true?

Smalley: This ties back in with what you were talking about this morning. If this model, one of several possible models, gave you that information, then you, as administrator, would have some basis for deciding whether it was better in the short run to spend a little bit more to achieve, eventually, lower unit cost in the long run.

Hullerman: But this would be a value that can be assigned. It wouldn't be local.

Smalley: I have even talked with manufacturers in terms of their helping to subsidize a promising item where the demand is so low now that low unit cost isn't feasible. Gambling, in effect, that by subsidizing now that when volume is high enough to make unit cost low enough, then profits will come later. I am not quite sure how much of this they would do but, at least, they are not ready to say, "We will not do it". Do you have any other observations or suggestions for Mr. Talbird in his area of interest? It is not often that a graduate student gets this large a committee to give him suggestions!

Talbird: I feel real fortunate.

Smalley: Well, suppose we move on to Mr. Davis who also has just barely begun to work with us on this. He has only had a few days to talk about his area of interest. Suppose you throw out your ideas.

Davis: I would like to reiterate that I am entirely fresh in this field, not only is this particular Project but in the field of industrial engineering. I have only been in I.E. since last fall. I have by BS in Mechanical Engineering. But, from a quick perusal of the literature, just to take a very quick look, I was just wondering what effect switching from reprocessable to disposable items would have on the business office, what other effects in addition to inventory. And then, too, I was wondering about developing a replacement model for the reprocessable equipment that you have now. In other words, how are you going to determine when you should switch over? Or if it would be possible to develop a decision system? I am sure it must be possible for reprocessable items. I don't know if a replacement model would be feasible or not; but these were my main lines of thought and interest. That is, equipment replacement and determining the useful life, the productive life of the reprocessable items you have now.

Emerzian: I am not certain I understand. You mean that you would charge off equipment which is now in existance, against the alternative?

Davis: Yes, sir. What I would be interested in is in determining a general model, not just for one particular situation, but for determining a replacement model so that, say, a hospital has a certain supply of reprocessable items on hand now, well, how soon are they going to have to switch over to make it economically feasible?

Smalley: As I understand, and this is new to me, too, and this is the first time he has mentioned this to me at all, such a study might very well be appropriate, whether or not disposables were the alternative. That is, are we replacing reprocessed items now at economically feasible points? When is it most feasible to replace light bulbs? After they have burned out or to go around systematically and replace them? I am not sure the analogy is appropriate, but you are interested in the application of replacement theory to reprocessed items.

Using "Old" Items:

Hullerman: You might also get into the emotional or psychological problems that are raised in the Staff when you have partial use of the disposable and continued use of the present stock of reprocessed items. It is a terrific problem in a hospital. There is a lot of stuff on shelves that is not being used just because nobody will use it if you give it to them, they will break it, or slam it on the floor, or something. This is not to be overlooked.

Smalley: Is this a variable that needs to go into the model? As to how much you now have on hand and the extent to which it is used, and how efficiently it is used?

Hullerman: I don't know how valuable it is, but we are changing our pattern of china. We run into a lot of real difficult problems as to how to make some kind of use of the old china.

Hogan: I think it is a very real part of it. The investment now in the reprocessed items in stock must be considered by the administrator.

Davis: Would that come under intangible cost? Or how would you enter it?

<u>Hogan</u>: I will ask Mr. McNulty to comment there.

<u>McNulty</u>: We went over the field of tangibles and intangibles this morning. I had my ears boxed around a little, so I will evade the question.

<u>Graves</u>: I think there is another thing here, too. We have, for example, a disposable item and one that is to be reprocessed, being used in the same unit. It is just a matter of the distribution and the pick-up. For example, the one item you are going to throw away, you will probably need to have furnished to the unit more rapidly than the other. And I think this is a factor that you mentioned as <u>Staff</u>, and whether you do this unit by unit, where you have the same thing going on in the same unit, or whether you get into people's not wanting to be bothered with both, so you throw away those that should be reprocessed, or you put back on the shelf those things that could be thrown away. This is something you have to look at with any system where you are changing over from one item to another.

<u>Emerzian</u>: I think this is a rather fascinating subject. I would like to get a little philosophical. I would like to see an analysis made of equipment valuation in hospitals. We value equipment, generally speaking, from an economic point of view, its value is a function of its gains in a particular organization, that is its real value, not necessarily what it costs us. Now how does one go about valuing a piece of equipment, and using it in a decision to replace it. Let's say the piece of equipment has been given to the hospital. What is the value of this piece of equipment? Let's assume that a particular donar has given a building to a hospital, or a room, how would this be valued? Is it to be charged off to specific alternative uses? I don't know. Now you're getting into philosophical questions.

<u>Smalley</u>: Are there any other observations or suggestions for Mr. Davis?

<u>New Disposable Items</u>:

<u>McNulty</u>: One of the other thoughts that Mr. Davis left with me was the structuring of the study. So far this morning and here now, we've discussed the analysis, if you will, of disposables vs. non-disposables on the basis of what exists. I take it this is on the basis of what manufacturers who serve the hospital and health field have designed as disposable. I was wondering if Mr. Davis was getting into the area where: Should we not also study those things that are now reprocessable in terms of designing a disposable for them? Or should we just wait for the manufacturer to come up with the recommendations? Are there some items now for which there could be savings, real, monetary and intangible, however you will, that from this study there might be analyzed and disposables designed, recommended and implemented?

Duncan: Well, this is a mighty big thought, Matt. It could go a long way. One of the things we have been talking about is the possibility of throw-away sheets and pillow cases, for instance. Think what an impact that would have if that should become economically feasible. We have been told that it appears that it will be at some appointed time, which we are not quite certain about. That would have an effect on the laundry, whether or not we should even have one.

McNulty: I may be entirely in error, but it is my understanding in my slight acquaintance with disposables, that the manufacturer has come up with this, the syringe we are now offering. We are now manufacturing it. Well, maybe there are many items that a study could observe, and then conceive of disposables as a most adequate supplement, if you will, or substitution.

Hullerman: Harold, since the objective here is to develop a formula, you might take Mr. McNulty's idea and, in the study, test it out as a formula to determine what might be done in some areas.

Smalley: I wonder if you could turn it inside out. Once you get your model or your formula that has some application and are reasonably satisfied with what you have, then take an idea and work the formula inside out and see how much the new item would have to save you to make it feasible before you even develop a new item. I wonder if anybody else has any ideas on that?

Psychological Issues:

Loveland: I was impressed when Prof. Emerzian mentioned the term "value" and that meant something different to me than it did to you. When Miss Graves came up with habits of people in using things. This is to be an empirically derived model, is it not? On the basis of current experiences? And it will be used for the purpose of predicting future events. I was wondering whether it would be important to make sure that the perception of these people of these various products which will be used, are more or less stabilized. That is, you may have training problems prior to the introduction of the disposables, which might conceivably, if neglected, reduce the predictive value of your model. That is, the conditions will change after this has been in use for a period of time. They will look upon some disposable items as being things that are no good, "We don't use those things", etc. I think this would be a rather important variable to investigate in the initial stages of the study. Then what are the attitudes of the people toward these kinds of things?

Smalley: Yes, that is interesting. This is the reverse of "it's being fashionable to use certain things". You are saying that, maybe, there is a "bugaboo" against using this, which would work against the alternative, you take it into account in your model.

Loveland: Well, it could work in either direction. But the point is that the conditions at the time you derive your model ought to approximate those that would exist when you use it. And these may not necessarily be the same unless you worry about it beforehand.

Existing Items First:

Ifrach: We have quite a number of items that are in the market but have not been studied enough. I think we are too early to start thinking about suggesting to manufacturers to manufacture new items. Right now we are still faced with the decision rule that you want to develop. We have quite a lot of existing disposable items that have not been studied enough. After these that are in the market have been studied and it is decided you are going to use certain items, then we might turn to developing new items. My thought is just try to tackle some of the existing items and make some decision rule for them.

Emerzian: Isaac, Dr. Hullerman was encouraging you to become an independent entrepreneur

Duncan: Otherwise, this project could become a career almost.

Smalley: Well, maybe we should have asked Dr. Whitley this morning about where we stand on copyright and patent privileges in this regard. I know that, shortly after I came to Ga. Tech, they sent over a form for me to waive all of my rights and patent privileges, but said I didn't have to sign it. So, I didn't! Well, Mr. Ifrach has given us one or two ideas. He is another of our Master's candidates and is interested in the Project. He has been on the Project a little longer than the others. He should be expected to have more ideas than the other two. Indeed, he has been doing a lot of the pick-and-shovel work on digging our literature for us, and compiling bibliographies. Perhaps you can tell us, Ike, what is the status of the literature search and the bibliographies, and then you might go on from there and explain your area of interest.

Literature Search:

Ifrach: I have been reading a few articles on the disposable vs. reprocessed. I would like to mention a few of them. One is an article, "Disposable Unit Less Expensive, Safer-Hospital Study Shows." This is a study that was done in Washington, D. C. in a general hospital. They studied needles and syringes. Their study was approached in three ways: They analyzed the nursing time and effort of the two systems and they had a detailed cost study of all elements of expense involved in the two systems. Then they evaluated the attitudes and opinions of the medical people, as well as the reactions of the patients. They came up with the conclusion that it is better and safer and less expensive to use disposable syringes. Then there are other articles that mention disposables without much study or evaluation. Non-woven fabrics are suggested for study, at least, to find out if it is feasible to change to the disposable items such as bandages, bed pan pads, drainage pads, diapers, reinforcements for surgical casts, surgical dressings, sponges, etc. They mentioned that this non-woven fabric has a good future since automation is going to be on our side to help us produce these materials at a cheaper cost, inasmuch as we are going to use more of them later on. There is another article about disposables in food service, disposable containers for food service. This article emphasized that it enabled fast service with minimum stock and easy cost accounting. I don't know if it is cheaper, but what is mentioned is easier cost accounting, which is not necessarily cheaper. As far as I am concerned, I feel that I would like to pick up certain items or a set of items and study them as such and find out the facts about them, if they are economically feasible, attitudes of patients and medical people to the use of this disposable item.

Smalley: Does anyone have any observations or comments to make to Mr. Ifrach?

Patient Reaction:

Hogan: I would like to thank you for bringing in the patient reaction. The patient reaction on some things is not too significant, they take for granted that you are going at it the right way and are using good tools. But paper cups are reacted to in different ways. Disposable linens are reacted to in different ways, by the patient. We find this very important in certain areas, the patient reaction. This should continually be kept in mind.

Smalley: I am convinced that this is important, and I am convinced that it is a very tricky area, too. I know we got our fingers burned a couple of times on our Bed Project when we tried to determine how important a piece of equipment looms in the mind of a patient. We had proceeded with a pretty high powered investigation of an area of which the patient didn't much care about. The team was quite interested in it, but the patient wasn't. There were ten items that ranked higher in his mind than the hospital bed itself.

Hogan: I have heard patients react different ways to a permanent salt and pepper shaker vs. the little kind you break open, or whether the coffee cream is in a paper container or in a real pitcher.

Smalley: I caught myself reacting this way, on an airline, where I had become accustomed to these plastic cups. I must admit they gave me an old DC-4 that wasn't pressurized, and there was a draft on the floor, and they were late leaving. And, on top of it all, they served my coffee in a paper cup, and that was the "last straw". This is just an indicator of the thing we are talking about.

Duncan: This is a tricky area, though, because our reactions on different days will be different. If it were raining and the salt wouldn't come out of the salt shaker, we would like very well to have this little crispy thing.

Hogan: It is hard to investigate.

Duncan: I guess we will have to delimit ourselves on this, too, because we can lay out so many things to investigate. It really would become monumental. My epitaph will be written on it. One of the areas I was greatly interested in is this woven clothing, in the textile field, because you might recall that Goldner, from LaSalle, assured us that clothing would become throw-away in a few years, especially uniforms and things of this sort in hospitals. He even went down to the point of saying shoes will eventually be throw-away.

Dudek: I have heard a better one on shoes: we will just spray them on.

Smalley: Do you wash them off at night?

Dudek: Yes, you spray them on in the morning and wash them off at night.

Someone: Just don't get caught in the rain!

Smalley: Well, while we are talking about student participation, perhaps we should ask Dr. Williams if she could give us any ideas on whether or not any of the nursing students at Emory might want to do a thesis or might want to do something that would have a bearing on this Project.

Emory's School of Nursing:

Williams: Well, we have students in the graduate program, all of whom are required to do Master's projects. We have never quite dignified them with the title, thesis. However, we have tried to maintain good research standards on that level. We see our Master's projects as being not so much independent research as research associated with larger projects that are going on. So, the fact that this Project is being considered at Emory University Hospital made us very happy, because we thought it might be a marvelous opportunity for our graduate nurse students to participate in interdisciplinary research. Now the question that keeps recurring to me is, actually, how would a graduate nurse fit into this type of investigation? We have certainly emphasized in our program at Emory, which is not altogether typical, however, that we prefer that our graduate nurses do research in the area of direct patient care. And so I am sitting here, reacting very favorably when such things come up as, What will we do about the evaluation of patient reaction to some of these things. I can see a nurse, especially, assisting in that category.

Smalley: Dr. Loveland, I was wondering, do you see anything fruitful in having a nursing student and a psychologist team up on this kind of problem?

Loveland: I think the nursing student would be an excellent person to gather data. The nurse is accepted in the hospital and is not regarded as an outsider and this would facilitate, I think, to a large extent, the data collection and working the data might provide the Project for your Master's candidate. Whereas the overall problem might provide the basis for the psychologist's work on your Project.

Smalley: Do I understand, then, that the psychologist would work with the nurse in designing the experiment and let the nurse go over in uniform on the ward unit and carry it out?

Loveland: I think this would be an excellent idea.

Williams: This is similar to what our graduate students are doing now. Actually, some studies go 24 hours around the clock. We have a team of graduate students working on some of these projects. Things that they have worked on so far have related specifically to psychological care of the patient. We haven't had the personnel, actually, to direct them in areas of psychological factors and attitudes, which we think are extremely important and would like to get into it.

The Team Approach:

Smalley: Dr. Howland, when you have some phase of your work like this, designing an experiment or setting it up, and you have someone who's principally interested in that area, do you operate that way? Do you design the experiment as a team? How do you work that?

Howland: Well, I guess really it's pretty much a matter of interest. You can't jamb these people into designing studies that they don't think are worth doing in the first place. What usually happens is that somebody gets an idea and then we have a staff meeting and he throws this thing out and gets a lot of advice, most of which he doesn't pay any attention to. And then it sort of begins to filter down to one or two people who are interested in whacking it together. For example, our sociologists who are trying to measure status relationships found that there was no metric lying around that they could use, so one of our statisticians and an engineer were interested in the mathematics of building scales, and these three guys sort of went off in a corner and cranked something out. So, this sounds like an awful sloppy way to operate, but I don't think you can structure this too much. This brings up another point that we've found. The mobility of team members may be fairly high as a function of areas of interest. People will come and go and bring their interests with them.

This gets back to the need for developing a fairly explicit conceptualization of what Dr. Hullerman has called "the cycle". For example, you have a choice, really, of picking a model and then going out in the hospital and finding a place to use it; or designing a cycle and seeing what you need to do to get answers to fit into your cycle picture. These may lead you to quite different kinds of research. I am not sure that, in starting out, it makes much difference which way you do it. But you do have this choice. Finally, I think it would be very important for you to pay some exclusive attention to this cycle or system, or whatever it is, this framework thing you think you are working in, and watch this develop as you go along. This can be a great focuser that will keep you from wandering off into little briar patches or little side alleys that look very attractive. Unless you consciously devote some effort to keeping track of this thing, which may be nothing more than a bookkeeping device at first, you will find, after you go along for a while, you will be very unhappy with the fact that you didn't think of this last year and start it then. This is worth keeping as you go, sort of a log, really, of the conceptualization of the framework in which these compartmental studies are done.

Smalley: It sounds like controlled chaos.

Howland: It is.

Dudek: Something like ours was on the Bed Project.

The Nurse's Role:

Fort: Hal, I would like to make a comment here. I think that for a long time in nursing we had pictured ourselves, and I think it was because we were expected to picture ourselves in nursing as being largely responsible for any sort of activity that went on in the hospital, whether it was the issuing of drugs, whether it was the supply room; for a long time we even took care of the linen, getting it to the linen room and back and we did in nursing across-the-board duties in the hospital, almost everything. We thought, too, we had to do this sort of investigation or it wouldn't get done. We did a lot of working on thermometers, as to which was the most economical thermometer to use. This was not nursing responsibility at all. So we are welcoming, just wholeheartedly, the coming in of the groups that ought to be doing this, such as you people are doing in this Project. Now, then, this gives us the opportunity in nursing to get back to our real job of nursing care of patients. And what I would hope that this Project would demonstrate, as much as anything else, in using nurses as part of the team, is how we can actually make a contribution while we maintain our major interest of nursing care of the patient. We would like for our studies at the graduate level to be patient centered, our interest to be patient centered. As I was gathering from what you were saying, you would like for the nurse to make a contribution because she is located in a spot where she knows some things that would be helpful to the other person, or would be useful because she is located there.

Well, we would like for you people who are doing the study to feel as at home in the hospital as the nurse feels and let the nurse make a contribution because she is interested in the patient, whatever this contribution can be. I am having a little difficulty seeing where it can be in a project such as this, except that it has to do with how the patient reacts to these supply items. At that spot, the nurse can be helpful. But I would hope that we don't demonstrate that we are going to use a nurse just because she is the person present on the floor, and not because she is a nurse. I hope I make myself clear about that.

Loveland: I don't believe I made myself clear because these two things are not mutually exclusive. The nurse can gather data which can be extremely valuable to you folks. For example, you say the patient's reaction. Well, I think the nurse's reaction is equally important for this focuses on the patient, too. It also focuses on Harold Smalley's Project. Without the other person's reaction, the other nurses' or physicians' reaction, whatever decision he makes in the course of his research may be wasted.

Helpful Models:

Hullerman: Harold, this is aiming at a decision system or a decision of systems. Let me illustrate how I could see what comes out of this Project having great value. At the moment I have about $75,000 worth of equipment requests from different departments of the hospital and about $15,000 available to take care of these at the moment. Now, I could use a committee of people to help decide which ones are going to get the $15,000. But, in this committee approach, "X" actually don't know anything about "Y's" needs, so I make the decision. When it comes down to it, the recommendations are pretty much my judgment. Well, if this decision system is any kind of a formula that helps me to weigh the merits of different requests so I am not just using a guess judgment or hunch, of which there is always going to be a lot of anyway in any decision of this kind, it would be helpful. But in making these decisions at the moment, I think this is probably generally true in every department in the hospital, you rest so much upon the subjective opinion of different groups of people. Now, I always get a little bit frustrated as to how valid opinion is in this particular area and also I find myself pyramiding the subjective opinions of quite a number of people, all of which I question to some degree. And, coming up with a formula here, it seems to me that the weighing of opinion or the undue accumulation of weight on the opinions of various groups might be something to be considered by the study group.

Criteria:

Howland: It seems to me that you have just raised the old criterion question. And, in a sense, Hal, you have managed to wiggle out of this by saying that cost was going to be your criterion. I think this is another decision you are going to have to make.

Smalley: Yes, I think we are cheating a little bit because we have run headlong into this question that's baffling your group right now. And yours is the only group, as far as I know, that has made a conscientious effort to get right into the middle of the thing. What we are trying to say is, let's hold that off for a while in the hopes that you fellows will come up with some helpful stuff in a few years. We will go ahead and make the decision on a cost basis, taking into account, wherever we can, some of the troublesome areas but not allowing the troublesome areas to stop us in the meantime. I am especially interested, while we have an M. D. at the table here, to get a reaction to a question which Dr. Moder and I have discussed a number of times, involving medical standards. I wonder if you, Joe, might want to throw that out and Dr. Hullerman and anyone else might react to it.

Medical Standards:

Moder: I have a neighbor who sells sterilization equipment. Of course, being a salesman, he has a lot of stories to tell me. From his stories, he claims that there is extreme variation in sterilization standards. So a disposable syringe would be quite attractive to a hospital with high standards, whereas it might not be attractive to a hospital with low standards. Is this going to be a big problem; how can we tackle it?

Howland: You have to say what you mean by "standards".

Smalley: I wonder if we are thinking of asepsis here?

Moder: Well, you can sterilize a needle, I suppose you can run water through it and then run soap or detergent through it, run alcohol through it, dry it and then boil it, etc. Or you can just do any one of these. I suppose there is a great deal of variation among the processes of sterilization on a syringe, for instance.

Howland: Yes, I am sure you could get standards for sterilization of a syringe, count bugs or something. But if you are going to generalize this beyond syringes, the problem is going to add a few grey hairs.

Hullerman: Now, this gets down to the salesman making a decision on what the standards of a hospital are as to whether sterilization is a questionable thing to begin with. This is why I question so much of this subjective thinking. What if a salesman thinks that a hospital "X" has a low standard and a hospital "Y" has a high standard? How valid is his opinion? I don't know. I don't see how you can answer that question. I think you will always have differences of standards. I sat in a meeting at Children's Hospital two weeks ago, and just on the question of whether or not you should have isolation wards for certain types of patients, there was divided opinion. And when you come down and say, "Well, are you going to decide on the basis of what ten out of fifteen people think? There is a more objective measure, I would think, of whether isolation in a ward for that purpose actually produces less cross-infection than isolation in a few units on each ward. And yet we make our decisions, how? On what a number of people think, and they can't back their thinking up with a single fact, in most instances.

Traditions:

Smalley: I wonder if tradition plays a big role in this. I know a study we were making a few years ago on sterilizing bed pans. Apparently it was the custom, or tradition, that as soon as the patient comes in, you change bed pans. It may have been the one across the hall; but you don't leave the same one in there for the patient that was in before. We had the bacteriologist study this and found that the sterilizer did an adequate job but there was something about traditions there that caused them to resist this sort of thing.

Hullerman: Oh, a person thinks he ought to have his own bed pan and have it properly sterilized. After all, what happens if it isn't completely sterile? When you go to a hotel, you don't get a separate toilet installation the minute you go in, and even with all the sterilization of seats, whatever came from those in the past? Does anybody have anything to document that it was bad in the past? It is this kind of hyper-idealism that makes me question whether we don't pay too much attention to subjective opinion.

Dudek: Oh, I think that in this tradition problem, you have to encounter it and have some way of handling it because, in a study we did in Iowa, we were trying to study the standard crew size, or number of nurses per ward. One of the items we found was that you could do quite a job if you could spread baths out during the day. But, no, they all had to come early in the morning. We even asked them, "When do you take your bath?" "Oh, at night or whenever I have to get cleaned up". Well, a patient doesn't necessarily have to be bathed every morning. But the first thing in the morning they just had a block of work and had to have a large crew size and then it just dwindled down in the afternoon. As far as I know, and this is four years later, they are still giving all the baths in the morning just because tradition says, "We give the baths before the doctor makes his rounds". I think you are going to encounter that problem here, but whether you make the assumption that you will forget it and let the hospital worry about that itself; or whether you will make some kind of a study as to how much effect it has, is going to be a question at the time.

Sterility vs. Cleanliness:

Hullerman: There is a difference between sterility and cleanliness. A standard for something might be one of cleanliness and yet we tend to apply sterility, and the other way around. In any formula, I think that somebody has got to make a decision as to whether you are aiming at cleanliness or sterility.

Medical Acceptability:

Smalley: Well, that brings up this question of minimum medical acceptability. This is one we have attempted to cope with tentatively, this way. We do not conceive of this Project's including a person competent to study the relative merits of an item from the medical point of view. We had assumed originally that we would only consider, as alternatives, those items which, at least, met minimal medical standards. Now I am wondering whether this is advisable or not. Should we not even consider items of questionable suitability from a medical point of view, and only consider those which at least meet minimal standards?

Fort: I think you will have a lot of different opinions as to what the minimum standards are. Getting back to the question he raised, as to the sterilization of a needle, there are still some places where they are sterilizing a needle with a little alcohol in a spoon on the patient unit, and they call it sterile. Most of us, I think, would say that this is most unsatisfactory and yet it is being accepted.

Hullerman: Yet, you don't say why, really, that it is unsatisfactory. I mean that is just an opinion.

Loveland: Hasn't there been any research on this kind of thing?

- - - - - (Nobody seems to know.)

Dudek: I feel I would like to inject this idea. Our assumption was going to be that we were not going to worry about this. We were going to start with something, a product that is on the market. Sure, there may be differences of opinion whether or not it is any good, but it is being used in some hospitals so it must be passing some test. Now, let's start with that one. This is one of the reasons the decision was made to start with a specific and then try to go from there. This is a method of attack, and we've got some specifics available so let's not raise this question. Dan Howland and his group are working long hours trying to answer some of these questions about patient care and quality, what factors are involved and what is the behavioral pattern, etc. In this study, we just by-pass this and say, "This is, let's look at this, and start from there." But develop a methodology such that, if and when real standards can be built, this could be reworked within these standards. But, until that time, we will just start with what is.

Fort: But, you've got the word, "versus", in your title and it's got to be versus something. Now, what is it versus?

Dudek: It is versus what is also. What is your reprocess? You have a standard reprocess item, you have a standard disposable that some hospitals are using. And we will start from there to fit, of course, a cost criterion. As Dan said, we kind of wiggled out of this question by saying we will evaluate this on the criterion of cost and we would bypass all these other questions because they are mammoth. There is no reason to get into this now. I think that this can be handled in this way and that a fairly sound practical approach, or practical model, can be evolved that will be usable until such time as new factors are brought to bear and new information is brought to bear on these other problems. Then it may have to have a completely new look. But for now, I think that this can be done without getting into these problems.

Hullerman: Medically, that is what I was trying to say, too.

Simplifying Assumptions:

Smalley: Well, I would think, too, that we can't be overly idealistic about this, for many reasons. For example, in mechanics, we develop a theory, an explanation of how structural members in a bridge function by taking a simple free body or simple mechanism and assuming a thing as a frictionless pin. Well, there is no such thing as frictionless pin. But we go ahead and develop a body of knowledge based upon a frictionless pin, we learn a lot about it. Then we bring in another piece of research out here that studies the effect of friction and then try to fit that in with the model we already have. I don't think that you get anywhere by being discouraged by the size of the problem. Go ahead and bite off a piece of it and throw some light in that area. And then, if it turns out, by virtue of subsequent findings, that you don't have a real neat solution here, there is something you didn't consider, then see what effect that has. Otherwise, you have to give up. This has been my philosophy.

Reprocessing Methods:

Emerzian: In your practical approach here, Dick, if I interpret it correctly, you emphasize the word, "versus". If it's reprocessed, it is reprocessed this way, one method; two, another method; three, another method; and four, another method. What are we comparing here? This is where the standards come in. There are different procedures of reprocessing which reach different standards. Where do you stop? I think you have to go as far as the alternative methods of reprocessing, because this is what is being done.

Dudek: Well, yes, but the thing that we were thinking about is, in your model, you are going to have so much labor for "reprocessables". Now I don't care, it may be ten minutes for dipping in a spoon, it may be one minute for lighting a match under it, and it may be fifteen minutes to put it into an oven and bake it. This is going to be the local analysis that we were talking about this morning. The model will just set up the procedure for obtaining the information of what is, in this situation versus what is that you are considering. I think this is why we have this big long study on variables, how many do you have to include? In one local situation, a variable that may be necessary because of these many different methods may be zero in one local situation, yet the variable is included in your model.

Hullerman: I don't see how you can do more than choose between a disposable product, there are numbers of those, too, and a system that is subjectively approved by any modern teaching center as being satisfactory and fairly widely used. From there on, your formula would have to be applied locally.

Setting Standards:

Howland: I think what you are saying gets back to the practical answers on the standards question. You don't ask people what their standards are, you go out and make a measurement. If you want to know how their sterilizing is, you go take samples and see how many dead bugs there are and that's it.

Smalley: I would certainly hope we wouldn't have to add bacteriologists and other people like this to the team to settle questions of that nature. I think this is not our mission here. A lot of people know a lot more about that than we do.

Howland: This is not saying that you are setting the standard. For example, I think of a freight line investigation that we have been working with. Their standard for delivery of boxes was 24 hours. You ask anybody and they will say, 24 hours. When you start collecting time data, it is not 24 hours, it varies up to a week. And this is what you work with.

Dudek: That's what I was saying. In order to get all of these variables, you are going to have to go out and see what these methods are, and then you are going to have to put all the variables you need in to cover all the methods, and then in the local situations, many of them may drop out to zero. But in this, it may have to be included.

Loveland: What you are suggesting then is that one of your independent variables would not be the method but the time required for the method.

Dudek: Yes.

Loveland: The only problem here is what Joe was getting at, the generality of the model. That was the point he raised.

Emerzian: Yes, I would think that the method would be independent. I would like Joe Moder's opinion on this.

Moder: Well, I should think we would want to sample different ways of doing the job, and spend some effort on this question. I think the scope of the Project certainly could include that; but I think we could probably find ourselves getting off in the woods if we set up a bacteriological team to study this. Not that somebody shouldn't do it. We should certainly track down every bit of literature, and perhaps encourage other people to research areas that seem needed. Where you would stop, I don't know. I think that we would certainly want to consider alternative methods, not try to create a hospital standard, but do enough looking around to be sure we are not using something that is not general enough that, when we are all through, that most of the hospitals could make use of ours.

Loveland: You have the possibility, then, of reactions between methods and one of your independent variables. That is the thing that I was thinking of. It may not be a simple time criterion.

Hullerman: Just think of using disposable bed pads as against laundered bed pads. If you are going to get into any kind of standards, you are going to get into the collection of the reprocessed item, the laundry methods, etc. How can you do more than assume that the standards of the present method are the standards you are going to use?

Dudek: That's right.

Loveland: I go along with that. I was just thinking that Dr. Emerzian's point was well taken. As we compare the different methods, regardless of whether they were adequate or inadequate, that would not matter. But the point is, you would have the effects of the different methods and their relationships to the other variables in your problem.

Smalley: I, too, think this is significant because in this outline it is not made explicit that all the various acceptable and usual ways of doing these things will be investigated. It is implied here that there is a standard method of reprocessing and there is one kind of disposable, and it is one or the other. I think we have recognized this for a long time, that it is not one of two alternatives, it may be one of eight alternatives, or four on each side, perhaps two of eight alternatives.

Duncan: But, as Dr. Howland says, our standards are not what we say they are, necessarily. They may be something else. We have to take a look at them.

Williams: From your point of view, you're not appraising the standards; you are appraising the relationship the method has to cost, aren't you?

Dudek: Yes. We are assuming that every hospital has set its standards and that we are working within that set of standards.

Williams: Yes, and how they relate to the cost factors.

Dudek: Now, this model should work within that set of standards, we hope. If it is general enough, it will work within this set of standards at hospital "A" and it will work within this set of standards at hospital "B." It may not; this remains to be seen.

Emerzian: Also, if I may use the word "interaction" again, the relationship between the particular method and the attitude of your nurses toward the method? And of your patients, perhaps, if they come in contact with the method. There are other secondary overtones here, I think.

Reprocessed Disposables:

Newberry: I understand that some of these disposable items can be reprocessed, so there may be a combination of these ideas.

Duncan: Some of the reprocessed are disposed of, too.

(Laughter.)

Ifrach: Tom was referring, probably, to gloves. Some types of gloves are considered by the manufacturer as being cheap enough to be disposed of, but if you like to keep it, you can.

Marking Prices on Items:

Smalley: There is another interesting problem that I imagine is highly psychological in its nature that I wanted to ask Dr. Loveland about. I was hoping that Mr. Humphrey would be here now to tell us about it. Emory Hospital is putting prices on the items used in the hospital. Are you doing this now?

Graves: It is something we hope we are going to do. We have not accomplished it yet.

Smalley: Could you tell us about it?

Graves: We plan to put a price tag, as it were, on the items being distributed from the storeroom when these things are received by the users. This is to develop a little cost consciousness of the item, rather than having the cost of supplies listed, say, on a requisition that comes back at a much later time. For example, a roll of adhesive tape would have a little price stamped on it. Each time you are taking off the adhesive, you are faced with it, the cost.

McNulty: A supermarket type?

Graves: That is right.

Duncan: Like an aspirin, you would have a 50¢ tag?

(Laughter.)

Benefits and Cautions:

Smalley: I am confident that the Project will do many things; but, frankly, I will be satisfied if the Project merely sheds light on an area that needs to be illuminated. If the Project does nothing more than focus attention upon hospital costs and it motivates hospital people to do more about identifying cost and to be more cost conscious, I think it will be worth while. I am confident that it will go beyond this.

Howland: It seems to me there is another area here in which you receive great benefit and that is, not only the training of your own staff but the people in the hospital in some of these investigative techniques. The higher the level you can get them involved, the better off you will be. Not only will they do the work for you, but this smooths the way all along the line. It is awfully hard to do this, particularly with your medical staff. These guys are so busy and harried and harrassed with one thing or another. This is a by-product that you should pay particular attention to. There is one other caution that I might mention. I am sure you have thought of this, but we didn't. That is the effect of having one group follow another through, and how a group of investigators who are not "sensitive" can louse things up for the people who come after them. Harold Papinsky had a little paper in the Journal of Counselling Psychology. (I will send you a copy of it.) It is about what happened to some psychologists who followed the sociologists around. The sociologists had gotten their data, but they had also left a trail of barbed wire entanglements that had to be cleared before they could get anywhere.

Duncan: That's certainly a good thing to watch for, but it has possibilities for good, too. The patients would react to intelligent investigation because, for a long time they have been saying that we are insensitive to cost areas and if we instituted good methods as did business, we could run hospitals a lot better. This is good publicity among patients to find that we are using the latest techniques and are concerned about this. It has possibilities for good and evil.

Dudek: That's right. In Pittsburgh, we took an experimental ward and gave the patients an opportunity to say, yes, they would participate in the study or, no, they would not. And I don't think we had a single refusal, did we?

Smalley: I don't believe so.

Dudek: There wasn't a single patient upon entering the hospital, when asked if they wanted to be assigned to this experimental ward and would they participate in this experimental study, who said, "No".

Smalley: This makes the experimentalist like to pull his hair out though, because he is never quite sure what effects this situation will have. You know the Fifth Floor of the Women's Hospital in Pittsburgh was used as a research area so long that the hospital people assigned to that floor were just "freaks". They were not the kind of people you would find anywhere. They cooperated in the studies to such an extent that what you find has no generalization. Of course, there are exceptions to this. The researcher is never quite sure what effect this prior experience has had, especially since people have memory and that sort of thing.

Hullerman: Dr. Davidson was showing me a graph on the threshold of disturbance which determined, to some extent, whether you did something or whether you waited to see if the problem got done of its own accord, And all that we have been talking about today, you have a lot more than you can incorporate in this study. But as I look at Page 5, Item 1, of the Outline, which I think is your first year, how much are you going to be slowed up in this study by Item C? Answer the question.

"Item C. Analyze cost accounts of a selected sample of hospitals.

1. Determine the kinds of accounting methods employed.

2. Determine the extent to which cost accounting is used.

3. Collect cost data pertinent to supply item.

4. If collected cost data are too gross:

    a. Build cost factors from gross costs by analysis and synthesis, using electronic computer or other device, or

    b. Collect actual cost data specifically for this Project, using temporary cost accounting system in each hospital in order to obtain cost factors.

5. Analyze this data to determine nature of interacting cost factors and their effect upon derived measures."

Smalley: That's a good question.

Dudek: Answer the question, Hal.

Smalley: I am trying to think of something to say! I can guess. First of all, I am not sure how important it is going to be to know this. The intent of having this in here is to have some measure of the present to compare with some measure of the future, so we would know where we have been between the two time periods. Of course, another purpose is to see if we can get data cheaply. We have already anticipated, in certain cases where there is no semblance to cost accounting, that we might have to institute a system in the hospital in order to get some cost accounting data. But we are hopeful that we will find one or more hospitals that has sufficiently good cost data to use without having to go out and dig it up.

Cost Accounting:

Howland: We have never done a study anywhere where anybody kept anything that we could use.

Dudek: This is why we put this stuff in here, Dan.

Smalley: Well, Tom. you could attest to the lack of this kind of data in some of the things we have done recently, can't you?

Newberry: Yes, most of the data is available if you want to research it. The invoices and the original documents are here. The closet's full of original documents, but you don't have the time to go through all of them.

Howland: It's often easier to just start from scratch and let the thing crank for a while to collect your data than it is to go through the "closet".

Dudek: And work on something else in the interim. We found the same thing on the Bed Project. If you wanted to look at five different pages, you could get one piece of information.

Staton: So often they have collected considerable quantity of data, but there is only one-tenth of that which you have to have to complete your circuit of information. Either you've got to guess at it, or not use it at all, or collect your own data. This has been my experience in this case. In many instances, they have done a wonderful job of collecting and tabulating data, but there is one little element that you are particularly interested in that didn't interest them at all.

Emerzian: May I attach a further significance to this? When you finish with your model, whatever it happens to be, it has to be, it seems to me, equated to the types of information which are available in the hospital readily. Otherwise, all of this work, I don't think, is going to be accepted, from a practical point of view.

<u>Dudek</u>: Except for this one item, Joe. We may not be able to make a practical model based upon that information that is readily available right now. When we originally talked about this Project, this being down in "C" didn't necessarily mean that we would start looking at accounting systems a long way into the future. We might start that concurrently with the rest of the Project. This did not mean that it had to be down at this point, because if you need data, you have to collect it. The other thing is, if you cannot work out a practical system that will make use of this readily available data, that it would take a revision in cost-accounting practices of hospitals to utilize these kinds of models, this might be one of those helpful things that comes out of this study. It could be a recommendation. It doesn't mean that the hospitals will use it; this may just die a slow death. We thought that this might even be of some help.

<u>Howland</u>: Isn't there an organization of hospital cost accountants?

<u>Duncan</u>: I was just thinking about that and, as a matter of fact, I am surprised that the situation is as bad as it is. I thought that we made some inroads on this cost accounting problem, through use of this classified system of accounts, which we are peddling even in the small hospitals. They are meeting and talking to bring about some degree of standardization. As a matter of fact, this group in Georgia is giving the next program for the Atlanta Hospital Council and is going to report to us the progress they have made. We will know a little more about it after listening to them. Maybe I will know less, maybe I will hear what we say and not what we do.

<u>McNulty</u>: I didn't think this was a critique; I thought what Dan was saying was that the information available was not helpful <u>to him</u>. This doesn't mean that the information available isn't very helpful to the individual for whom it is collected. A profit and loss statement is very meaningful to me; it may be hopeless for whatever Dan wants to do with it, if and when he came to our institution. But it may be very significant for my needs.

<u>Hullerman</u>: One of the objectives of the study might be, to determine the usefulness of your decision system for reprocessed as against disposables, regardless of the cost accounting system.

<u>Dudek</u>: In my experience with two hospitals in Nebraska, they didn't use cost accounting as such and, therefore, we couldn't get cost data as we went.

<u>Hullerman</u>: You mean you couldn't compare the two hospitals?

<u>Dudek</u>: No, we couldn't even get the cost data we needed in each specific hospital.

Smalley: I am afraid there is a problem of semantics here. By cost accounting, we industrial engineers don't mean the same thing as do we hospital administrators, if I can wear two hats.

Duncan: I think you're right on that.

Smalley: The industrial engineer looks at a cost accounting system as a system whereby, among the things you get is a dollar per unit produced. If you have 10,000 linen packs put up in a year, each one costs you so much. This is not determined by just how much it cost divided by the number of packs. This is done by establishment of standards and measuring deviations from the standards in quite a complex system. I don't believe hospitals, as a rule do this sort of thing.

Hullerman: From the standpoint of study, Harold, we ought to know whether or not the decision system, formula, or whatever you want to call it, is useful to a hospital with its own system.

Dudek: What I am trying to say, Dr. Hullerman, is that this may not be possible. You may not be able to get a general model that is applicable within the systems that these various hospitals use. Therefore, the study would just point to the fact that if and when these kinds of changes occur in cost accounting, then this model that was evolved, will be applicable.

Duncan: To test any one part of the model, if you need something which is a little finer guage than we have, we could run through our system. You know we have 175 hospitals on a single system with EAM Cost Accouting procedures, in which everything is set up and it really is a cost accounting system, as far as hospitals go. It still isn't the industrial concept, but it is pretty good. We could test any facet of it just through our system.

Dudek: I think you will find that you can work within some systems and that you cannot work within some others.

Hullerman: For the Staff to take a look at, that cost study made for the National League by the United States Public Health Service actually did do what you are verging on here. They got a group of 16 or 17 hospitals together and quite a few of them did reorganize their accounting so that there would be some comparability between them. You might want to look at that if it has any value. I don't think it has too much value, as I look at this; but, if it has, you might use two or three of those on the assumption that you have fairly comparable groups.

Emerzian: What about this Uniform Accounting?

Duncan: We all have one. There is one that the American Hospital Association sponsors, and we are all headed in that direction. We think we have made some progress but it still isn't as fine as you would want.

Emerzian: Oh, it's quite gross.

McNulty: I was going to say that the model should be applicable to this National Generalization on Accounting and what you are saying, I think, Dick, is that these two hospitals in Nebraska didn't use it.

Dudek: That was several years ago.

McNulty: They may not be using it today, on the basis that the amount of money invested to set up such a system does not merit its existence. This may be right or wrong, but someone made that decision.

Dudek: How long has this system been available?

McNulty: Oh, 1942, I think, was its origin. Am I right?

Duncan: Yes, but we haven't really speeded up on it until the past half a dozen years, have we?

McNulty: The growth of the third party payment system and government purchase of services are things that have implemented its greater utilization, but it is in existence. Anything that you should come up with should fit into this system.

Smalley: I think we need to use some imagination, too, and this ties back to the matter of not becoming discouraged, if you can't get a neat solution. For example, in a lot of our statistical theories, we find that we can do certain things if we know the standard deviation of a population. Well, if we knew that, we wouldn't need the sample to begin with. So what we do is make an approximation of that from something we do know. I think there is an analogy here. Suppose that this system depends for the value of its dependent variables on certain independent variables that are not readily available from the kind of data hospitals collect. Well, let's not let that stop us. Let's go ahead and get our model and see if we can temporarily relate the data that the hospital does have with the data that we need, even if this is an imperfect estimator. Use this as a way of connecting the two. I can see a lot of different ways that this might be done, once we get into it.

Hullerman: I think I was making a plea here that you try to do that. Hospitals are nowhere near as bad off as people think about the similarity of their accounting systems, they are pretty good. But there is still wide variation within the system that can be used. If you can minimize that "C" as far as the study is concerned, to the greatest possible extent, I think you are going to save an awful lot of time.

Final Comments:

Smalley: What I would like to do now, before we run out of time, is ask each person, individually, to give us his ideas and comments. Perhaps there are issues which you have been thinking about and couldn't get them in. Maybe you will want to re-emphasize some point that has been made, or to reiterate what you think ought to be done in this study. I would like to give everybody a chance to say something. Ed, how about you?

Loveland: I feel that I have said enough.

Smalley: Well, maybe you will feel free to come back in later if anything occurs to you. Dick?

Dudek: Well, I don't know anything more to add because I think I am reading into the outline more than others are. I have my conceptualization and I don't think we put it all down on paper. I think that a lot of good points have been brought up.

Smalley: Dan?

Howland: I don't think I have anything new to add. I think I have said most of the things that have given us trouble that I thought might help you. I might emphasize, however, you have some kind of conceptual basis of the "cycle" and that you feel free to modify this as you get information. But, for Pete's sake, have one! That is my advice. Have it as explicit as you can get it, until you find out which of these models to pick. Don't just pick a model that looks cute and use it, that you have it in some kind of focus, I think you are going to find, we have, that most of the standard O.R. models have some simplifying assumptions that you are just not going to be able to make in the hospital situation. For example, in working on inventory of blood, blood changes in inventory. It is not like a bolt, a bolt is a bolt when you put in in and a bolt when you get it out. Well, there has been a little work done on this, but not in terms of the kind of time lags that we are talking about. If you don't just go out and plug models, you are going to come up with some information, I think, that would be quite valuable in a general way about where these things are inadequate. Perhaps basic mathematical work or something else is required to crank them around into a more usable form.

Smalley: Joe?

Emerzian: I think I tried to comment on two points that were raised. The only additional thing I would like to say is, reporting from Connecticut, the people with whom I have talked are very interested in this. They think this can be a very valuable study, and they are looking for very practical results. This is something they think at the moment. I'd rather put it this way: This is something they hope that they can use when it is published.

Smalley: If I have been surprised at all in this, it is the emphasis that people are placing upon the practical aspects. We did not anticipate this when the study was conceived.

Howland: This can be a double-edged weapon, and you may end up making simplifying assumptions to satisfy this practical need that will backfire. You may have to fight this whole thing out.

Hullerman: I don't think, Dan, that the emphasis is on the practical alone, but the ability to see the practical side from all the things that need to be covered. This is the difficulty with so much of the research that is done.

Smalley: Joe, I didn't mean to "short-circuit" you there.

Emerzian: This is all I have to say. Thank you.

Smalley: Harold?

Duncan: I was going to say that we have raised some difficulties here this afternoon along practical lines from the point of view of administration, but I was going on to say that, don't feel bad about it, and don't feel pessimistic about it, because once we have given consideration to that, whatever we are able to come up with, I think we are going to be able to use to a great deal of advantage. We have just about gotten to the point now to where the administrator is going to have to be able to illuminate certain areas. Or we are going to have to eliminate certain administrators. We are going to have to roll up our sleeves and share the responsibility. The last thing I wanted to say is, I am one of those who have to leave early and I have to slip out right now, as a matter of fact, and I was going to say, if you all make more progress after I have gone than you did while I was here, I will understand. I enjoyed it very much.

Smalley: Thank you, Harold. We appreciate your coming so much. Dr. Rocker Staton, Assistant Dean of Engineering at Georgia Tech, came in after we had introductions. Rocker?

Staton: I know all but two or three of the people here, I believe. I would like to say aomething that, maybe, Dan has already said. Let's start off crossing a desert or forest that we aren't familiar with. We may need to send out a reconnaissance team. Maybe in this sort of a situation we are in a similar situation. We don't know exactly where we are going, or the path we want to take, so if we can start collecting data and if in doubt, collect it, you may think you are going that way, when you are going to end up going some other way. Or you get some elements that you think might be valuable for a tangential or by-product aim which becomes more important than your initial aim. This, I have found to be quite important in the sort of a study where I don't think we know exactly where we are going except to gather information. It may mean attempting to quantify where it is impossible or merely getting opinions and recording those opinions. I think this can be very helpful and I don't think we need to have our complete trip from here to there mapped out from point to point. We start out in that direction, we know that we are going generally that way, so by taking these items that are already available, reprocessable as well as disposable, and evaluating them, comparing them under the situation under which they are used or would be used, we have at least started. We can go to the top of the next hill and then look from there. This is about all I have to comment on, but I think, by all means, we should emphasize in the beginning that we should collect data that we may not even expect to use because, so often, we will wish when we look back that we had those elements of data.

Smalley: Thank you, Rocker.

Hullerman: Has Harold Duncan left? I was just thinking, if you eliminate these administrators, maybe you are eliminating the people who create the problems which make these studies necessary and you may eliminate a lot of studies, too.

Smalley: I will convey that to him when I see him.

McNulty: We ought to get very basic, Hugo, and say, if we could only get rid of the patients, we would have no particular problem.

Hullerman: I would just like to add this. I feel that somebody said over here that this is really a fundamental study and there is a lot of hope that something will come out of it. Even if we don't understand what it means, I would like to see some of the paper work that comes out of this study before the next meeting.

Smalley: Tom?

Newberry: The opinions and suggestions that have been brought out in this meeting will certainly be most useful to me. I have been associated slightly with hospitals during the past nine months and it's a very interesting area to me. I am looking forward to my association with this team.

Smalley: I don't know if we made it clear, but Tom is in hopes that, somewhere within or close to this Project, he will find a dissertation topic for his doctoral work. He is about ready to embark upon his research, concurremt with his participation as an Assistant Research Engineer on the Project Staff. We hope to be able to use his dissertation results in this Project.

Staton: Maybe this will be one of these by-products I am thinking about. It has happened at Johns Hopkins on numerous occasions. As some of you know, I did my dissertation at Hopkins. So often, we start off in one direction and completely by-pass the initial goal for a by-product.

Smalley: You are not ready to tell us what your dissertation is yet?

Newberry: No, not yet.

Smalley: Matt?

McNulty: I would repeat something that Dean Staton and Dr. Howland said and that is that there is a spectrum in front of us here. We had better bring some portion of it into focus and delimit it, yet, with such mobility, such flexibility, that you can select any particular avenue at any time as it may bear fruit. I made an observation that practicality is important, but I would again mention that I don't think practicality to the extent that there is issued some form of a report which this administrator in "Squedunk" who is about to buy syringes, can say, "Ah, based on this report, I'll no longer buy the disposable", or "I'll no longer buy the reprocessed type", "I'll buy 'X' type." I do think we should avoid that oversimplification. I like the analogy of a double-edged sword or a two-sided coin, perhaps. But I would look for us to be evolving something that would deal with methodology, that would make available to the field of administration some aspects of the methodology employed in this and how it might be adaptable to other types of problems.

Smalley: Thank you, Matt. Joe Moder?

Moder: I think we got one of our questions answered and that is that we should include, if at all possible, a validation study, where we actually apply this to some case study. I don't know if we have any more time, but I just wondered if, not only implementation, but control of these methodologies will become a problem that we ought to consider.

Smalley: That is, how variable are the methods of reprocessing; do they change from day to day, for example?

Moder: Well, certainly, in inventory control, you put in a system, but if you just forget about it, turn your back on it, leave it alone; in a year from now, it could be worse than what was there originally, if you don't keep some eye on things in a formal way. I don't know whether or not that will be a problem in this field.

Smalley: My first reaction to that is that this is similar to the problem that was mentioned much earlier, that this may be largely a function of supervision and management. It is like freeing a man of certain tasks as a result of methods improvement and what do you do with the time saved. It may be more a function of how good your supervision and management are. Maybe this problem of control is related to this. I don't know whether you could conceive of establishing some control as a part of this project or not. It is an interesting question. Does anyone want to react to that?

Loveland: I think acceptance on the part of the top people in the hospitals is going to be essential. Getting back to your point, the first impressions that you make in gathering this data will have one effect; the second is, they may think this is a fine idea, but if they don't buy it to the extent that they are willing to try it, you may get what happens very often in personnel selection programs. You build a fine program and as long as you are there to control the collection data and the measurement of the variables with which you are dealing, everything works fine. You go away and come back a year later and you want to go crawl under the rug. I think this is important. Control ought to be done. You are going to run a validation study between the time that you leave off your initial model building study and the time you collect your validation data, there ought to be some control.

Hullerman: But the emphasis here is on the decision system you are trying to arrive at. How often it is used is a part of management, isn't it?

Smalley: I think Dr. Loveland was addressing himself principally to the interval from original data gathering to the time when you come back to test your model, to see if there has been any changes taking place in the meantime.

Loveland: Yes, but I would like to assure that there weren't any changes.

Howland: This is going to be awfully hard to do.

McNulty: It is a miserable question.

Howland: Let's raise another point. Do you run out with little bits and dabs of data as you collect them, or do you wait until you can bale up a great big report and dump it on somebody's desk? We have worked both ways, and we find that it works much better if you are working with an organization where you can run out and hand them little pieces of data and act on them. Now, this isn't very respectable in terms of getting a report written, and I am not sure that the founding fathers of operations research would approve; but this leads to all kinds of "bubbling up" of new stuff, because managers very often can see things in simple data that, as researchers, we haven't seen. We have been able to take advantage of this, and move into things that we just never thought of, because nobody else ever thought of it.

Smalley: Hasn't this inherently broadened your team? These people to whom you give the bits and pieces, if they react, they become a new source, too.

Howland: That's right.

Dudek: And I think that if it is publishable, publish it right away. Whatever piece you've got, publish it, because you can never tell in what corner of the earth some guy is going to read it and say, "Ha! What about this!" and send you a good questioning letter and off you go on another study.

Smalley: I can see by this that there is no place for a vain man on this team, one who is afraid to stick his neck out and ask somebody to chop it off.

Emerzian: From the team's point of view, I think this practice you suggested is important, because it gives you a sense of periodic accomplishment. You don't have to wait three years before you see something come out.

McNulty: You sustain some interest, too, by this way of operating.

Smalley: This is probably behind Dr. Hullerman's question. I don't know whether or not he had this in mind, but let's have some "feed-back" here between meetings to see how things are going, to stimulate other people's thinking, and to get an idea of what these fellows are up to.

Hullerman: Yes.

Smalley: We have heard from three graduate students who are here from Georgia Tech. We have also a guest, Mr. Miller, one of Dr. Dudek's students at Texas Tech. Dr. Dudek has interested him in research and, perhaps, teaching. I am not sure if he had in mind interesting him in hospital research. I wonder, Mr. Miller, if you have had any reactions at all of this?

Miller: I really had several reactions. I am afraid to say anything because I haven't thought this through.

Smalley: We are certainly happy to have you with us. We hope that you have at least observed how some of these things are brainstormed. Anyone else have any observations or comments?

Adjournment:

Smalley: I do want to express again our appreciation for those of you who came from out of town, in some cases quite a long distance, to be with us and also to those of you locally who gave us your Saturday to spend it with us instead of doing other things. We certainly do appreciate your participation. I'm sure we got a lot out of it. We will study the proceedings and see if they can assist us in structuring a project that will do for the field what all of us hope such a project will do. I invite and urge you to pass on to me anything that occurs to you when you get back, anything and everything that you didn't say here that needs to be said, and that you communicate with me. We would certainly appreciate hearing from you. We anticipate that there will be a Local Steering Committee in the fall, if not sooner. We would like to have the national group back next Spring, sooner if we have something worthy of showing you. By the time that we meet again, it is hoped that we will have some data and we will have made a sufficient start to report on some of the mistakes we have made and some of the things we have done and let you point out what our mistakes are. With that, I would like to close the meeting and again thanks so much for being with us. Meeting adjourned.

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August 1959

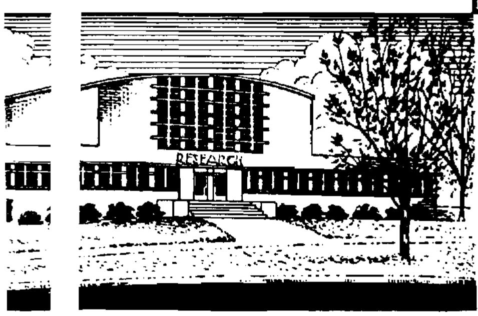
"Disposable versus Reprocessed Hospital Supplies"

USPHS GRANT #GN-5968

BULLETIN NO. 3

Edited by:

Harold E. Smalley, Ph.D.
Principal Investigator



Engineering Experiment Station
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Atlanta, Georgia

3

Disposable versus Reprocessed Hospital Supplies

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Engineering Experiment Station Project #B-158

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August 1959

BIBLIOGRAPHY

Objective

The objective of this work is to make available ready listings of important articles concerning applications of Industrial Engineering to hospitals, as well as articles relating to disposable and reprocessed hospital supplies.

Annotations of these articles are available in the project office at Georgia Institute of Technology. The listings and annotations of the articles are available to members of the project staff, the National Advisory Committee, and the Local Steering Committee.

This report covers progress made to date on compiling useful bibliographies in pursuit of the project objective, to develop a practical decision system for determining the relative economic feasibility of disposable and reprocessed supply items for hospitals.

Procedure

A set of annotated references previously compiled by the Principal Investigator was used as a basis for the present work. A systematic search of the pertinent literature was undertaken in January of 1959 by a graduate research assistant serving on the project team. Some periodicalswere subscribed to and others were obtained at the libraries of Georgia Tech, Emory University Hospital, and the Medical School and Business School of Emory University.

Articles of interest were read and annotations were prepared on 3 x 5 cards. The cards were divided into two general classifications, I and II, and each classification was further subdivided as explained later. In order to facilitate the location of references in the several subclassifications, consideration will be given the McBee and other systems of punching and sorting cards.

It is anticipated that the present listing, which covers 1958 and 1959 references, will be expanded to include references prior to 1958 and new references appearing after June 1959. Other plans are to cross-classify the articles in Classification I by Industrial Engineering tool, e.g., cost accounting, engineering economy, inventory control, layout, materials handling, motion economy and methods, personnel, production control, purchasing, safety, training, wage administration, work measurement, and operations research.

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DEVELOPMENT OF AN INVENTORY MODEL

FOR HOSPITAL SUPPLIES

by

Joseph B. Talbird, Jr.

March 1960

"Disposable versus Reprocessed Hospital Supplies"

USPHS GRANT #GN-5968

PROJECT BULLETIN NO. 4

Harold E. Smalley, Ph.D.
Principal Investigator

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Disposable versus Reprocessed Hospital Supplies

DEVELOPMENT OF AN INVENTORY MODEL FOR HOSPITAL SUPPLIES

by

Joseph B. Talbird, Jr., B.I.E.

A Research Report
done in collaboration with

Thomas L. Newberry, Jr., M.S.I.E.
David C. Ekey, Ph.D.
Harold E. Smalley, Ph.D.

Based upon a Master's Thesis
in the

School of Industrial Engineering
Georgia Institute of Technology

PROJECT BULLETIN NO. 4

Engineering Experiment Station Project #B-158, B-178

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March 1960

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PREFACE

This report (Bulletin No. 4) is the first in a series of studies being conducted under the auspices of USPHS Grant #GN-5968. The overall objective of this research project is to develop a practical decision system for determining the relative economic feasibility of disposable and reprocessed supply items for hospitals.

The subject of this bulletin is the development of an inventory model for hospital supply items for which the demand and the lead time are of a variable nature and can be approximated by probability distributions.

Bulletin No. 5 will report a study on methods of forecasting the demand for certain hospital supply items. A subsequent bulletin will be concerned with hospital supply inventories in which the effects of various inventory policies are considered upon the costs of aggregate supply items with certain constraints placed on purchasing procedures. It is anticipated that the type of inventory policy in use in a hospital will be a definite factor in the decision system for selecting between disposable and reprocessed supply items.

With the introduction of disposable items into hospital use, the need for the storage of increased quantitites will exist. No longer will it be possible merely to expedite items through a sequence of processing steps when the stock becomes low. It will be necessary to procure the items externally where the hospital will exercise less control over the response to the request. Increasingly, it will become desirable to have decision rules in addition to the conventional "rule of thumb" methods commonly used in hospitals.

Studies concerned with other phases of the research project presently in process are as follows:

1. Ranking of various supply items with regard to dollar volume of present and possible future expenditures.
2. Classification of possible disposable items according to method of processing.
3. Research studies in conjunction with the School of Nursing, Emory University, on such topics as:
    a. Nurse acceptance
    b. Physician acceptance
    c. Patient acceptance
    d. Cost of Shortage
    e. Medical Practices
4. Bibliography of methods improvement studies in hospitals.
5. Preliminary cost models.

Results from these and other research efforts will be reported via periodic bulletins to be published through the Engineering Experiment Station of Georgia Institute of Technology.

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SUMMARY

The objective of this study was to provide decision rules for determining optimal purchase quantities and reorder points for hospital supplies. A decision model that considers the following factors was constructed:

1. The distribution of the demand for a single supply item.
2. The distribution of the time to send out and receive orders (lead time distribution).
3. The purchase cost of the item.
4. The costs associated with odering the item.
5. The costs associated with carrying the item in inventory.

Inventory costs were selected as the measure of effectiveness. To optimize this measure of effectiveness, hospital administrators are herein provided with decision rules which will determine:

1. Economic lot sizes.
2. Reorder points.
3. Protective stock levels.
4. Costs of various inventory policies.

Data was collected at Emory University Hospital, Atlanta, Georgia, on a specific item, surgical rubber gloves, and the operational characteristics of this model were evaluated.

The demand was found to be approximately normally distributed and the lead time was found to vary. Insufficient data on lead time required that an assumption be made as to the nature of this distribution. The Poisson distribution was selected for this purpose.

With information on these two distributions and other relevant factors, it was possible to construct a statistical inventory model to optimize the measure of effectiveness.

Results of this study were as follows:

1. To improve the accuracy of the model all relevant factors should be considered where possible.
2. The inventory records of the hospital frequently lack the necessary information for a complete solution by the model.
3. The decision model can provide an accurate guide to evaluate the various inventory policies.

It is recommended that further study be conducted on this subject in the areas of:

1. Determining methods for accurately estimating ordering costs and inventory carrying costs.
2. Extending the table of reorder points calculated from the joint density function of two Poisson distributions.
3. Calculating tables of reorder points for other typical types of demand and lead time distributions.

CHAPTER I

INTRODUCTION

The objective of this study is to provide decision rules for determining optimal purchase quantities and reorder points for hospital supplies. Inventory costs are used as the measure of effectiveness. Analysis of pertinent literature and discussions with certain hospital administrators indicate a need for improving inventory policies.

The administrators of some hospitals apparently have not taken advantage of even the most elementary inventory tools to help solve their inventory control problems. Many hospitals determine how much to buy on the basis of purchase price, i.e., a cost break motivation. Fair (1)[1] states in his article, "When is Quantity a Good Buy?":

> Price is always the primary factor in determining how large a quantity of any given item we are buying, since the dollar saving economics invariably go along with quantity purchases of any supplies or materials by every hospital. But, many an executive has learned to his sorrow that price can never be the sole determining factor. Where nothing else is considered losses invariably result.

Fair further points out several factors that should be considered in addition to price. These factors are as follows:

1. Rate of use.
2. Danger of obsolescence.
3. Deterioration in storage.
4. Future changes in market price.

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[1]Numbers in parenthesis refer to references listed in bibliography.

5. Earning capacity of capital funds.

6. The storage factor.

7. Added insurance costs.

A second inventory policy, i.e., setting buffer stocks, that has been observed as common practice in some hospitals is that of setting minimum inventory levels on the experience factor of maximum demand per time unit. It seems that these reorder points are rarely adjusted downward. The usual practice is to set a reorder point which is maintained until the demand reaches a new maximum and the reorder point is reset upward.

It is felt that the present trend in type of hospital supplies[2] makes the necessity for correct inventory decisions more acute. The trend seems to be to eliminate the use of reprocessed type supply items and increase the use of disposable items. This change in type of supply items may increase inventories by a factor of from five to twenty, (i.e., the reprocessing factor) depending on the kind of supply item.

This change in type of supply item will create a need for the closer control of inventories because a greater risk of shortage may be encountered using disposable items. At present, if a reprocessable item is in short supply, the reprocessing schedule can often be shortened to provide the necessary item when needed. This is not possible with disposable items because they are discarded after use.

To optimize the measure of effectiveness, hospital administrators

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[2] Smalley, Harold E., Tentative Plans for a Study of Hospital Cost Systems, Bulletin No. 1, Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia, January 1959.

need decision rules that will determine:

1. Economic lot sizes.
2. Reorder points.
3. Protective stock levels.
4. Cost of various policies.

In the development of inventory decision models it is a common procedure to assume a constant lead time. On the other hand, the demand function has been subjected to considerable investigation for both variable and constant conditions. The assumption of a constant lead time, under real conditions of uncertainty, can lead to serious errors in determining the reorder point. Brown (2) has recently proposed a method for handling variable lead time. Since Brown's method is not well defined and utilizes a correlation between order quantity and lead time, it was necessary to develop a new method for this study. The reorder point model developed in this study is based on a statistical evaluation of the distributions of both demand and lead time. A joint density function of the actual demand and lead time is then used to determine the proper reorder points at various levels of probability of a shortage. This reorder point also defines the protective stock level.

To evaluate the operational characteristics of this model a typical supply item, surgical rubber gloves, was selected at Emory University Hospital in Atlanta. While complete operating data was not available to rigorously test this model, it was possible to use certain historical data to approximate costs associated with the use of this model. The model can be tested against the control variable of future inventory costs by collecting operating data concerning this item. The actual testing of the model is not included as a part of this study.

It is assumed that the persons using this model to solve hospital inventory supply problems will be able to evaluate demand and lead time distributions statistically.

To understand how statistical inventory control will help in answering the hospital administrators' questions of, "How much of a supply item to buy?," "When to buy this item?," and "How much of this item to keep on hand?"; one must first understand the general concepts of inventory control. These general concepts will be explained in terms of answers to the above three questions.

Inventory control answers the question of "How much of a supply item to buy?" by finding the order size that gives the lowest total cost. These are the costs associated with placing the order (or ordering costs) and the costs associated with maintaining the inventory. Figure 1 shows how these costs vary in a typical situation.

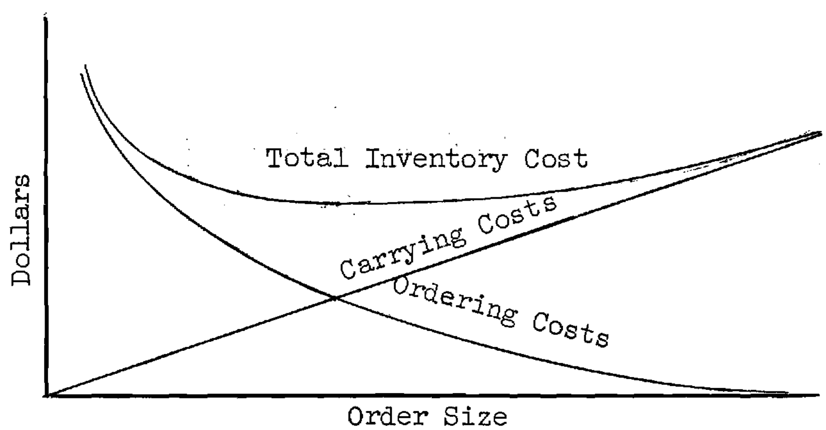

Figure 1 - Typical Inventory Costs

The third curve or total inventory cost curve that appears in Figure 1 shows the sum of these two opposing costs. Inventory control provides a method of finding the order quantity which will give the minimum total cost.

The other two questions that inventory control answers are, "When should this item be bought?" and "How much of this item should be kept on hand?". The answers to these questions require information relative to the demand, to the lead time, and to the level of shortage which will be tolerated. With this information these questions can be answered. Inventory control determines the level of stock (i.e., the reorder point) that must be on hand when an order is placed to insure that the hospital will not have a "stock out" more frequently than indicated by a chosen probability level of a shortage.

Since the early 1950's there has been a remarkable advancement in the development of tools to answer these and other difficult inventory questions. The developments prior to the 1950's and until about 1952 have been summarized and augmented by Whitin (3). Arrow, Karlin and Scarf (4) present a summary of the economic theory involved in inventory control and develop many new mathematical techniques for handling inventory problems with a special emphasis on stochastic inventory processes. Churchman, Ackoff and Arnoff (5) present summaries of the various inventory models developed between the publication of Whitin's book and the recent publication of Arrow, Karlin and Scarf. Some of these models have been designed to accommodate variable costs or price breaks as they are normally called. The majority of these models were developed by people in Operations Research. More Operations Research has been directed toward inventory control than toward any other problem area in business and industry.[3]

Bowman and Fetter (6) present a development of inventory models under two conditions. The first of these conditions is certainty; i.e., situations in which inventory control variables are assumed to be constant. The second condition is uncertainty, i.e., situations in which the inventory control variables are not constant. Morse (7) shows how queueing theory can be utilized to analyze the effects of the variance of supply and demand under certain restricted conditions. Vasonyi (8) presents a summary of statistical inventory control and develops the mathematics necessary to handle the problem of variable demand. He also developes cost equations similar to those in most of the other literature cited. Welch (9) has made an attempt to present many of the concepts of inventory control in the language of elementary mathematics for use by supervisors in business and industry.

This study incorporates many of these principles in the construction of an inventory model appropriate for hospital use. Evaluation of the lead time and demand distributions with subsequent analysis of their joint density function to predict the probability of a shortage at selected reorder points is of importance in the development of this inventory model.

The joint frequency function as shown in Figure 5 is composed of two components of variation--the distribution, $f(x)$, associated with lead time (Poisson) and the weighted conditional demand distribution $f(D_x)$ given a particular lead time (normal).

The summation of the areas for all of these weighted conditional

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[3]Churchman, op. cit., p. 195

demand distributions (normal) over all possible lead times will equal one. The area associated with any lead time is the probability of that lead time occurring. For a particular reorder point the summation of the area from the reorder point over all possible demand in excess of the reorder point for all possible lead times will give the probability of a shortage.

CHAPTER II

EXPERIMENTAL PROCEDURE

In an attempt to determine if any of the inventory models found in the current literature were applicable to the hospitals' inventory problem, it was first necessary to find a hospital in the Atlanta area that would cooperate in providing the necessary information, then to select a typical supply item, gather data concerning this item, and investigate the feasibility of the model selected.

Selection of Supply Item.-- Emory University Hospital agreed to provide the necessary information if it was available in the existing records of the hospital. It was felt that a typical item should be selected for this study. The criteria used to select this typical item were:

1. Intermediate volume of use.
2. Intermediate purchase cost.
3. Necessary information available.

After examining various items in use at Emory University Hospital and determining the availability of the necessary information, surgical rubber gloves were selected as the supply item to be used in testing the inventory models.

Data Collection.-- The demand for gloves was obtained from requisitions at the hospital. This information was collected for a continuous period of 66 weeks and was collected for all sizes of gloves. The data was later enlarged to include a period of 170 weeks. An attempt was made to fit the demand distribution for each size of glove to some theoretical distribution. It was hoped that each size of glove would fit the same theoretical distribution and would differ only in respect to parameters for each size.

An attempt was made to determine the distribution and variability of the lead time. This was not successful since the purchasing records were incomplete with respect to lead time data. However, from the existing information it was found that the lead time does vary. The average of the lead times for five dated orders that were available was found to be one week. This was corroborated by the Purchasing Department personnel as they felt that it took about one week to obtain gloves. The main point is that the assumption of a constant lead time is not appropriate for this inventory model.

Other information that was needed was the inventory carrying cost and the ordering cost. These two costs were estimated with the help of the hospital personnel. Exact costs were impossible to obtain for various reasons. Inventory carrying costs include the cost of storage area and interest on money invested in inventory. These two costs were not known exactly by the hospital administration. However, it is felt that 20 per cent per year of the first cost of the item being studied was in the right range.[1] Emory University Hospital is not an autonomous unit; therefore, the ordering cost of interest to the hospital personnel is only the portion of the cost borne by the hospital directly. If Emory University were considered as a whole, this ordering cost would be higher as the actual work

[1]Whitin, op. cit., p. 220

of sending out, receiving and accepting bids is performed by the purchasing department of the University. The paper work necessary to pay for the item once it has been received is also performed by this purchasing department. However, it was felt that consideration of these factors would only complicate the problem situation and would detract from the general nature of the study within the time limits of this study. The ordering cost to be used in calculations is arbitrarily set at five dollars. Regardless of the specific values obtained in practice for inventory carrying cost and ordering cost the operational characteristics of this model are valid.

The last factor investigated was the cost of a shortage. In the beginning it was felt that it would be important to know the cost of a shortage, but since this cost was unavailable, it was decided that it would be more practical to determine the cost of added protection. Hospitals have a unique problem in determining this cost. For example, what does it cost to put off an operation or to operate with bare hands if no gloves are available? It could cost the life of the person being operated upon, or it could delay this person's recovery. A determination of these costs on a probability basis is beyond the scope of this study. Therefore, only the real costs incurred at the various levels of risk of a shortage will be considered here.

Model Construction.-- A chi-square test was used to compare the actual demand distribution for each size of glove with the theoretical Poisson distribution having the same mean as the observed data. The hypothesis that the observed demand distributions were Poisson distributed with the same mean as the observed data was accepted for five of the seven sizes of gloves at the five per cent significance level. See Table 18 for actual demand for gloves during 170 weeks.

Since all sizes of gloves did not fit the same type of distribution, a different approach was tried. It was observed that the proportion of each size glove did not vary appreciably, regardless of the total demand for the week. Therefore, it was decided to test the hypothesis that the proportion of each size of glove used each week was independent of the total demand for the week. A chi-square contingency table test was used, e.g. as is presented in Hoel (10). The hypothesis was accepted at the five per cent significance level; therefore, only the total demand for gloves per week would be considered at this point.

With the economic lot size determined for the total gloves needed, the order was prorated by sizes using the proportions to determine what amount of the order would be of each size. This is possible because quantity discounts are based on total gloves ordered rather than on the total for each size. This total demand distribution was compared with the theoretical Poisson distribution having the same mean as the observed distribution. The hypothesis that the observed distribution was from a Poisson distributed population was rejected at the five per cent significance level but could be accepted at the two per cent level. The demand distribution was then compared with the theoretical normal distribution having the same mean and standard deviation as the observed distribution. The hypothesis that the observed distribution was from a normally distributed population could be accepted at the five per cent level of significance. However, it was felt that the sample size of 66 weeks was too small to give conclusive results. The sample size was increased to 170 weeks and the same hypotheses was again tested. The hypothesis that the observed total demand distribution was from a Poisson distributed population was rejected at the five per cent level and up to the one-tenth of one per cent level. The normal hypothesis was again accepted at the five per cent level. With an approximation of the actual demand distribution with a theoretical distribution and the information concerning inventory carrying costs and ordering costs, it was possible to use a "two-bin" inventory model such as the one found in Vazsonyi.[2] A "two-bin" system of inventory control provides an active stock and a lead time stock. These two stocks need not be physically separated into two bins. This inventory model shows the level of inventory at which a new order should be placed. The stock that is on hand when the new order is placed is known as the reorder point. This stock will fill the demand during the lead time with a specified probability of a shortage. This model also provides equations for determining the inventory cost per year.

The model at first appeared to meet all the requirements of the hospital for solving its inventory problem. However, after observing the variability that existed in the lead time, it was felt that the reorder point was incorrect and would produce a much higher level of shortage than would be tolerated under the assumption of a constant lead time. On theoretical grounds the distribution was assumed to be Poisson, although there were insufficient data for testing this hypothesis. On the assumption that these supply item orders have discrete lead times whose mean value is constant, e.g., independent of order size, then the further assumption that the duration of these lead times are random and independent leads to the

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[2]Vazsonyi, op. cit., pp. 330-338

use of the Poisson distribution as the model for this variable. With an assumed theoretical distribution to describe the lead time and another distribution to describe the demand, the joint density function of the two was then evaluated to determine the reorder points for various levels of probability of a shortage.

Controls are provided which will show a significant shift in the proportion of each size of glove used. Controls also are provided which will detect significant shifts in the mean and variability of both the demand distribution and the lead time distribution. With information on the reorder point, the protective stock level could then be calculated, and the related carrying costs evaluated. This completes the information required to use this inventory model.

Calculation of Other Reorder Point Curves.-- In an attempt to provide hospital administrators with another guide to reorder points, curves were calculated from the joint density function of two Poisson distributions. An attempt was made to utilize the IBM 650 computer for compiling this information. A workable program was written using an interpretive system but was found to be no faster than a desk calculator when used in conjunction with Molina's (11) Poisson's Exponential Binomial Limit Tables. Due to this fact the computer was not used for calculations within the range of the tables. However, an attempt was made to utilize the computer for the calculation of curves beyond the range of the tables. This procedure had to be abandoned after the calculation of two curves, as the computer routines immediately accessible do not raise "e" to a sufficiently high power. Therefore, the range of the tables for conditions of variable demand and variable lead time was restricted by both the computer program and time.

CHAPTER III

ANALYSIS OF DATA AND RESULTS

The Demand Distribution.-- The first approach that was used in determining the demand distribution was to examine the requisitions for each size of glove for the period, December 30, 1957 - March 30, 1959. The demand for each size of glove was tabulated by weeks for this 66 week period. This demand data was first plotted by weeks to determine if there were seasonal fluctuations in the demand for each size of glove. The demand fluctuations for each size of glove were comparable to those for the total gloves as shown in Figure 2. No seasonal fluctuations were observed. An $\overline{X}$ control chart was used to check the stability of total demand with respect to time, and it was found to be in control. (See Figure 7).

The actual demand distribution for each size glove was next compared with a theoretical Poisson distribution having the same mean as the observed distribution. Table 2 shows the observed demand and expected demand from Poisson distributed population. A chi-square test was used to test the hypothesis that the observed distributions were from Poisson distributed populations. The results are shown in Table 1. With sizes six and one-half and eight the hypothesis that the actual distribution was from a Poisson distributed population was rejected at the five per cent level of significance. With the other sizes the test gave no reason to reject the hypothesis that the observed distributions were from Poisson distributed populations with the same mean as the observed data at the five per cent level of significance.

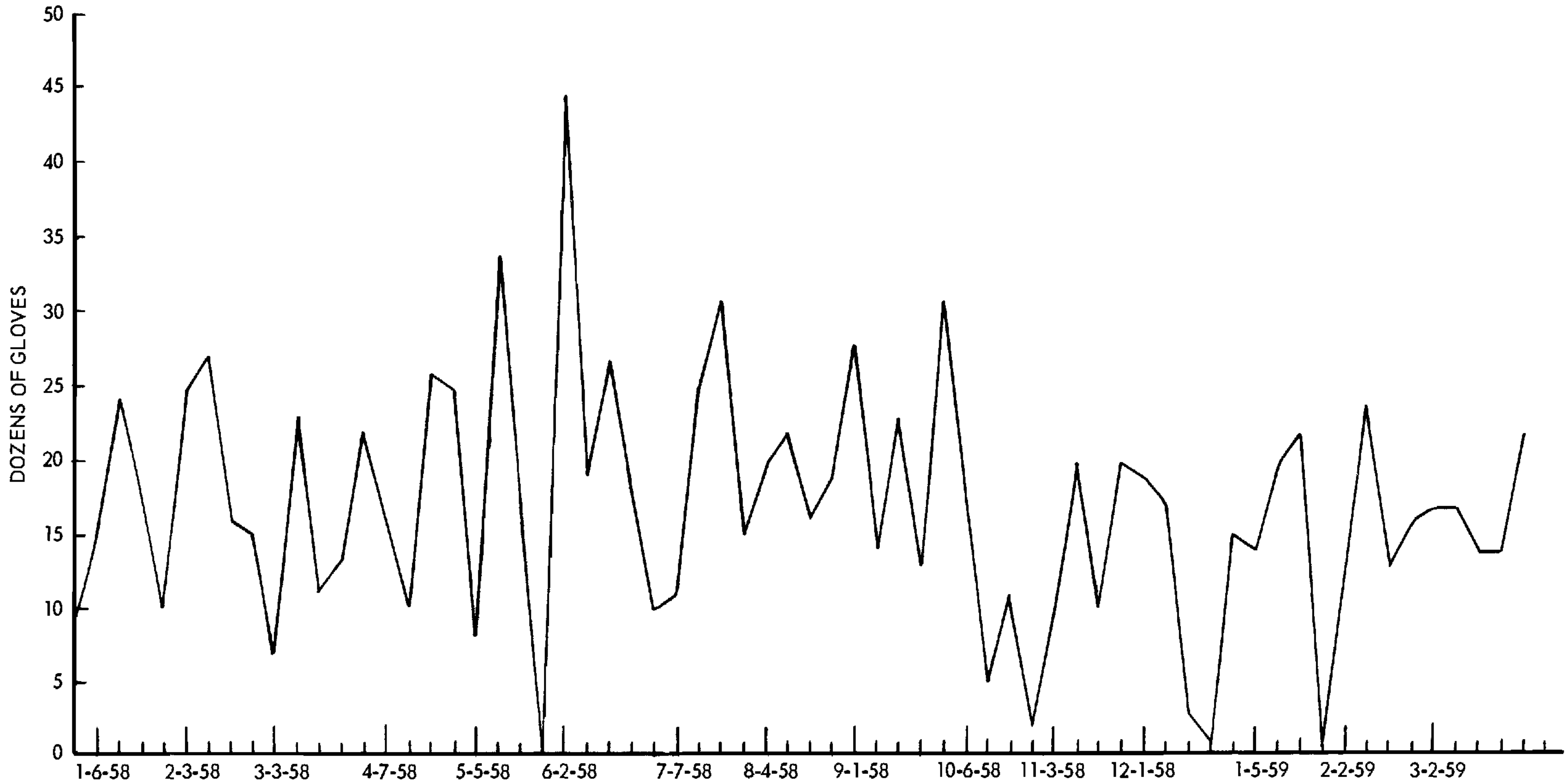

Figure 2. Variation of Total Gloves Requested Per Week from the Store Room.

Table 1. Results of Chi-square Test of Hypothesis that the Demand Distribution for Each Size of Glove is from Poisson Distributed Population

Size	6*	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9
χ^2 actual	0.03	24.00	9.91	6.94	12.29	2.55	0.38
χ^2 .05	3.80	11.10	12.59	11.07	11.07	5.99	3.85

Table 2. Observed Demand and Expected Demand from Poisson Distributed Populations for All Sizes of Gloves for 66 Weeks

Dozens of Pairs	Observed	Expected from Poisson Distribution	Dozens of Pairs	Observed	Expected from Poisson Distribution
<u>Size 6</u>			<u>Size 7</u>		
0	43	43	0	8	1
1	18	18	1	5	6
2	5	4	2	8	11
			3	10	13
<u>Size $6\frac{1}{2}$</u>			4	10	13
			5	8	10
0	15	4	6	9	6
1	7	11	7	1	3
2	13	15	8	6	2
3	8	15	9	0	1
4	3	10	10	0	0
5	8	6	11	0	0
6	8	3	12	0	0
7	1	1	13	1	0
8	3	1			

(Cont.)

Table 2 (Cont.). Observed Demand and Expected Demand from Poisson Distributed Populations for All Sizes of Gloves for 66 Weeks

Dozens of Pairs	Observed	Expected from Poisson Distribution	Dozens of Pairs	Observed	Expected from Poisson Distribution
<u>Size $7\frac{1}{2}$</u>			<u>Size $8\frac{1}{2}$</u>		
0	5	0	0	43	41
1	2	1	1	15	20
2	1	3	2	7	5
3	3	6	3	1	1
4	9	9	<u>Size 9</u>		
5	4	11			
6	12	11			
7	8	9	0	53	53
8	18	7	1	11	15
9	0	4	2	2	1
10	0	3			
11	0	1			
12	3	1			
13	1	0			
<u>Size 8</u>					
0	16	3			
1	3	9			
2	8	14			
3	8	15			
4	13	12			
5	7	7			
6	7	4			
7	1	2			
8	1	1			
9	2	0			

Since all seven sizes did not fit the same Poisson distribution a different approach was tried. It was observed that the proportions of each size of glove requisitioned did not vary greatly, regardless of total demand for gloves for the week. These proportions (p_i), where i indicated the i th size, were determined and are shown in Table 3 below.

Table 3. Proportion of Total Demand
for Each Size of Glove for 66 Week Period

Size	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9
p_i	0.0255	0.1692	0.2284	0.3558	0.1811	0.0291	0.0109

A chi-square contingency table test was used to compare the expected demand for each week of each size with the actual demand for each week. This test is

$$\chi^2 = \sum_{\substack{\text{all} \\ \text{sizes}}} \sum_{\substack{\text{all} \\ \text{weeks}}} \frac{(\text{observed demand} - \text{expected demand})^2}{\text{expected demand}},$$

where the expected demand is the product of the proportion of each size and the total number of gloves ordered for the week. This equation was summed for all seven sizes and for 66 weeks. The chi-square value was found to be

$$\chi^2 = 493.19 \;.$$

The critical chi-square value must be computed as the degrees of freedom are large. The degrees of freedom are

$$n = (7 \text{ sizes} - 1)(66 \text{ weeks} - 1) = 390 .$$

For large values of degrees of freedom the approximate formula is given by Dixon and Massey (12), page 385, as follows:

$$\chi^2 = n\left(1 - \frac{2}{9n} + Z_\alpha \frac{2}{9n}\right)^3$$

where Z_α is the normal deviate and n is the number of degrees of freedom. The critical value was computed to be

$$\chi^2_{.05} = 572 .$$

As the actual chi-square value is less than the computed value at the five per cent level of significance, there is no reason to reject the hypothesis that the proportions of each size of glove are independent of total demand for the week. Therefore, all sizes of gloves were grouped and only the total demand for gloves was considered.

The total demand distribution was compared with the theoretical normal distribution (Figure 3) having the same mean and standard deviation as the observed data. The mean (μ_d) was found to be 16.89 dozens of pairs of gloves per week and the standard deviation (σ_d) was 8.1 dozens of pairs of gloves per week. Table 4 shows the observed demand and the expected demand from a normally distributed population. The chi-square test was used to test the hypothesis that the observed distribution

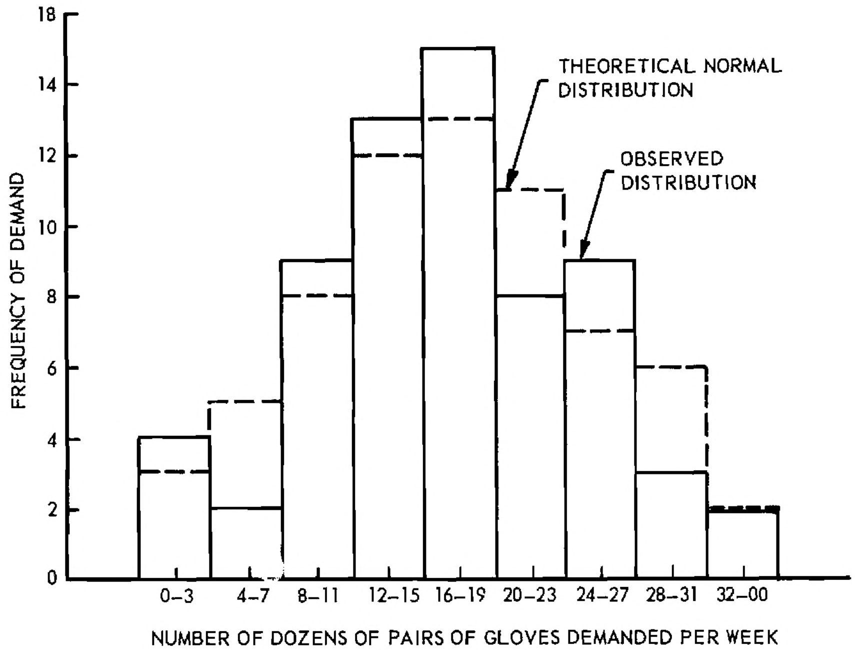

Figure 3. Actual and Theoretical Frequency Distributions of Total Gloves Requisitioned Per Week for 66 Weeks.

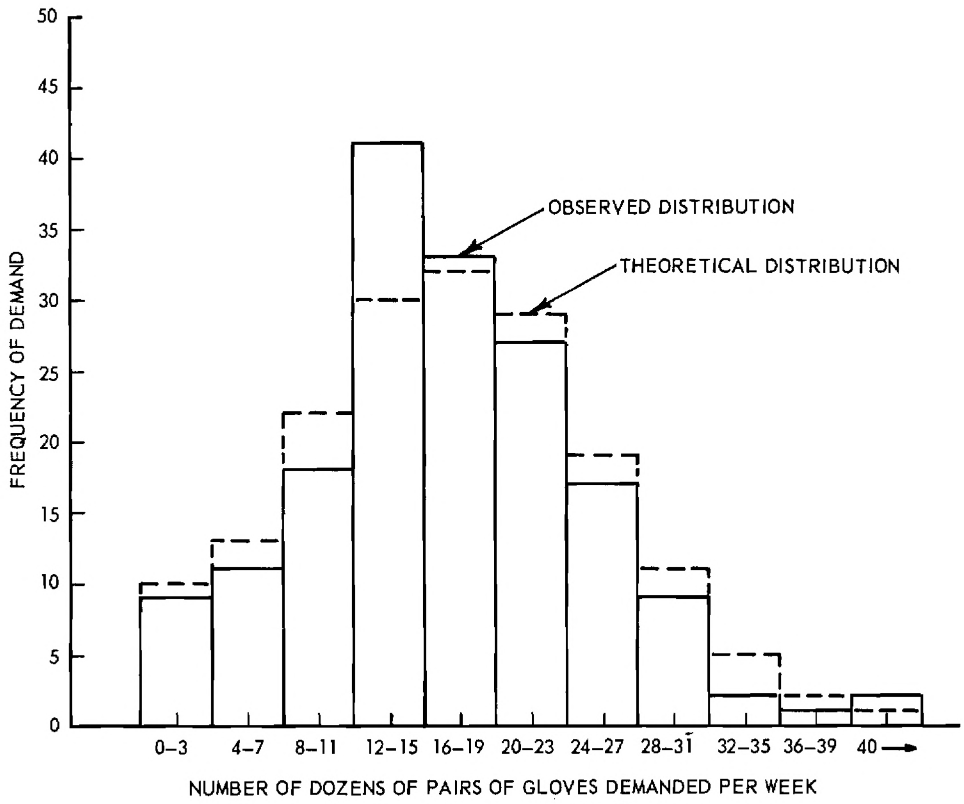

Figure 4. Actual and Theoretical Frequency Distributions of Total Gloves Requisitioned Per Week for 170 Weeks.

Table 4. Observed Demand and Expected Demand from a Normally Distributed Population for Total Gloves for 66 Weeks.

Dozens of Pairs	Observed	Expected from Normal Distribution
0 - 3	4	3
4 - 7	3	5
8 - 11	9	8
12 - 15	13	12
16 - 19	15	13
20 - 23	8	11
24 - 27	9	7
28 - 31	3	4
32	2	2

was from a normally distributed population. The chi-square value was found to be

$$\chi^2 = 2.2 .$$

The critical value at the five per cent level of significance is

$$\chi^2_{.05} = 12.59 .$$

As the actual chi-square value is less than the critical $\chi^2_{.05}$ value there is no reason to reject the hypothesis that the observed distribution is from a normally distributed population.

However, as the distribution is truncated at zero, it was felt that the theoretical Poisson distribution could possibly approximate the actual demand distribution. Table 5 shows the observed demand and the expected demand from a Poisson distributed population. The chi-square

Table 5. Observed Demand and Expected Demand from a Poisson Distributed Population for Total Gloves for 66 Weeks.

Dozens of Pairs	Observed	Expected from Poisson Distribution
0 - 3	4	0
4 - 7	3	0
8 - 11	9	5
12 - 15	13	19
16 - 19	15	24
20 - 23	8	13
24 - 27	9	14
28 - 31	3	1
32	2	0

test was used to test the hypothesis that the observed distribution was from a Poisson distributed population. The actual chi-square value was

$$\chi^2 = 5.48 .$$

The critical chi-square value at the five per cent level of significance is

$$\chi^2_{.05} = 3.84 .$$

As the actual chi-square value is greater than the critical $\chi^2_{.05}$ value the hypothesis that the observed distribution is from a Poisson distributed population was rejected.

Because the sample size was only 66 weeks, it was felt that the results were not conclusive. Therefore, the sample was enlarged to 170 weeks by utilizing data from January 1, 1956, in the records at Emory University Hospital. A new demand distribution was tabulated for this enlarged sample. This distribution was compared with both the normal (Figure 4) and Poisson distributions. Table 6 shows the observed demand and the expected demand from a normally distributed population. Table 7 shows the observed demand and the expected demand from a Poisson distributed population. The results were as follows:

Normal Distribution Comparison

$$\mu_d = 16.89$$
$$\sigma_d = 8.41$$
$$\chi^2 \text{ actual} = 7.42$$
$$\chi^2_{.05} = 12.59 \ .$$

As the actual chi-square value is less than the critical $\chi^2_{.05}$ value the hypothesis that the observed distribution was from a normally distributed population was again accepted.

Poisson Distribution Comparison

$$\mu_d = 16.89$$
$$\chi^2 \text{ actual} = 117.68$$
$$\chi^2_{.05} = 7.82 \ .$$

Since the actual chi-square value is greater than the critical $\chi^2_{.05}$ value, the hypothesis that the observed distribution was from a Poisson distributed population was again rejected.

Table 6. Observed Demand and Expected Demand from a Normally Distributed Population for Total Gloves for 170 Weeks.

Dozens of Pairs	Observed	Expected from Normal Distribution
0 - 3	9	10
4 - 7	11	13
8 - 11	18	22
12 - 15	41	30
16 - 19	33	32
20 - 23	27	29
24 - 27	17	19
28 - 31	9	11
32 - 35	2	5
36 - 39	1	2
40	2	1

Table 7. Observed Demand and Expected Demand from a Poisson Distributed Population for Total Gloves for 170 Weeks.

Dozens of Pairs	Observed	Expected from Poisson Distribution
0 - 3	9	0
4 - 7	11	1
8 - 11	18	14
12 - 15	41	50
16 - 19	33	62
20 - 23	27	33
24 - 27	17	8
28 - 31	9	1
32 - 35	2	0
36 - 39	1	0
40	2	0

Economic Lot Size.-- It is possible to determine the optimum ordering quantity by using conventional economic lot size equations. The economic lot size (q)[1] is found by

$$q = \sqrt{\frac{2YA}{pC}}$$

where Y = yearly demand

A = cost of ordering

p = inventory carrying cost expressed as a per cent of the unit cost

C = purchase cost per unit

The development of this equation is dependent upon the following assumptions:

1. Procurement costs are fixed.
2. There is no interaction between protective stock and economic lot size.
3. The average time between orders, over an extended period of time, is used as a constant.
4. The average demand per fixed unit of time is used as a constant.
5. Interest, risks, depreciation, obsolescence and storage costs may be pooled into one percentage figure.
6. This percentage is constant.
7. The inventory is dispersed in small lots, and no back orders allowed.

If it were possible to determine the cost of a shortage, the equation used to determine the economic lot size[2] would become

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[1]Whitin, op. cit., p. 33

[2]Vazsonyi, op. cit., p. 337

$$q = \sqrt{\frac{2Y}{pC} \left\{ A + E \left[1 - \Phi(t) \right] \right\}}$$

where E is the cost of the shortage and $[1 - \Phi(t)]$ is the probability of a shortage. However, as this cost cannot be determined at the present time it will be considered implicitly by specifying the tolerated probability of a shortage.

Price Breaks.-- The following values were used in the calculations for the economic order quantity for gloves when price breaks exist:

Y = 878 dozen pairs

A = \$5.00 per order

p = 0.20 per year

The price per unit varies with the order quantity as follows:

Price Break in Dozen Pairs	$b_1 = 13$	$b_2 = 37$	$b_3 = 109$	
Quantity	(1-12) dozen	(13-36) dozen	(37-108) dozen	over 108 dozen
Cost	$C_1 = 6.59$	$C_2 = 5.30$	$C_3 = 4.80$	$C_4 = 4.70$

Following the procedure by Churchman[3]

1. Compute q_4. $q_4 = \sqrt{\frac{(2)(878)(5)}{(0.2)(4.70)}} = 97$ dozen pairs of gloves.

2. Compute q_3. $q_3 = \sqrt{\frac{(2)(878)(5)}{(0.2)(4.80)}} = 96$ dozen pairs of gloves.

Since $TEK_{b_3} < TEK_{q_3}$, the purchase quantity which will result in a minimum cost is $b_3 = 109$ dozen pairs. Since q_3 is greater than b_2, the TEK (total expected cost), which includes the variable cost of purchasing the items,

[3]Churchman, op. cit., p. 252

is compared where the order quantity is q_3 and b_3.[4] The quantity which results in the smaller cost will be selected.

$$TEK_{q_3} = \left[C_3Y\right] + \left[A\frac{Y}{q_3} + (\tfrac{1}{2}q_3 + W_\alpha)\ C_3p\right]$$
$$= [\$4214.40] + [\$45.73 + \$59.39]$$
$$= \$4319.52$$
$$TEK_{b_3} = \left[C_4Y\right] + \left[\frac{AY}{b_3} + (\tfrac{1}{2}b_3 + W_\alpha)\ C_4p\right]$$
$$= [\$4126.60] + [\$40.28 + \$64.26]$$
$$= \$4231.14$$

Table 8. Optimum Order Quantity for Each Glove Size

Size	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9
No. pairs	33	216	291	454	231	37	14

When the reorder point is reached, the new order will be placed for the number of gloves indicated in Table 8, above. When the controls maintained on the proportions indicate the proportions have changed, a new breakdown of the economic lot size should be made.

Reorder Point.-- In the first calculations for reorder point the assumption will be made that the lead time is constant (one week).

Let f(d) denote: the probability density function of the demand for a fixed time period; and R.P. denote the reorder point. Then the probability of a shortage during the reorder period is given by

$$P\ \{D \geq R.P.\} = 1 - \int_{-\infty}^{R.P.} f(D_x)dD_x\ .$$

Where $f(D_x)$ is the density function of total demand for a constant number (x) of time periods.

[4]The cost of a shortage is excluded from this comparison and W is determined subsequently to be 13.86 dozens of pairs of gloves.

Out of 340 requisitions examined during the 66 week period there were found to be 17 shortages. It will be assumed that this is the shortage level that management will tolerate. Therefore,

$$1 - \int_{-\infty}^{R.P.} f(D_x)\,dD_x = \frac{17}{340} = 0.05 \ .$$

The demand distribution f(d) is normal with mean (μ_d) of 16.89 dozen pairs of gloves and standard deviation (σ_d) of 8.4 dozen pairs of gloves. Using the properties of the normal distribution, and recognizing that when x equals 1 that f(d) equals $f(D_1)$. It follows from above

$$\int_{-\infty}^{R.P.} f(d)\ dd = 0.95$$

and therefore R.P. is located at a sigma deviation (t) from the mean μ_d of:

$$+ \ t \ \sigma_d = + \ 1.65 \ \sigma_d \ .$$

The reorder point (R.P.) is calculated from the equation,

$$\text{R.P.} = \begin{array}{c}\text{Expected demand}\\ \text{during lead time}\end{array} + \begin{array}{c}\text{Protective}\\ \text{stock}\end{array}$$

$$\begin{aligned} \text{R.P.} &= \mu_d + (t)\ \sigma_d \\ &= 16.89 + 1.65\ (8.4) \\ &= 30.75 \text{ dozens of pairs of gloves} \ . \end{aligned}$$

It is observed that the insurance against a shortage (W), or protective stock level, is 13.86 dozens of pairs of gloves.

To illustrate how the assumption of constant lead time causes higher probabilities of shortages when the lead time actually varies, the reorder point will again be calculated assuming that the lead time has a Poisson distribution with mean (μ_x) of one week. The same demand distribution will be used as before. The reorder point is calculated from the equation

$$\text{probability of a shortage}^{5} = \sum_{x=0}^{\infty} p(x) \int_{RP}^{\infty} f(D_x|x)dD_x \ .$$

These calculations have been made for the range of probabilities of a shortage from 10 per cent to one-tenth of one per cent. A pictorial representation of this model is shown in Figure 5. An assumption is that the variables of lead time and demand are randomly distributed. These values have been tabulated in Table 9. Figure 5 shows these values plotted.

It will be noticed in comparing the two reorder points that the assumption of Poisson lead time increases the reorder point from approximately 31 dozen pairs of gloves to approximately 53 dozen pairs, and the level of protective stock has been increased from 13.86 dozen pairs to 36.11 dozen pairs. If the lead time is actually Poisson distributed and 31 dozen pairs of gloves were used as the reorder point, the probability of a shortage would be greater than 12 per cent. To show that it is possible to make these calculations using demand and lead time numbers of smaller magnitude, the demand distribution was recalculated in terms of gross per week and the calculations for probabilities of a shortage

[5] See Appendix A for derivation of this equation.

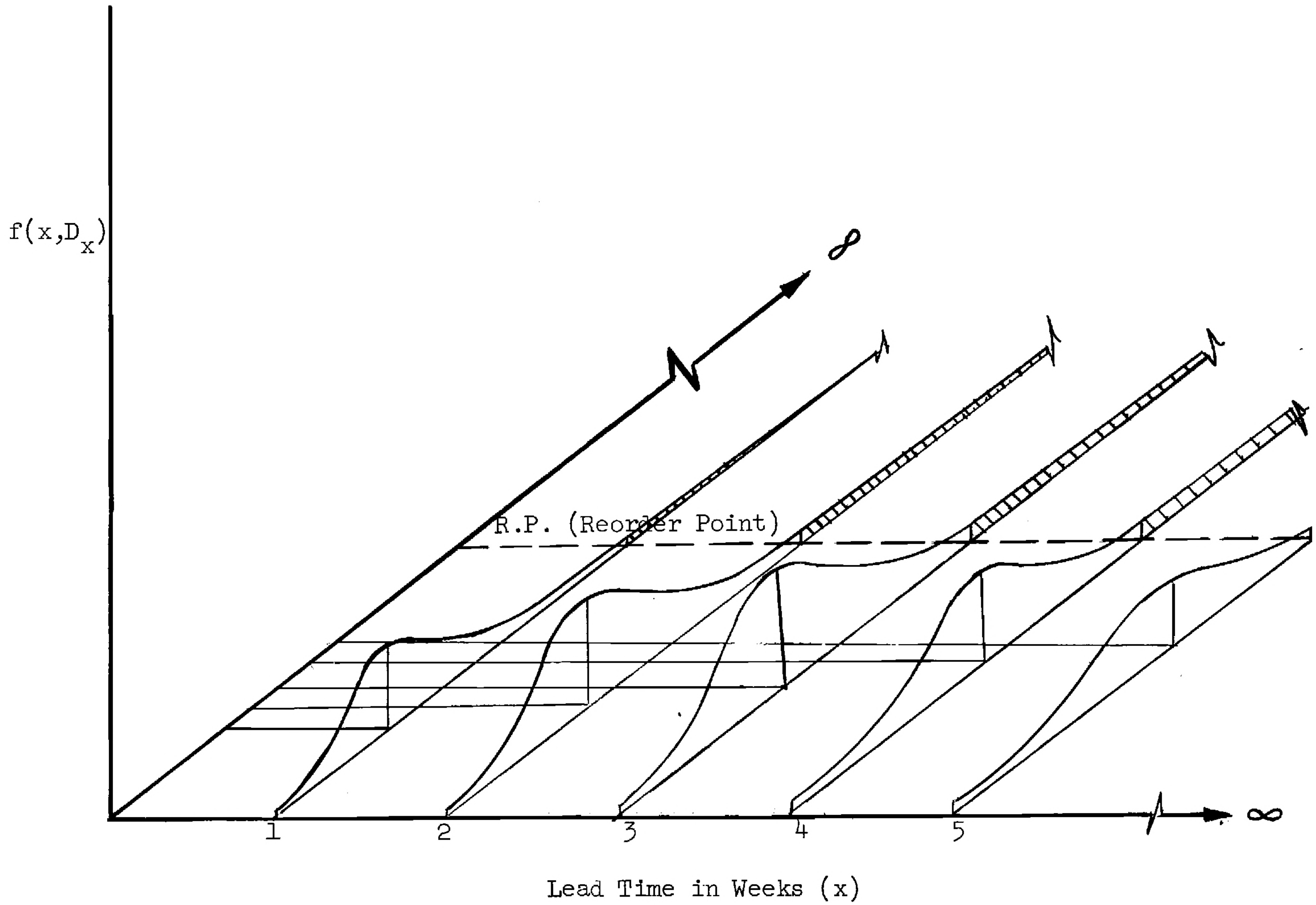

Figure 5. A Pictorial Representation of a Typical Inventory Model for Varying Lead Time and Demand.

Table 9. Tables of Probability of a Shortage at Various Reorder Points Where the Lead Time Has a Poisson Distribution with Mean (μ_x) of 1 Week and the Demand Distribution is Normal With Mean (μ_d) of 16.9 Dozen.

R.P.	Probability of a Shortage	R.P.	Probability of a Shortage
40	0.11844	73	0.01203
41	0.11117	74	0.01113
42	0.10478	75	0.01030
43	0.09815	76	0.00952
44	0.09208	77	0.00879
45	0.08695	78	0.00817
46	0.08122	79	0.00754
47	0.07618	80	0.00694
48	0.07107	81	0.00641
49	0.06656	82	0.00592
50	0.06227	83	0.00545
51	0.05824	84	0.00503
52	0.05445	85	0.00466
53	0.05089	86	0.00431
54	0.04736	87	0.00398
55	0.04423	88	0.00367
56	0.04116	89	0.00337
57	0.03839	90	0.00311
58	0.03601	91	0.02286
59	0.03350	92	0.00264
60	0.03120	93	0.00243
61	0.02902	94	0.00222
62	0.02708	95	0.00206
63	0.02507	96	0.00188
64	0.02273	97	0.00173
65	0.02185	98	0.00159
66	0.02034	99	0.00146
67	0.01888	100	0.00133
68	0.01753	101	0.00123
69	0.01624	102	0.00113
70	0.01506	103	0.00103
71	0.01405	104	0.00095
72	0.01300		

were again performed. These values have been tabulated in Table 10. Figure 6 shows these values plotted. It will be noticed that exactly the

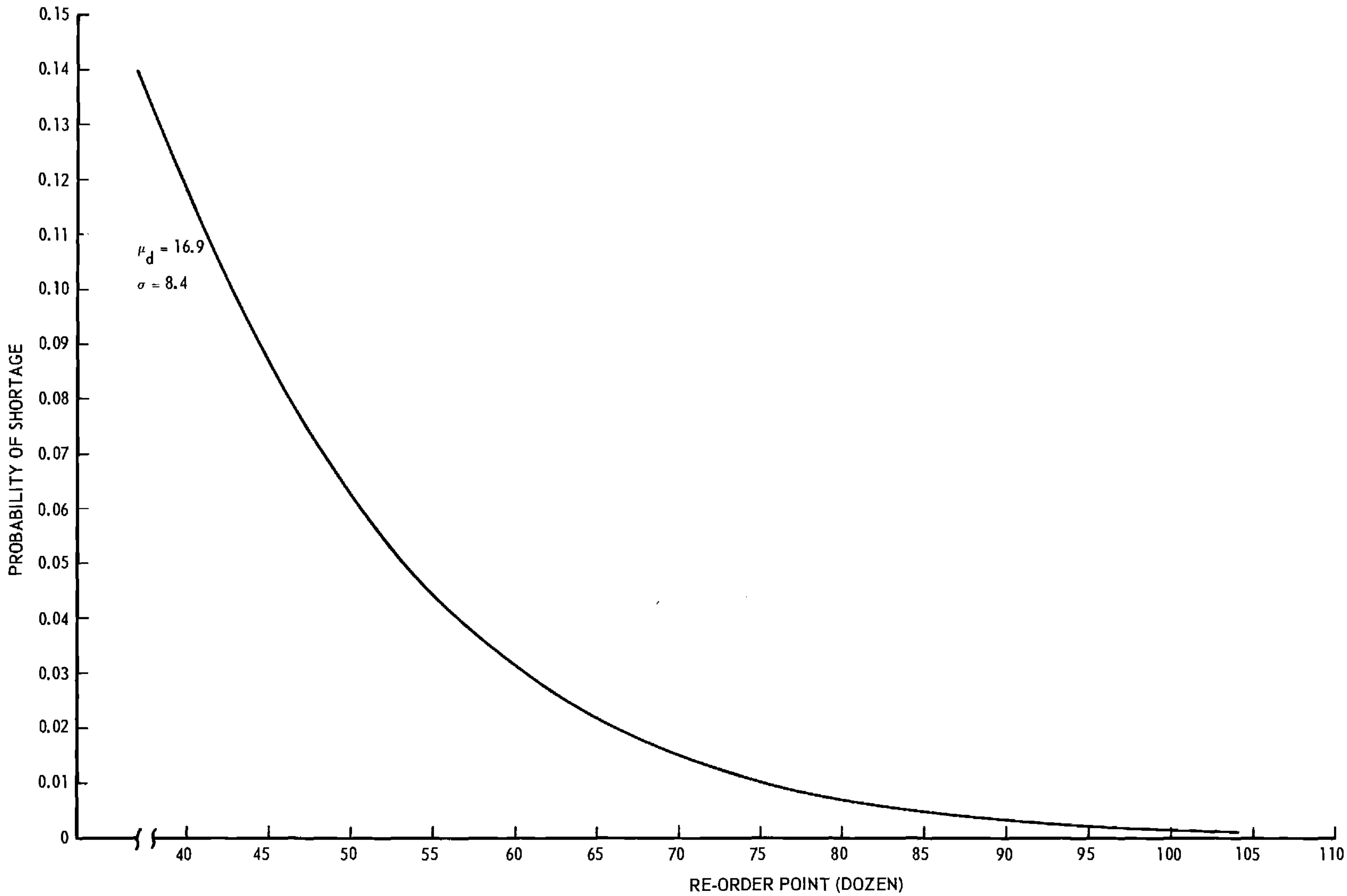

Figure 6. Graph of Two Variables; Probability of Shortage and Reorder Point with the Means of the Poisson Lead Time Function and Normal Demand Function Held Constant.

Table 10. Tables of Probability of a Shortage at Various Reorder Points Where the Lead Time Has a Poisson Distribution With Mean (μ_x) of 1 Week and the Demand Distribution is Normal With Mean (μ_d) of 1.408 Gross.

R.P.	Probability of a Shortage
3	0.14866
4	0.07107
5	0.03120
6	0.01300
7	0.00503
8	0.00188
9	0.00066

same probabilities of shortage were obtained for corresponding reorder points. For example, it will be noted that for a reorder point of 48 dozen pairs of gloves the probability of a shortage is 0.07107 and for a reorder point of 4 gross of pairs of gloves the probability of a shortage is also 0.07107. This indicates that care should be taken in choosing the units for the demand distribution, so that the magnitude of the numbers is as small as is practical.

Total Inventory Costs.-- With the economic lot size and correct protective stock level determined, the total cost (Z) for a year can be calculated from the following equation[6]

$$Z = A\frac{Y}{q} + \left(\tfrac{1}{2}q + W_\alpha\right) cp .$$

This equation is used to determine the cost of various inventory policies, where W_α is the protective stock necessary to insure a probability of α of not having a shortage. The example of gloves shows that for a level of

[6] Vazsonyi, op. cit., p. 333

shortage of five per cent the appropriate level of protective stock is 36.11 dozen pairs of gloves. Therefore, the total annual cost associated with ordering and maintaining the inventory with a probability of a shortage of five per cent is

$$\begin{aligned} Z &= (5.00)\,\frac{878}{109} + \left(\frac{109}{2} + 36.11\right)(4.80)\,(0.20) \\ &= 40.28 + 85.17 \\ &= \$125.45. \end{aligned}$$

However, this figure may not be meaningful. The figure that most hospital administrators would be interested in is the cost per pair of gloves. This cost is

$$\text{cost per pair} = \frac{\$125.45}{878 \text{ dozen x } 12 \text{ pair/dozen}} = \$0.0119 \text{ per pair of gloves.}$$

This figure can be compared with the cost of other inventory policies. For example, the hospital administrator intuitively may feel that five per cent is too high a probability of a shortage to tolerate. The administrator may want to investigate the incremental increase is cost that would be associated with lowering the probability of a shortage to one per cent and to one-tenth of one per cent. From Figure 6 the reorder point is found to be approximately 76 dozen pairs of gloves for a one per cent probability of a shortage and approximately 104 dozen pairs of gloves for a one-tenth of one per cent probability of a shortage. This means that the protective stock level is now 59.11 dozen pairs of gloves for a one per cent probability of a shortage and 87.11 dozen pairs of gloves for a one-tenth of one per cent probability of a shortage. The total cost would now be as follows:

(1) where the probability of a shortage = 1%

$$Z = 5.00 \left(\frac{878}{109}\right) + \left(\frac{109}{2} + 59.11\right) (4.80) (0.20)$$
$$= 40.28 + 106.77$$
$$= \$147.07,$$

and the cost per pair of gloves would be

$$\frac{\$147.07}{878 \times 12} = \$0.0140 \text{ per pair of gloves.}$$

(2) where the probability of a shortage = 0.1%

$$Z = 5.00 \left(\frac{878}{109}\right) + \left(\frac{109}{2} + 87.11\right) (4.80) (0.20)$$
$$= 40.28 + 133.11$$
$$= \$173.39,$$

and the cost per pair of gloves would be $\frac{\$173.39}{878 \times 12} = \$0.0165$.

The hospital administrator is thus able to evaluate the various inventory policies in terms of "out of pocket" costs relative to selected probability levels of a shortage and quantitatively determine what level of protection the hospital can afford.

Detection of Changes in the Model.-- If the proportion of a size of glove used or the total demand or lead time for gloves changes, economic lot size, reorder points and the protective stock level calculations based on these values would not give accurate results. To detect any significant shifts in any of these values control charts have been constructed (Figures 7, 8, 9, and 10) using techniques presented by Duncan (13).

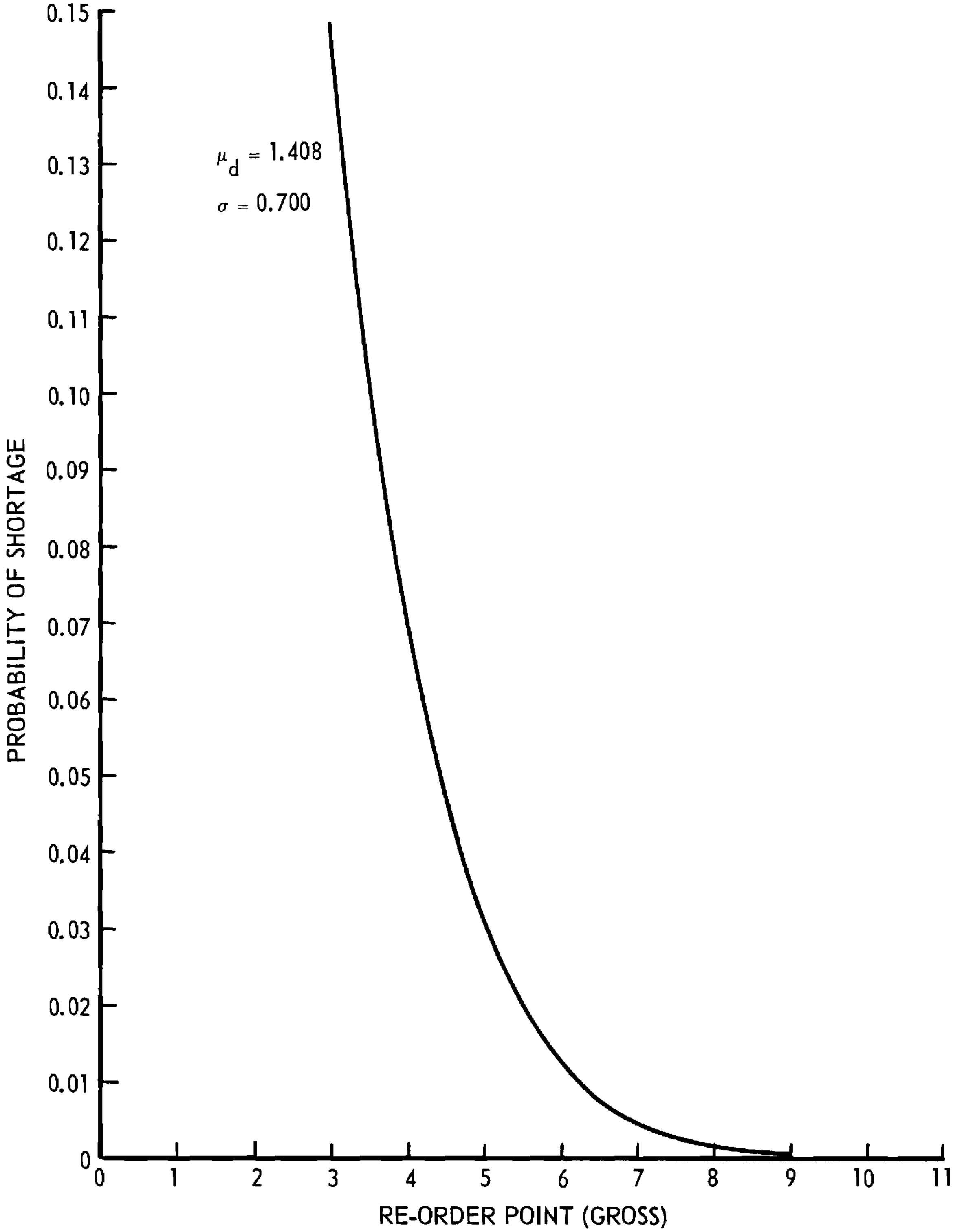

Figure 7. Graph of Two Variables; Probability of Shortage and Reorder Point with the Means of the Poisson Lead Time Function and Normal Demand Function Held Constant.

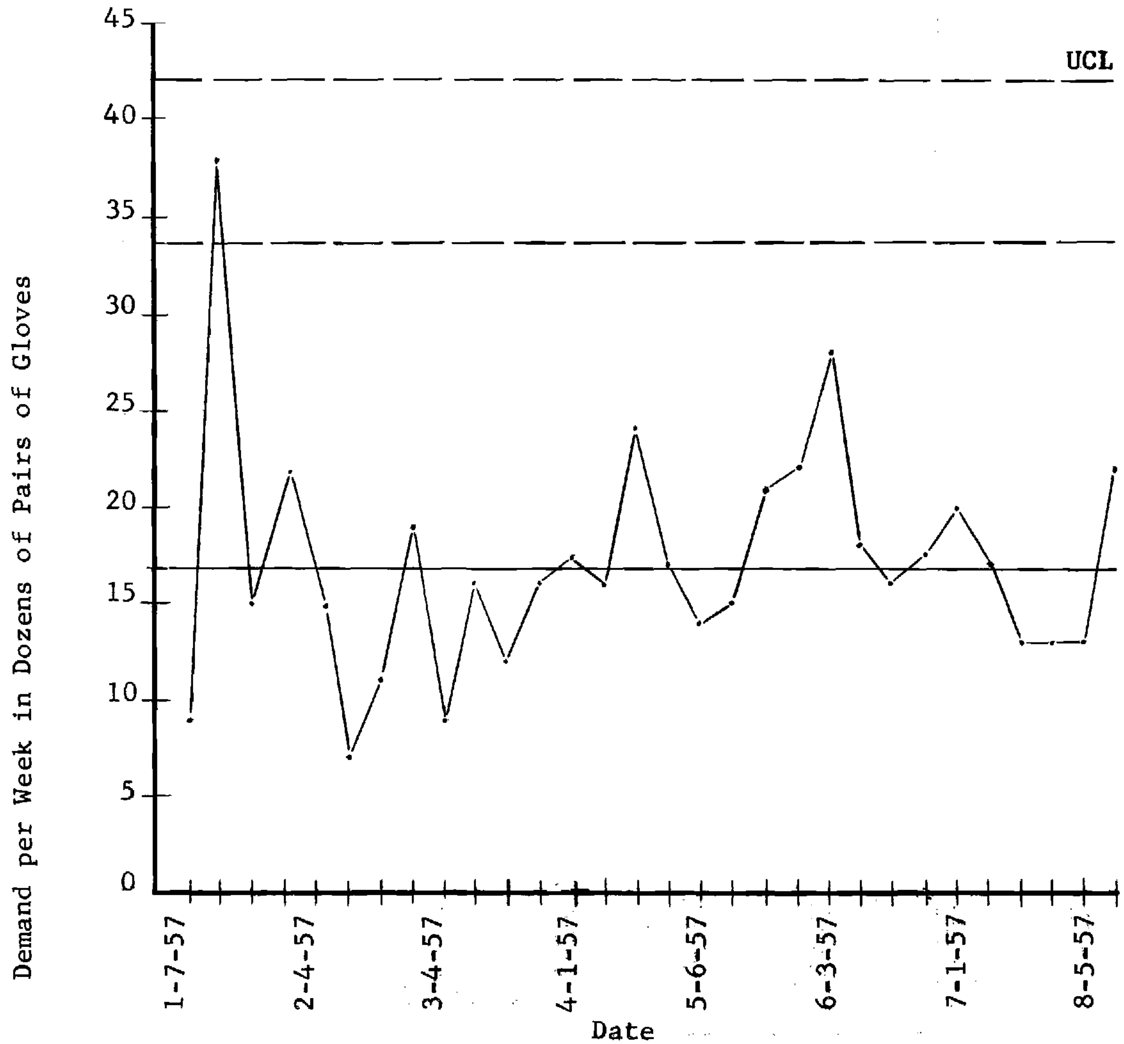

Figure 8. Control Chart for Mean (μ_d)
of Normally Distributed Demand

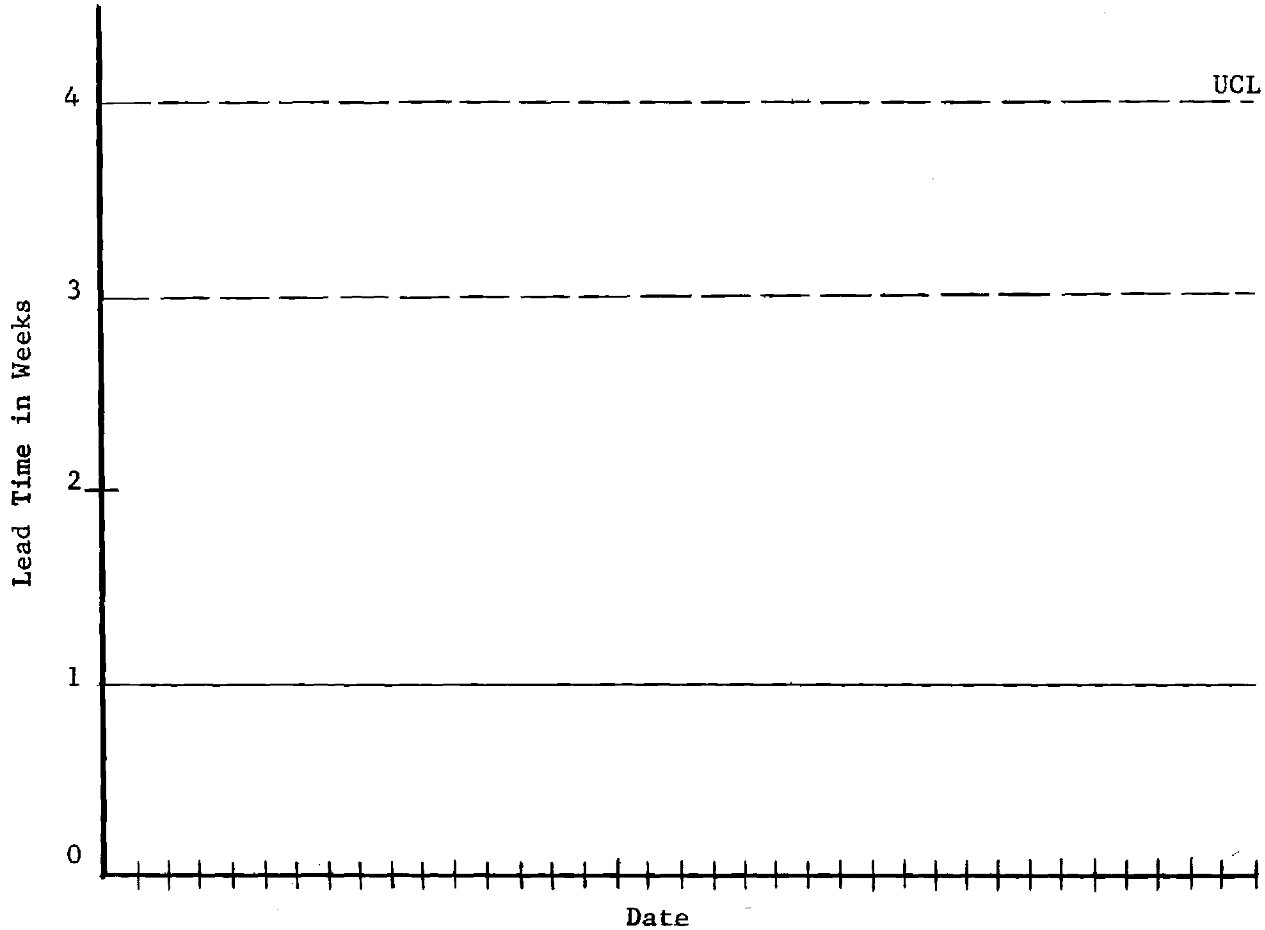

Figure 9. Control Chart for Mean (μ_x) of Poisson Distributed Lead Time

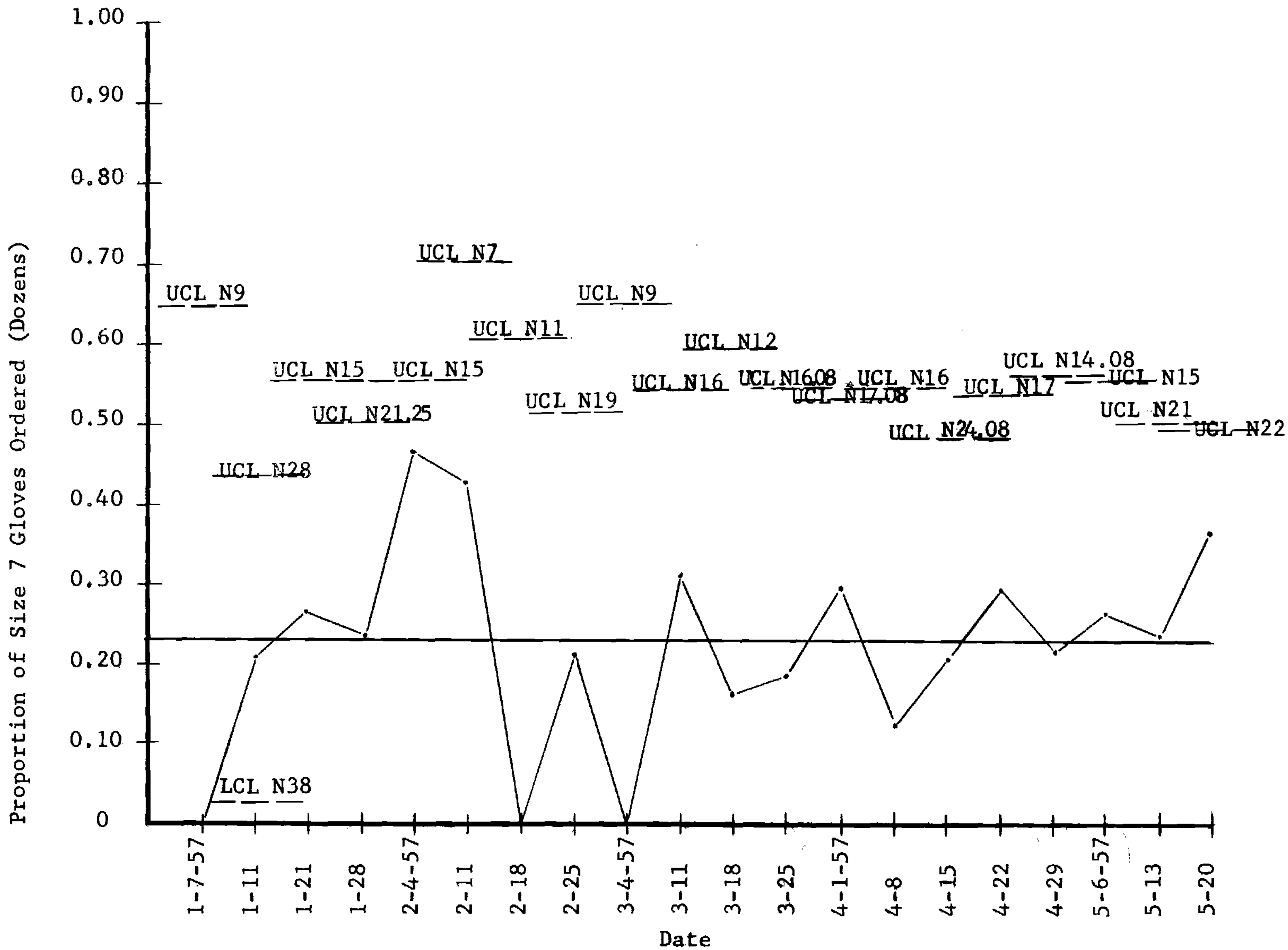

Figure 10. Control Chart for Proportion ($\bar{p}_7$) of Size Seven Gloves Used Showing Various Control Limits.

Figure 7 illustrates an $\bar{x}$ chart[7] that will detect any significant shift in the mean of the total demand distribution for gloves. The demand per week for gloves for the period January 7, 1957 - August 5, 1957 has been plotted to illustrate how the chart is used. To detect any shifts in the variance of the total demand distribution, a σ chart[8] could be constructed.

Figure 8 illustrates a $\bar{c}$ chart[9] that will detect any significant shift in the mean of the lead time distribution.

Figure 9 illustrates a $\bar{p}$ chart[10] that will detect any significant shift in the proportion of the size of glove used. This chart has been constructed for size seven gloves. In actual practice it would be necessary to have six of these charts as the proportions of all sizes would need to be examined for shifts in the proportion used. The upper control limit (UCL) for various total numbers (N) of gloves requisitioned per week are shown. Figure 10 shows the proportion of size 7 gloves requisitioned per week for the period January 7, 1957 - May 20, 1957. This control chart was constructed to illustrate the use of this type of control chart.

To determine if there were significant shifts in any of the values being examined the control charts would be analyzed for runs in addition to points out of control.[11]

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[7] Duncan, *op. cit.*, pp. 363-70

[8] *Ibid.*, pp. 376-77

[9] *Ibid.*, pp. 350-52

[10] *Ibid.*, pp. 330-35

[11] *Ibid.*, pp. 117-22

Calculation of Other Reorder Point Curves.-- In an attempt to provide hospital administrators with a guide to reorder points when the demand distribution is other than normal, reorder point curves have been calculated from the joint density function of two Poisson distributions. An attempt was made to utilize the IBM 650 computer for these calculations. A workable program was written, using an interpretive system (Figure 11), but this was found to be no faster than the use of a desk calculator, when used in conjunction with Molina's Tables. Because of this fact, the use of the computer was discontinued for calculations within the range of the tables. The following curves were calculated:

$\mu_x = 1$, $\mu_d = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11$[12]

$\mu_x = 2$, $\mu_d = 1, 2, 3, 4, 5, 6, 7, 8$

$\mu_x = 3$, $\mu_d = 1, 2, 3, 4, 5, 6$

$\mu_x = 4$, $\mu_d = 1, 2, 3, 4, 5, 6$

$\mu_x = 5$, $\mu_d = 1, 2, 3, 4, 5$

$\mu_x = 6$, $\mu_d = 1, 2, 3, 4, 5$

$\mu_x = 7$, $\mu_d = 1, 2, 3, 4, 5$[12].

Figures 12, 13, 14, 15, 16, 17, and 18 show the results of these calculations and Tables 11, 12, 13, 14, 15, 16, and 17 present these results in tabular form. To utilize these curves it will be necessary to choose the units for the distributions so that they fall within the range of these curves. Appendix B shows a sample calculation for one point on the curve $\mu_x = 2$, $\mu_d = 6$.

[12]Calculated on IBM 650 computer.

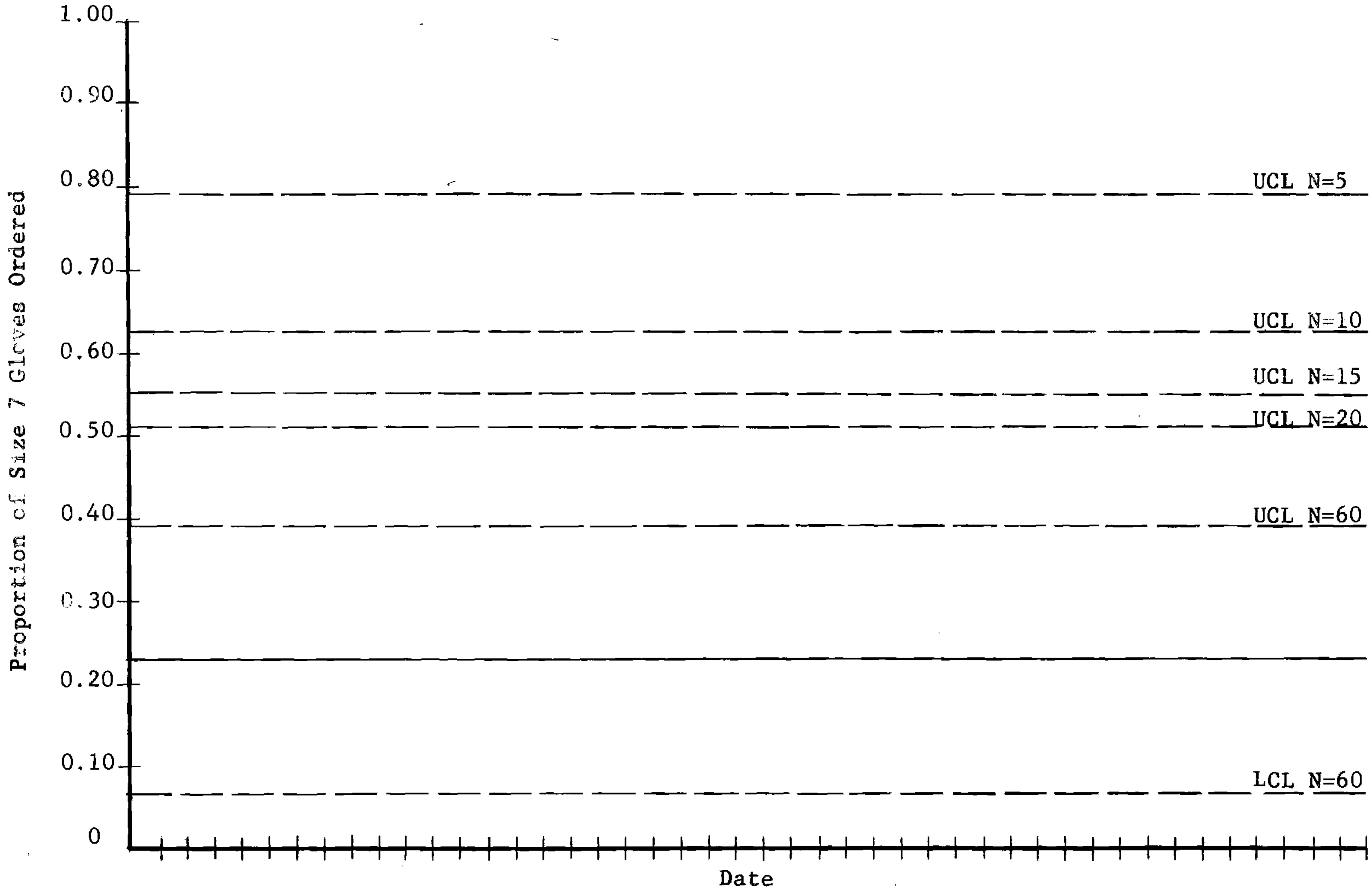

Figure 11. Control Chart for Proportion ($\overline{p}_7$) of Size Seven Gloves Used

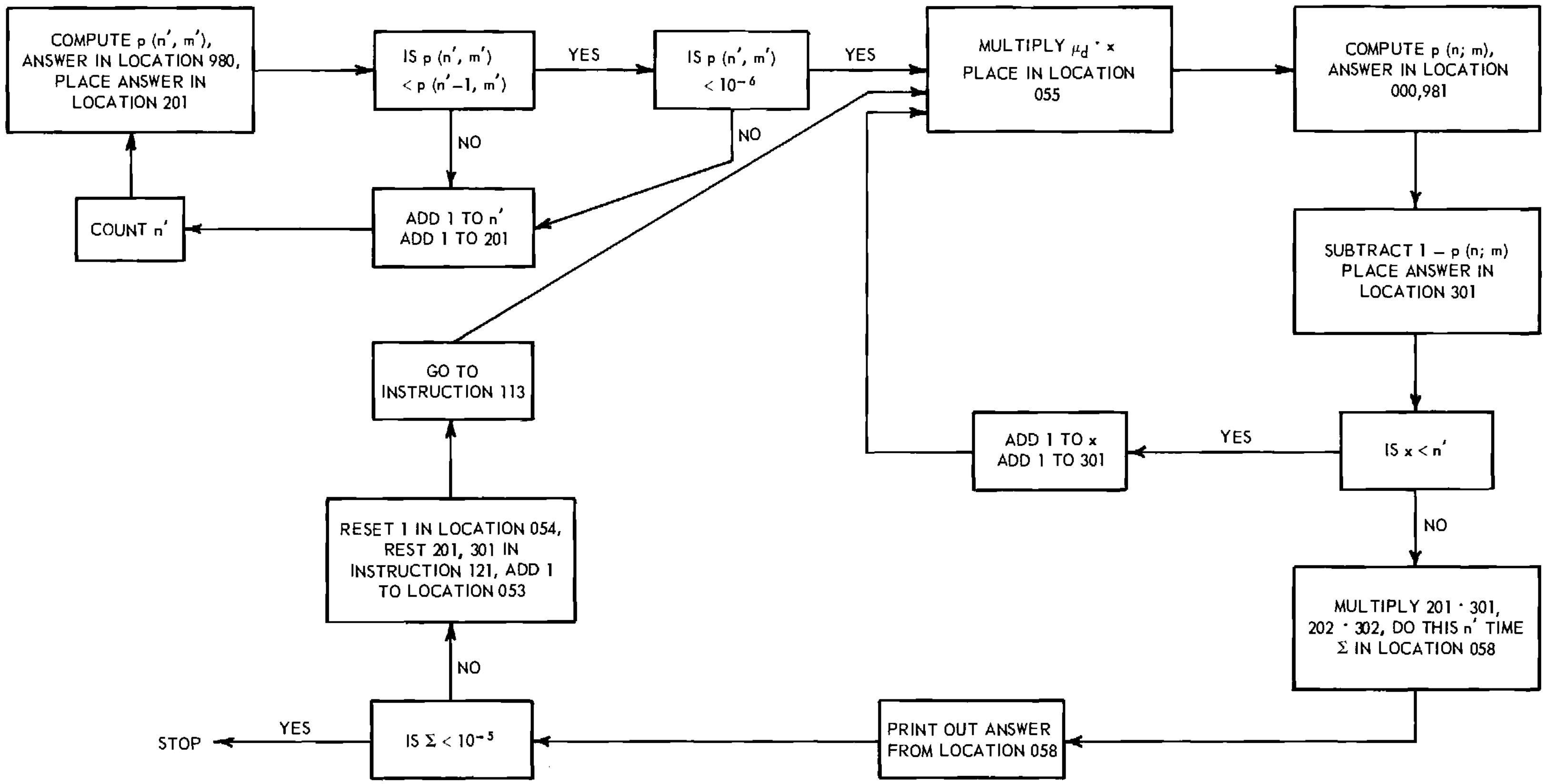

Figure 12. Flow Chart for the IBM 650 Computer Routine.
(Bell Statistical Interpretive System).

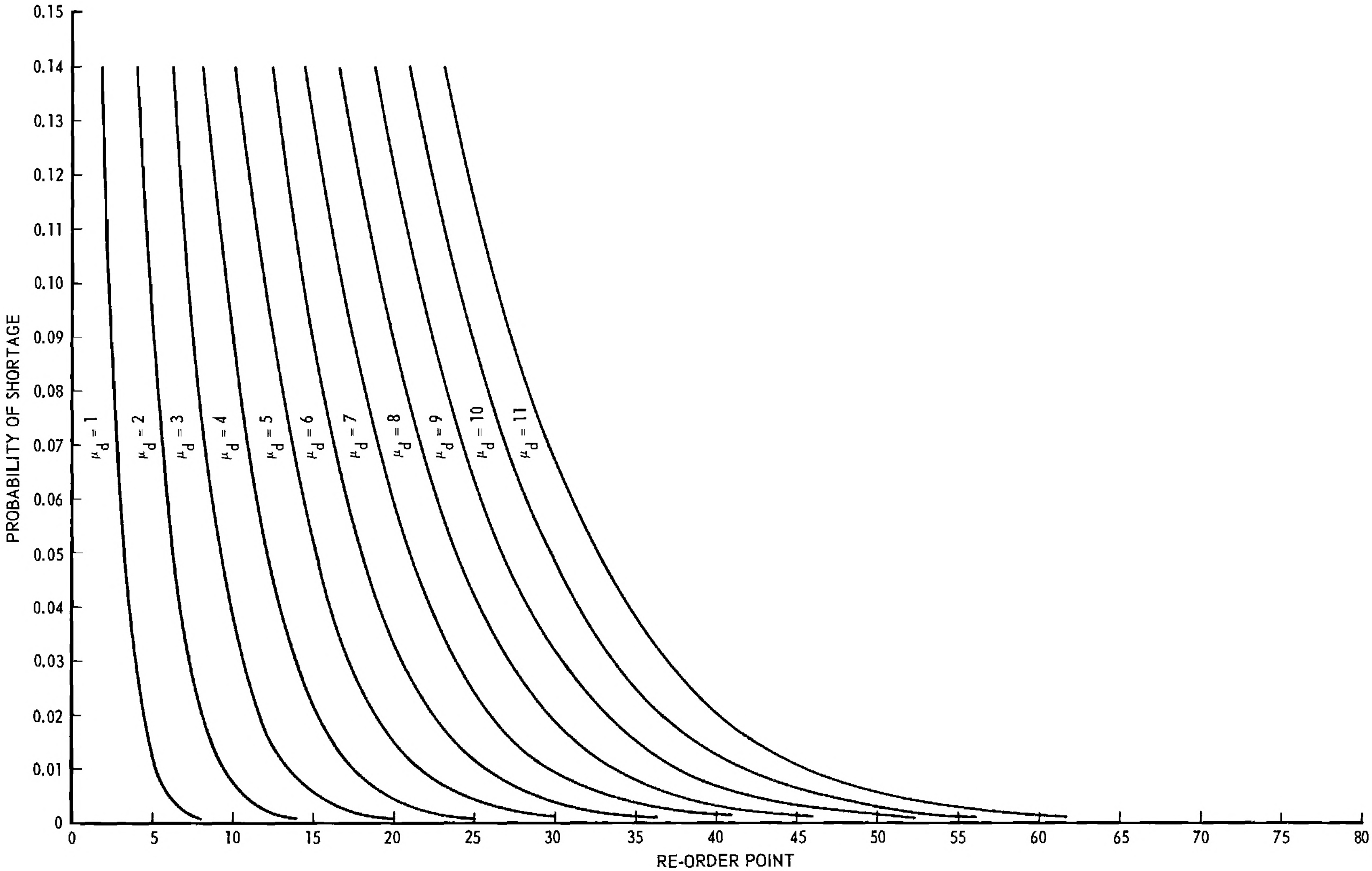

Figure 13. Graph of Three Variables; Probability of a Shortage, Mean (μ_d) of a Poisson Demand Function, and the Reorder Point with the Poisson Lead Time Held Constant, $\mu_x = 1$.

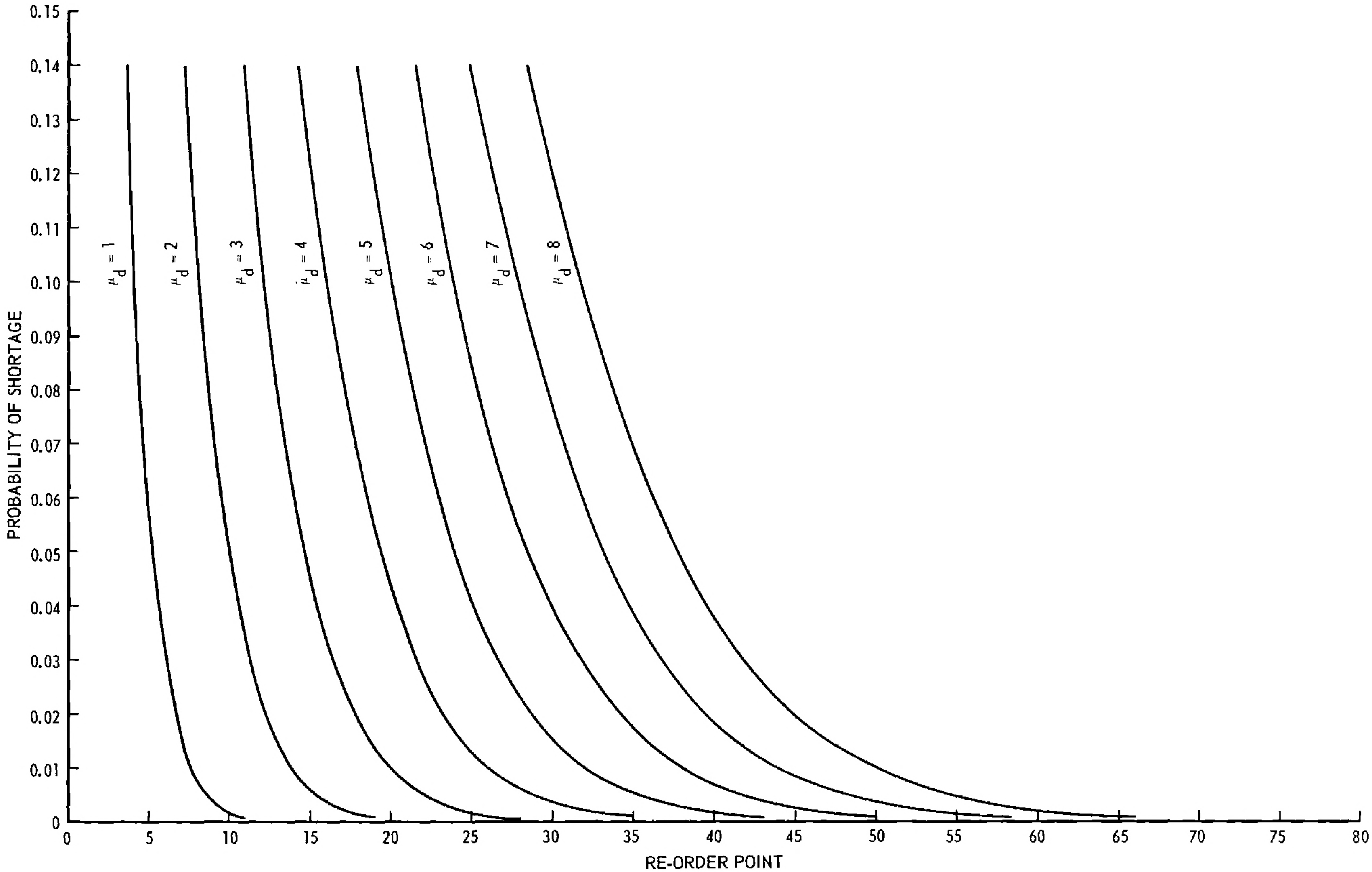

Figure 14. Graph of Three Variables; Probability of a Shortage, Mean (μ_d) of a Poisson Demand Function, and the Reorder Point with the Poisson Lead Time Held Constant, $\mu_x = 2$.

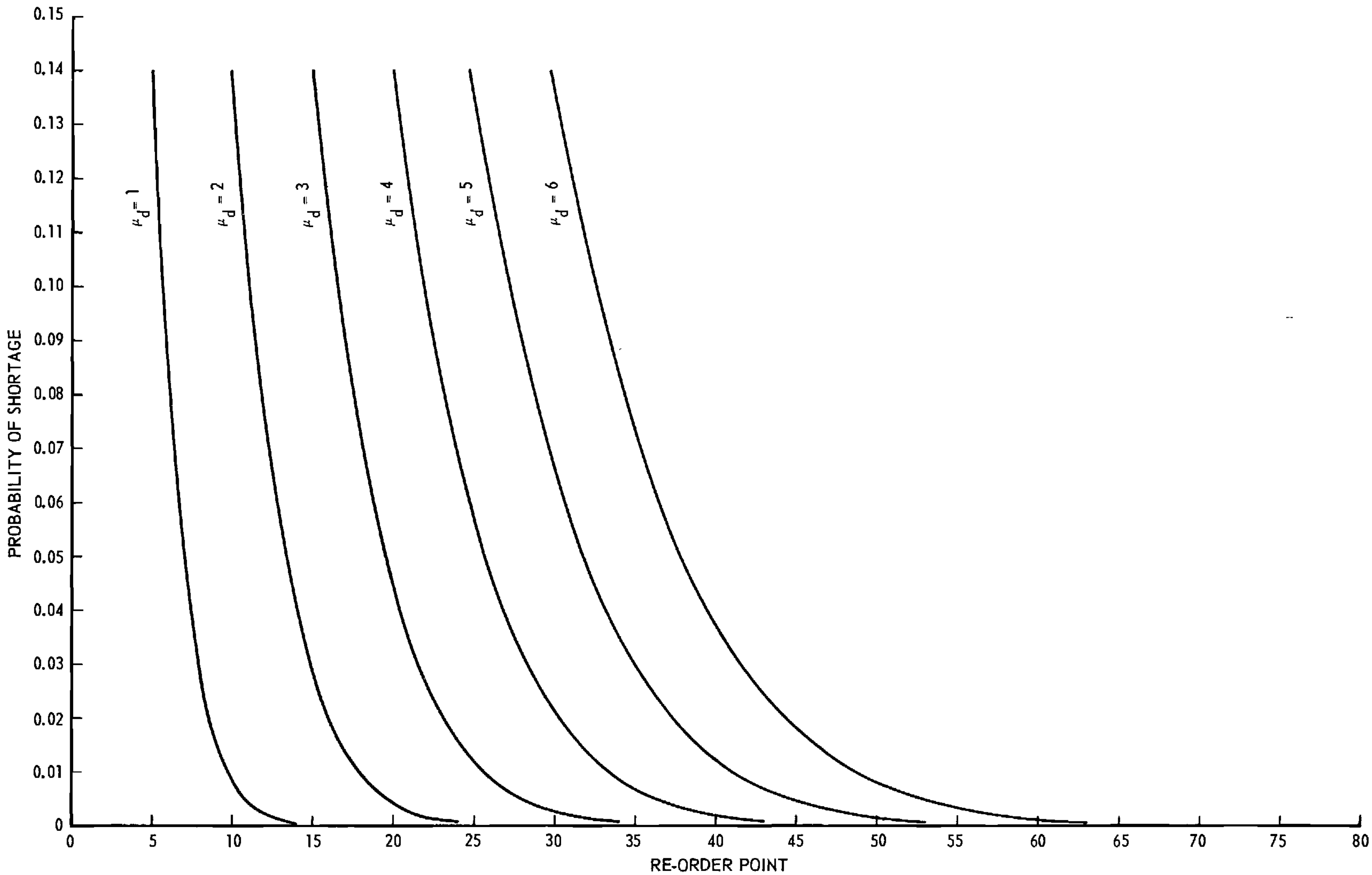

Figure 15. Graph of Three Variables; Probability of a Shortage, Mean (μ_d) of a Poisson Demand Function, and the Reorder Point with the Poisson Lead Time Held Constant, $\mu_x = 3$.

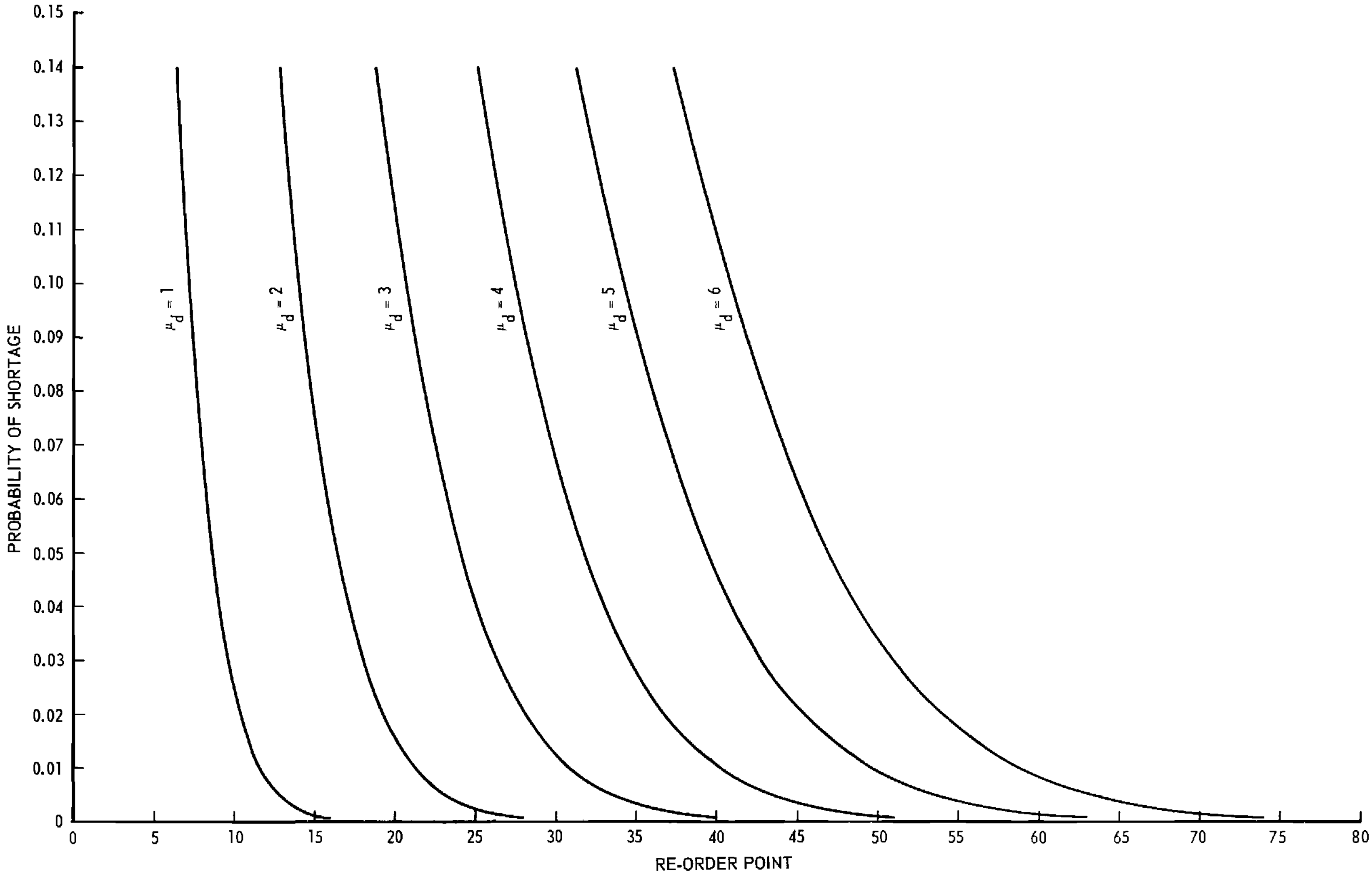

Figure 16. Graph of Three Variables; Probability of a Shortage, Mean (μ_d) of a Poisson Demand Function, and the Reorder Point with the Poisson Lead Time Held Constant, $\mu_x = 4$.

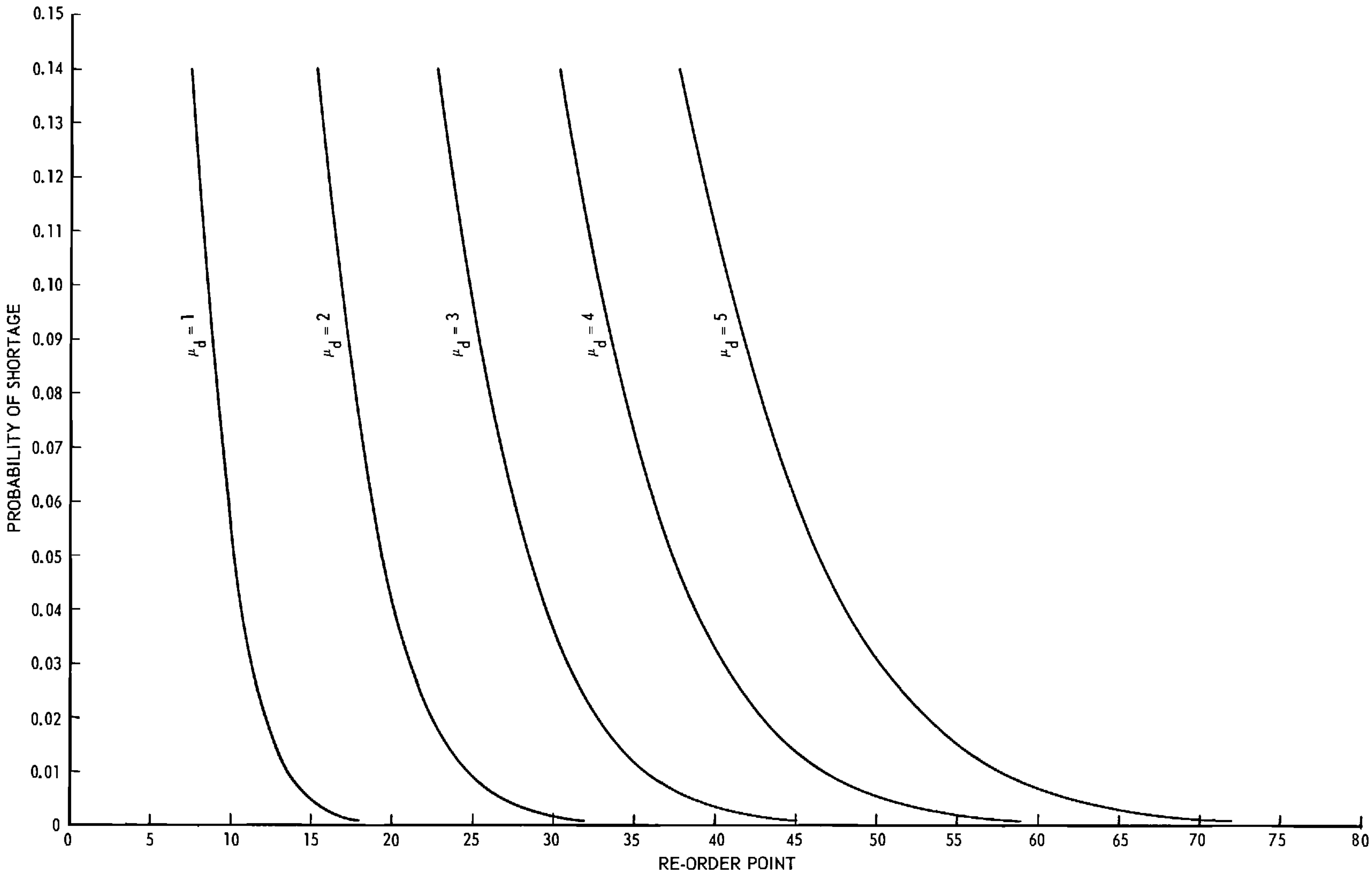

Figure 17. Graph of Three Variables; Probability of a Shortage, Mean (μ_d) of a Poisson Demand Function, and the Reorder Point with the Poisson Lead Time Held Constant, $\mu_x = 5$.

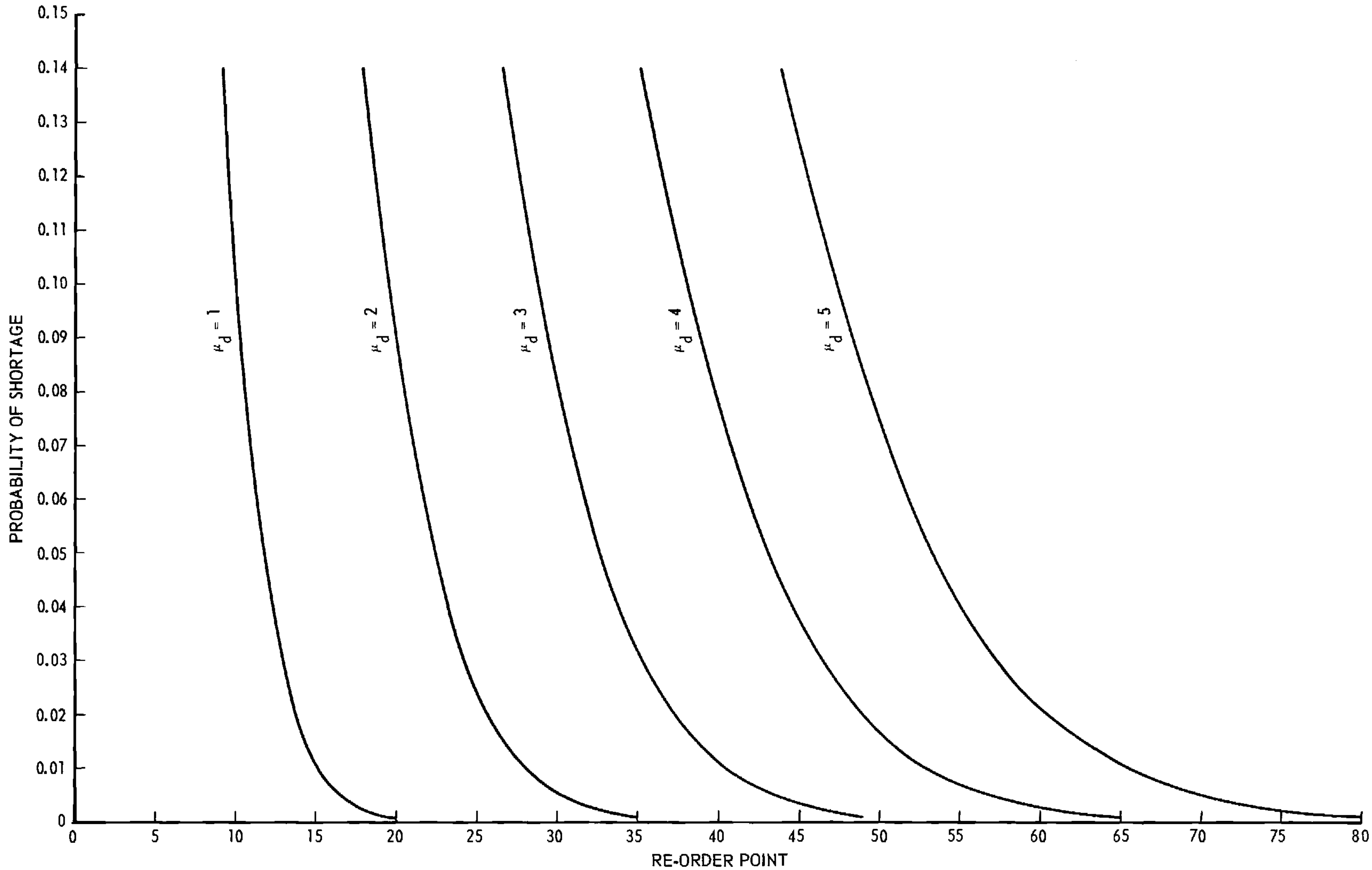

Figure 18. Graph of Three Variables; Probability of a Shortage, Mean (μ_d) of a Poisson Demand Function, and the Reorder Point with the Poisson Lead Time Held Constant, $\mu_x = 6$.

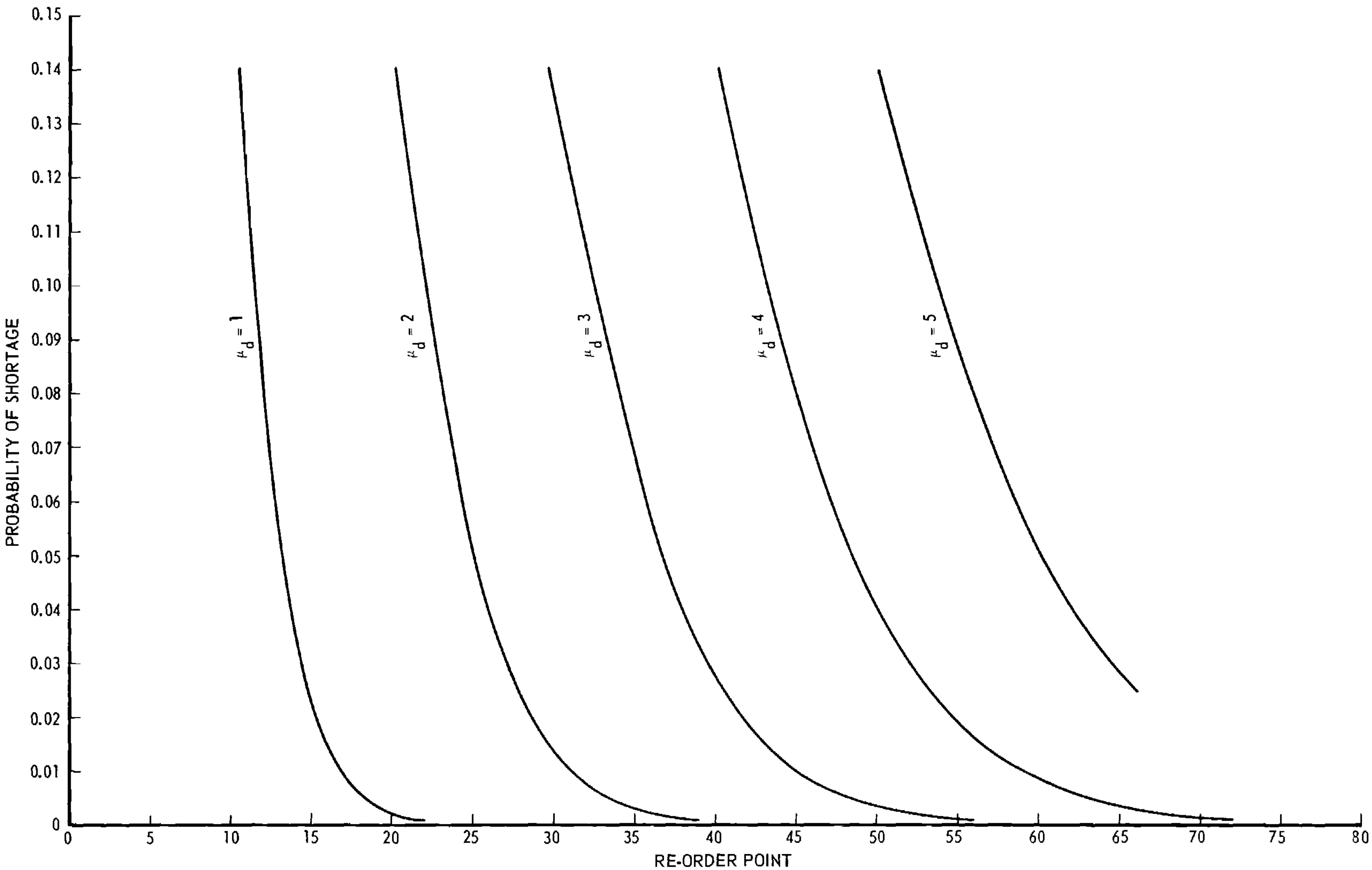

Figure 19. Graph of Three Variables; Probability of a Shortage, Mean (μ_d) of a Poisson Demand Function, and the Reorder Point with the Poisson Lead Time Held Constant, $\mu_x = 7$.

Table 11. Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 1 Week and the Demand Distribution is Poisson with Means (μ_d) of 1 through 11 Dozen.

$\mu_x = 1$

Reorder Point	$\mu_d =$ 1	2	3	4	5	6	7	8	9	10	11
1											
2	0.13930										
3	0.06634										
4	0.03196	0.14884									
5	0.01322*	0.09544									
6	0.00559*	0.05992									
7	0.00229	0.03683	0.11048								
8	0.00092	0.02218	0.07936								
9		0.01312	0.05619	0.11988							
10		0.00764*	0.03926	0.09270							
11		0.00438*	0.02712	0.07091							
12		0.00248	0.01853*	0.05374	0.10237						
13		0.00139	0.01255*	0.04041	0.08355						
14		0.00076	0.00842	0.03182	0.06652	0.10969					
15			0.00559	0.02239	0.05199	0.09100					
16			0.00369	0.01650	0.04106	0.07513	0.11541				
17			0.00241	0.01208	0.03227	0.06181	0.09803				
18			0.00156	0.00879	0.02524	0.05071	0.08298				
19			0.00101	0.00635	0.01965	0.04148	0.07009	0.10373			
20			0.00064	0.00457	0.01521	0.03380	0.05911	0.08946			
21				0.00326	0.01172	0.02744	0.04977	0.07708	0.10844		
22				0.00232	0.00899	0.02218	0.04179	0.06637	0.09488		
23				0.00164	0.00687	0.01785	0.03499	0.05712	0.08300	0.11237	
24				0.00116	0.00522	0.01431	0.02918	0.04907	0.07264	0.09945	
25				0.00081	0.00396	0.01144	0.02425	0.04206	0.06358	0.08805	
26					0.00299	0.00911	0.02008	0.03594	0.00562	0.07805	0.10332

*Computed on IBM 650

(Cont.)

Table 11 (Cont.). Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 1 Week and the Demand Distribution is Poisson with Means (μ_d) of 1 through 11 Dozen.

$\mu_x = 1$

Reorder Point	μ_d = 1	2	3	4	5	6	7	8	9	10	11
27					0.00225	0.00723	0.01658	0.03061	0.04857	0.06925	0.09238
28					0.00168	0.00573	0.01365	0.02598	0.04231	0.06145	0.08273
29					0.00126	0.00452	0.01210	0.02198	0.03674	0.05548	0.07421
30					0.00094	0.00356	0.00919	0.01855	0.03180	0.04821	0.06663
31						0.00279	0.00751	0.01563	0.02744	0.04269	0.05981
32						0.00219	0.00613	0.01314	0.02361	0.03742	0.05361
33						0.00171	0.00499	0.01102	0.02028	0.03281	0.04795
34						0.00133	0.00405	0.00924	0.01738	0.02869	0.04276
35						0.00103	0.00328	0.00773	0.01488	0.02502	0.03801
36						0.00080	0.00265	0.00645	0.01273	0.02179	0.03368
37							0.00214	0.00538	0.01087	0.01895	0.02976
38							0.00172	0.00447	0.00928	0.01645	0.02613
39							0.00139	0.00371	0.00790	0.01429	0.02305
40							0.00110	0.00307	0.00672	0.01240	0.02030
41							0.00088	0.00254	0.00571	0.01075	0.01787
42								0.00209	0.00483	0.00931	0.01571
43								0.00173	0.00409	0.00805	0.01381
44								0.00142	0.00345	0.00695	0.01213
45								0.00117	0.00291	0.00599	0.01065
46								0.00096	0.00245	0.00515	0.00934
47									0.00206	0.00443	0.00817
48									0.00173	0.00380	0.00715
49									0.00145	0.00325	0.00624
50									0.00121	0.00238	0.00543
51									0.00102	0.00203	0.00473
52									0.00085	0.00173	0.00406

(Cont.)

Table 11 (Cont.). Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 1 Week and the Demand Distribution is Poisson with Means (μ_d) of 1 through 11 Dozen.

$\mu_x = 1$

Reorder Point	$\mu_d =$ 1	2	3	4	5	6	7	8	9	10	11
53										0.00148	0.00353
54										0.00126	0.00307
55										0.00107	0.00267
56										0.00091	0.00231
57											0.00200
58											0.00173
59											0.00150
60											0.00129
61											0.00111
62											0.00096

Table 12. Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 2 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 8 Dozen.

$\mu_x = 2$

Reorder Point	$\mu_d =$ 1	2	3	4	5	6	7	8
1								
2								
3								
4	0.11470							
5	0.06311							
6	0.03327*							
7	0.01697							
8	0.00839	0.10872						
9	0.00403	0.07572						
10	0.00189	0.05183*						
11	0.00087	0.03523						
12		0.02342	0.10487*					
13		0.01534	0.08071*					
14		0.00978	0.06151*					
15		0.00624	0.04644*					
16		0.00393	0.03475*	0.10241				
17		0.00245	0.02579*	0.08335				
18		0.00151	0.01898*	0.06741				
19		0.00092	0.01386*	0.05419				
20			0.01005*	0.04344	0.10070			
21			0.00723*	0.03441	0.08497			
22			0.00517*	0.02720	0.07137			
23			0.00367*	0.02138	0.05970	0.11455		
24			0.00259*	0.01672	0.04973	0.09958		
25			0.00182*	0.01301	0.04126	0.08605		
26			0.00127*	0.01008	0.03410	0.07422		
27			0.00088*	0.00777	0.02807	0.06273	0.11142	
28			0.00060	0.00596	0.02302	0.05470	0.09848	

(Cont.)

Table 12 (Cont.). Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 2 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 8 Dozen.

$\mu_x = 2$

Reorder Point	$\mu_d =$ 1	2	3	4	5	6	7	8
29				0.00456	0.01881	0.04674	0.08683	
30				0.00347	0.01532	0.03982	0.07637	
31				0.00263	0.01243	0.03383	0.06700	0.10903
32				0.00198	0.01005	0.02866	0.05864	0.09773
33				0.00149	0.00810	0.02421	0.05120	0.08743
34				0.00112	0.00651	0.02039	0.04460	0.07806
35				0.00083	0.00521	0.01713	0.03876	0.06955
36					0.00416	0.01436	0.03361	0.06227
37					0.00332	0.01200	0.02908	0.05488
38					0.00263	0.01001	0.02511	0.04861
39					0.00208	0.00833	0.02163	0.04265
40					0.00164	0.00691	0.01860	0.03793
41					0.00130	0.00572	0.01596	0.03342
42					0.00102	0.00485	0.01367	0.02939
43					0.00080	0.00389	0.01168	0.02581
44						0.00320	0.00997	0.02262
45						0.00263	0.00849	0.01980
46						0.00215	0.00721	0.01730
47						0.00176	0.00612	0.01509
48						0.00143	0.00518	0.01314
49						0.00117	0.00438	0.01143
50						0.00095	0.00370	0.00992
51							0.00311	0.00860
52							0.00262	0.00745
53							0.00220	0.00644
54							0.00184	0.00556
55							0.00154	0.00479

(Cont.)

Table 12 (Cont.). Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 2 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 8 Dozen.

$\mu_x = 2$

Reorder Point	$\mu_d =$ 1	2	3	4	5	6	7	8
56							0.00126	0.00412
57							0.00103	0.00355
58							0.00090	0.00304
59								0.00261
60								0.00223
61								0.00191
62								0.00163
63								0.00139
64								0.00119
65								0.00101
66								0.00086

Table 13. Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 3 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 6 Dozen.

$\mu_x = 3$

Reorder Point	$\mu_d =$ 1	2	3	4	5	6
5	0.15045					
6	0.09152					
7	0.05367*					
8	0.03046*					
9	0.01678					
10	0.00899					
11	0.00470	0.10332				
12	0.00241	0.07907				
13	0.00120	0.05710				
14	0.00059	0.04067				
15		0.02860				
16		0.01987	0.11440			
17		0.01364	0.09172			
18		0.00926	0.07292			
19		0.00623	0.05753			
20		0.00414	0.04505			
21		0.00273	0.03502	0.11786		
22		0.00178	0.02703	0.09926		
23		0.00115	0.02073	0.08315		
24		0.00074	0.01579	0.06931		
25			0.01195	0.05749		
26			0.00899	0.04745		
27			0.00673	0.03899	0.10427	
28			0.00500	0.02880	0.09027	
29			0.00370	0.02596	0.07789	
30			0.00272	0.02105	0.06693	
31			0.00199	0.01700	0.05734	
32			0.00145	0.01367	0.04896	0.10784

(Cont.)

Table 13 (Cont.). Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 3 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 6 Dozen.

$\mu_x = 3$

Reorder Point	μ_d = 1	2	3	4	5	6
33			0.00105	0.01094	0.04167	0.09549
34			0.00076	0.00873	0.03535	0.08427
35				0.00694	0.02990	0.07427
36				0.00549	0.02521	0.06525
37				0.00433	0.02119	0.05719
38				0.00341	0.01776	0.04999
39				0.00267	0.01484	0.04360
40				0.00208	0.01237	0.03794
41				0.00162	0.01028	0.03293
42				0.00126	0.00852	0.02852
43				0.00097	0.00705	0.02465
44					0.00581	0.02125
45					0.00478	0.01829
46					0.00392	0.01570
47					0.00321	0.01345
48					0.00262	0.01150
49					0.00213	0.00981
50					0.00173	0.00836
51					0.00141	0.00710
52					0.00114	0.00603
53					0.00918	0.00510
54						0.00431
55						0.00364
56						0.00306
57						0.00257
58						0.00216
59						0.00181
60						0.00151
61						0.00126
62						0.00105
63						0.00088

Table 14. Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 4 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 6 Dozen.

$\mu_x = 4$

Reorder Point	$\mu_d =$ 1	2	3	4	5	6
7	0.11574					
8	0.07277					
9	0.04438					
10	0.02631					
11	0.01520					
12	0.00857					
13	0.00473					
14	0.00256	0.10280				
15	0.00136	0.07767				
16	0.00071	0.05796				
17		0.04275				
18		0.03117				
19		0.02249				
20		0.01606	0.11723			
21		0.01135	0.09635			
22		0.00795	0.07864			
23		0.00516	0.06375			
24		0.00379	0.05134			
25		0.00259	0.04109			
26		0.00175	0.03269			
27		0.00118	0.02585	0.10809		
28		0.00078	0.02032	0.09253		
29			0.01588	0.07887		
30			0.01235	0.06693		
31			0.00955	0.05657		
32			0.00735	0.04762		
33			0.00562	0.03993	0.11613	
34			0.00428	0.03335	0.10240	

(Cont.)

Table 14 (Cont.). Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 4 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 6 Dozen.

$\mu_x = 4$

Reorder Point	$\mu_d =$ 1	2	3	4	5	6
35			0.00325	0.02774	0.08592	
36			0.00245	0.02300	0.07889	
37			0.00184	0.01899	0.06894	
38			0.00138	0.01563	0.06008	
39			0.00102	0.01282	0.05220	
40			0.00076	0.01048	0.04523	0.10973
41				0.00854	0.03909	0.09850
42				0.00693	0.03369	0.08823
43				0.00561	0.02896	0.07885
44				0.00453	0.02483	0.07033
45				0.00364	0.02123	0.06259
46				0.00292	0.01811	0.05558
47				0.00233	0.01541	0.04926
48				0.00186	0.01308	0.04358
49				0.00148	0.01108	0.03847
50				0.00117	0.00936	0.03389
51				0.00093	0.00789	0.02980
52					0.00664	0.02615
53					0.00557	0.02291
54					0.00466	0.02003
55					0.00390	0.01748
56					0.00325	0.01523
57					0.00270	0.01325
58					0.00224	0.01150
59					0.00186	0.00997
60					0.00154	0.00862
61					0.00127	0.00745
62					0.00105	0.00642

(Cont.)

Table 14 (Cont.). Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 4 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 6 Dozen.

$\mu_x = 4$

Reorder Point	$\mu_d =$ 1	2	3	4	5	6
63					0.00086	0.00553
64						0.00475
65						0.00408
66						0.00349
67						0.00299
68						0.00255
69						0.00218
70						0.00185
71						0.00158
72						0.00134
73						0.00113
74						0.00096

Table 15. Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 5 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 5 Dozen.

$\mu_x = 5$

Reorder Point	μ_d = 1	2	3	4	5
8	0.12447				
9	0.09022				
10	0.05800				
11	0.03630				
12	0.02218				
13	0.01325				
14	0.00775				
15	0.00444				
16	0.00250	0.12319			
17	0.00138	0.09626			
18	0.00075	0.07427			
19		0.05669			
20		0.04283			
21		0.03203			
22		0.02373			
23		0.01742			
24		0.01267	0.11682		
25		0.00914	0.09766		
26		0.00654	0.08114		
27		0.00464	0.06703		
28		0.00327	0.05505		
29		0.00229	0.04496		
30		0.00159	0.03653		
31		0.00109	0.02951		
32		0.00075	0.02372	0.11293	
33			0.01897	0.09812	
34			0.01510	0.08492	
35			0.01196	0.07323	

(Cont.)

Table 15 (Cont.). Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 5 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 5 Dozen.

$\mu_x = 5$

Reorder Point	$\mu_d =$ 1	2	3	4	5
36			0.00943	0.06292	
37			0.00740	0.05386	
38			0.00578	0.04595	
39			0.00450	0.03906	
40			0.00349	0.03310	0.11037
41			0.00269	0.02795	0.09829
42			0.00207	0.02353	0.08731
43			0.00158	0.01974	0.07735
44			0.00121	0.01651	0.06836
45			0.00092	0.01377	0.06026
46				0.01145	0.05298
47				0.00949	0.04649
48				0.00785	0.04068
49				0.00647	0.03552
50				0.00532	0.03092
51				0.00436	0.02690
52				0.00356	0.02333
53				0.00291	0.02019
54				0.00236	0.01743
55				0.00192	0.01502
56				0.00155	0.01291
57				0.00125	0.01108
58				0.00101	0.00949
59				0.00081	0.00811
60					0.00692
61					0.00589
62					0.00500
63					0.00424

(Cont.)

Table 15 (Cont.). Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 5 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 5 Dozen.

$\mu_x = 5$

Reorder Point	$\mu_d =$ 1	2	3	4	5
64					0.00359
65					0.00304
66					0.00256
67					0.00216
68					0.00181
69					0.00152
70					0.00127
71					0.00107
72					0.00089

Table 16. Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 6 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 5 Dozen.

$\mu_x = 6$

Reorder Point	$\mu_d =$ 1	2	3	4	5
10	0.10600*				
11	0.07095*				
12	0.04633*				
13	0.02956*				
14	0.01846*				
15	0.01129*				
16	0.00677*				
17	0.00399*				
18	0.00231*				
19	0.00132	0.11290			
20	0.00074	0.08933			
21		0.06999			
22		0.05431			
23		0.04176			
24		0.03182			
25		0.02404			
26		0.01800			
27		0.01338			
28		0.00986	0.11463		
29		0.00721	0.09703		
30		0.00524	0.08169		
31		0.00378	0.06841		
32		0.00270	0.05700		
33		0.00192	0.04726		
34		0.00136	0.03899		
35		0.00095	0.03201		
36			0.02612		
37			0.02127		

(Cont.)

Table 16 (Cont.). Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 6 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 5 Dozen.

$\mu_x = 6$

Reorder Point	$\mu_d =$ 1	2	3	4	5
38			0.01723	0.10125	
39			0.01389	0.08862	
40			0.01115	0.07732	
41			0.00891	0.06724	
42			0.00709	0.05828	
43			0.00562	0.05036	
44			0.00444	0.04338	
45			0.00349	0.03725	
46			0.00274	0.03189	
47			0.00214	0.02722	0.10391
48			0.00129	0.02317	0.09321
49			0.00099	0.01967	0.08342
50				0.01665	0.07449
51				0.01405	0.06637
52				0.01182	0.05901
53				0.00992	0.05234
54				0.00831	0.04634
55				0.00694	0.04093
56				0.00578	0.03608
57				0.00480	0.03174
58				0.00398	0.02786
59				0.00329	0.02441
60				0.00271	0.02134
61				0.00223	0.01862
62				0.00183	0.01622
63				0.00150	0.01410
64				0.00122	0.01223
65				0.00100	0.01059

(Cont.)

Table 16 (Cont.). Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 6 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 5 Dozen.

$\mu_x = 6$

Reorder Point	$\mu_d =$ 1	2	3	4	5
66					0.00916
67					0.00790
68					0.00681
69					0.00585
70					0.00502
71					0.00430
72					0.00368
73					0.00314
74					0.00268
75					0.00228
76					0.00194
77					0.00164
78					0.00139
79					0.00118
80					0.00099

Table 17. Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 7 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 5 Dozen.

$\mu_x = 7$

Reorder Point	$\mu_d =$ 1	2	3	4	5
11	0.12029				
12	0.08318				
13	0.05619				
14	0.03714				
15	0.02403				
16	0.01526				
17	0.00951				
18	0.00582				
19	0.00351				
20	0.00208				
21	0.00121				
22	0.00070	0.10321			
23		0.08255			
24		0.06545			
25		0.05144			
26		0.04009			
27		0.03099			
28		0.02377			
29		0.01809			
30		0.01367			
31		0.01025			
32		0.00764	0.11151		
33		0.00565	0.09530		
34		0.00415	0.08106		
35		0.00303	0.06861		
36		0.00220	0.05781		
37		0.00158	0.04849		
38		0.00114	0.04049		

(Cont.)

Table 17 (Cont.). Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 7 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 5 Dozen.

$\mu_x = 7$

Reorder Point	$\mu_d =$ 1	2	3	4	5
39		0.00081	0.03366		
40			0.02786		
41			0.02297		
42			0.01885		
43			0.01541	0.10279*	
44			0.01255	0.09077*	
45			0.01018	0.07991*	
46			0.00823	0.07014*	
47			0.00662	0.06139*	
48			0.00531	0.05358*	
49			0.00424	0.04663*	
50			0.00338	0.04047*	
51			0.00269	0.03502*	
52			0.00212	0.03023*	0.11891
53			0.00167	0.02602*	0.10771
54			0.00131	0.02234*	0.09737
55			0.00103	0.01913*	0.08773
56			0.00080	0.01634*	0.07901
57				0.01392*	0.07080
58				0.01183*	0.06367
59				0.01003*	0.05698
60				0.00848*	0.05089
61				0.00716*	0.04526
62				0.00602	0.04030
63				0.00506	0.03580
64				0.00424	0.03174
65				0.00354	0.02809
66				0.00295	0.02481

(Cont.)

Table 17 (Cont.) Tables of Probability of a Shortage at Various Reorder Points where the Lead Time has a Poisson Distribution with Mean (μ_x) of 7 Weeks and the Demand Distribution is Poisson with Means (μ_d) of 1 through 5 Dozen.

$\mu_x = 7$

Reorder Point	$\mu_d =$ 1	2	3	4	5
67				0.00246	
68				0.00204	
69				0.00169	
70				0.00140	
71				0.00115	
72				0.00095	

Table 18. Demand for All Sizes of Gloves by Weeks for 170 Weeks, January 2, 1956 - March 30, 1959.

Week Ending Date	Glove Size 6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	Total
1-2-56	0	4	6	6	4	1	1	22
1-9	0	0	7	8	4	0	1	20
1-16	0	0	0	0	0	0	0	0
1-23	0	0	0	0	0	0	0	0
1-30	2	0	3	3	3	1	1	13
2-6-56	0	6	3	4	0	0	0	13
2-13	1	3	3	2	3	0	1	13
2-20	0	3	3	4	4	0	0	14
2-27	0	3	3	4	0	1	0	11
3-5-56	0	1	4	4 6/12	1	1	1	12 6/12
3-12	0	2	3	6	1	0	0	12
3-19	0	0	0	12	8	0	0	20
3-26	0	6	3	4	4	1	0	18
4-2-56	0	8	6	8	8	0	0	30
4-9	0	0	3	3	3	0	0	9
4-16	1	11	15	22	7	6	1	63
4-23	1	4	6	8	4	4	1	28
4-30	0	0	0	0	0	0	0	0
5-7-56	0	4	0	6	4	2	1	17
5-14	0	0	0	0	0	0	0	0
5-21	0	4	2	5	1	2	3	17
5-28	0	5	0	2	2	0	0	9
6-4-56	1	4	9	7	4	2	0	27
6-11	0	0	0	6	0	0	0	6
6-18	0	10	7	7	3	1	0	28
6-25	2	4	4	3	2	0	0	15

(Cont.)

Table 18 (Cont.). Demand for All Sizes of Gloves by Weeks for 170 Weeks, January 2, 1956 - March 30, 1959.

Week Ending	Glove Size							
Date	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	Total
7-2-56	0	1	1	5	3	0	0	10
7-9	2	4	5 6/12	5	3	2/12	0	19 8/12
7-16	0	3	5	6	2	2	2	20
7-23	0	2	2	8	2	0	1	15
7-30	1	2	3	8 3/12	4	2	0	20 3/12
8-6-56	0	3	7	8 6/12	4	1	1	24 6/12
8-13	0	0	0	4	0	1	0	5
8-20	0	4	1	3	5	0	1	14
8-27	0	7	4	5 1/12	14	2	0	32 1/12
9-3-56	0	2	2	9	5	2	0	20
9-10	2	0	5	7 6/12	1	1/12	0	15 7/12
9-17	0	4	1	6	1	0	0	12
9-24	2	4	5	7	4	0	0	22
10-1-56	0	6	1	6	0	0	0	13
10-8	0	3	4	2	4	0	2	15
10-15	0	1	5	0	4	0	1	11
10-22	0	2	2	2	0	0	0	6
10-29	0	4	4	20	1	0	0	29
11-5-56	2	6	5	7	5	0	0	25
11-12	2	3	0	7	6	2/12	0	18 2/12
11-19	0	1	6	1 4/12	4	1	1	14 4/12
11-26	0	6	6	8	0	1	0	21
12-33-56	0	6	6	8	6	1	2	29
12-10	1	6	5	7	5	2	1	27
12-17	0	4	3	8	5	0	0	20
12-24	0	0	0	0	0	0	0	0
12-31	0	0	6	0	0	0	0	6

(Cont.)

Table 18 (Cont.). Demand for All Sizes of Gloves by Weeks for 170 Weeks, January 2, 1956 - March 30, 1959.

Week Ending Date	Glove Size 6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	Total
1-7-57	0	6	0	0	2	0	1	9
1-14	0	4	8	16	6	0	4	38
1-21	0	3	4	8	0	0	0	15
1-28	1/4	5	5	7	4	0	0	21 3/12
2-4-57	1	2	7	5	2	1	1	15
2-11	0	2	3	2	0	0	0	7
2-18	0	2	0	5	2	0	2	11
2-25	2	3	4	4	5	1	0	19
3-4-57	0	0	0	6	3	0	0	9
3-11	0	3	5	8	0	0	0	16
3-18	0	2	2	8	0	0	0	12
3-25	0	3 1/12	3	6	4	0	0	16 1/12
4-1-57	0	5 1/12	5	6	0	0	1	17 1/12
4-8	0	0	2	7	5	2	0	16
4-15	0	6	5	10	3 1/12	0	0	24 1/12
4-22	0	7	5	5	0	0	0	17
4-29	0	0	3	8 1/12	3	0	0	14 1/12
5-6-57	0	6	4	0	3	1	1	15
5-13	0	4	5	8	4	0	0	21
5-20	0	4	8	8	0	1	1	22
5-27	0	7	8	7	6	0	1	28
6-3-57	0	3	2	8	5	0	0	18
6-10	0	2	2	7	5	2/12	0	16 2/12
6-17	0	4	5	7 2/12	2/12	1	0	17 4/12
6-24	0	3	3	8	5	1	0	20

(Cont.)

Table 18 (Cont.). Demand for All Sizes of Gloves by Weeks for 170 Weeks, January 2, 1956 - March 30, 1959.

Week Ending	Glove Size							
Date	6	6½	7	7½	8	8½	9	Total
7-1-57	1	3	6	6	0	1	0	17
7-8	2	2	2	5	2	0	0	13
7-15	0	0	4	6	3	0	0	13
7-22	1	0	0	8	4	0	0	13
7-29	0	8	3	6	3	0	2	22
8-5-57	0	2	6	4	0	1	0	13
8-12	0	6	5	8	5	0	2	26
8-19	0	4	3	6	6	1	1	21
8-26	0	2	0	13	3	0	0	18
9-2-57	0	0	4	8	9	1	0	22
9-9	0	5 10/12	1	3	2	0	0	11 10/12
9-16	2	0	6	8	3	1	0	20
9-23	0	0	4	0	0	1	0	5
9-30	0	8	4	13	5	0	1	31
10-7-57	1	5	2	3	5	0	0	16
10-14	0	8	3	6	3	0	0	20
10-21	0	5	6	2	6	0	1	20
10-28	2	0	2	8	2	0	0	14
11-4-57	0	0	4	6	3	0	0	13
11-11	0	5	5	2	1	1	1	15
11-18	0	3	4	8	0	0	0	14
11-25	1	1	1	8	5	0	0	16
12-2-57	0	4	2	0	1	0	0	7
12-9	0	2	5	6	1	0	0	14
12-16	0	5	6	8	6	1	0	26
12-23	1	1	1	1	0	0	0	4
12-30	0	1	3	4	0	0	1	9

(Cont.)

Table 18 (Cont.) Demand for All Sizes of Gloves by Weeks for 170 Weeks, January 2, 1956 - March 30, 1959.

Week Ending	Glove Size							
Date	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	Total
1-6-58	1	3	2	7	2	0	0	15
1-13	5	4	6	4	2	2	0	23
1-20	2	5	6	4	1	0	0	18
1-27	0	1	2	7	0	0	0	10
2-3-58	1	6	6	8	4	0	0	25
2-10	0	7	8	8	3	1	0	27
2-17	2	0	0	8	5	1	0	16
2-24	0	0	7	8	0	0	0	15
3-3-58	1	2	0	4	0	0	0	7
3-10	0	3	8	8	2	1	1	23
3-17	0	0	3	6	2	0	0	11
3-24	1	0	1	7	3	1	0	13
3-31	1	5	5	6	5	0	0	22
4-7-58	1	0	4	5	4	2	0	16
4-14	0	0	5	3	0	0	2	10
4-21	1	5	6	8	4	1	1	26
4-28	2	2	5	8	6	1	1	25
5-5-58	0	0	0	8	0	0	0	8
5-12	0	6	8	13	6	1	0	34
5-19	0	3	6	4	3	0	0	16
5-26	0	0	0	0	0	0	0	0
6-2-58	0	8	13	12	9	2	1	45
6-9	0	2	6	6	5	0	0	19
6-16	0	5	6	9	7	0	0	27
6-23	0	2	0	0	0	0	0	2
6-30	0	3	2	4	1	0	0	10

(Cont.)

Table 18 (Cont.). Demand for All Sizes of Gloves by Weeks for 170 Weeks, January 2, 1956 - March 30, 1959.

Week Ending Date	Glove Size 6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	Total
7-7-58	0	2	3	4	3	0	0	12
7-14	0	2	8	6	6	3	0	25
7-21	2	6	8	12	3	0	0	31
7-28	0	6	1	5	2	1	0	15
8-4-58	0	8	3	7	2	0	0	20
8-11	0	5	4	8	0	0	0	17
8-18	1	1	4	8	2	0	0	16
8-25	0	4	4	6	5	0	0	19
9-1-58	0	5	5	8	8	2	0	28
9-8	1	2	3	6	2	0	0	14
9-15	0	6	5	8	4	0	0	23
9-22	0	3	3	4	3	0	0	13
9-29	0	6	4	12	9	0	0	31
10-6-58	1	3	5	3	6	0	0	18
10-13	0	2	2	1	0	0	0	5
10-20	1	2	2	5	1	0	0	11
10-27	0	0	0	0	0	2	0	2
11-3-58	0	3	2	4	0	1	0	10
11-10	1	5	3	6	4	1	0	20
11-17	1	0	1	6	0	1	1	10
11-24	0	6	3	4	5	1	1	20
12-1-58	1	3	5	7	3	0	0	19
12-8	0	1	4	7	5	0	0	17
12-15	1	1	0	4	0	0	0	6
12-22	0	0	1	0	0	0	0	1
12-29	1	2	3	8	1	0	0	15

(Cont.)

Table 18 (Cont.). Demand for All Sizes of Gloves by Weeks for 170 Weeks, January 2, 1956 - March 30, 1959.

Week Ending Date	Glove Size 6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	Total
1-5-59	1	5	0	3	4	1	0	14
1-12	0	2	4	8	4	1	1	20
1-19	0	4	6	8	6	0	0	24
1-26	0	0	0	0	0	0	0	0
2-2-59	0	4	1	7	0	0	1	13
2-9	2	6	6	6	4	0	0	24
2-16	0	2	1	5	4	0	1	13
2-23	0	2	4	6	4	0	0	16
3-2-59	0	4	2	7	4	0	0	17
3-9	1	6	2	6	2	0	0	17
3-16	2	2	4	2	2	2	0	14
3-23	0	0	3	5	6	0	0	14
3-30	0	0	8	8	6	0	0	22

The following example illustrates the use of these curves. The lead time distribution has been examined and found to be Poisson distributed with a mean (μ_x) of 2 weeks. The demand distribution has been examined and found to be Poisson distributed with a mean (μ_d) of 6 gross per week. The tolerable level of shortage that management will permit is two per cent. From Figure 13 the reorder point is found to be 34 gross. This means that when the inventory level reaches 34 gross, an order should be placed for the economic lot size.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Conclusions.-- The conclusions that can be drawn from this study are as follows:

1. Factors, in addition to price, should be considered when determining the proper quantity of an item to buy.
2. The lead time distribution should be considered when determining protective stock levels as this improves the accuracy of the inventory model. In particular the assumption of constant lead time leads to underestimate of requisite protective stock.
3. Protective stock levels can be set for hospital use by the statistical evaluation of demand and lead time distributions.
4. The inventory records of the hospital frequently lack the necessary information for a complete solution by the model.
5. The model constructed in this study can provide an accurate guide to evaluate the costs of various inventory policies, when the required information is available.

Recommendations.-- In view of the limitations, results, and conclusions of this study, the following recommendations are made with regard to further methodological and further computational studies:

1. Methodological Studies
   a. The cost of various types of shortages, on a probability basis, should be investigated.

b. Methods for accurately estimating the ordering cost and inventory carrying costs should be investigated.

2. Computational Studies

a. The table of reorder points calculated from the joint density function of two Poisson distributions should be extended.

b. A method of interpolating between calculated values in the table of reorder points should be determined.

c. Tables of reorder points should be calculated for typical types of demand and lead time distributions, other than from combinations of normal and Poisson distributions. Typical distributions that should be considered are:

(1) Log Normal

(2) Chi-square

(3) Erlang.

Hospital administrators are encouraged to utilize this decision model to effect real savings in inventory costs. In addition to the cost savings there are other definite advantages in that data required for this model provides an opportunity for administrators to exercise judgement and control over factors which are hidden at present.

It is apparent that the inventory model developed in this study also can be used in industries other than hospitals. Objective decision models of this type are playing an ever increasing role in the reduction of costs and in the improvement of continuity of operations.

APPENDIX

APPENDIX A

Derivation of Joint Density Function for the Calculation of Reorder Points for Specified Probability of a Shortage

Probability of a shortage[1] $= \sum_{x=0}^{\infty} \sum_{D_x > R.P.}^{\infty} p(x)\, p(D_x|x),$

where x = random variable lead time and

μ_x = mean lead time.

Under the assumption of Poisson distributed lead time

$$p(x) = \frac{e^{-\mu_x} \mu_x^{x}}{x!}$$

where d = random variable (number of units per time unit),

μ_d = mean demand per time unit,

σ_d = standard deviation of demand,

and the total demand (D_x) during lead time is

$$D_x = d_1 + d_2 + d_3 + \ldots + d_x$$

with mean $= \mu_d$.

For the normal distributed demand

the standard deviation (σ_{D_x}) is

$$\sigma_{D_x} = \sqrt{x}\ \sigma_d$$

---

[1]Course Notes - Special Problem Course I.E. 705, Dr. J. J. Moder, Professor of Industrial Engineering, Georgia Institute of Technology, 1959. See also Harling and Bramson (14).

and $p(D_x|x) = f(D_x|x)\, dD_x$.

The probability of a shortage, for the conditions stated, becomes

$$\text{probability of a shortage} = \sum_{x=0}^{\infty} p(x) \int_{R.P.}^{\infty} f(D_x|x)\, dD_x$$

$$= \sum_{x=0}^{\infty} \frac{e^{-\mu_x} \mu_x^x}{x!} \int_{R.P.}^{\infty} \frac{1}{\sigma_{D_x} \sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{D_x - x\mu_d}{\sigma_{D_x}}\right)} dD_x .$$

However, for the condition of a Poisson distributed demand

$$p(D_x|x) = \frac{e^{-x\mu_d} (x\,\mu_d)^{D_x}}{D_x!}$$

and

$$\text{probability of a shortage} = \sum_{x=0}^{\infty} \sum_{D_x > R.P.}^{\infty} \frac{e^{-\mu_x} \mu_x^x}{x!} \cdot \frac{e^{-x\mu_d} (x\mu_d)^{D_x}}{D_x!} .$$

APPENDIX B

A Sample Calculation for One Point on the Curve $\mu_x = z$, $\mu_d = 6$, with Demand and Lead Time Poisson Distributed

$\mu_x = 2$ $\mu_d = 6$ R.P. = 34 $D_x = 35$

x	P(x)		$P(D_x \mid x)$		
1	0.270671	x	0.000000	=	0.00000000
2	0.270671	x	0.000000	=	0.00000000
3	0.180447	x	0.000248	=	0.00004475
4	0.090224	x	0.020570	=	0.00185591
5	0.036089	x	0.202692	=	0.00731495
6	0.012030	x	0.588503	=	0.00707696
7	0.003437	x	0.878581	=	0.00301968
8	0.000859	x	0.978679	=	0.00084069
9	0.000191	x	0.997593	=	0.00019054
10	0.000038	x	0.999812	=	0.00003799
11	0.000003	x	0.999989	=	0.00000700
12	0.000001	x	0.999999	=	0.00000100
				Σ =	0.02039220

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5

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FORECASTING THE DEMAND FOR

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by

Edward W. Davis

March 1960

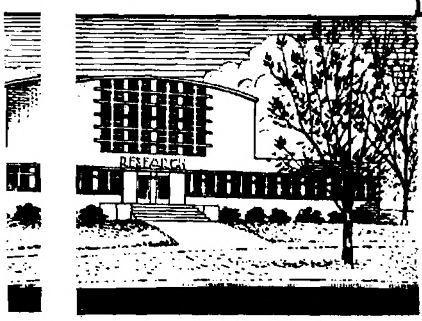
"Disposable versus Reprocessed Hospital Supplies"

USPHS GRANT #GN-5968

PROJECT BULLETIN NO. 5

Harold E. Smalley, Ph.D.
Principal Investigator

DJ



Engineering Experiment Station

Georgia Institute of Technology

Atlanta, Georgia

5

Disposable versus Reprocessed Hospital Supplies

FORECASTING THE DEMAND FOR HOSPITAL SUPPLY ITEMS

by

Edward W. Davis, B.M.E.

A Research Report
done in collaboration with

Thomas L. Newberry, Jr., M.S.I.E.
Joseph J. Moder, Jr., Ph.D.
Harold E. Smalley, Ph.D.

Based upon a Master's Thesis
in the

School of Industrial Engineering
Georgia Institute of Technology

PROJECT BULLETIN NO. 5

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March 1960

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PREFACE

This report (Project Bulletin No. 5) is the second in a series of studies being conducted under the auspices of USPHS Grant #GN-5968. This series of studies, which is only a portion of the research project, is concerned with ascertaining ordering quantities and storage quantities.

The first report of this series considered the case of variable lead time and variable demand where the expected demand was constant throughout the year. In this report attempts were made to adequately forecast changes in expected demand. The first attempt at forecasting demand changes was to determine a statistical relationship between the demand for a specific item, rubber gloves, and three selected independent variables. The three independent variables selected were total hospital census, total number of births, and total number of operations performed. Since the latter variables are readily available to the hospital administration, it was thought that they might be used as indices of future demand for the relevant supply item. Therefore, with the aid of an IBM 650 computer, a linear multiple regression equation was calculated, relating these four variables. This equation was found to be unsatisfactory, however, and a simple regression equation relating weekly glove demand and weekly hospital census was calculated which specifies the relationship between these two variables in a more usable manner. The simple correlation coefficient for this second equation was calculated as 0.80, which was too low for forecasting purposes in conjunction with a forecast of census. The unsatisfactory nature of the statistical results determined in both cases prompted use of a second, more direct method of forecasting.

This method, called exponential smoothing, is described and its application illustrated. Using an IBM 650 computer, the glove demand data was analyzed on a monthly and weekly basis, and forecasts were made for each of the periods in the sample, employing different combinations of the smoothing constant and base series. The predicted and actual results were compared by computing the standard deviation of the forecast errors and selecting as best, those values of the smoothing constant and base series which yielded a minimum standard deviation.

The conclusions of the study are that exponential smoothing is suitable for use in forecasting monthly and weekly glove demand at Emory University Hospital. Specific values of the smoothing constant and base series are suggested for use in the forecasting model, and economic implications of usable forecasts are pointed out.

It is anticipated that this series of studies relating to inventory will be understood and appreciated more by the industrial engineer and those engaged in operations research than by health oriented people in the field of hospital administration. It is not the intention of the project staff to sacrifice scientific principles nor sound research methodology in the interest of communicating readily with decision makers in the hospital. However, the project staff does appreciate the need for interpreting study findings in such a way that the decision system eventually developed will have practical application. To accomplish this purpose, an attempt will be made to write a practical version of findings in this series of inventory studies for publication later this year.

Studies concerned with other phases of the research project presently in process are as follows:

1. Ranking of various supply items with regard to dollar volume of present and possible future expenditures.
2. Classification of possible disposable items according to function and method of processing.
3. Work and time measurements of steps involved in both disposable and reprocessed items.
4. Research studies in conjunction with the School of Nursing, Emory University, on such topics as:
    a. Nurse acceptance
    b. Physician acceptance
    c. Patient acceptance
    d. Cost of Shortage
    e. Medical Practices
5. Bibliography of methods improvement studies in hospitals.
6. Preliminary cost models.
7. Macro-scopic measures of hospital supply functions.
8. Methods and standards studies in cooperation with the School of Industrial Engineering, Georgia Institute of Technology.
9. Inventory policies and costs.
10. Compilation of demand data.

Results from these and other research efforts will be reported via periodic bulletins to be published through the Engineering Experiment Station of Georgia Institute of Technology.

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CHAPTER I

INTRODUCTION

This study is concerned with the development of a practical forecasting model for use by hospital administrators in estimating the future demand for a certain hospital supply item. The need for such a model may be explained by the following remarks.

The ever increasing demand for hospital services and the rise in labor and associated operating costs have created increasing requirements for more efficient use of hospital facilities and personnel. Since illnesses and accidents are largely unpredictable, hospitals must be prepared to provide services for demands which may vary greatly from day to day. This situation results in a varying demand on the medical and nursing staffs. One traditional approach to the problem of allocation of staff time and supplies has been to provide at all times adequate facilities to meet past peak demands, accepting as normal procedure the presence of standby personnel. The justification for this approach lies, of course, in the concept of providing acceptable patient care--the ultimate criterion for judging any measure of hospital performance.

However, when operating costs become so great that they become a matter of concern, the hospital administration seeks means of providing facilities for adequate patient care with less wasteful use of available resources. One of these means has been the introduction of disposable supply items which would require less processing and application times at possibly lower total cost; another means has been to attempt better scheduling of nursing and medical staff time.

The purpose of this study was to develop a method of forecasting the probable future demand for certain supply items. Two of the more obvious benefits of accurate forecasts exist in the form of possible reductions in inventory levels and in better scheduling and utilization of the available labor force. Also, in consideration of disposable supply items, a knowledge of variability of demand would be of use in minimizing the risk of a shortage, by having sufficient stock on hand and yet at the same time preventing unnecessary over-stocking of the relevant item.

A literature search indicated a surprising lack of information on practical ways to forecast demand. Most of the works available which concern forecasting deal with the mechanics of long-range business forecasting rather than with the day-to-day variations in demand for a certain item. One popular method of economic forecasting, based on a theory of cycles, is described by Abramson (4) and Forrester (15). They show how random variations can generate sympathetic oscillations in industrial operations and how these oscillations have predictable cyclic variations. Another method (5) is based on cross correlation with a leading index; i.e., correlating the unknown variable with some known or predictable variable, and using this known variable as an index of future demand for the unknown variable. Another, somewhat more complicated variation of this method is outlined by Cotter (9), in which the "trend line" of past demand for the unknown variable and the "trend line" of the index are utilized. Given a future forecast of the index, the amount of deviation of this forecast from its trend line is determined, and a related degree of deviation of the unknown variable about its trend line is calculated from a known correlation between the two variables.

Two other methods mentioned by various authors attempt to give a prediction of the future level of demand of a variable from an analysis of the variations of its past level of demand. The first of these two methods involves use of probability theory; the distribution of past demand is approximated by a theoretical probability distribution, and the prediction of future demand is based upon the properties of this theoretical distribution. Specific applications of this method in areas of hospital research are described by Balintfy (7), Sonnendeker (16) and others (14),(8). The second of these two methods utilizes some form of moving average to calculate the general long-term trend of past demand, and extrapolates this trend into the future. Moroney (3) treats this method and its associated limitations at some length, as does Hanson (6). Brown (12) treats several variations of the method of moving averages, for applications to inventory control, and was the only source discovered which offered a routine practical method of forecasting day-to-day variation in demand.

The present study describes an attempt to apply a combination of these methods to the problem of forecasting the future level of demand for hospital supply items. One original goal of this study was to quantify the relationship between the number of supply items used and total hospital census, number of births, and number of surgical operations performed. Since the latter variables are readily available to the hospital management, it was thought that they might be used as indices of future demand for the relevant supply items. However, the weakness of the statistical relationships discovered between the variables prompted use of a second method of forecasting. This method, developed by Brown (12), is described in Chapter IV of this study.

The scope of this study was planned to include several hospitals so that conclusions might be drawn regarding the general pattern of demand for hospital supply items and their association with the mentioned hospital variables. However, limitations of time and the unavailability of data narrowed the scope to one hospital and one supply item. Although it was possible to institute a continuing system of data collection (for possible future application of the methodology described in this paper), the statistics and accompanying conclusions herein must be recognized as being restrictive in nature and inadequate for broad generalization.

CHAPTER II

EXPERIMENTAL ENVIRONMENT AND DATA COLLECTION

For the purpose of this study, two of the most important supply items (in terms of comparative usage) were originally selected for investigation; viz, surgical rubber gloves and glass-barreled hypodermic syringes. Because of incomplete and inaccurate data, however, the syringe data was eventually eliminated from the study, and all subsequent work refers to data collected on surgical rubber gloves at Emory University Hospital, Atlanta, Georgia. Data on the daily number of rubber gloves processed by the Central Supply Department were collected for a continuous 22-month period from January 21, 1957, to June 30, 1959.

Figure 1 indicates the typical flow pattern of reprocessed rubber gloves within the hospital system; the numbers given are approximate average daily flow rates. In general, gloves which are used on one day are processed on the evening of the same day or on the following day, the number processed being recorded by central supply personnel. New gloves are introduced into the system as needed, and over a period of time, other things being equal, the total number of gloves introduced into the system will equal the total number discarded during that period. A previous study[1] indicated that each pair of gloves is used approximately five times before being discarded.

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[1]Unpublished research study, "Introductory Cost Determination For Disposable versus Reprocessed Hospital Supplies," Engineering Experiment Station, Georgia Institute of Technology, 1959., Project B-158.

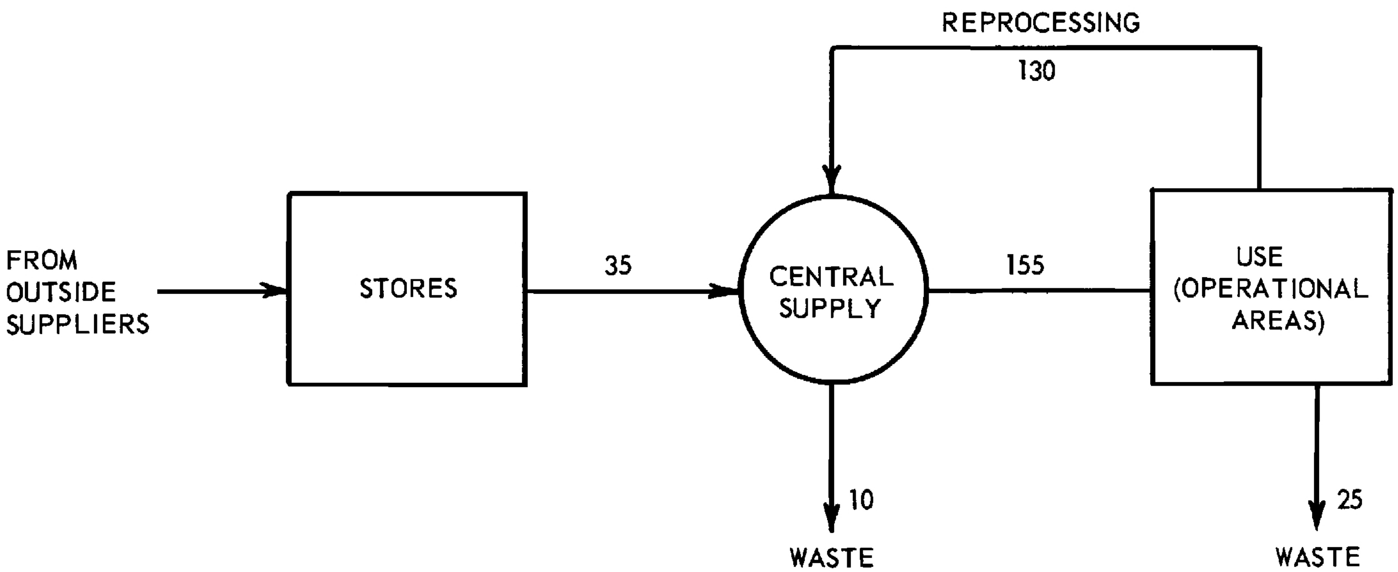

Figure 1. Simplified Diagram of Glove Flow in Hospital.

Slight daily inaccuracies in this representation of demand may arise from the fact that some of the items may have been on the floors (point of use) for more than one day, or because central supply personnel for one reason or another processed more than the actual number used (such cases comprised about 2.5 per cent of the total observations). Over a period of time, however, these daily inaccuracies balance out, since each glove processed is eventually used, and only at the end points of the time interval under observation would there be any expectation of error. Initial analysis of the data indicated that a period of one week would be sufficient to allow these daily inaccuracies to balance out. Accordingly, final analysis of the glove processing data was carried out on a weekly basis. Figure 2 shows the variation in average daily glove demand, by weeks, for the 22-month observation period.

Since the glove processing data can be taken as an index of demand over time, hereafter the data will be referred to as demand data. This should cause no misconceptions if one keeps in mind the differences pointed out above.

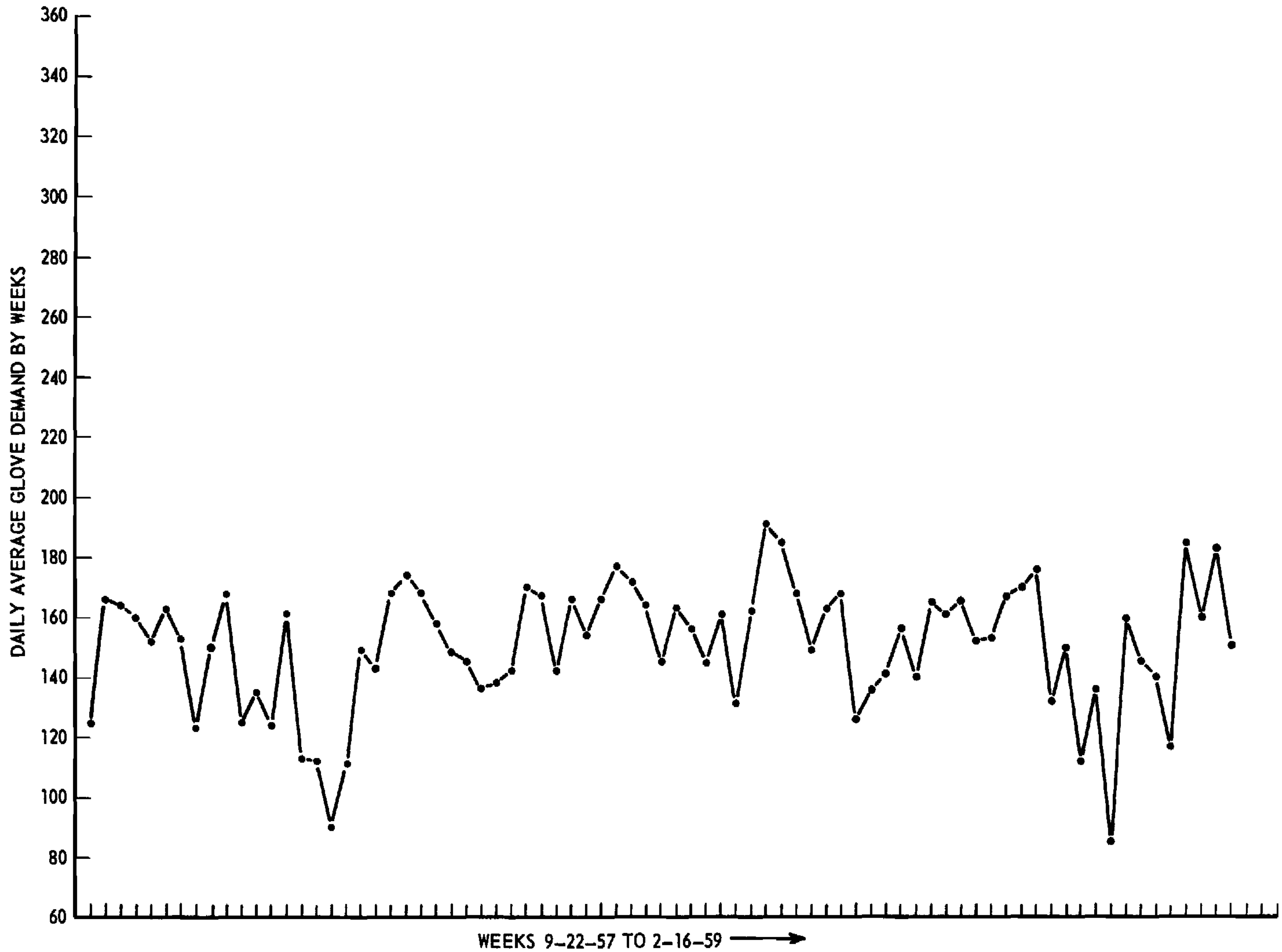

Figure 2. Average Daily Glove Demand by Weeks, September 1957 - June 1959.

CHAPTER III

CORRELATION AND REGRESSION ANALYSIS

In an attempt to quantify the relationship between the supply item demand under investigation and several hospital parameters, the variables were classified in the following manner:

<u>Dependent Variable</u>

Y_i = the number of pairs of gloves demanded during the i^{th} week.

<u>Independent Variables</u>

X_{1ij} = the sum of the daily hospital census figures for the i^{th} week which started j days before the start of the glove demand week. ($j = 0, 1, 2, 3$),

X_{2ij} and X_{3ij} are defined as above for daily number of births and daily number of operations, respectively.

The proposed multiple regression model, given in equation (1) below, assumes that demand is a linear function of each of the above independent variables.

$$(1) \qquad Y_i = \beta_0 + \beta_1 X_{1ij} + \beta_2 X_{2ij} + \beta_3 X_{3ij} + \epsilon_{ij},$$

where β_i = true regression coefficients for the i^{th} independent variable.

ϵ_{ij} = random error for the i^{th} week and a lag of j days.

An IBM 650 digital computer was used in the analysis, first to obtain weekly sums, Y_i, X_{1ij}, X_{2ij}, X_{3ij}, and then to compute the correlation and regression statistics given in Table 1 below. The standard least squares regression equations were justified since the X_{ij}'s are known without error and there were no reasons to suspect that the ϵ_{ij}'s were correlated with the X_{ij}'s or that the variance was not constant.

The multiple regression equation for the model equation (1) is given as follows:

$$(2) \quad Y_{i(\text{predicted})} = \hat{Y}_i = b_o + b_1 X_{1ij} + b_2 X_{1ij} + b_3 X_{3ij} ,$$

where $\hat{Y}_i - Y_i = e_{ij}$ = residual for the i^{th} week with a lag of j days.

As can be seen in Table 1, a time lag of two days (j = 2) yielded the highest degree of correlation between the dependent and independent variables. Accordingly, input data from this group was used to obtain the multiple regression equation (3),

$$(3) \quad Y_i = 238 + 0.45\ X_{1i2} - 0.20\ X_{2i2} + 1.33\ X_{3i2}.$$

The multiple correlation coefficient for this model was found to be R = 0.80, as shown in Appendix I.

The standard error of estimate of the regression coefficients and the residuals were found to be the following:

$S_{b_1} = 0.07 \quad (b_1 = 0.45)$,

$S_{b_2} = 2.12 \quad (b_2 = -0.20)$.

Table 1. Results of Correlation Analysis

		j = 0	j = 1	j = 2	j = 3
Mean:	$\bar{Y}$	1061.1	1061.1	1060.1	1060.1
	$\bar{X}_1$	1614.4	1609.8	1560.0	1599.0
	$\bar{X}_2$	17.1	17.3	16.8	17.0
	$\bar{X}_3$	91.1	90.0	89.2	90.2
Standard Deviation:	σ_y	141.0	141.0	168.0	145.0
	σ_{x1}	178.0	185.3	255.8	215.9
	σ_{x2}	6.2	6.1	5.7	6.3
	σ_{x3}	29.2	29.4	19.2	31.6
Simple Correlation Coefficients:	r_{yx_1}	0.49	0.50	0.80	0.47
	r_{yx_2}	-0.001	-0.006	0.22	0.06
	r_{yx_3}	0.50	0.35	0.65	0.32
	$r_{x_1x_2}$	0.22	0.20	0.30	0.28
	$r_{x_1x_3}$	0.50	0.60	0.72	0.37
	$r_{x_2x_3}$	-0.09	0.25	0.12	0.31
Partial Correlation Coefficients:	r'_{yx_1}			0.60	
	r'_{yx_2}			-0.001	
	r'_{yx_3}			0.17	

$S_{b_3} = 0.90 \qquad (b_3 = 1.33),$

S_e = Standard error of estimate = 103.

On the basis of the above results and principally because of the high standard error of the regression coefficients b_2 and b_3, it was concluded that equation (3) is not suitable for predicting glove demand. Since the simple correlation coefficient $(j = 2)\, r_{YX_1} = 0.80$, was of the same magnitude as the multiple correlation coefficient R = 0.80, this suggested the possibility of developing a model using X_1 only. Such a model would have the form

$$(4) \quad Y_i = \beta_0 + \beta_1 X_{1ij} + \epsilon_{ij}.$$

This was evaluated for j = 2 only; i.e.,

$$(5) \quad Y_i = b_0 + b_1 X_{1i} + e_i,$$

and the final regression equation using Y_i and X_{1i} only, was calculated to be:

$$(6) \quad Y_i = 242 + 0.52\, X_{1i},$$

$$S_{b1} = 0.092, \quad (b_1 = 0.52),$$

$$S_e = 103.$$

Figure 3 shows the scatter diagram for census versus glove demand with this least squares regression line together with 95 per cent confidence intervals for predicted values of Y_i. These confidence intervals were calculated from the relation,

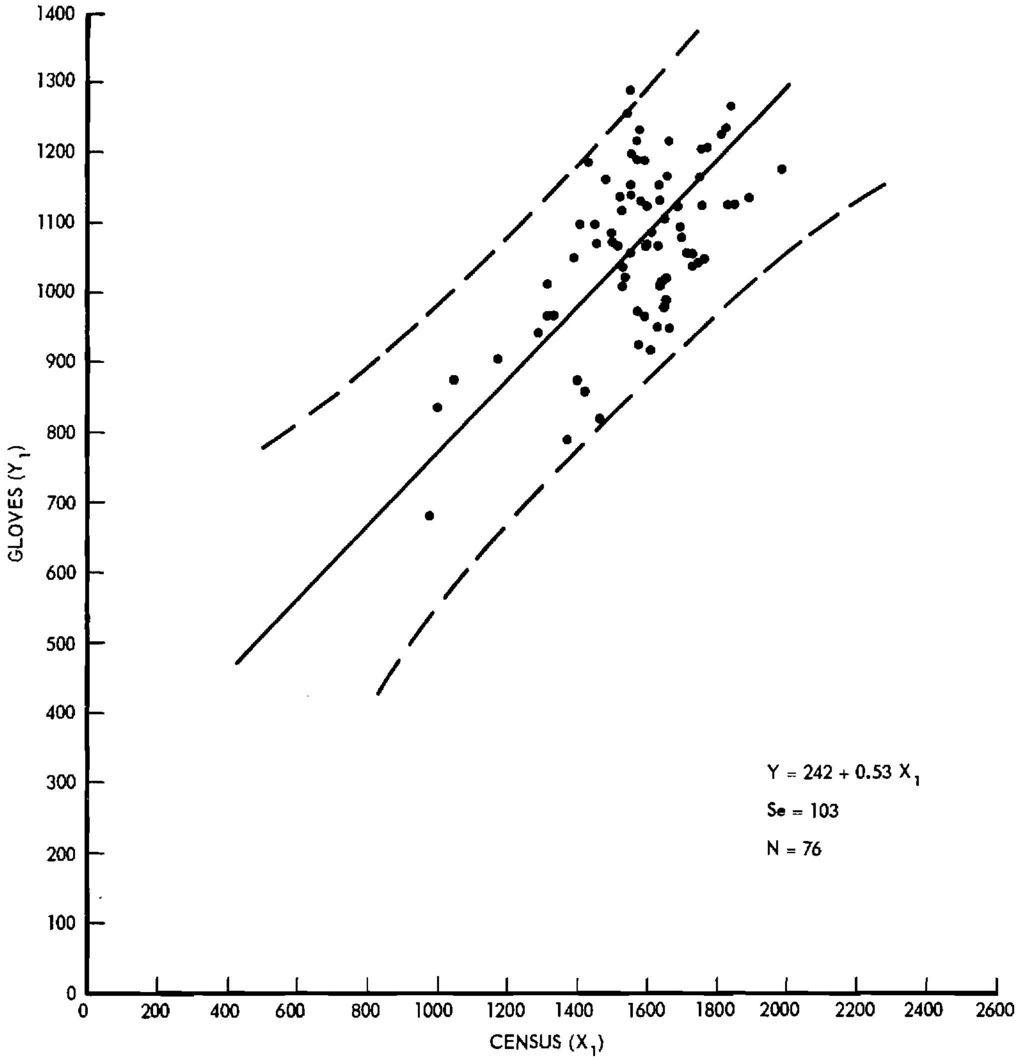

Figure 3. Scatter Diagram for Census Versus Glove Demand with Least Squares Regression Line.

$$\hat{Y} \pm t_{.05}\, s_e \sqrt{1 + \frac{1}{n} + \frac{(X - \bar{X})^2}{\Sigma\,(X - \bar{X})^2}}$$

where $t_{.05}$ is read from Students "t" table with n-2 = 74 degrees of freedom, at the .05 probability level.

In order to ascertain the individual influence of each of the other variables, scatter diagrams for glove demand versus births and operations were plotted and are shown in Appendix I.

If high correlations had been obtained in this study, efforts would then have been directed toward finding some method to forecast the independent variables involved in the prediction equation. Although the statistical correlations discovered in the course of this analysis are interesting per se, they were not of sufficient strength to warrant further work in this direction. For this reason attention was focused on predicting the future glove demand directly. This approach is described in the next chapter.

CHAPTER IV

DEMAND FORECASTING

Exponential Smoothing.--"Exponential Smoothing" is the name given by one author[1] for this description of a practical method of smoothing out the fluctuations in a demand history to get a stable estimate of the expected rate of demand. This method has a stable response to changes, and the rate of response can be controlled by the selection of the appropriate "smoothing constant."

Exponential smoothing is similar to a moving average, but does not require keeping extensive records of past demand data. At the end of each new month (or week) the demand for this month (called the new demand) is compared with an old average demand (computed up to this month) and the old average adjusted accordingly. If the new demand is higher than the old average, the estimate of the new average should be higher, and vice versa. In addition, if the difference between the old average and the new demand is small, the adjustment should be small and vice versa.

Brown[2] has formulated this rule: To get a new estimate of the average demand add to the previous estimate a fraction of the amount by which demand this month differs from that estimate. The fraction used

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[1]Brown, R. G., Statistical Forecasting For Inventory Control, McGraw-Hill Book Company, New York, 1959.

[2]Brown, op. cit., p. 46.

is called a smoothing constant. Denoting this constant by α, $(0 < \alpha < 1)$, the above rule can be written as follows:

new estimate = old estimate + α (new demand − old estimate),

or restated,

(7) new estimate = α (new demand) + $(1 - \alpha)$ (old estimate)

where α = smoothing constant.

Substituting a new expression for the old estimate,

new estimate = α (new demand) + $(1 - \alpha)$ [α(previous demand) + $(1 - \alpha)$ (previous old estimate)]

this process could be continued.

In general, if we let

$$
\begin{aligned}
D_0 &= \text{new demand,} \\
D_1 &= \text{demand last month,} \\
D_2 &= \text{demand 2 months ago,} \\
&\vdots \\
D_k &= \text{demand k months ago,}
\end{aligned}
$$

then

(8) new estimate = $\sum_{i=o}^{k} \alpha (1 - \alpha)^i D_i + (1 - \alpha)^k$ (estimate made k months ago).

Clearly, when k is large, the last term in equation (8) can be neglected, and so the starting estimate, made k months ago, is unimportant.

The new estimate is merely a linear combination of the demand experienced during the past k months. Since the sum of the coefficients in this linear function is equal to unity as shown below, it can be referred to as a weighted average, with the magnitude of the weights steadily decreasing as i increases.

$$\alpha + \alpha(1-\alpha) + \alpha(1-\alpha)^2 + \alpha(1-\alpha)^3 + \ldots = \frac{\alpha}{1-(1-\alpha)} = 1.$$

Thus, equation (7) can be restated as follows:

(9) new average = α (new demand) + $(1-\alpha)$ (old average)

This estimate of the average will lag behind actual demand with a systematic lag, where the magnitude of the lag is given as $\frac{1-\alpha}{\alpha}$ times the rate of growth in demand[3]. If this rate of growth, or trend, can be estimated, adjustments can be made to eliminate the lag, as described below.

The current trend is defined as the new average minus the old average and the average trend can be estimated by the exponential smoothing method as described above. In terms of equation (9) the new trend can be written as follows:

(10) new trend = α (current trend) + $(1-\alpha)$ (old trend).

Now, knowing the trend, the magnitude of the lag can be computed and an expected demand, corrected for lag can be written as

(11) expected demand = new average + $\frac{1-\alpha}{\alpha}$ (new trend).

When the equation is expressed in this form, only the previously calculated values of the average and trend are necessary to compute an expected demand for the period under consideration.

Equations (9), (10), and (11) were used to estimate the most probable level of glove demand in the future. Obviously, one estimate

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[3]Brown, op. cit., p. 48.

which could be used is to assume that demand in some month in the near future will be the same as the current expected demand. Then the total demand during a lead time of L periods would be equal to L times the expected demand.

Base Periods for Seasonal Forecasting.--Some of the most common methods of forecasting when there is a seasonal pattern of demand depend on a comparison between the observed demand in a period this year and that in a corresponding period during the previous year, or between the average of the demand in the corresponding periods in several previous years.[4] This standard of comparison is called a "base series" and the criterion for its selection is the closeness with which its pattern follows the pattern of demand of the item being forecast.

Since the monthly glove demand data appeared to be cyclical with an annual low caused by the Christmas holidays (see Figure 4), it was decided to attempt to forecast demand by using as a standard of comparison for months in 1958-59 the demand for appropriate months during 1957-58. First, an attempt was made to forecast monthly demand, varying the value of the base series in an attempt to find the optimum base. The base was taken first as the average of the surrounding quarter (previous year) then as the average of a two-month period (same month and following month in previous year) and last simply as the demand during the same month of the previous year. Next an attempt was made to forecast weekly demand, taking as the value of the base series the average of the three surrounding weeks in the previous year.

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[4]Brown, Op. Cit. p. 129

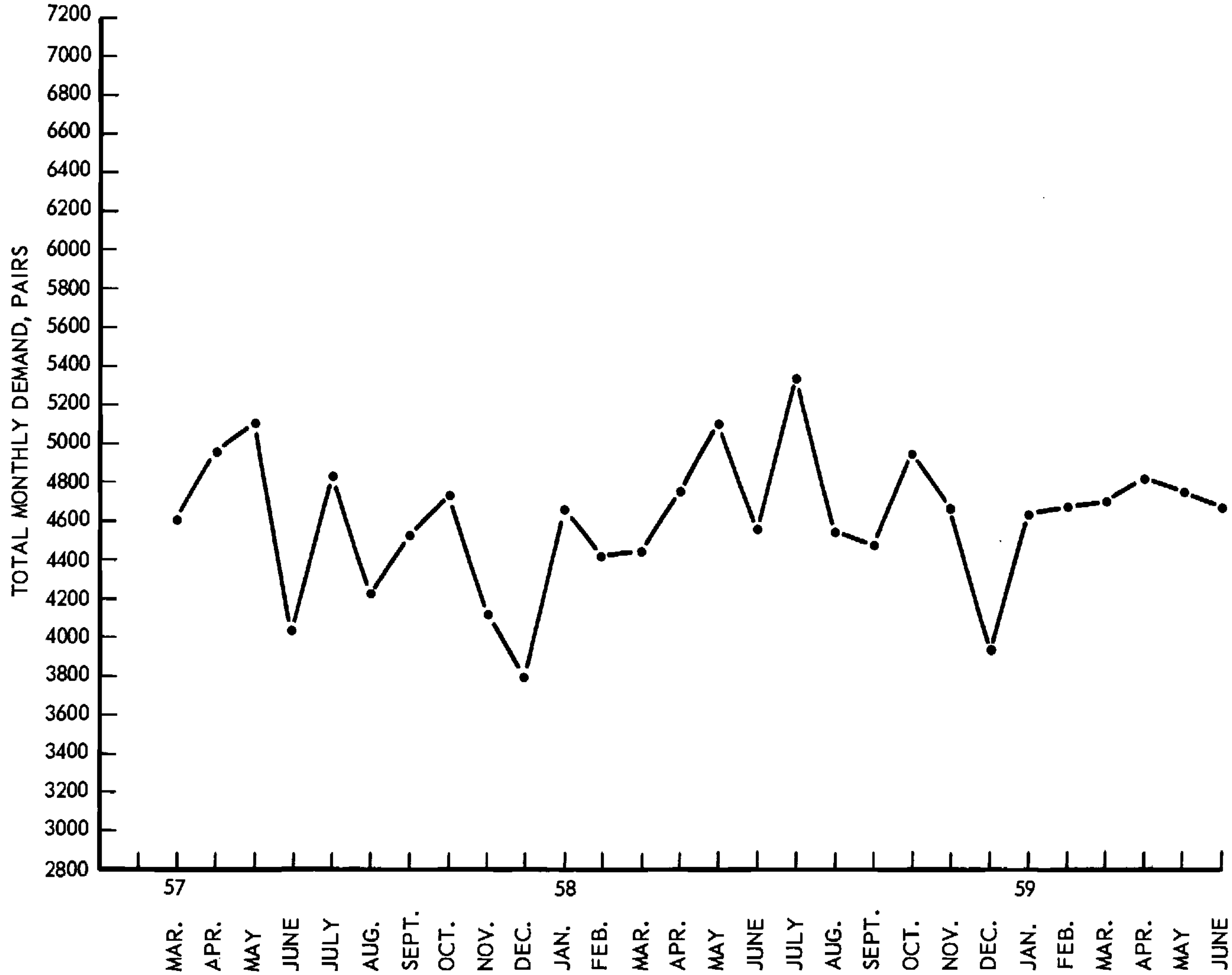

Figure 4. Total Monthly Glove Demand, March 1957 - June 1959.

In all cases the base series was utilized to compute a demand ratio by dividing the current demand by the value of the base series, and the method of exponential smoothing described above was used to smooth this ratio instead of the actual demand. The average, the trend, and the expected value of the demand ratio were calculated as described earlier. Obviously, for any current month, the actual demand is equal to the demand ratio times the value of the base series for that month.

Forecasting by Months.--The following illustrative calculations are carried out for a lead time of one month (forecasting one month in advance) using as a base series the demand for the same month in the previous year. The value of the smoothing constant used in this example is 0.50.

Taking the forecast for April, 1958 as an example,

$$\text{demand ratio for March} = \frac{\text{demand in March 1958}}{\text{demand in March 1957}}$$

$$= \frac{4412}{4602} = 0.958.$$

The initial value of the average ratio was arbitrarily taken as 1.0; thereafter it was computed as follows:

$$\underline{\text{average ratio}} = (1 - \alpha)\ (\text{average ratio for previous month}) + \alpha\ (\text{demand ratio for current month}),$$

$$= (1 - 0.5)(1.0) + (0.5)(0.958) = 0.979,$$

$$\underline{\text{change}} = (\text{average ratio current month}) - (\text{average ratio last month}),$$

$$= 0.979 - 1.000 = -0.021.$$

<u>Trend</u>: Initial value taken as 0; thereafter,

$$\text{trend} = (1 - \alpha)\ (\text{trend last month}) + \alpha\,(\text{change}).$$

$$\underline{\text{Expected ratio}} = \text{average ratio} + \frac{1-\alpha}{\alpha}\ (\text{trend}),$$

$$= 0.979 + \frac{1 - 0.5}{0.5}\ (-\ 0.010)$$

$$= 0.969.$$

This is the expected ratio for March. The forecast for April (lead time equal one month) was computed from this expected ratio and from the value of the base series for April, as follows:

$$\text{Forecast for April} = \left[\begin{array}{c}\text{expected ratio}\\ \text{for March}\end{array}\right] \times \left[\begin{array}{c}\text{value of base}\\ \text{series for April}\end{array}\right],$$

$$= 0.969 \times 4967 = 4813.2.$$

$$\text{Forecast error} = \text{predicted demand} - \text{actual demand},$$

$$= 4757.0 - 4813.2 = -56.2\ .$$

This same procedure with a base series of one month (B = 1) was then carried out to obtain a forecast for each of the remaining sixteen months. The smoothing constant was varied from 0.001 to 0.009 in increments of 0.002, from 0.01 to 0.09 in increments of 0.01 and from 0.1 to 0.9 in increments of 0.1, for lead times of one and two months. Computations also were made for the same ranges of the smoothing constant and lead time using a base series of two and three months as described above. The magnitude of the task involved necessitated use of an IBM 650 digital computer to perform the computations (see Appendix II for program flow chart).

After the predicted values and forecast error between predicted and actual values were obtained from the computer, the machine was again utilized to determine (1) correlation between predicted and actual values and (2) standard deviation of the forecast error. Figure 5 shows the results of trying different values of the base series in an attempt to find the most accurate base for a lead time of one month. For the range of smoothing constant values used (0.1 – 0.9) a base of one month (demand in same month of previous year) gave consistently best results. Table 7 lists the results of these computations.

Since the smallest standard deviation of forecast errors in this series was obtained using a base of one month, a new series of calculations for this base was undertaken in an attempt to find the best value of the smoothing constant for use in forecasting. The character of the curves in Figure 5 suggested that smaller values of the smoothing constant might give better results. Accordingly, the smoothing constant was varied from 0.001 – 0.09, and the results are shown in Figure 6.

Figure 6 indicates the errors to be expected in forecasting demand for the next month and also the second month hence, using a sequence of smoothing constants and the actual demand data shown in Table 3. It can be seen that the smaller the smoothing constant, the smaller is the standard deviation of forecast errors for either lead time. Note that $\alpha = 0.001$, the smallest value tried, gives the most accurate results for both cases. Note also the rather peculiar nature of these two curves; for values of the smoothing constant less than about 0.023, the standard deviation of forecast errors is less for a lead time of two

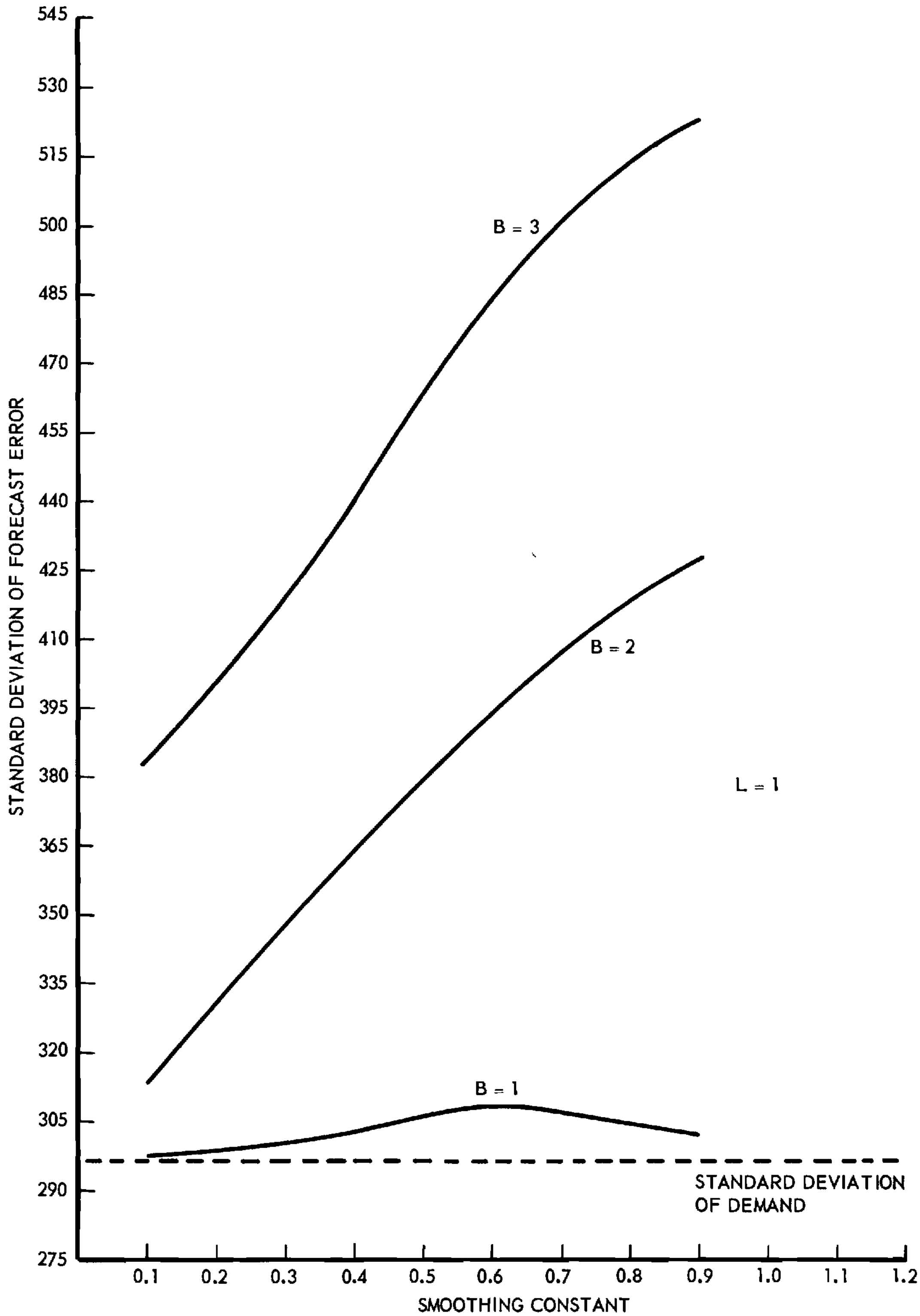

Figure 5. Standard Deviation of Forecast Error, Forecasting by Months, L = 1, B = 1, 2, 3.

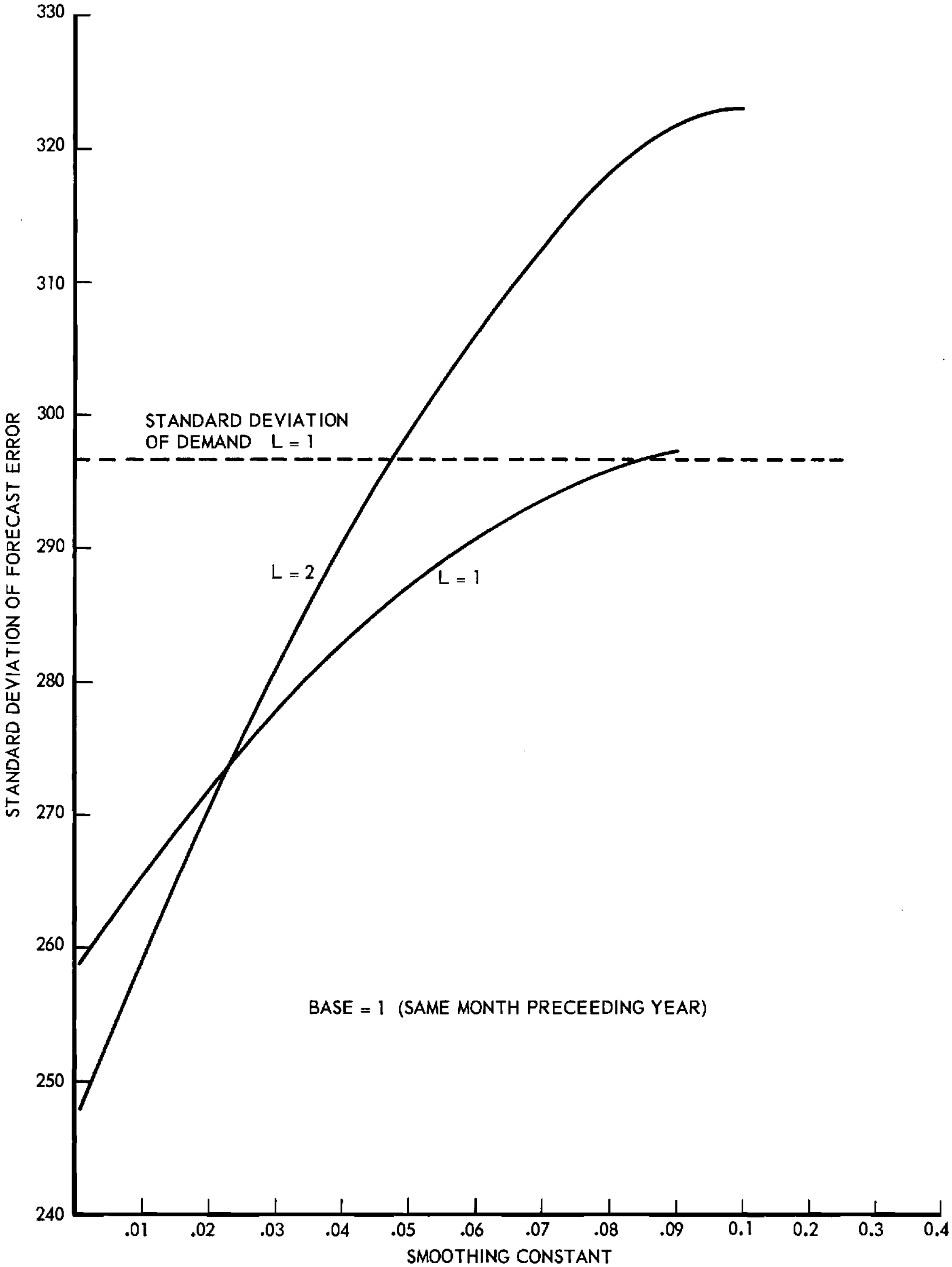

Figure 6. Standard Deviation of Forecast Error, Forecasting by Months, Base = 1, L = 1, 2.

months than for a lead time of one month. The minimum standard deviation computed occurs for a lead time of two months, in contrast to what might be expected. Table 7 gives the actual and predicted values for the series L = 1, B = 1, α = 0.001; Table 8 gives corresponding values for the series L = 2, B = 1, α = 0.001.

Assuming the forecast errors to be normally distributed and neglecting error in the estimate of the standard deviation of this distribution of forecast errors, an approximate 97.5 per cent upper confidence limit for individual future forecasts may be set as being equal to the forecast value plus two times the standard deviation of forecast error for the particular smoothing constant being used.

For example, using a smoothing constant of 0.001, and L = 1 or 2,

$$(12) \quad \text{maximum expected demand} = \text{forecast} + 2S_e,$$
$$\approx \text{forecast} + 500.$$

<u>Forecasting by Weeks</u>.--In exactly the same method as described previously, a forecast was made for each of the weeks from January 20, 1958 - January 19, 1959 (current year), utilizing weekly demand figures from the period January 21, 1957 - January 20, 1958 (previous year) to compute the base series (the value of the base series was taken as the average of the three surrounding weeks in the "previous year"). The smoothing constant was varied from 0.01 - 0.9 and the lead time from one to three weeks. The standard deviation of forecast error and the correlation between predicted and actual values were obtained as before; Table 9 lists the data used in these calculations and Figure 7 gives the results in graphic form.

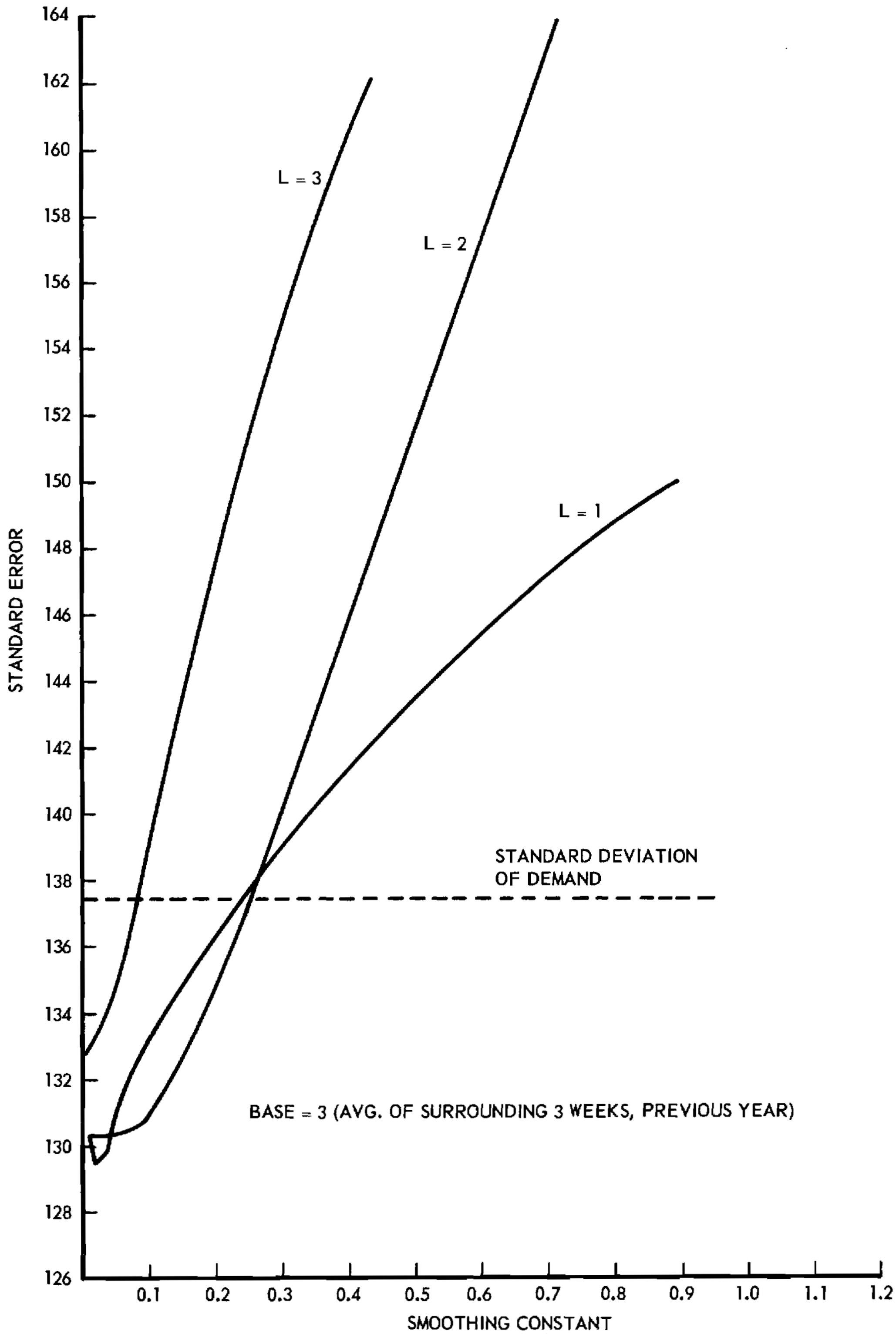

Figure 7. Standard Deviation of Forecast Error, Forecasting by Weeks, Base = 3, L = 1, 2, 3.

Note that for this series a smoothing constant value of 0.02 gave best results as evidenced by the lowest point on the curve. Also note that the minimum standard deviation occurs for a lead time of one week.

Table 9 also gives the predicted values and forecast error for the series which gave best results ($L = 1$, $B = 3$, $\alpha = 0.02$). For this value of the smoothing constant; i.e., 0.02, and $L = 1$ or 2, Equation (13) below gives an approximate 97.5 per cent upper confidence limit for individual future forecasts.

$$\text{(13)} \quad \text{Maximum expected demand} = \text{forecast} + 2S_e,$$

$$\approx \text{forecast} + 260.$$

CHAPTER V

CONCLUSIONS

The results of this study were obtained using data on the number of surgical rubber gloves processed daily by the Central Supply Department of Emory University Hospital, Atlanta, Georgia, during a 22-month period from September 1957, through June 1959.

With these restrictions in mind, the conclusions of this study are as follows:

1. The calculated multiple regression Equation (3) relating weekly glove demand to weekly census, weekly number of births and weekly number of operations was found to be unsuitable for forecasting glove demand.

2. The simple linear regression Equation (6) relating weekly glove demand with weekly hospital census quantifies the relationship between these variables. However, before weekly glove demand can be forecast, total weekly census must be estimated. The magnitude of the standard error of estimate associated with Equation (6) raises doubts as to the practicability of this procedure.

3. Using the method of exponential smoothing, glove demand can be forecast monthly and weekly. Only the values of the average ratio (Equation 9) and the trend (Equation 10) are necessary for calculating an expected ratio (Equation 11) for the current month or week. This expected ratio is then used with the appropriate value of the base series in making the forecast, as explained in Chapter IV. The initial value of the trend and the average ratio should be taken as 0 and 1.0

respectively. For weekly forecasts, a smoothing constant of 0.02 and a base of three weeks should give best results. For monthly forecasts, a smoothing constant of 0.001 and a base of one month appear best. Equations (12) and (13) can be used to calculate the maximum expected demand for any particular case with 97.5 per cent confidence that this estimated demand will not be exceeded.

4. These figures apply for the hospital environment studied in this study. If there is any indication that the state of the system is changing (i.e., significant changes in hospital bed capacity, changes in inventory policy, and/or new sources of glove demand), tests should be made with higher values of the smoothing constant to increase the speed of response of the model, keeping in mind that the model will then also be more responsive to purely random variations.

CHAPTER VI

DISCUSSION OF CONCLUSIONS AND RECOMMENDATIONS

It is felt that the unsatisfactory results obtained in the regression analysis part of this study are due more to selection and definition of the independent variables than to any inherent limitations in the proposed linear form of the multiple regression model, although no tests were made to support this assumption. Future investigations might check this assumption, and also incorporate other variables in the model, such as: major operations (as opposed to total number of operations); census, classified by medical service, such as pediatrics, obstetrics, medical and surgical; number of available students and/or interns; number of patients cared for in Gynecology and Cancer Clinics; and work load in Pathology Department.

Some of the limitations of the results obtained in this study with exponential smoothing should be mentioned. First, for inventory control purposes, glove demand can be forecast up to two months in advance with an accuracy indicated by Equation (12). It should be noted that this forecast yields an estimate of the total number of gloves to be used, inclusive of all sizes. Since some gloves are used more frequently than others, a more specific estimate of the demand for each size could be obtained by examining the relative proportion of use by size and making corresponding allowances.

Second, for scheduling the Central Supply work force, maximum glove demand can be forecast up to two weeks in advance with an accuracy indicated by Equation (13). Since examination of the 22-month sample indicated that there is some variation in glove demand by day of the week (see Figure 12, Appendix), an estimate of the relative proportion of the weekly glove demand to be allocated to each day could be obtained. If inventory levels and other limitations in Central Supply permit, this would facilitate the establishment of certain weekly periods for glove processing, instead of handling the work on a day-to-day basis as is presently being done.

Finally, whether forecasting weekly or monthly, knowledge of future glove demand can be useful in economic comparisons of reprocessed and disposable gloves. Knowing the standard time for processing one pair of gloves, an estimate of the expected labor cost can be made. The total costs associated with using these gloves in the hospital can then be obtained readily.

A P P E N D I X

Table 2. Values Used in Multiple Correlation and Regression Analysis with Time Lag j = 2

Observed Input Values				Predicted Values	Residual Values = $\hat{Y}_i - Y_i$
Y_i	X_{1i2}	X_{2i2}	X_{3i2}	$\hat{Y}_i$	e_{12}
1059	1726	22	82	1128	69
1206	1750	20	101	1164	−42
1205	1766	12	93	1161	−44
1065	1517	13	81	1032	−33
1038	1728	14	93	1144	106
1162	1746	17	86	1143	−19
1092	1692	11	92	1126	−34
1040	1741	8	83	1137	97
1224	1806	12	96	1183	−41
1064	1595	18	82	1069	5
949	1623	13	81	1080	131
1130	1580	13	93	1077	−53
1037	1527	14	79	1034	−3
1184	1426	13	85	996	−188
1177	1980	12	72	1230	53
948	1660	24	74	1088	140
1122	1750	16	98	1161	39
1125	1825	20	99	1196	71
1122	1594	21	88	1076	−46

Table 2. Values Used in Multiple Correlation and Regression Analysis with Time Lag j = 2 (continued)

Observed Input Values				Predicted Values	Residual Values = $\hat{Y}_i - Y_i$
Y_i	X_{1i2}	X_{2i2}	X_{3i2}	$\hat{Y}_i$	e_{i2}
1067	1599	19	85	1075	8
1139	1551	32	72	1035	−104
1086	1451	25	67	984	−84
832	995	15	42	744	−88
1135	1520	20	82	1035	−100
1067	1627	26	86	1089	22
1054	1710	18	84	1124	70
1078	1698	14	85	1120	42
1010	1633	25	77	1079	69
856	1422	13	64	967	111
922	1576	28	90	1071	149
815	1461	24	86	1013	198
1121	1683	16	104	1138	17
903	1172	23	59	847	−56
915	1609	19	74	1065	150
1095	1446	11	81	1000	−95
1070	1499	16	85	1029	−41
1266	1837	26	112	1218	−48

Table 2. Values Used in Multiple Correlation and Regression Analysis with Time Lag j = 2 (continued)

Observed Input Values				Predicted Values	Residual Values = $\hat{Y}_i - Y_i$
Y_i	X_{1i2}	X_{2i2}	X_{3i2}	$\hat{Y}_i$	e_{i2}
1236	1822	22	110	1209	-27
1188	1591	13	129	1130	-58
1125	1848	23	97	1204	79
1048	1761	14	92	1158	110
988	1658	16	108	1132	144
1199	1550	11	94	1065	-134
1214	1659	12	89	1107	-107
1130	1637	13	68	1070	-60
1105	1642	12	97	1110	5
1014	1639	11	122	1142	128
1116	1525	15	77	1031	-85
1094	1402	9	78	976	-118
1049	1384	14	81	972	-77
1086	1612	7	106	1109	23
874	1044	18	46	771	-103
1165	1655	16	112	1136	-29
1151	1631	20	99	1108	-43
1007	1535	13	83	1043	36

Table 2. Values Used in Multiple Correlation and Regression Analysis with Time Lag j = 2 (continued)

Observed Input Values				Predicted Values	Residual Values = $\hat{Y}_i - Y_i$
Y_i	X_{1i2}	X_{2i2}	X_{3i2}	$\hat{Y}_i$	e_{i2}
1253	1540	23	90	1055	−198
1217	1562	16	93	1069	−148
1082	1495	10	90	1034	−48
962	1311	9	66	919	−43
963	1331	18	90	960	−3
789	1373	10	87	975	186
940	1283	22	83	929	−11
679	976	15	44	738	−59
1011	1309	12	57	906	−105
1021	1535	24	105	1072	51
972	1568	18	102	1083	111
1188	1567	17	79	1052	−136
1053	1547	10	105	1078	25
1152	1542	13	95	1062	−90
1289	1545	10	91	1058	−231
1231	1576	20	87	1067	−164
1020	1654	16	134	1165	145
1135	1883	25	89	1209	74
962	1586	8	97	1085	123
978	1644	17	79	1087	109

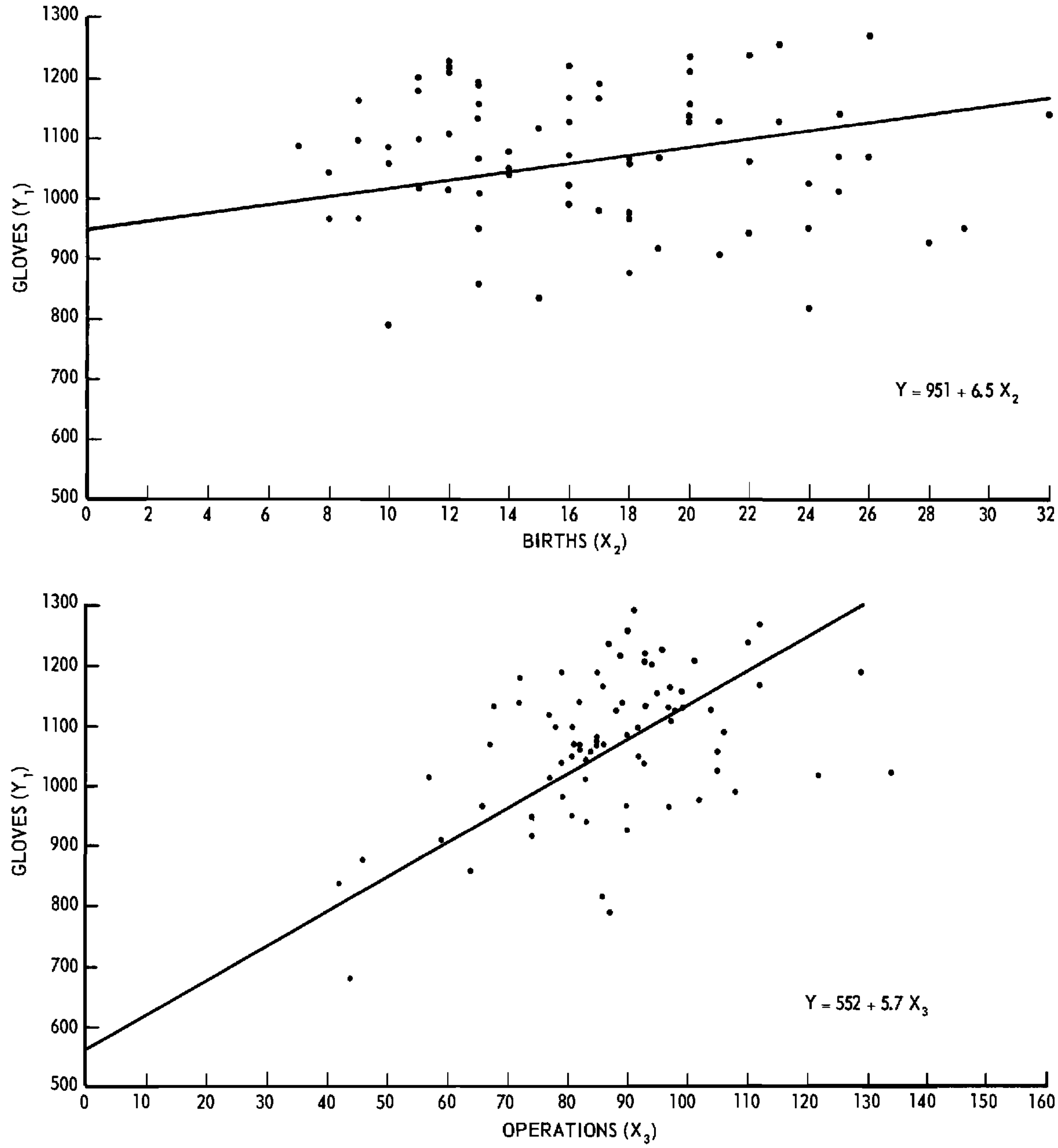

Figure 8. Scatter Diagrams of Glove Demand Versus Operations and Births Respectively, with Least Squares Regression Line.

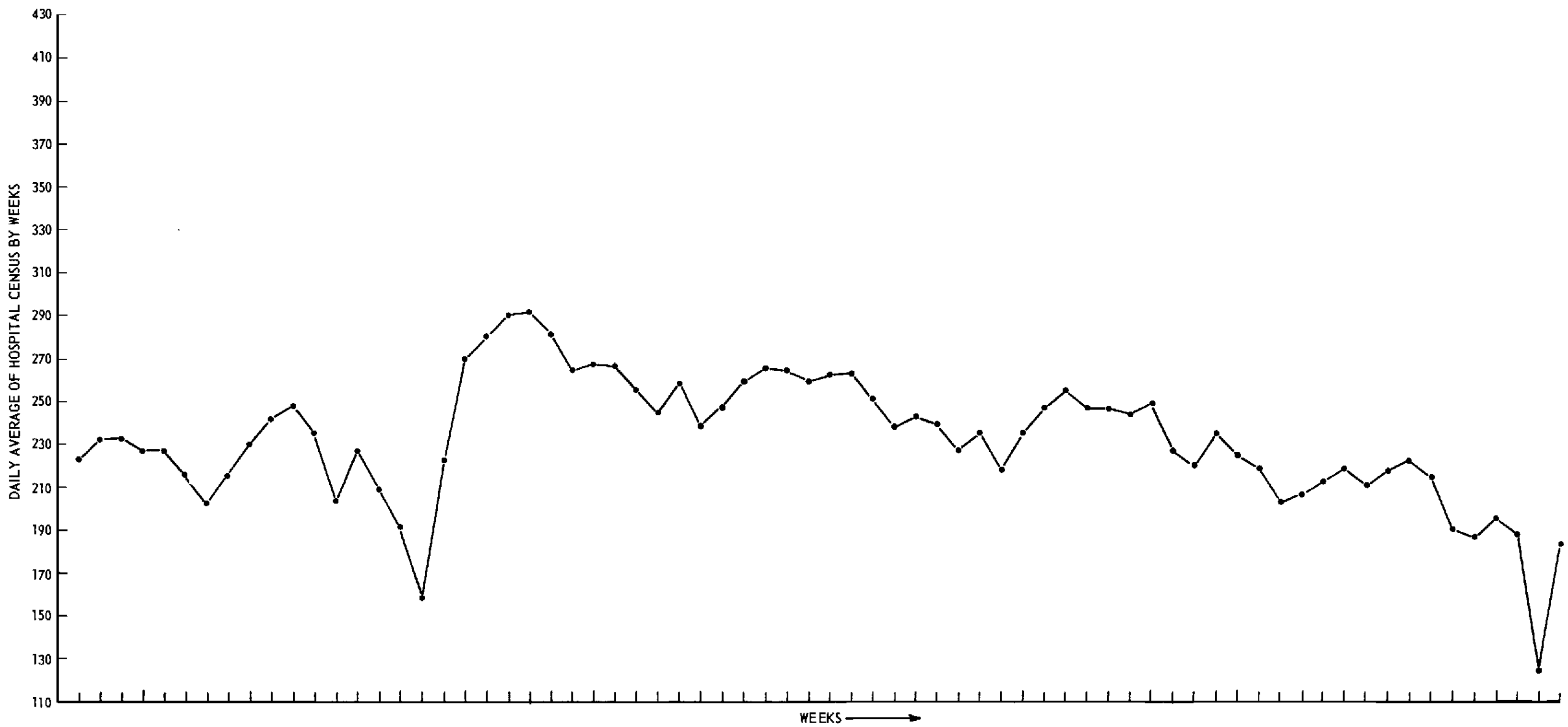

Figure 9. Average Daily Hospital Census, by Weeks, September 1957 - January 1959.

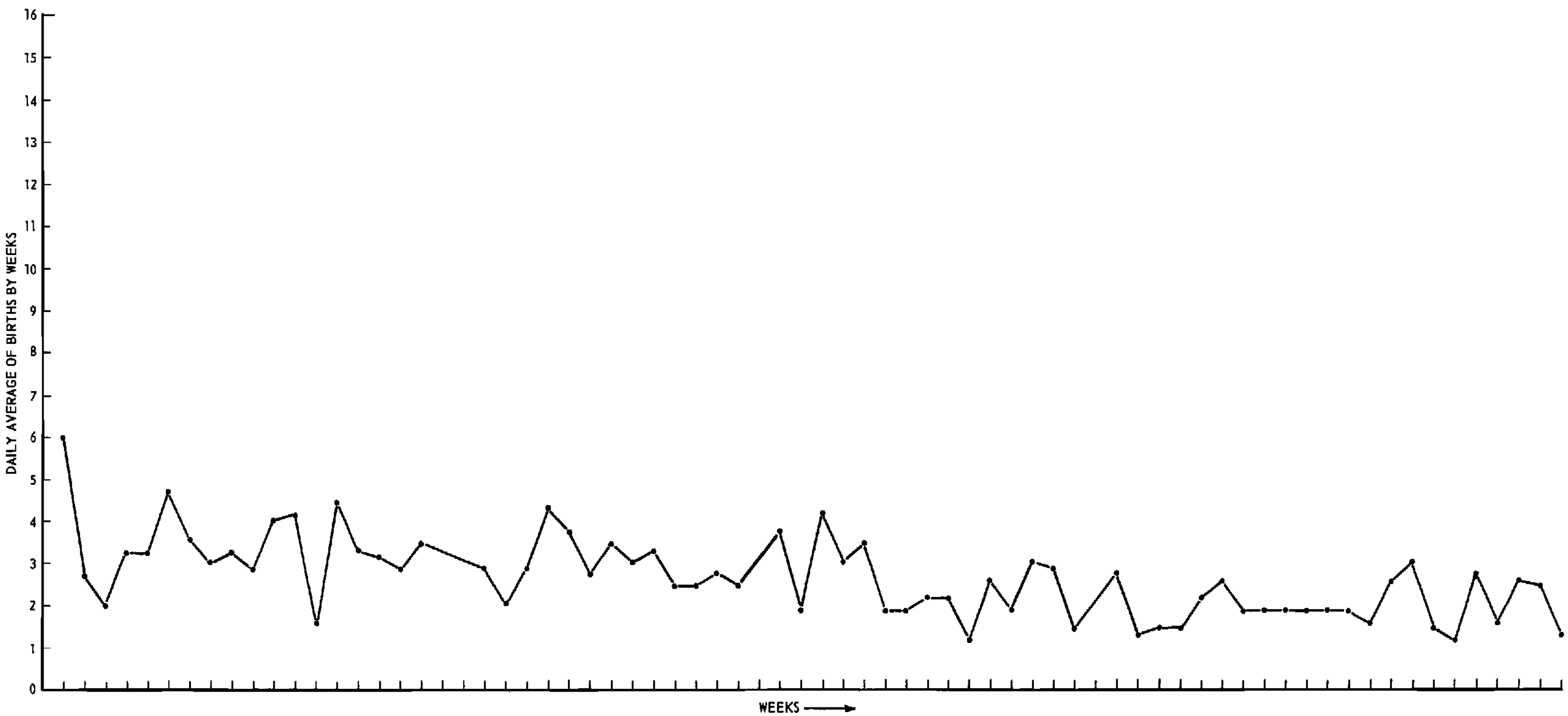

Figure 10. Average Daily Births, by Weeks, September 1957 - January 1959.

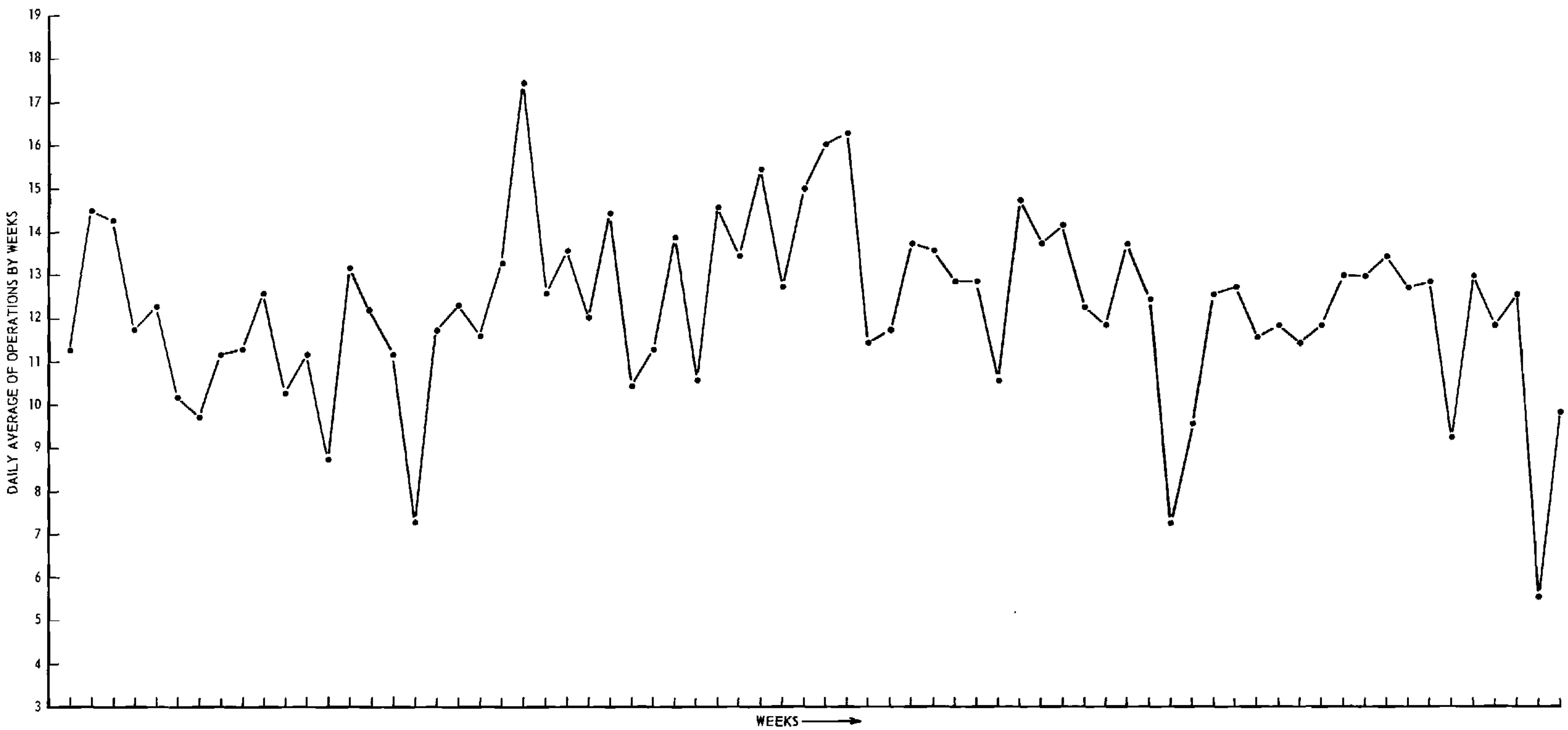

Figure 11. Average Daily Number of Operations, by Weeks, September 1957 - January 1959.

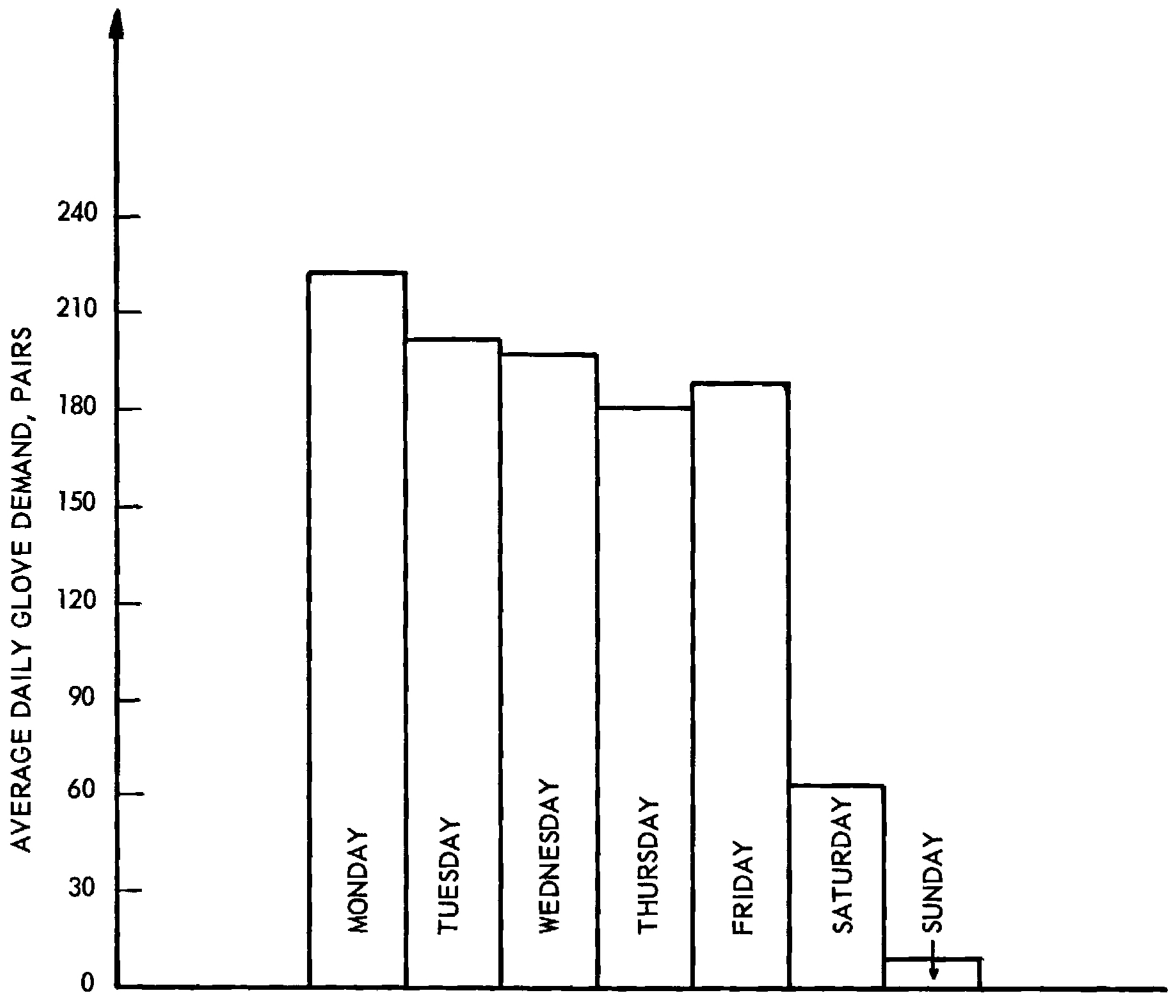

Figure 12. Average Glove Demand by Day of the Week, September 1957 - June 1959.

SAMPLE CALCULATIONS

The matrix of simple correlation coefficients for the regression model Equation (3) is defined below as A.

$$A = \begin{bmatrix} r_{YY} & r_{YX_1} & r_{YX_2} & r_{YX_3} \\ r_{X_1Y} & r_{X_1X_1} & r_{X_1X_2} & r_{X_1X_3} \\ r_{X_2Y} & r_{X_2X_1} & r_{X_2X_2} & r_{X_2X_3} \\ r_{X_3Y} & r_{X_3X_1} & r_{X_3X_2} & r_{X_3X_3} \end{bmatrix}$$

For the sample data analyzed in this study, this A matrix is as follows:

$$A = \begin{bmatrix} 1.0000 & 0.7968 & 0.2196 & 0.6485 \\ 0.7968 & 1.0000 & 0.2951 & 0.7233 \\ 0.2196 & 0.2951 & 1.0000 & 0.1149 \\ 0.6485 & 0.7233 & 0.1149 & 1.0000 \end{bmatrix}$$

The inverse of this matrix is as follows:

$$A = \begin{bmatrix} 2.8233 & -1.9416 & 0.0019 & -0.4266 \\ -1.9416 & 3.6541 & -0.4994 & -1.3266 \\ 0.0019 & -0.4994 & 1.1204 & 0.2313 \\ -0.4266 & -1.3266 & 0.2312 & 2.2097 \end{bmatrix}$$

Now let

$$(a_{ij}) = (r_{ij})^{-1},$$

where $(r_{ij})^{-1} = A^{-1}$ is the inverse of the matrix of simple correlation coefficients. The elements a_{ij}, of this inverse matrix, are used in computing the following statistics.

Multiple Regression Coefficients

$b_i = - \frac{a_{1j}}{a_{11}} \frac{\sigma_1}{\sigma_j}$ (j = 2, 3, 4), where σ_j = standard deviation of the j^{th} variable, and σ_1 = standard deviation of the dependent variable, Y_i.

$$b_2 = \frac{1.9416}{2.8233} \times \frac{168.7}{255.8} = 0.4535,$$

$$b_3 = \frac{-0.00189}{2.8233} \times \frac{168.7}{5.7} = -0.0198,$$

$$b_4 = \frac{0.4266}{2.8233} \times \frac{168.7}{19.2} = 1.3263.$$

Multiple Correlation Coefficient

$$R' = \sqrt{1 - \frac{1}{a_{11}}},$$

$R' = \sqrt{1 - \frac{1}{2.8233}} = 0.804$, unadjusted and

$R^2 = 1 - (1 - R^2) \; [(N - 1/N - n)]$, where N = sample size and n = number of parameters fitted in the regression model; i.e., b_1, b_2, b_3, and b_4.

$$R^2 = 1 - (0.3536)(75/72) = 0.63191$$

$$R = 0.795, \text{ adjusted.}$$

Standard Error of Estimate

$$\text{Biased standard error} = S'_e = \frac{\sigma_1}{\sqrt{a_{11}}},$$

$$S'_e = \frac{168.7}{\sqrt{2.8233}} = 100.43.$$

$$\text{Unbiased standard error} = S_e = \sqrt{N/N - n}\; S'_e$$

$$= \sqrt{76/72}\;(100.43) = 103.14.$$

Unbiased Standard Error of Multiple Regression Coefficients

$$S_{b_j} = \frac{b_j}{r_{1j}} \sqrt{\frac{1 - r_{1j}^2}{N - n}}$$

for j = 2, 3, 4

where r_{1j} = partial correlation coefficient between the first variable and the j^{th} variable

and b_j = regression coefficients

$$S_{b_2} = \frac{0.4535}{0.6044} \sqrt{\frac{1 - (0.6044)^2}{72}} = 0.0704,$$

$$S_{b_3} = \frac{-0.0198}{-0.0011} \sqrt{\frac{1 - (0.0011)^2}{72}} = 2.12,$$

$$S_{b_4} = \frac{1.326}{0.1707} \sqrt{\frac{1 - (0.1707)^2}{72}} = 0.901.$$

Simple Regression Coefficients

$$b'_{yx} = r_{yx} \frac{\sigma_y}{\sigma_x},$$ where r_{yx} = simple correlation coefficient between y and x

σ = Standard Deviation

$$b'_{yx_1} = 0.797 \times \frac{168.7}{255.8} = 0.53,$$

$$b'_{yx_2} = 0.220 \times \frac{168.7}{5.7} = 6.5,$$

$$b'_{yx_3} = 0.648 \times \frac{168.7}{19.2} = 5.7.$$

Standard Error of Estimate, Simple Regression

$$\text{Total S.S.} = nS_y^2 = 76 \times 168.0^2 = 2,145,024,$$

$$\text{S.S. for regression of Y on } X_1 = \left[\frac{\Sigma(X-\bar{X})(Y-\bar{Y})}{\Sigma(X-\bar{X})^2}\right]^2$$

$$= n\,r^2 S_y^2$$

$$= 76(.797)^2(168)^2$$

$$= \underline{1,360,322}\ ,$$

$$\text{S.S. for deviations} = 2,145,024 - 1,360,322 = 784,702.$$

$$\frac{\text{S.S. for deviations}}{\text{Degrees of Freedom}} = S_e^2 = \frac{784,702}{74} = 10,605,$$

$$S_e = 103.$$

95 Per Cent Confidence Limits, Simple Regression

$$\text{95\% Confidence Interval} = \hat{Y} \pm t_{.05}\, S_e \sqrt{1 + 1/n + (X-\bar{X})^2/\Sigma(X-\bar{X})^2}$$

From Student's "t" tables, $t_{.05} = 2.00$ (d.f. = 74)

$$Y = \hat{Y} \pm (2.00)(103)\sqrt{1 + 1/76 + \frac{(X - 1560)^2}{4,980,000}}$$

X	95% Confidence Limits
800	$\hat{Y} \pm 222$
1000	$\hat{Y} \pm 214$
1200	$\hat{Y} \pm 210$
1500	$\hat{Y} \pm 207$
1800	$\hat{Y} \pm 209$
2000	$\hat{Y} \pm 211$

Table 3. Observed Glove Demand Data and Demand Ratios Used in Forecasting by Months

Month	Demand for Month in Current Year	Demand for Same Month in 1957-58 (Base)	Demand Ratio
1958			
February	4406	6083	0.724
March	4412	4602	0.958
April	4757	4967	0.957
May	5103	5100	1.000
June	4579	4094	1.113
July	5363	4815	1.114
August	4565	4216	1.082
September	4480	4526	0.989
October	4964	4728	1.048
November	4660	4107	1.134
December	3962	3797	1.043
1959			
January	4645	4674	0.993
February	4689	4406	1.064
March	4700	4412	1.065
April	4822	4757	1.013
May	4749	5103	0.930
June	4674	4579	1.020

Table 4. Results of Exponential Smoothing: Correlation Between Actual and Predicted Demand, and Standard Deviation of Forecast Errors

Monthly, L = 1

For explanation of symbols see next page.

	α	$\overline{X}_p$	r_{AP}	$\overline{X}_z$	σ_z
Base = 1					
$\overline{X}_A$ = 4714.1	0.1	4694.6	0.616	19.5	298.6
σ_A = 296.7	0.2	4723.5	0.591	-9.4	299.6
	0.3	4722.1	0.585	-8.0	300.2
	0.4				
	0.5	4710.3	0.577	3.7	307.1
	0.6	4705.9	0.576	8.2	308.5
	0.7	4702.5	0.577	11.5	307.5
	0.8	4700.2	0.582	13.9	304.8
	0.9	4698.9	0.587	15.2	301.8
Base = 2					
$\overline{X}_A$ = 4714.1	0.1	4644.1	0.382	70.0	313.3
σ_A = 296.7	0.2	4677.3	0.279	36.8	333.9
	0.3	4682.7	0.234	31.3	347.1
	0.4	4681.0	0.215	33.1	362.0
	0.5	4678.4	0.205	35.7	377.9
	0.6	4676.1	0.198	37.9	393.8
	0.7	4674.4	0.196	39.7	408.5

Table 4. Results of Exponential Smoothing: Correlation Between Actual and Predicted Demand, and Standard Deviation of Forecast Errors (continued)

Monthly, L = 1

	α	$\overline{X}_p$	r_{AP}	$\overline{X}_z$	σ_z
	0.8	4673.3	0.198	40.7	420.6
	0.9	4672.8	0.203	41.2	428.6
Base = 3					
$\overline{X}_A$ = 4714.1	0.1	4671.0	-0.323	43.1	384.1
σ_A = 296.7	0.2	4699.0	-0.221	14.4	402.6
	0.3	4700.5	-0.307	13.5	419.9
	0.4	4696.7	-0.319	17.3	440.9
	0.5	4693.7	-0.312	20.4	462.9
	0.6	4691.6	-0.302	22.5	483.5
	0.7	4690.3	-0.292	23.7	501.5
	0.8	4689.6	-0.279	24.5	515.4
	0.9	4689.3	-0.265	24.8	524.1

α = Smoothing constant ($0 < \alpha < 1$).

$\overline{X}_A$ = Average observed monthly demand.

σ_A = Standard deviation of observed monthly demand.

$\overline{X}_p$ = Average predicted monthly demand.

r_{AP} = Correlation between observed and predicted demands.

$\overline{X}_z$ = Average of forecast errors.

σ_z = Standard deviation of forecast error.

Table 5. Results of Exponential Smoothing: Correlation Between Actual and Predicted Demand and Standard Deviation of Forecast Error

Monthly, Base = 1

	$\overline{X}_A$	σ_A	$\overline{X}_p$	σ_P	r_{AP}	$\overline{X}_Z$	σ_Z
L = 1							
0.001	4714.1	296.7	4554.6	371.1	0.721	159.5	258.9
0.003	4714.1	296.7	4559.5	371.2	0.718	154.6	260.3
0.005	4714.1	296.7	4564.3	371.3	0.714	149.7	261.7
0.01	4714.1	296.7	4575.9	371.7	0.707	138.2	265.2
0.02	4714.1	296.7	4597.1	372.3	0.692	117.1	271.7
0.03	4714.1	296.7	4615.7	372.8	0.678	98.4	277.6
0.04	4714.1	296.7	4632.1	373.1	0.665	82.0	282.7
0.05	4714.1	296.7	4646.5	373.1	0.654	67.6	287.0
0.06	4714.1	296.7	4659.1	372.7	0.644	55.0	290.6
0.07	4714.1	296.7	4670.0	372.1	0.636	44.1	293.5
0.08	4714.1	296.7	4679.5	371.1	0.628	34.6	295.7
0.09	4714.1	296.7	4687.6	370.0	0.622	26.5	297.4
L = 2							
0.001	4711.1	306.9	4524.8	367.1	0.743	186.3	247.9
0.003	4711.1	306.9	4529.5	368.1	0.738	181.5	250.4
0.005	4711.1	306.9	4534.1	369.0	0.734	176.9	252.9
0.01	4711.1	306.9	4545.2	371.4	0.724	165.9	258.9
0.02	4711.1	306.9	--	--	--	--	--

Table 5. Results of Exponential Smoothing: Correlation Between Actual and Predicted Demand and Standard Deviation of Forecast Error (continued)

Monthly, Base = 1

	$\overline{X}_A$	σ_A	$\overline{X}_p$	σ_P	r_{AP}	$\overline{X}_Z$	σ_Z
0.03	4711.1	306.9	4584.2	380.6	0.686	126.9	280.8
0.04	4711.1	306.9	4600.7	384.6	0.669	110.4	290.3
0.05	4711.1	306.9	4615.4	388.2	0.653	95.6	298.7
0.06	4711.1	306.9	4628.6	391.2	0.640	82.5	306.1
0.07	4711.1	306.9	4640.3	393.8	0.627	70.8	312.6
0.08	4711.1	306.9	4650.7	396.0	0.616	60.4	318.2
0.09	4711.1	306.9	4659.8	397.7	0.606	51.3	323.2

Table 6. Results of Exponential Smoothing: Correlation Between Actual and Predicted Demand, and Standard Deviation of Forecast Errors

Weekly, Base = 3

	$\bar{X}_A$	σ_A	$\bar{X}_p$	σ_P	r_{AP}	$\bar{X}_Z$	σ_Z
L = 1							
0.01	1073.9	137.5	1044.4	106.6	0.457	32.80	130.2
0.02	1073.9	137.5	1051.2	102.2	0.450	26.00	129.5
0.03	1073.9	137.5	1056.9	99.7	0.443	20.40	129.6
0.04	1073.9	137.5	1061.4	98.6	0.436	15.80	129.8
0.10	1073.9	137.5	1068.1	102.4	0.414	5.83	133.2
0.20	1073.9	137.5	1070.2	109.9	0.412	3.68	136.1
0.30	1073.9	137.5	1070.4	118.9	0.420	3.52	138.9
0.40	1073.9	137.5	1070.0	126.7	0.430	3.88	141.4
0.50	1073.9	137.5	1069.5	132.5	0.437	4.38	143.4
0.60	1073.9	137.5	1069.0	136.8	0.440	4.88	145.2
0.70	1073.9	137.5	1068.6	140.2	0.440	5.34	147.0
0.80	1073.9	137.5	1068.2	143.0	0.438	5.75	148.7
0.90	1073.9	137.5	1067.9	145.0	0.437	6.04	150.0
L = 2							
0.01	1074.1	136.1	1039.6	106.0	0.451	34.20	130.3
0.03	1074.1	136.1	1052.1	99.9	0.436	21.70	130.0
0.04	1074.1	136.1	1056.6	99.2	0.429	17.20	130.4
0.10	1074.1	136.1	1071.7	98.8	0.410	0.88	130.9

Table 6. Results of Exponential Smoothing: Correlation Between Actual and Predicted Demand, and Standard Deviation of Forecast Errors (continued)

Weekly, Base = 3

	$\bar{X}_A$	σ_A	$\bar{X}_P$	σ_P	r_{AP}	$\bar{X}_Z$	σ_Z
0.20	1074.1	136.1	1074.0	105.1	0.400	0.07	134.6
0.30	1074.1	136.1	1074.6	113.2	0.381	-0.58	140.0
0.40	1074.1	136.1	1074.9	120.1	0.359	-0.84	145.7
0.50	1074.1	136.1	1075.0	125.7	0.333	-0.98	151.4
0.60	1074.1	136.1	1075.1	130.6	0.306	-1.04	157.2
0.70	1074.1	136.1	1075.1	135.2	0.281	-1.04	162.7
0.80	1074.1	136.1	1075.1	139.4	0.261	-1.01	167.5
0.90	1074.1	136.1	1075.0	142.7	0.247	-0.97	171.1
L = 3							
0.10	1071.3	138.0	1064.2	104.2	0.368	8.90	139.1
0.20	1071.3	138.0	1064.6	112.8	0.327	6.70	146.9
0.30	1071.3	138.0	1064.9	123.2	0.308	6.40	154.1
0.40	1071.3	138.0	1064.9	133.5	0.299	6.40	160.7
0.50	1071.3	138.0	1064.8	142.1	0.293	6.50	166.5
0.60	1071.3	138.0	1064.7	148.8	0.287	6.60	171.5
0.70	1071.3	138.0	1064.6	154.1	0.280	6.70	175.7
0.80	1071.3	138.0	1064.4	158.1	0.274	6.80	179.1
0.90	1071.3	138.0	1064.3	160.8	0.269	7.00	181.6

Table 7. Observed Monthly Demand, Predicted Demand, and Forecast Errors for Series
$L = 1$, $B = 1$, $\alpha = 0.001$

Month	Actual Demand	Predicted Demand	Forecast Error
1958			
April	4757	4966.5	-209.5
May	5103	5099.1	3.8
June	4579	4093.3	485.6
July	5363	4815.3	547.6
August	4565	4217.3	347.7
September	4480	4528.0	-48.0
October	4964	4730.0	234.0
November	4660	4109.2	550.8
December	3962	3800.1	161.9
1959			
January	4645	4678.0	-33.0
February	4689	4409.9	279.1
March	4700	4416.4	283.6
April	4822	4762.4	59.6
May	4749	5108.9	-359.9
June	4674	4583.7	90.3

Time Span of Forecast: 1 month
Base Period: Same Month of Previous Year
Smoothing Constant: 0.001
Correlation Coefficient of Actual and Predicted: 0.721
Standard Deviation of Error: 258.9

Table 8. Observed Monthly Demand, Predicted Demand, and Forecast Errors for Series
$L = 1$, $B = 1$, $\alpha = 0.001$

Month	Actual Demand	Predicted Demand	Forecast Error
1958			
May	5103	5099.6	3.4
June	4579	4093.3	485.6
July	5363	4814.2	548.8
August	4565	4216.3	348.7
September	4480	4527.4	-47.4
October	4964	4730.2	233.8
November	4660	4108.8	551.2
December	3962	3799.1	162.9
1959			
January	4645	4677.8	-32.8
February	4689	4409.9	279.1
March	4700	4415.9	284.1
April	4822	4761.8	60.2
May	4749	5108.8	-359.8
June	4674	4584.3	89.7

Time Span of Forecast: 2 months
Base Period: Same month of previous year
Smoothing Constant: 0.001
Correlation Coefficient of Actual and Predicted: 0.743
Standard Deviation of Error: 247.9

Table 9. Exponential Smoothing Results--Weekly

Time Span of Forecast: 1 week
Base Period: 3 weeks
Smoothing Constant: 0.02
Correlation Coefficient of Actual and Predicted: 0.457
Standard Deviation of Forecast Error: 130.2

Week Beginning	Actual Demand	Predicted Demand	Forecast Error
2-3-58	1176.0	1176.3	-0.3
2-10-58	1103.0	1193.4	-90.4
2-17-58	1034.0	1185.5	-151.5
2-24-58	1013.0	1171.6	-158.6
3- 3-58	952.0	1067.3	-115.3
3-10-58	966.0	1052.4	-86.4
3-17-58	994.0	1032.5	-38.5
3-24-58	1187.0	1051.7	135.3
3-31-58	1169.0	1044.4	124.6
4- 7-58	994.0	1103.2	-109.2
4-14-58	1163.0	1121.8	41.2
4-21-58	1076.0	1191.0	-115.0
4-28-58	1168.0	1211.2	-43.2
5- 5-58	1237.0	1203.1	33.9
5-12-58	1206.0	1061.8	144.2
5-19-58	1148.0	994.6	153.4
5-26-58	1012.0	995.0	17.0

Table 9. Exponential Smoothing Results--Weekly (continued)

Week Beginning	Actual Demand	Predicted Demand	Forecast Error
6- 2-58	1144.0	1039.0	105.0
6- 9-58	1093.0	1046.1	46.9
6-16-58	1017.0	1021.3	-4.3
6-23-58	1129.0	929.2	199.8
6-30-58	920.0	939.2	-19.2
7- 7-58	1132.0	995.9	136.1
7-14-58	1338.0	1151.9	186.1
7-21-58	1293.0	1119.7	173.3
7-28-58	1347.0	1125.0	222.0
8- 4-58	893.0	1077.2	-184.2
8-11-58	1143.0	1034.7	108.3
8-18-58	1176.0	953.6	222.4
8-25-58	882.0	909.3	-27.3
9- 1-58	955.0	1007.4	-52.4
9- 8-58	989.0	1104.7	-115.7
9-15-58	1091.0	1186.1	-95.1
9-22-58	980.0	1149.0	-169.0
9-29-58	1154.0	1138.5	15.5
10- 6-58	1126.0	1120.9	5.1
10-13-58	1153.0	1051.9	101.1
10-20-58	1067.0	1026.9	40.1

Table 9. Exponential Smoothing Results--Weekly (continued)

Week Beginning	Actual Demand	Predicted Demand	Forecast Error
10-27-58	1074.0	1066.0	8.0
11- 3-58	1169.0	1069.4	99.6
11-10-58	1192.0	1034.9	157.1
11-17-58	1233.0	933.8	299.2
11-24-58	921.0	1035.3	-114.3
12- 1-58	1049.0	978.5	70.5
12- 8-58	787.0	952.1	-165.1
12-15-58	950.0	771.6	178.4
12-22-58	592.0	774.0	-182.0
12-29-58	1122.0	859.1	262.9

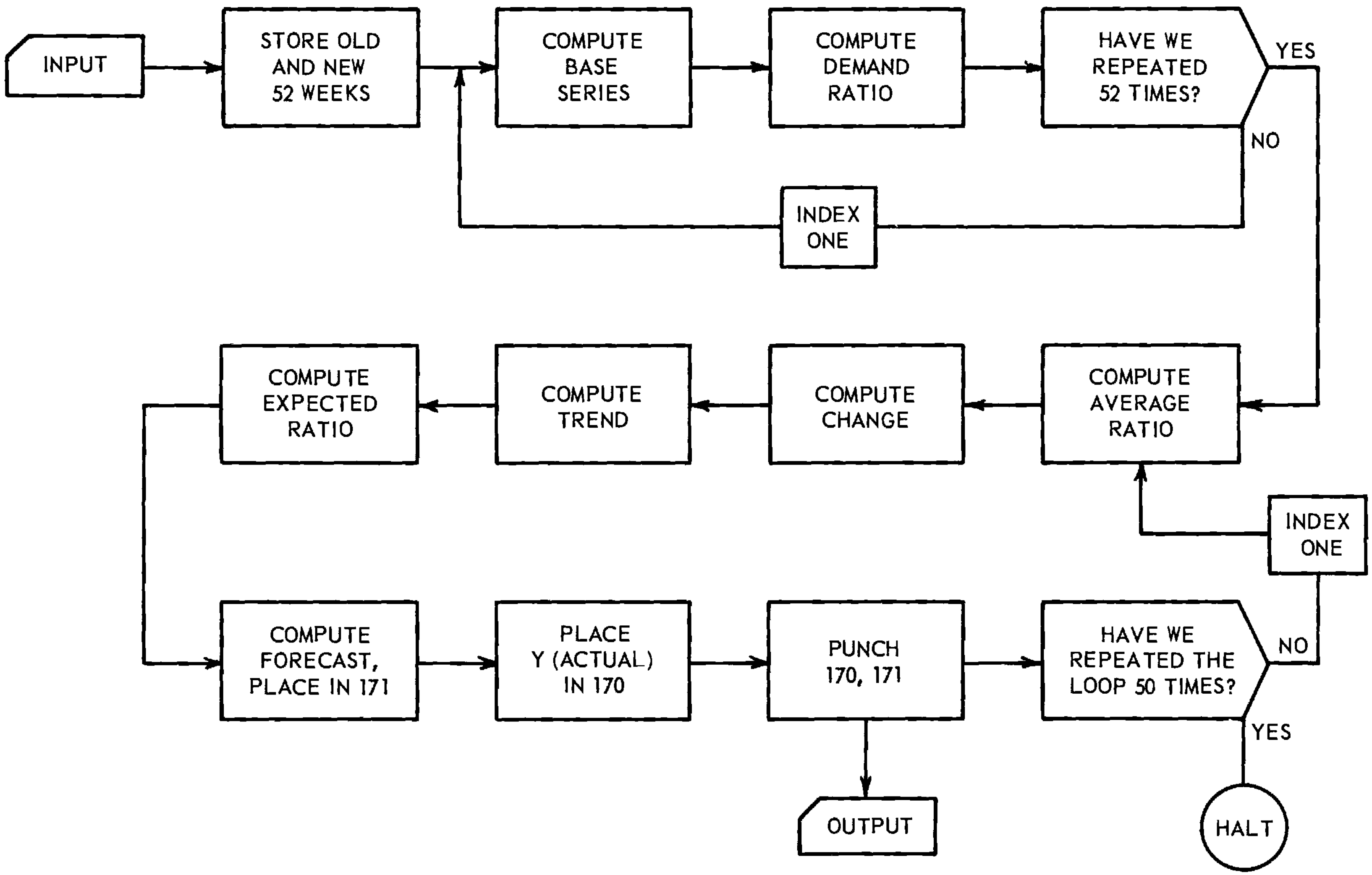

Figure 13. Flow Diagram of IBM 650 Program for Exponential Smoothing Method, by Weeks.

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PROGRESS REPORT

(January 1959 - June 1960)

by

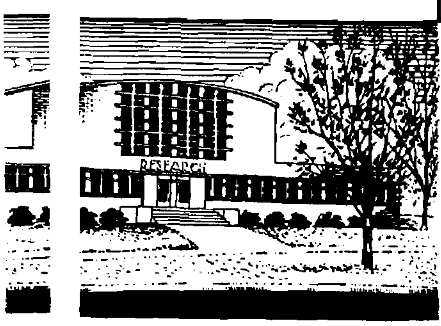
Harold E. Smalley, Ph.D.
Principal Investigator

June 1960

"Disposable versus Reprocessed Hospital Supplies"

USPHS GRANT #GN-5968

PROJECT BULLETIN NO. 6



Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia

Disposable versus Reprocessed Hospital Supplies

PROGRESS REPORT

(January 1959 - June 1960)

by

Harold E. Smalley, Ph.D.
Principal Investigator

PROJECT BULLETIN NO. 6

Engineering Experiment Station Project #B-158, B-178

This investigation is supported in part by a research grant (GN-5968: "Disposable versus Reprocessed Hospital Supplies") from the Division of General Medical Sciences and the Division of Nursing Resources of the United States Public Health Service Harold E. Smalley, Ph.D., Principal Investigator.

June 1960

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Dr. Rocker T. Staton, Assistant Dean, College of Engineering, Georgia Institute of Technology.

Identification and Aims

Project B-178 is a continuation of Project B-158 supported by National Institutes of Health Grant #GN-5968: "Disposable versus Reprocessed Hospital Supplies." This project was activated on January 1, 1959 and is to continue through December 31, 1961 under terms of the original grant from the Division of General Medical Sciences and the Division of Nursing Resources of the United States Public Health Service.

The specific aim of this project is to develop a practical decision system for determining the relative economic feasibility of disposable and reprocessed supply items for hospitals. This study constitutes the first phase of an investigation of decision alternatives and their relation to hospital supply costs. The project is organized in the School of Industrial Engineering of Georgia Institute of Technology through the Engineering Experiment Station and is being conducted in cooperation with Emory University Medical Center and hospitals in the Atlanta area. The approach to the overall investigation is divided into four parts:

1. Determine the cost factors which govern the two types of supply items.
2. Determine the relationship of cost factors to the two types of supply items.
3. Determine a hypothetical decision system.
4. Test the hypothetical decision system through evaluation and revise the system as required.

A continuation study, while not being a part of the immediate study, will be devoted to an investigation of extensions of the decision system for possible application to other procurable supply items. This will be followed by an investigation of extensions of the decision system for possible application to the procurement of other resources, such as materials, equipment, and labor, and to other broad management decisions involving choices between alternatives. (See Project Bulletin No. 1, "Tentative Plans for a Study of Hospital Cost Systems," Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia, January 1959.)

Organization

The research project is organized under the direction of the Principal Investigator and is being conducted by him and an interdisciplinary research team. This team includes several industrial engineers, a registered nurse, a social psychologist, several graduate research assistants, student assistants, secretaries, and periodic assistance from consultants. The original plan for a full-time team leader (a research economist) has not materialized. Plans are being made to consolidate findings to date and to project studies for the remaining eighteen months, using the research economist as a consultant. These revised plans will emphasize the use of full-time staff people supported by several key consultants. The Local Steering Committee has met several times and has been helpful in identifying problem areas and suggesting experiments. The National Advisory Committee met in May of

1959 in Atlanta. (See Project Bulletin No. 2, "Proceedings of National Advisory Committee Meeting," Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia, May 16, 1959.) A second meeting of the National Advisory Committee is planned for the latter part of October 1960.

Specific Projects

The approach toward the attainment of the overall objective of the research is the pursuit of a number of related projects, each under the responsibility of a project leader. In the paragraphs to follow the progress on each of these projects is related.

1. Bibliography.--Considerable work was done on consolidating previously compiled references and devising a system of classification during the first few months of the grant period. An abbreviated bibliography was compiled and published in August 1959. (See Project Bulletin No. 3, "Bibliography," Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia, August 1959.)

In September 1959 this project was referred to the nurse member of the team for expansion and maintenance. The objective of the bibliography project was to make available ready references concerning disposable and reprocessed hospital supply items as well as important works concerning applications of industrial engineering to hospitals. Also included are examples of in-service methods improvement activities and articles of a general nature dealing with hospital costs, quality of care, and other administrative matters pertinent to this research.

All references were entered upon McBee cards and were filed according to four major classifications with sub-classifications of each. A project bulletin is being prepared and will contain approximately 1,000 listings. This publication should be completed in August 1960.

The bibliography is being maintained by systematic additions. It is planned that supplemental bibliographies will be issued annually for the life of the project.

2. Classification of Disposable Items.--The objectives of this study are to determine which hospital supply items are generally available as disposable products, to classify these in some useful scheme, to determine which supply items deserve first consideration by the project, and to suggest which items or classes of items deserve to be included in final decision models. Results indicate that gloves, needles, and syringes should be studied first. A report on this study includes a priority listing of other supply items.

3. Inventory Policies and Costs.--Several specific studies have been done in the area of inventory policies and costs. One of these was a master's thesis entitled "Development of an Inventory Model for Hospital Supplies." (See Project Bulletin No. 4, "Development of an Inventory Model for Hospital Supplies," Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia, March 1960.)

Another study, also a master's thesis, was entitled "Forecasting the Demand for Hospital Supply Items." (See Project Bulletin No. 5, "Forecasting the Demand for Hospital Supply Items," Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia, March 1960.)

A third study attempted to evaluate the practicability of the methods suggested in Scientific Inventory Control by J. Everett Welch. This study was carried out at Emory University Hospital by undergraduate students under the supervision of a faculty member in the School of Industrial Engineering. The results were found to be inconclusive.

Several preliminary studies were undertaken concerning decision rules for aggregate supply items and inventory policies with their resulting costs. These projects were decelerated last February due to a shortage of staff time.

A study of demand distributions has been under way for several months, and this information is being tabulated for use in several phases of the overall project.

It is anticipated that this series of studies relating to inventory will be understood and appreciated more by the industrial engineer and those engaged in operations research than by health oriented people in the field of hospital administration. It is not the intention of the project staff to sacrifice scientific principles nor sound research methodology in the interest of communicating readily with decision makers in the hospital. However, the project staff does appreciate the need for interpreting study findings in such a way that the decision system eventually developed will have practical application. To accomplish this purpose, an attempt will be made to write a practical version of findings in this series of inventory studies for publication by August 1960.

4. <u>Methods Classification and Work Measurements</u>.--The objective of this project is to identify the methods used and the corresponding standard times to process supply items. The supply functions are being described according to a system of classification. By the end of June,

times and descriptions will be obtained for gloves from Emory, Grady, St. Josephs, Crawford Long, and Piedmont Hospitals. This data will be analyzed before other items are studied.

Extensive data on work measurements are being compiled so as to approach the problem of work times and costs associated with supply items. This phase is concerned with a microscopic approach which hopefully will synthesize costs of processing and handling items in the hospital.

As a kind of replication of the work measurement approach, a work sampling study is being done to obtain various percentage allocations of different supply items in the central supply of Emory University Hospital. A secondary purpose is to obtain normal times for performing various tasks associated with the different supply items. Additional observations may be required pending an analysis of the raw data. This study may be extended to include other hospitals.

As a further replication of the work measurement study and to attempt a "break through," a project is being done on macro-measures. Results to date on this attempt are encouraging but inconclusive.

Another significant part of the methods classification study involves the classification of hospitals according to their methods of performing certain basic supply functions. This project involves the determination of the basic functions, followed by an investigation of how these functions are performed in different hospitals. To date, three separate sets of definitions have been derived, one for needles, one for gloves, and one for syringes. This has necessitated visits to six hospitals in the Atlanta area. After the definitions were refined, the next step involved returning to each hospital and classifying them. To date, three hospitals have been classified and the results are tabulated on a master control chart developed for this purpose. Yet to be done are the classifying of the remainder of the hospitals in the Atlanta area and as many other hospitals as may be accessible. A progress report is due July 1, 1960.

To supplement the work of project personnel, several term projects have been done by classes in the School of Industrial Engineering. The results of these studies are being reviewed for possible inclusion in the study proper.

5. Emory Student Nurses.--The objective of this study is to assist graduate nursing students interested in investigating aspects of the research relating to quality of care, the influence that patients and nursing personnel may bring to bear upon the decisions to purchase supplies and equipment used in hospitals, and certain other intangible or unmeasurable facets of the decision system. This project has been in progress for some time with three nurses interested in making studies along these lines. To date, one nurse is actively engaged in gathering data. The other two nurses were unable to select a problem that would meet the requirements of both Emory University School of Nursing and Project B-178.

6. Preliminary Cost Models. The purpose of this project was to ascertain the items of models which would seem to be necessary in the overall cost analysis of disposable versus reprocessed supply items. The work

done on this subject is interesting and may be helpful later. The study terminated with a progress report.

7. Human Factors.--Various studies dealing with human factors and intangible costs are being planned under the general supervision of the social psychologist consultant.

The Future

After a relatively slow start early in 1959, the project staff was gradually assembled and specific studies have been undertaken as indicated above. As significant results are forthcoming, periodic reports will be published as project bulletins through the Engineering Experiment Station.

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Thomas J. Hall, M.S.I.E.
Tee H. Hiett, Jr., M.S.
Harold E. Smalley, Ph.D.

November, 1960

"Disposable Versus Reprocessed Hospital Supplies"

USPHS GRANT #GN-5968

Project Bulletin No. 7

Harold E. Smalley, Ph.D.
Principal Investigator

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia

7

"Disposable Versus Reprocessed Hospital Supplies"

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Engineering Experiment Station Project No. B-178

This investigation is supported in part by a research grant (GN-5968: "Disposable Versus Reprocessed Hospital Supplies") from the Division of General Medical Sciences and the Division of Nursing Resources of the United States Public Health Service, Harold E. Smalley, Ph.D., Principal Investigator.

November, 1960

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BIBLIOGRAPHY

Comprehensive Through 1959

OBJECTIVE

The objective of this bibliography is to make available ready references concerning disposable and reprocessed hospital supply items as well as important works concerning applications of industrial engineering to hospitals. Also included are examples of in-service methods improvement activities and articles of a general nature dealing with methods improvement in hospitals.

The bibliography index is maintained in the project office at the Georgia Institute of Technology for use by members of the project staff, the National Advisory Committee, the Local Steering Committee, and others.

This report (Project Bulletin No. 7) covers progress to date in compiling a comprehensive bibliography through December, 1959, including the lists published in Project Bulletin No. 3 dated August, 1959. This is one of several activities pertinent to the project's development of a practical decision system for determining the relative economic feasibility of disposable and reprocessed supply items for hospitals.

PROCEDURE

A systematic search of pertinent literature was undertaken to select references not covered by previous listings. In addition, references compiled and published in Project Bulletin No. 3 have been included in this bibliography. Hence, the current bulletin is referred to as a comprehensive listing through 1959.

Selected references from hospital, nursing, and engineering journals, hospital and nursing abstracts, theses, and related material were divided into four general classifications. All classifications were sub-divided with the exception of Classification IV, as explained later.

To facilitate the location of reference material in the several classifications, the McBee Keysort system was utilized. There are approximately one thousand index cards included in this bibliography file. The plan for maintaining the index includes a supplemental bulletin at the end of each successive calendar year for the duration of the project.

For the sake of clarity a description of the four classifications is placed herein at the beginning of the several listings.

CLASSIFICATION I; DISPOSABLE AND REPROCESSED HOSPITAL SUPPLIES

References in this classification relate to the use of disposable hospital supply items, the use of reprocessed items for which comparable disposable items are feasible, and comparisons between disposable and reprocessed items.

The classification contains an itemized sub-division of references relating to specific supply items. Two additional sub-classes list general and unclassified references to literature regarding hospital supplies.

1. General

This section contains references on the use of disposable and reprocessed items in general, without specific reference to any one supply item.

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CLASSIFICATION II; INDUSTRIAL ENGINEERING APPLICATIONS

References in this classification deal with illustrations of the specific application of industrial engineering principles and techniques to the solution of hospital problems. Specifically excluded from this classification are examples of methods improvements directly related to the use of disposable or reprocessed hospital supply items (see Classification I), as well as examples of methods improvement not utilizing industrial engineering techniques (see Classification III).

Classification II is sub-divided according to the specific industrial engineering principle or technique employed in the improvement. In order to gain comprehensiveness, certain management functions not normally considered an integral part of industrial engineering *per se* are shown as sub-divisions.

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CLASSIFICATION III; IN-SERVICE

METHODS IMPROVEMENT

References in this classification deal with examples of methods improvements in specific hospital situations using the in-service, or "do-it-yourself", approach. Specifically excluded are examples of improvements based upon industrial engineering approaches (see Classification II), as well as examples of methods improvements directly related to the use of disposable or reprocessed hospital supply items (see Classification I). Classification III is sub-divided into sixteen sections according to the hospital department, division, or area in which the improvement was made.

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PROCEEDINGS

of

NATIONAL ADVISORY COMMITTEE MEETING

October 31 and November 1, 1960

Edited by

Harold E. Smalley, Ph.D.
Principal Investigator

December 1960

"Disposable Versus Reprocessed Hospital Supplies"

USPHS GRANT #GN-5968

DJ

Project Bulletin No. 8

REVIEW
PATENT 1-17 1964 BY
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Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia

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"Disposable Versus Reprocessed Hospital Supplies"

P R O C E E D I N G S

of

NATIONAL ADVISORY COMMITTEE MEETING

October 31 and November 1, 1960

Edited by

Harold E. Smalley, Ph.D.

Project Bulletin No. 8

Engineering Experiment Station Project No. B-178

This investigation is supported in part by a PHS research grant #GN-5968 from the Division of General Medical Sciences and the Division of Nursing Resources, Public Health Service, Harold E. Smalley, Ph.D., Principal Investigator.

December 1960

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Sister Incarnata, Nursing Service Administrator

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P R O C E E D I N G S

of

NATIONAL ADVISORY COMMITTEE MEETING

October 31 and November 1, 1960

MONDAY MORNING SESSION

Present:

National Advisory Committee

Dr. Richard A. Dudek
Dr. Lillian M. Gilbreth
Dr. Daniel Howland
Dr. Hugo V. Hullerman
Dr. Ruth P. Kuehn

School of Industrial Engineering

Colonel Frank F. Groseclose

Engineering Experiment Station

Dr. Wyatt C. Whitley

Staff

Dr. John T. Doby
Dr. A. D. Joseph Emerzian
Mr. T. J. Hall
Mr. T. H. Hiett, Jr.
Dr. Jerry L. L. Miller
Miss Louelia Owen
Mrs. Mary Kate Rush
Dr. Harold E. Smalley
Mr. Howard W. Woods, Jr.

Others

Miss Helen Belcher
Mr. E. F. C. Fisk
Mr. Robert L. Zwald

Absent:

Dr. Charles Flagle
Mr. Matthew F. McNulty, Jr.

Illustration No. 1
COL. GROSECLOSE WELCOMING THE NATIONAL ADVISORY COMMITTEE

Illustration No. 2
DR. WHITLEY ADDRESSING THE GROUP

INTRODUCTION

Dr. Smalley: Welcome to the second meeting of the National Advisory Committee. We have hopes of picking your brains considerably while you are here. We want to take advantage of this opportunity and hope that we can stimulate you to such an extent that you will give us your ideas and evaluations. Before we get into the study, I would like to call on Col. Groseclose, Director of the School of Industrial Engineering, to say a few words on behalf of the School, Col. Groseclose.

Welcoming For School of Industrial Engineering

Col. Groseclose: Good morning, folks. We are delighted to have you all here and hope you enjoy your visit. I'm not sure which direction this weather came from so I don't know which one of you to blame for it. This is not normal I assure you. We are honored to have this project here; we are honored to have all you folks give your time to come here from busy schedules. I know what that means. A couple of Japanese gentlemen are waiting for me right now. I wont be able to stay too long with you this time. It's always a pleasure to have folks visit in this town and I must be a little partial. Dr. Gilbreth is our special guest.

Dr. Gilbreth: We've known each other the longest.

Col. Groseclose: That's right, and time has a way of offsetting everything else. There's nothing to take the place of it. There are too many important things to happen here and too many important people present for a fellow like me to take up your time. If there's anything at all that Harold Smalley can't do for you, he'll probably call on our supporting group at the Research Station represented here today by Dr. Whitley, and if you just get to the end of your rope why I'll just get you anything you want. I don't have it myself but I have friends. Delighted to have you and hope you have a nice stay.

Dr. Smalley: Thank you, Colonel. Now on behalf of the Engineering Experiment Station, the unit at Georgia Tech through which this project is administered, Dr. Whitley, Chief of Chemical Sciences Division, Dr. Whitley.

Welcoming For Engineering Experiment Station

Dr. Whitley: I'm delighted to add my expressions of welcome, particularly to you people who've come to visit us from out of town and hope that you find your stay here a very pleasant one. Somebody was commenting to me yesterday that he didn't know how much longer our pretty weather was going to last. He said it couldn't last much longer so it must have given out sometime during the night because when I got up this morning it was raining. As the Colonel says we don't know who to blame in this case. I hope that Dr. Smalley doesn't work you so hard today and

Illustration No. 3
DR. SMALLEY GIVING THE ADMINISTRATIVE REPORT

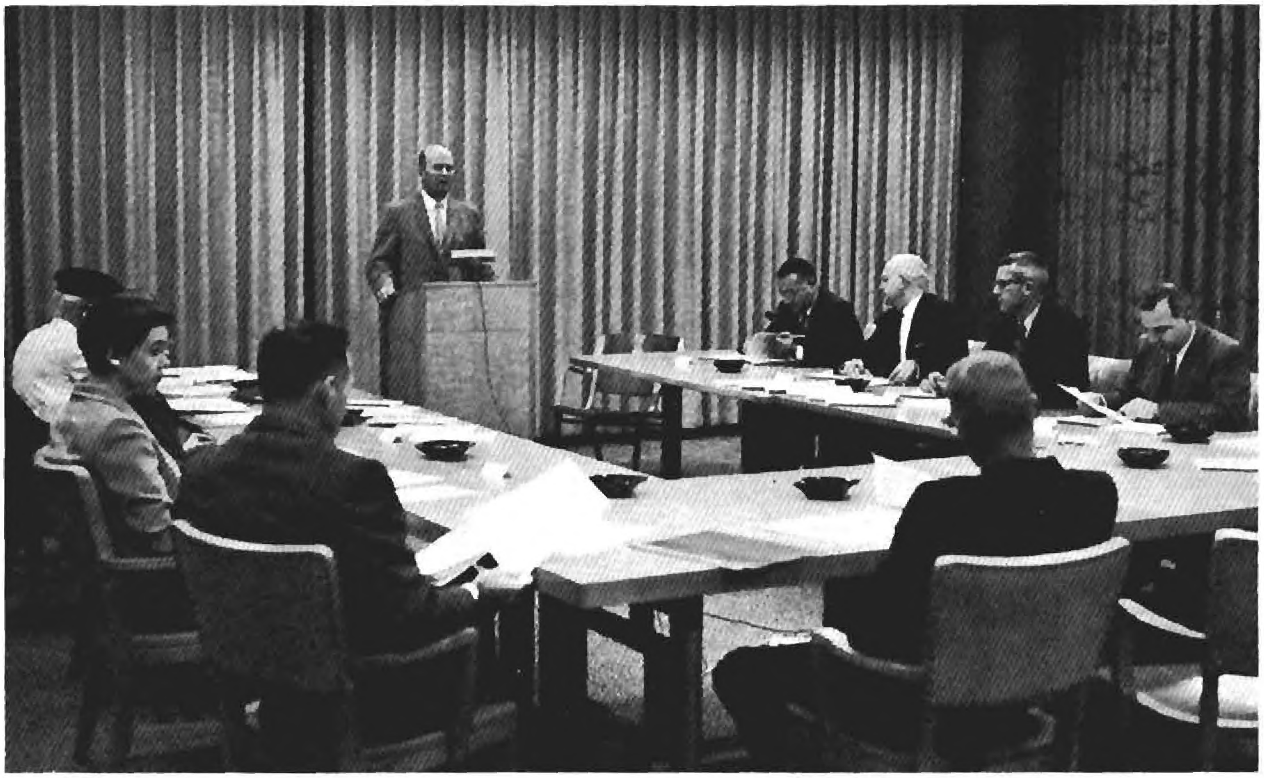


Illustration No. 4
DR. EMERZIAN, DR. HULLERMAN, DR. HOWLAND, AND DR. DUDEK

tomorrow that you don't have an opportunity to visit at least some of the nice places we have on the campus. We do have a few places on the campus we are quite proud of and the library is one of them. Actually our library is two libraries. We have a science and technology library on the third and fourth floors and we have a general library on the first floor. So we hope that you will take time during some break to spend a few minutes in taking a look at our library. There are a number of other places of interest, but we can't show you many places because I know you have a big job to do today and tomorrow. As Col. Groseclose says, if there is anything that we can do in order to help speed your work along or to cooperate with you in any way, we'll be happy to do so. I'm going to leave now because you people talk one language and Col. Groseclose and I talk another. He and I don't even talk the same language when we get into technical portions of our work. We'll be available if there's anything that we can do to help you along with your work. Thank you very much.

Program Preview

Dr. Smalley: Thank you Dr. Whitley. Now we would like to give you a preview of the program that we have arranged. While it looks formalized and formidable, we hope that this won't discourage you from dealing with these matters at length when the urge moves you. We purposely set up the program in this way so that we would be sure to cover all important topic areas during the two days that you will be with us. Please refer to the agenda on Georgia Tech letterhead which supercedes the previous ones that you got through the mail. (A preview of the agenda was covered here. See Illustration No. 6.)

Background of Project

Dr. Smalley: Most of you have been on the National Committee for some time and I wouldn't want to bore you with preliminaries which you know about, but for the benefit of those who are with us for the first time, and also to refresh all of us, I'd like to give you a brief summary on just what it is we're engaged in here in this project.

The roots of this project really go back to work in methods improvement, applications of industrial engineering to the health services industry generally, to hospital operations in particular, back to about 1951 when a number of studies were being done to explore the possibilities of methods improvement in hospitals, to consolidate some of the approaches which had been made for some decades as an integral part of hospital administration, nursing administration, and other activities. In 1952 I became involved in this movement when Mrs. Gilbreth and Mrs. Kuehn conspired to get a group from the University of Pittsburgh indoctrinated in the ways of work simplification and methods improvement techniques. Through a grant from a foundation Mrs. Kuehn sent some thirty-five nurses, nursing educators and nursing researchers, a few administrators, pharmacist and others to the University of Connecticut, when Dr. Emerzian and I were there together as colleagues. There we spent

Illustration No. 5

Agenda for National Advisory Committee Meeting

U.S.P.H.S. Project GN-5968

Monday, October 31, 1960

Morning Session, 9:00 a.m., Wilby Room, Price Gilbert Library

9:00 - Introductions . . . . Dr. Smalley
Welcoming . . . . Col. Groseclose, Dr. Whitley
Administrative Progress Report . . . . Dr. Smalley

10:00 - Bibliography Project . . . . . Miss Owen, Mr. Hall, Mr. Hiett

10:30 - Human Factors Project . . . . Dr. Doby, Dr. Miller, Miss Owen

Luncheon Session for Cooperating Hospitals, 12:30 p.m., ODK Room
Brittain Dining Hall

Afternoon Session, 1:30 p.m., Wilby Room, Price Gilbert Library

1:30 - Advertisement Project . . . . Miss Owen

2:00 - Processing Costs Project . . . Mr. Hall, Mr. Hiett, Mr. King

4:00 - Recess

Tuesday, November 1, 1960

Morning Session, 9:00 a.m., Wilby Room, Price Gilbert Library

9:00 - Inventory Policies . . . . Mr. Newberry
Inventory Carrying Costs Project . . . . Mr. Newberry
Inventory Order Costs Project . . . . . Mr. Hiett, Mr. Hall, Mr. Standard

11:00 - Academic Senate Meeting, Textile Auditorium

Luncheon Session for Local Steering Committee, 12:15 p.m., Section 4 of the Blue Room, Second Floor, Food Service Building, Emory University

12:15 - Welcoming on behalf of Emory University . Miss Helen G. Graves

Afternoon Session, 1:30 p.m., Section 1 of the Gold Room, Second Floor, Food Service Building, Emory University

1:30 - Decision System . . . . Dr. Emerzian

2:30 - General Discussion of Project . Dr. Smalley, Committee, Staff
Evaluation by individual Committee Members
Remarks . . . . Dr. Gilbreth

4:00 - Adjournment

two weeks in a full-time program on methods improvement. As this group from Pittsburgh went back to Pittsburgh, they did not stop but immediately set out to implement some of the developments at Connecticut. Among these were additional grants for other research projects, a cooperative effort with the Methods Engineering Council of Pittsburgh, cooperation with hospitals in that area and other units of the University. Concurrent with this, the American Hospital Association and other groups began to explore the feasibility of methods improvement. In 1954 I was asked to come to the University of Pittsburgh on a leave of absence to help with a study being done on nursing procedures, and at the same time, to continue the educational work of indoctrinating hospitals in the area with methods improvement philosophies and techniques and to work with some of the local hospitals in putting into effect some of these principals that had been talked about. After spending eight months in that work, I stayed on in the Office of the Vice Chancellor, with a close liaison with the School of Nursing. During that time a number of other projects developed at Pittsburgh, one of which was the Public Health Service sponsorship of a hospital bed project, to develop and evaluate features of the hospital patient unit. That project continued after I left Pittsburgh and we're expecting a final report any time now.

This project, the development of a decision system for determining the relative economic feasibility of disposable and reprocessed supply items, really came about as a casual conversation Dr. Dudek and I had with a representative of one of the "disposable" companies. We were appalled that apparently so little was known in hospitals and among manufacturers as to what the factors are that go to make up the rationale behind decisions. We were also anxious to test the applicability of certain industrial engineering approaches and philosophies to problems of "make or buy," <u>disposable</u> versus <u>reprocessed</u>, and all of this. Out of this, over a period of a year or more, a study was developed to be done by the group that was then engaged in the hospital bed project at Pittsburgh. After this project had been approved for support by the Public Health Service, a reorganization occurred in which I came to Georgia Tech. Dr. Dudek went to Texas Tech, Dr. Dinnerstein went to California, and Mrs. Gailani went back home to have a baby. We decided to leave the hospital bed project at Pittsburgh to be continued there but that we would request that the funds previously allocated for this be transferred to Georgia Tech. The Public Health Service went along with this and has been supporting this study since January of 1959. We are now approaching the end of the second year of a three-year grant by the National Institutes of Health.

Organization of Project

This project has been organized here at Georgia Tech along similar lines to our project organization at Pittsburgh. Characteristic of this organization is that we approach these problems in what is called loosely a multi-disciplinary approach through operationally, as Dr. Howland has often pointed out to us and we have learned ourselves, it doesn't always work just this way, but at least we have more than one discipline involved. We feel that there are problems and subtleties of an investigation of decision alternatives in this particular realm which transcend disciplines, that a social scientist just

Illustration No. 6
COL. GROSECLOSE CHATS WITH DR. GILBERTH;
MISS BELCHER AND DR. KUEHN SEATED

cannot go off by himself and develop this, an engineer cannot go off and develop it, an economist cannot, a nurse cannot, so that we've tried to bring to bear upon this problem a varied approach. Toward that end, we have organized a full-time staff of professionals supplemented by student assistants and graduate assistants, and in addition, we lean heavily upon our special consultants, Dr. Emerzian and Dr. Doby. Dr. Emerzian has been working with us almost from the beginning and has been fairly active in it. As a matter of fact he spent most of the past summer with us on a full-time basis and was quite instrumental in helping to determine just what has been done, where we now stand, what needs to be done, and in designing certain specific studies that we want to talk with you about today. We're still hopeful that Dr. Emerzian will be attracted by two or three standing offers he has to come with Georgia Tech. If he does not come, we are still expecting to use him as a special consultant, to make frequent trips here, and to spend all of his holidays and summers with us.

During the past year, we've been quite fortunate in making contact with and beginning to work with Dr. Doby of Emory. We value this association highly. Dr. Doby worked with us on a half-day a week basis for a number of months, and then during the summer, he and Dr. Emerzian worked together and designed an experiment which they'll tell you about later this morning. That particular project is moving ahead now. We have certain deadlines that we're going to try to hold to, and given any reasonable success, we will have that project ready to incorporate into the final report. We hope to have the final report done and submitted by fall a year from now. Shortly after this "human factors" project was developed, Dr. Doby got his colleague, Dr. Miller, to help out. Dr. Miller is responsible for the testing of the instrument and the coordination and the direction of the interviewing. Miss Owen, nurse member of our project staff, is working with Dr. Miller as well as one or two other projects.

Miss Owen joined us in September of last year on a full-time basis and spent all of last year working with us in cooperation with Emory University Hospital and with Emory University School of Nursing. She has had the bibliography project as one of her major responsibilities and has been a tremendous help to us in terms of being a built-in, health orientated resource. She has worked in gathering data, evaluating ideas, and many other things. Her experience with us has been quite diversified. She has done work sampling, for example, and has gone to teas with the School of Nursing, to give the extremes of the spectrum of her responsibilities. As we moved into more and more clinical testing and survey work, we worked out an arrangement with Miss Graves, Director of Nursing at Emory, that Miss Owen would join her staff and would share her time between Emory and us beginning September of this year. In many respects, this arrangement has made Miss. Owen even more valuable to us because she's a natural liaison with Emory Hospital. Miss Graves is vitally interested in our project and is doing everything that one could expect in terms of making resources available including some of Miss Owen's time.

We have had a number of graduate assistants do studies related to the overall project. Two Master's theses were done last year, both in the realm of inventory control. Both of these were published as project bulletins which you all received. We've had other lesser projects that didn't appear worthy of publication, but the results are being incorporated in our present work. We have had a number of class projects. Undergraduate students in industrial engineering have done term projects, have done special problem work on methods work in central supply, work measurement data, a technique of aggregate inventory control to some of the hospital and medical supply items in the hospital. We've been able to use these kinds of studies principally to explore in a preliminary sort of way some of the problems that we anticipate getting into. So far we have not been successful in actually using in any substantial way any of the results of student projects. This is one of the lessons we've learned in this project. We have found that you cannot use results of term papers or student projects and put any confidence in results.

For the past year and a half, we have worked toward an emphasis upon more full-time people supplemented by topnotch consultants, and lesser emphasis upon part-time people who share their time between our project and some other interest. We still have at least two people who do share their time and they're quite valuable to us, but our emphasis is shifting to the full-time basis. Mr. Hall, who got his Master's degree in industrial engineering here last year is with us full time. Mr. Woods, who is a Georgia Tech graduate of 1955, has been out since then gaining experience particularly in the areas in which we expect to accelerate our work. He has just joined us on a full-time basis.

Current Projects

At the present time, we have several projects in progress. During the summer these were defined in more precise terms and each one is headed up by what we call a project leader. This is a man who is responsible for seeing that study objectives are met. (A summary of each project was given here. See Illustration No. 7.)

The "Bibliography Maintenance" is our attempt to add to, maintain, and supplement the cross index McBee file system that we have developed for pertinent references. Miss Owen has been carrying the major responsibility and Mr. Hall has some responsibility for this also. At the present time, this work involves a relatively small amount of time in terms of searching literature and calling to the attention of project staff any pertinent published material.

Next, we have a project on "Inventory Policies." This is a project that Mr. Newberry has been engaged in for some time, and he'll be talking about this tomorrow morning. This phase of our studies of inventory costs is not regarded as "mainstream" in terms of pointing directly to our project objective. It is supplementary; it is complementary. We anticipate that this material will be included in an appendix in the final report. There are two reasons for including such an appendix. First, it gives a better understanding of the nature of inventory costs and the inventory function with respect to disposable and reprocessed items; it will shed a good deal of light on areas that, by and large, have been clouded for lack of information and lack of interest on

Illustration No. 7

List of Current Studies

Project Number	Title	Project Leader	Assisted By
6	Bibliography Maintenance	Hall	Owen Freeman
19	Inventory Policies (Appendix)	Newberry	Smalley
22	Processing Cost Study	Hall	King Woods
24	Human Factors	Doby	Miller Owen Hall Westermann
27	Planning (Decision Systems)	Emerzian	Smalley
28	Inventory Carrying Costs	Newberry	Standard
29	Inventory Order Costs	Woods	Standard Hiett
30	Advertisement Study	Owen	Smalley

storage problem and the ordering problem and the shortage problem. The second reason is that we expect this part of the project will expose areas that need additional investigation next year or the year after or in some years to follow.

Another phase of our inventory studies is "mainstream" to project objectives. We have divided this into parts. One we're calling "Order Costs," and Mr. Hiett will be reporting to us on that a bit later. In this, we are attempting to develop a method for determining the nature of order costs, their prediction, manipulation, and incorporation into the final decision system. The other part is on "Carrying Costs," a very tricky sort of an area in which we deal with questions like "What does it cost to hold an item?" "What is the lost interest on lost opportunities?" "What does it cost to invest your money in inventory items?" Also, "What about spoilage and pilferage, obsolescence and depreciation in storage?" "What about the cost of the storage area itself and things of that nature?" So our inventory studies have been divided into those three projects, two of which are "mainstream," one of which is rather incidental.

Our "Processing Costs" project is one in which, for a number of months, we were in the old "pick and shovel" era of going out and simply measuring work in hospital situations to determine how to classify the methods and to gather information. During the past summer, we brought this information together and determined just how much more of it we needed. Since about July, we've been putting a main effort on developing and manipulating work measurement information. Before Dr. Emerzian left in September, we had completed the compilation of work measurements for all processing steps for surgeon's rubber gloves, both the OR variety and the ward variety. This fall, we immediately set out to develop similar data for needles and syringes. Mr. Hall has the principal responsibility for this. He has had excellent assistance from Mr. King who is a graduate assistant with us. By the end of November, we expect to have total work measurement data on gloves, syringes, and needles, and will move from there into the building of some sort of standard data or model construction for use by an administrator or a decision maker in estimating and predicting costs.

Incidentally, for convenience we are using the term "administrator" in our project in two distinctly different senses. I hope it doesn't make for confusion. When we talk about an administrator we ordinarily think of the hospital administrator, but when we speak of an administrator on this project we mean a decision maker. This might be the hospital administrator, it might be the purchasing agent, it might be the head nurse, it might be the supervisor of central supply. When we talk about administrators, we're talking about decision makers. I hope that this won't be too confusing.

There is another study that, in a sense, was preliminary to the "Human Factors" project. Miss Owen did this work by searching the ads in magazines. She will tell you about this later.

These are the principal studies that we have underway now. It is anticipated that with our present staff and help from our consultants and meetings with our Local Steering Committee and perhaps another meeting of this group about a year from now, we will be in a position to satisfy the major objective of the project by the end of 1961. We will spend most of the next calendar year in finishing up the present studies and integrating these results into a total decision system of some sort so as to be a practical tool for administrators.

Objectives of Meeting

One of the things that we need is your opinion as to the extent to which validity testing will be important to us within our present scope. It looks now as if we are not allowing ourselves enough time, perhaps not any at all, for testing our system on any broad basis, either regionally or nationally. We need your opinion by the time we leave here as to just how important this is. Would it be more important to consolidate and perfect the decision system using a relatively limited sample in the Atlanta area, or would it be better to do a less thorough job with that and do some validity testing before this project expires.

We are particularly interested in areas of indecision. We have a lot of them, and we'll be free to talk about them, areas in which we are not sure what we ought to be doing. We're also interested in alternatives to current approaches. We have considered many approaches to certain problems and have embarked upon a certain approach. We're interested in your ideas as to alternatives that might be more fruitful or more efficient. We're also interested in your opinions with respect to studies beyond the present studies to achieve our project objective -- just what we need in addition to what we now have projected. We know what some of these are, but we want to get your ideas too. As is always the case with any good research, you can expect many projects to be generated by one. We are aware and want you to be conscious of the identification of fruitful areas of investigation which could come as extensions to this project or as some tangetial offshoot of this project. I wonder if there are any reactions or questions at this point before we move on?

Modus Operandi of Meeting

To make sure that we don't have you sit here for two days and merely listen and have us pass up the chance of getting information from you, we are purposely planning the sessions so that about half the session will be information-giving and about half would be information-receiving. Each one of the project leaders will be expected to limit his presentation to about half the allotted time, at which time we will be ready for discussion, questions, reactions and so on.

Generally speaking, our purposes here are to fill you in on the background for the project, to report to you what we have been doing, to consider the questions or comments which you have about what we've been doing, to form some sort of appraisal or evaluation as to where we now stand, to help us perfect the studies we now have in progress, and to help us identify and define in some way the studies that need to be done beyond what we're now doing. If we can do part of this, we'll be happy with the result. We're hopeful that our project leaders will tell you in each case what is the purpose or objective of the particular study they are working on, how it fits into the overall project, how it's being pursued, and what the present status is. In this way, you'll be in a position to react to it.

Project Resources

I would like to remind you as to where we stand organizationally, and then we'll move on to the research work. This is a U.S. Public Health Service grant to me as Principal Investigator, with Georgia Institute of Technology, Engineering Experiment Station, as the institution through which the project funds are administered. The study is being done in cooperation with Emory University Medical Center and hospitals in the Atlanta area. We also have a close liaison with the Georgia Hospital Association and, by virtue of my membership on the A.H.A.'s Committee on Methods Improvement, we have a close liaison with them.

Important resources are the two major advisory committees, the National Advisory Committee and the Local Steering Committee. There are two members of the National committee who were not able to come today. Professor McNulty, former chairman of the Committee on Methods Improvement of the American Hospital Association, is having meetings in Miami and is not able to be here but sends his regards and best wishes, and Dr. Flagle of Johns Hopkins was not able to come to these meetings either. We are certainly happy that the rest of you could come. Obviously, our greatest resources are our staff; our special consultants, Dr. Emerzian and Dr. Doby; and our other consultants, Dr. Miller, Miss Owen, and others. Miss Owen is called a consultant, but we still look upon her as a regular staff member of the project. Then we have other kinds of consultants in areas like hospital administration (Professor Klein), engineering education, nursing education, nursing research, and some others.

One other resource, an indispensable resource for this project, happens to be the excellent cooperation we've been able to get in local hospitals. Emory University Hospital is really our main base of operations, in terms of not only intellectual resources, but also as a laboratory or data gathering environment, but in order to get hospital differences and to ascertain some of the other variables involved, we have been working actively in six other hospitals. (The hospitals were mentioned by name. See Illustration No. 8.) You may wonder why we go that far away. (To Birmingham to include University Hospital and Hillman Clinic.) There are two or three reasons for this. One is that we were instrumental in helping them recruit a full-time industrial engineer about a year ago and we were anxious to work with them in helping to implement that program. As a result, we've been able to use in our research a good deal of what the industrial engineer has done in University Hospital. We've found this cooperative effort to be mutually advantageous. Also, Miss Mary Edna Williams who was with us from the very beginning at the University of Pittsburgh, joined University Hospital as the Director of Nursing about a year ago. And too, Mr. McNulty (Administrator), is a member of this Committee. Thus, we've included them in our local sample. Are there any questions or comments?

Illustration No. 8

List of Participating Hospitals

Crawford W. Long Memorial Hospital

Emory University Hospital

Georgia Baptist Hospital

Grady Memorial Hospital

Piedmont Hospital

Saint Joseph's Infirmary

University Hospital and Hillman Clinic
Birmingham, Alabama

Discussion

Dr. Gilbreth: I would like for you to speak a little more on the definition of "administrator." Seems to me a serious thing to change the meaning.

Dr. Smalley: Yes, well I could say a word or two by way of amplification and then perhaps Dr. Doby and Dr. Miller will clarify the meaning for their own purposes.

Unfortunately in the general realm of administration and management there is still considerable confusion about terminology. There is a school of thought, for example, that says administration is policy formulation, hence, an administrator would be a policy maker, and that management is policy execution. So, "hospital administrator" would be a misnomer, he is really a "hospital manager." But on the other hand, there are people who would turn that around and say, that management is top management--policy formulation - and that administration is administering the affairs of things. So, immediately we get a contriduction. Now, complicating this is the fact that we realize that policy is not only made at the top level, but policy in some respects is made at every level, even the lowliest supervisor or foreman in a factory makes policy. In that sense he's an administrator under that definition, and also we realize that policy execution is exercised at many levels. Now we defined administrators in Dr. Doby's project for a specific purpose and when we use it in that context we mean just one thing. By "administrator," we mean non-users who have something to say about supply decisions. This would include the hospital administrator, his assistant, maybe the Medical Chief of Staff, the director of nursing, a head nurse, a purchasing agent, anyone who conceivably would exercise a significant influence in the decision with respect to supply items. An "administrator" for purposes of this study should not be confused with the "hospital administrator," a position on the organizational chart. Now perhaps I confused things more than I clarified them, but maybe Dr. Miller and Dr. Doby can straighten us out when they talk about their project.

Dr. Doby: I think you did a good job there. It's not confusing to me at at least.

BIBLIOGRAPHY PROJECT

Dr. Smalley: I'd like now to call on Miss Owen who will tell us about the Bibliography Project. Miss Owen, it's all yours.

Miss Owen: The Bibliography Project was begun before I came here last September. We used as a starter a number of 3 x 5 annotated cards that Dr. Smalley brought with him from the Pittsburgh project. We began to collect articles and published Bulletin No. 3 in August, 1959. I think you have received it. The classification system has been changed in continuing it. We did feel that there would be a need for it and there has been. There have been many calls on us for references in this field which we have been able to supply. In continuing this bibliography, we decided to go back to January 1, 1957, and to make it inclusive through December 1959. The results of that survey and collection of items have been published in Bulletin No. 7 and that's what I want to talk about.

We reorganized the original method of classification and divided our material into four classifications. We bought a McBee filing drawer and punch and also a needle to needle out our required cards in the specific classifications and set to work on it. As Dr. Smalley has indicated, this new bulletin is the result of all of the work that we have been doing and we have revised it many times. The plan has been to search the literature of the hospital magazines, nursing magazines, industrial engineering sources, engineering reports, and other publications. We have amassed quite a bit of material.

The value to the project we don't feel is direct, but it is a service tool and as I have mentioned before, we have used it as such to supply needed information to others in the community, the nursing students on the graduate level at Emory have used it extensively. There have been methods analysts in the Army with many requests coming to us for literature, there have been administrators and many others have written in and asked for certain publications which we have been able to supply.

Now the McBee file and the four classifications I think I can best describe by showing you. We divided it into four classifications. No. 1 being the disposables. We didn't judge these articles whether they were good or not so good, but included them as articles that had been written about disposable supplies. The second classification was the industrial engineering articles found from many sources. We have searched many sources for this classification. The third classification is what you'd call "do it yourself in hospitals." It's in-service methods improvement as hospitals themselves have experimented with improvements, for example, "We like this in our hospital," "This works fine," "We have saved money," "We've saved people," "We've saved time," etc. Classification 4 is a general classification with no sub-heading under it and to me has been rather a catchall, but we have tried to limit it to articles that would not have any special hospital department, but is applicable to the administrator or to the chief of nursing service, to other people in the hospital but will apply all over.

If you will turn to Bulletin No. 7, we will go into it. (See Illustration No. 9).

Illustration No. 9

Bibliography Classifications

CLASSIFICATION I: DISPOSABLE AND REPROCESSED HOSPITAL SUPPLIES

1. General

2. Unclassified

Sub-Classification by Item:

3. Syringes and Needles
4. Enemas
5. Containers
6. Wearing Apparel
7. Packs and Wraps
8. Food Service Items
9. Sheets and Drapings
10. Towels, Sponges, and Dressings
11. Gloves

CLASSIFICATION II; INDUSTRIAL ENGINEERING APPLICATIONS

1. General

2. Unclassified

Sub-Classification by Technique:

3. Cost Accounting
4. Engineering Economy
5. Equipment Design
6. Inventory Control
7. Layout
8. Materials Handling
9. Motion Economy and Methods
10. Personnel
11. Production Control
12. Purchasing
13. Safety
14. Statistics
15. Wage Administration
16. Work Measurement
17. Work Sampling
18. Work Simplification

CLASSIFICATION III; IN-SERVICE METHODS IMPROVEMENT

1. General

2. Unclassified

Sub-Classification by Hospital Department:

3. Business Office
4. Central Supply
5. Dentistry
6. Food Service
7. Housekeeping
8. Lab & X-Ray
9. Laundry
10. Maintenance
11. Medical Practice
12. Medical Records
13. Nursing
14. Operating Room
15. Out Patient
16. Pharmacy
17. Ward Unit

CLASSIFICATION IV; HOSPITAL AND MEDICAL ADMINISTRATION

The value of this project is not direct, but we hope it will be a service to others; we know it's going to be a service to us. Our plan for the future is to survey the literature that comes in each month, make annotated cards of the articles which we want to include in our bibliography, and at the end of each year, to print a supplemental bibliography including that year's collection of works in the same manner in which we have published Bulletin No. 7. In that way we hope to keep current with what is going on, what is being written, what other people are doing, and have at hand a source of references for our use and for others.

We have in the Project office an additional reference from the Hospital Abstract Service of the Physicians Record Company which duplicates some of the things that we have selected but includes many others also. It's an accumulative monthly index, and we cross reference with it. We also have monthly publications from the libraries here on the campus which are sent to us regularly. I think that about concludes what we have done. Joe, if there's anything that you'd like to add, I'd like for you to do it right now.

Discussion

Mr. Hall: I think not, Lou, you've covered it very well.

Miss Owen: Incidentally, Mr. Hall has been responsible for the industrial engineering section of the bibliography which I proceeded to really ruin the first time we went through it, because not being familiar with I.E. terms, I really got them in the wrong places. Would anybody else like to ask questions or make comments or suggestions?

Dr. Smalley: Could we see some of the cards?

Miss Owen: Yes.

Dr. Smalley: Miss Owen mentioned that we had had some demand for information of this nature. I would like to add that at a meeting of the AHA's Committee on Methods Improvement, that committee decided that it would like to compile references for use by hospitals who wanted to go into methods improvement and wanted additional information. It is likely that we would work out a cooperative arrangement with them whereby we could make available to them the results of our compilations so that this work would not be duplicated. There'll be a meeting of this A.H.A. Committee in Chicago about the middle of November at which time this will come up for discussion. Also, hardly a week passes that we don't get inquiries from some hospital administrator or some nurse doing research or a study of some sort and they want to know what has been done in this or what has been the experience of this that and the other. We found this to be very helpful as a way of putting in the hands of these people clues as to how they might get on the track of what has been done. We don't use it very much in researching the literature for a particular study. Georgia Tech has a Technical Information Service which compiles bibliographies in specific areas. The latest of these was a bibliography they compiled for Dr. Doby and Dr. Miller on that project. This service is quite helpful if we're dealing with a technical subject or a technical tool and the researchers involved may not be familiar with the hospital literature. This is a service to let them know what hospital people have been doing about problems like this. Also, the researcher might be quite conversant with his own literature but not know anything about what's been written or done about problems of application or the environmental characteristics of the hospital. We can put them on the track of this either through our own source here or through the Technical Information Service.

Dr. Gilbreth: How far can you go in the international field?

Dr. Smalley: Well, I don't know. I think that's a good idea. We've done precious little in exchanging information with foreigners. I think it's too bad. Dick, you know when we were studying the hsopital bed we got some information about some of the Swedish beds. I think that there's almost an iron curtain between countries in communicating things of this sort.

Dr. Gilbreth: Now would be a good time to think about it because we have so many foreign students coming from every country.

Dr. Smalley: Now we did have on our staff a graduate assistant some time ago who is a national of Israel, and he made some inquiry of the UN's World Health Organization about this.

Dr. Gilbreth: I see you have a New Zealand reference, you have a Great Britain reference, so let's start with the English speaking people. But let's go beyond the English speaking people. I know there's a lot in Swedish and German.

Dr. Smalley: I think you've put your finger on the weakest part of the whole thing.

Dr. Gilbreth: Is there an international association of librarians? Who might become interested.

Miss Owen: I don't know. But, it would certainly be interesting to find out.

Dr. Gilbreth: I think it could be the first step.

Dr. Hullerman: Harold, does this (Bulletin) cover just hospital journals?

Dr. Smalley: The great emphasis is on that. I would suspect that there are fewer gaps in hospital literature than others. But there are other sources besides that. We'll find some of these (other hospital and medical periodicals) publications there, but not nearly as exhaustive in that realm as in the five major hospital magazines, the nursing journals, and the medical journals.

Dr. Hullerman: Coverage isn't good enough to indicate to the reader what magazines from 1957 to 1959 were thoroughly covered, is it? I mean, would there be an index of the magazines covered?

Miss Owen: No, there isn't an index of the magazines.

Dr. Smalley: Now this was started really for internal purposes, as a tool for ourselves, but the demand for it has become so great from outsiders that we find we use it more for that than anything else. We also subscribe to the Physicians Record Company Service and we get abstracts from them. On the cards, Miss Owen has been indicating, "For more information, see so and so." We do tie in that way.

Dr. Gilbreth: It's really an amazing piece of work.

Dr. Hullerman: I wonder if the Schools of Hospital Administration might find this of value.

Dr. Smalley: I would certainly think so.

Miss Owen: I would certainly think so too.

Dr. Hullerman: As I looked at it, I was thinking that it has certain uses that I can see tight away, particularly administrative residency projects in hospitals. It would be a little more helpful if you have really covered all of the items in Hospitals, for example. If there was an indication here, we wouldn't have to search the index on Hospitals or Modern Hospital. It could be quite time consuming.

Dr. Smalley: I appreciate that, Dr. Hullerman. We have just about come to the conclusion, though, that this bibliography work is not sufficiently pertinent to our main objective to use project resources to the extent that would be necessary to make it that kind of tool. I think that we ought to seriously consider the possibility of taking that on as a side project and support it separately and really do the kind of job you are talking about and the one that Dr. Gilbreth mentions of tieing in with foreign work as well.

Dr. Howland: You are asking for a complete literature search, Dr. Hullerman.

Miss Owen: But it would be a full-time job, I know.

Dr. Hullerman: What I was thinking was that if you do cover it, then you will not have to have somebody else look up those indexes in those journals.

Dr. Smalley: Now that could be done, but the implications of going on much beyond that are too time consuming and costly.

Dr. Emerzian: I suspect you've done this Harold. You really have done it.

Dr. Smalley: We may have done it but we are reluctant to say, yes, because we don't want to come out and say that we've covered everything that is pertinent in this magazine to this period, because we didn't approach it for that purpose.

Miss Owen: No, we didn't.

<u>Dr. Smalley</u>: And therefore I wouldn't be surprised that any of you could say, "Well, I know of an article. Let's see if it's here." And you find it's not. This wouldn't surprise me at all.

<u>Dr. Hullerman</u>: Well, your Section IV is such a broad section anyway, it would hardly count anyway. But the first three sections look like a fairly comprehensive index of interesting literature.

<u>Dr. Smalley</u>: Joe, do you have any reaction to this?

<u>Dr. Emerzian</u>: Well, the reaction at the moment is that I think Dr. Hullerman's idea is a very good one. I don't think that it would take too much more to cover what I think is bothering him.

<u>Dr. Hullerman</u>: Oh, it's not bothering me. It's just an idea for you.

<u>Dr. Emerzian</u>: Well, let's say that I think they would bother me if I were a researcher. "Is it complete, or isn't it?" Which journals did they cover? I think most of the works like this make a statement that the following have been covered. I think that's pretty standard and I don't think it would take too much more time to do this.

<u>Dr. Hullerman</u>: However, I would exclude Section IV because you have only a fraction of what you might put in there.

<u>Dr. Kuehn</u>: I see another use here. It seems to me that the supplements will be a good tool to look at in terms of trends and areas of study and concern; it could be a little profile which from the standpoint of the research group would be very helpful in relation to structuring new studies in the field.

<u>Miss Belcher</u>: I wonder how you selected the articles. Have you ever looked at any article and wondered, "Shall I put it in or not put it in?"

<u>Miss Owen</u>: Oh, Yes. Well, I will have to confess to being rather subjective in the selection that was made. I tried to use as a criterion of selection those articles that would fit into our methods improvement type of situation. Having been in methods improvement in nursing service for hospitals, I'll have to admit it colored it quite a bit. However, I did try to choose articles in education and those in other areas of nursing that might have some application for improvement in the actual care of the patient. I think I had the patient in mind, maybe too much, I don't know.

<u>Dr. Smalley</u>: I'm wondering, too, if what you, Miss Belcher, are asking is, "Were we mainly interested in making sure that it went in the category rather than making sure that everything being done was in that category. I believe it was the former. At least our intention was that it was appropriate for that category, when it came to our attention by one means or another, rather than making a conscious attempt to compile everything that had been done in that particular category. That's the reason that I observed a moment ago that I would not be surprised at omissions.

Miss Owen: Yes, that's right.

Dr. Hullerman: Wasn't that part of the value of this, that it is selective?

Miss Owen: I don't like that word, "selective" because---

Dr. Hullerman: You put something in and took something out?

Miss Owen: I guess you could call it "selection," but I don't like it to be called as a selective bibliography at all. It's really the literature that has been reviewed, the articles that came to our attention as being applicable to our project. That's actually what we did.

Dr. Emerzian: Well, then, you took them all?, all that you read?, all that you thought were applicable to this particular classification were included.

Miss Owen: That's right.

Dr. Emerzian: There was no evaluation on your part as to whether this was a good piece of work, or a mediocre piece of work. Is this correct?

Miss Owen: That's true.

Dr. Smalley: The reason we stayed clear of the "selective" adjective is that this connotes passing some value judgment as to its worth. We made no attempt to do this.

Dr. Dudek: Anytime that you make any selection, this will flavor your decision, so that the only way to include everything would be complete inclusion. The only way that you will have this is to have some central service, something like the American Hospital Association's putting out a bibliography service monthly, right? This was compiled basically for your own purpose.

Miss Owen: That's right.

Dr. Smalley: It's a biased sample.

Dr. Kuehn: It seems to me the problem would be in deciding whether it goes in or does not fit the category.

Miss Owen: This is very difficult.

Dr. Emerzian: There's a confusion in definition and not a confusion as to the quality of insertion or omission. And as I understand it, you included everything you saw and thought belonged in this category.

Miss Belcher: I was thinking it might be more useful to other people who don't know much about this project, in addition to listing the periodicals covered and to what extent they were covered, to say a little more about how you selected the references and how they were put into the various categories. I presume that you must have had a way to do it, and it might be more useful to someone else if they could understand the rather broad definition that you have used. This looks like a very complete list.

Miss Owen: That's a good suggestion.

Dr. Smalley: These are all very helpful comments.

Dr. Howland: And one other thing. We have talked with Miss Vreeland (USPHS). We have done something similar to this, that is, picking the ones we like. We also pick the references which might be appropriate by sending our cards or copies of our cards to her (someone in the USPHS library).

Miss Belcher: You send these to Edith?

Dr. Howland: We haven't done it yet. We are trying to get some workable mechanism for doing this, but maybe it should be somebody in your (Belcher's) office. The projects you are supporting could turn in their stuff to you for review.

Dr. Smalley: Give yourself a grant to do this.

Basic Grants for Research Groups

Miss Belcher: I'm not sure mentioning this at this time is appropriate, but if this project has just one more year to go, there is a question here as to what happens to this kind of thing at the end of that time. You have done a very complete useful job; at this time you can only be able to bring it up to date once. Then the question arises as to what we might do after 1961, because it would be too bad to have this die?

Dr. Kuehn: It certainly would.

Miss Belcher: I know this is a problem in several research projects that are being supported, and I have no ready answer for this. There are problems. I don't know whether you people have thought about that.

Miss Owen: Yes, we have, but we don't have the answer either.

Dr. Smalley: Well, I would say that you put your finger on one of the biggest wastes in a scarce commodity, namely, research know-how and research organization. This problem would be only incidental to allowing resources of groups, like Howland's group and Flagle's group and all the others, to expire for one reason or another; once you go to the tremendous, almost impossible, task of accumulating a nucleus of people and resources and environmental attitudes and contacts, and so on, that you don't dare let this go by the board, that you find ways of perpetuating it. Now we are not projecting ourselves beyond December of 1961 because we have no assurances that we have any support beyond that time. We're all optimistic that, by that time, we will have some good solid intentions with respect to extending the present project, or pursuing tangential results of it, or indeed, even going into another needed area of research for which we might have some competence to pursue. We had the same problem at Pittsburgh when we were about half way through the Bed Project, we wanted to pick up another project to maintain the momentum of the group, and I think the same problem applies everywhere. This bibliography is only one facet of that.

Dr. Kuehn: Excuse me, Hal, but I can hardly wait to get in on that because I think this is one of the terrific needs in all areas of health research. When you get below medical research, if we could get a basic grant, a system of basic grants, established for our good on-going centers, as we have basic grants for some of our hospital programs, and then some kind of a formula could be worked out to give a basic grant and then another formula applied for a specific grant, I think this is a tremendous need for the paramedical groups. I certainly would like to second that.

Dr. Smalley: Some of us may not be aware of just what a basic grant means.

Dr. Kuehn: I don't mean committed money against a specific research design, but rather a basic grant to support on-going research. I think that expecting a researcher to be under constant pressure to come up with specific designs may negate the possibility of what might evolve if they could think in a quiet atmosphere without pressure to produce something in X number of months. I think there are two ways to go on this and I would certainly like to be on record as supporting this need, particularly in the paramedical groups, a basic grant to be supplemented by specific grants for specific research designs. I think we need a grant.

Dr. Gilbreth: May I ask a question on that. I take it that you feel that something of the sort that a company like General Electric has for a certain group where no pressure is put on them, where they have everything they need, and at certain times their findings are looked over. But of course the first thing you have to have I think to get such a grant is people you can actually vouch for to have the background, training, and creative ability in this field. Once you get your project, then you can say, "We have such people."

Dr. Kuehn: Absolutely!

Dr. Howland: Something that bothers me too is trying to do a ten-year job in three. I would say that out of the three years, you spend a year and a half figuring out what you are going to do, and then you spend a year and a half getting ready for the next onslaught. In our group, it took us from January to March to get our report written and rewritten and a new proposal written and nothing got done research-wise. It's the old business of the granters making a decision about committing Type I and Type II errors. They want to make sure that nothing gets through that they don't know what they're squashing.

Dr. Hullerman: When do you want this time made available?

Dr. Kuehn: Well, it's my own theory of research.

Dr. Hullerman: Why do you want it"

Dr. Kuehn: I think that Hal's project; once he establishes the quality of his research; a few such areas over the U. S. should be supported with a basic grant that would help carry the organization of, say, 3 or 4 full time researchers.

Dr. Hullerman: It may be hard to convince people to give a grant for nothing tangible.

Dr. Kuehn: I don't think so.

Dr. Hullerman: At the end of a project like this, you ought to have 6 months, or a year, to think up new projects.

Dr. Kuehn: I think a national committee would have to establish some pretty good criteria (for on-going grants).

Dr. Hullerman: I'm concerned about the allocation of funds.

Dr. Kuehn: Well, I am, too.

Dr. Hullerman: Once you've taken off and you have proven that you can do it, you get an undesignated grant for a period of time.

Dr. Emerzian: It is a financial problem.

Dr. Smalley: Well, I think Dr. Howland has put his finger on a part of this, too, that's of practical importance when we are sitting on this side of the fence. Take our own situation, for example. If we don't want to see our group get away, and incidentally, with any hint that this might happen, the people are not going to wait until the end to leave. What they are going to do is have their eyes somewhere else a year or two before. Not only that, but you are not going to get people to come in who know they are to run out of support. So what we do, then, a year from the time the grant expires, is divert some of our precious resources that could otherwise be used to wrap up a project and get some good solid results drawn, we divert a good bit of that energy and attention to working up our proposal that will be due. You have a lead time, in some cases, of six months as a minimum.

Dr. Dudek: Dr. Hullerman suggested that you give this team so much money to come up with another idea, if they produce good results. But, you don't perpetuate it indefinitely.

Dr. Hullerman: If you have come up with a good project, as you said earlier, You're going to have 100 other good projects suggested by it. All right, you have a period of time, in which to produce a recommendation for further studies.

Someone: Yes, but what about funds?

Someone: Yes, but what about lost time, uncertainties, and continuity?

Dr. Hullerman: I can see that this might not be an impossible thing to achieve. On the other hand, a permanent sort of arrangement with basic "thinking" grants given to X number of centers would seem to me to be diluting the available resources very greatly for each of those Centers.

Dr. Howland: You do need thinking time.

Dr. Kuehn: You can lose the effectiveness though. It would be possible, by the middle of Project A, that you hit a tangent that isn't in your research design and then you are frustrated, with this one eye on the ball, getting your report in to Washington, and the effect of that report on your next grant. For over a year, you have a burning desire to go off on your tangent. Now there should be a few researchers of stature, who meet certain criteria that have been established, who should have this freedom of movement. I don't know how to get it in, but I think it is basic to research needed in the paramedical group.

Dr. Smalley: I think this is sound reasoning. As a matter of fact, when you think about it, isn't this the way you run a research team internally. You get confidence in this man and his ability and you leave him alone and let him do what he needs to do. You don't closely supervise individual researchers and I don't think, in this sense, you can closely supervise project groups around the country either.

Dr. Emerzian: An example of this is at Connecticut where a researcher recently received a 20 year grant.

Someone: That's interesting.

Dr. Hullerman: Yeah, but I don't like this.

Dr. Smalley: You could do it over blocks of time, perhaps, without committing yourself from now on.

Dr. Howland: The other extreme is what the Army does and that is just one year, and I just can't get anyone to work on a one-year basis. Our grant with the Public Health Service is two years. Everybody has got his bag packed and they are waiting.

Dr. Dudek: Some of the Air Force organizations, though, provide funds in an area. They will renew your grant with no strings attached to stay in this same area.

Dr. Howland: I think it's a matter of the timing.

Dr. Smalley: Well, perhaps we can come back to this later. We don't want to take too much of Dr. Doby's time. We've got a real interesting one coming up. Thanks so much. Now I would like to call on Dr. John Doby who may want to call on Dr. Miller and Miss Owen to tell us about their project. John.

HUMAN FACTORS PROJECT

Dr. Doby: Thank you Dr. Smalley. I suppose the reason for this study arose out of the basic grant objective which was to develop a practical decision system for determining the relative economic feasibility of disposable and reprocessable supply items. There is an implicit assumption in this design, tacit assumption you might say, that the economic cost factor is the major consideration if not the whole consideration in the decision-making process. This particular project was designed to test that assumption, that is, to see if there were other factors involved, and if so, what they are and to what extent they operate. The tentative title as indicated is "Human Factors Project." I, myself, with personal predilections prefer the title, "Behavioral Factors." For really that's what we are examining--behavioral characteristics and actions. Well, that's the reason for it.

I won't pretend to be exhaustive here this morning or complete in my presentation of the design. Dr. Miller will talk to you later and provide you with a picture of the operational phase of it. What I wish to do is try to give you an introduction to the problem and the rationale behind it, that is, the kind of thinking which underlies the formulation of the argument--what you might call the theoretical argument.

The problem simply stated as we see it is (1) to identify these non-economic factors, factors which enter into the decision-making process. What are these behavioral science factors? And, (2) to determine the relative weights which each organizational component assigns to these factors. By organizational component, we are referring to such units as the nursing unit, central supply, medical practice, and administration. We are using the term, "administrators" strictly in the sense Dr. Smalley indicated earlier. So then we have these two things: one, to identify behavioral considerations which enter into decision-making in regard to the alternatives, reprocessables, and disposables. And two, to try to determine the relative weights which the various units within the hospital assign to these factors.

This posing of the problem presupposes certain kinds of assumptions, in other words, it presupposes an argument. And if I were to attempt to summarize the argument it would be in terms of five basic propositions which we have used as a guide to the development of what we think may be the preference system out of which decisions are made that are primarily non-economic in nature.

The first guiding proposition in this regard is: supply decisions are controlled or determined by vested interest groups in the hospital. I might say, before I go any further, that, in our efforts to establish whatever preference system is operating that influences decision-making, we are not attempting to outline the objective or real system which may be operating; that is to say, we are not trying to get at these factors in a causal sense, we are not trying to get at the factors which the administrators should be using to maximize rationality in the decision-making process. That would be an interesting project to pursue after this spade work has been done, I readily admit. Nor are we attempting to imply that the hospital administrator himself has some such system in mind. Actually if he did, it is quite obvious that such a study as this would be unnecessary. Rather we are trying to get at his conception or representation of these (decision-influencing) factors. You might say we are trying to get at his phenomenological system, at the factors he uses while making up his mind or while choosing in respect to these alternatives, without saying anything whatsoever about the validity of his choice, the wisdom of it, or the feasibility of it. We are simply trying to ask what it is he puts his finger on when he does choose. He may put it on something which is irrational, or he may put it on something which is very rational. We don't know and we are not attempting to assess that at this point, but I do think that's important enough to be assessed at another point. So, first then, we simply assume that supply decisions are controlled or determined by vested interest groups in the hospital. Two such vested interest categories, you might say, have been identified for purposes of this research, and, as was indicated earlier, we are labeling these "administrators" and "users." These two types are "sponge types" as you gathered and are used simply to allow us to separate functionally two categories of people who we think, are important and who exert most if not essentially all of the influence on the devision-making process.

Two, the relative weight of the group's influence is assumed to be a function of his relative position in the hospital power structure and the degree of monopoly of knowledge or skills held in respect to the use of the item in question. That is to say, if a user has a very new item like a "heart machine" --suppose it falls in that category-- now, that's a highly technical type of machine, the use of which presently is not very widespread; it resides primarily in the hands of highly competent professional practitioners. So we would assume then that for such types of items the user would exert a very great influence in the choice -- maybe the whole influence. But, of course, the particular items we are examining here do not fall in that category, as you know -- needles, syringes, and gloves being the ones with which this study is primarily concerned. Therefore, we would assume the converse of this: technical knowledge and skills required are rather widely diffused and are possessed by large numbers of people within the hospital service. To the extent that is true, then, we would assume that various people who use them may have relatively equal amounts of influence in this regard, or the people might not be so concerned from the standpoint of the performance of their roles in this matter.

The third factor, or guiding factor you might say, which we considered in formulating the study is: the degree of interest or concern in choosing supply items will vary with the person's conception of the effect the choice may have upon his role. To illustrate what we mean by that, one would expect administrators, as here defined, to be principally concerned with cost, time, and efficiency of operation. Now I don't know whether that is true or not; it may not be, but that is something that we have hypothesized and we are going to try to find out. On the other hand, one might expect a physician to assign greater weight to factors that affect the public's image of his medical performance. By public here I mean both his professional colleagues and his clientele, that is, his patients. From the particular things which the people do themselves come their major interest in the decision making process. How does the decision affect the things they do and the things for which they are responsible in terms of their role.

Four: it is assumed that different groups will assign different weights to the same factor since their conception of the relation of the factor to their perceived dependence upon the factor for status enhancement.

Dr. Dudek: May I ask a question? When you say the different groups, are you still referring just to the two groups, "administrative" versus "user" groups?

Dr. Doby: Yes, but we have groups within that. "Administrators" will refer to nursing, medicine, central supply, purchasing, and what we call general hospital administration, these people that you ordinarily refer to as the administrator and his immediate staff. Naturally, we have three or four groups within the "administrator" group, and we will have three or four groups within the "user" group.

Now, the second source of interest here (the first one I mentioned was status enhancement, I mean, they make their choice in terms of how they think the choice affects their own position or their status in the structure or in the system.) The second factor is what I call, for lack of a better term, the principle of least effort in the application of the item. That involves a number of considerations and is not meant to indicate an invidious comparison here. It's just a normal thing that all human beings do, I think, they try to take, other things being equal, the path that will achieve the same results in terms of efficiency, etc., that requires the least effort. This will involve such things as time to learn to use the new item, the side effects in its use -- that is, is it messy, or is it simple and clean, clear-cut, will it result in his being worked more than I would have been worked if another choice had been made -- such things as that.

Five, and the last of our propositions which you might sum up simply as the argument: it is assumed that the preference system of the "users" and "administrators" is based upon their perception of factors which affect their status and which affect their role performance. Now this is just a correlary of number 4, in other words, stating number 4 in a more determinant sense, in a more specific sense. Now out of these kinds of considerations, we developed an instrument, a questionnaire, which is to be administered under certain conditions.

Discussion

Dr. Hullerman: Has this human factor approach been taken or studied in industry, or is this peculiar to hospitals? Secondly, would you give us just a little idea of how the findings might be useful in action aside from the interest that they generate.

Dr. Doby: From the standpoint of the argument here used, many studies of this sort have been used in industry. This is a basic approach, but the practical application, if any, that comes out of this will be more clearly perceivable at the end than it is right now. If we are able to show that behavioral factors do enter, to a significant extent, in the choice of supply items (<u>within this kind of structure</u> and I am reasonably sure that they do but I don't know which ones and I don't know just what kind of value system operates in this kind of setting), then I should think the next task would be to try to develop a mathematical model which administrators could use, a practical version to inject a little more rationality into the decision-making process in this regard. How successful this particular study will be in allowing the generating of such a model of course remains to be seen because, as I look at it at this point, it is simply an exploratory step.

<u>Dr. Howland</u>: It seems to me you are headed for a kind of multiple regression.

<u>Dr. Doby</u>: That's one way we have considered handling the variables. Actually, you see, we have the dependent variable here as a dichotomy. That is, you have on the one hand a choice of a disposable item and on the other hand a choice of a reprocessable item, which is simply a quality or a characteristic that we have assigned an item. They choose one or the other. In that sense, they reject the other. What we have then is a multiple regression analysis with a dichotomized dependent variable.

<u>Dr. Howland</u>: This is what I was going to ask you next. What is your dependent variable? Would it be vastly oversimplifying it to say that we are trying to relate cost to status?

<u>Dr. Doby</u>: Dr. Smalley has a project that is designed to deal almost entirely with the cost factor. The only way in which we are considering cost here (in this part of the total project) is in a relative sense, as one of the factors among possible factors.

<u>Dr. Howland</u>: This gets back to Hullerman's question, it seems to me that one of the functions of these studies is to present organized information and I can see somewhere along the line what you would present really is some kind of a concept of what the status system is costing, relative to the supplies.

<u>Dr. Smalley</u>: If I might react to that just a moment, I think that is possible. Implicit in this will be, even if we don't express it as such, a costing of alternative decisions that may be influenced by status factors among others. This is to say that if a certain group is highly instrumental in forcing a decision in a certain direction and if any sort of assignable cause could be attached with respect to status, then one could cost out (as a result of other phases of the project) what he is paying to maintain that status. In that sense I think he is costing out status. That's only part of it as I see it. Another part is that we are really running the risk that, if this study shows that costs do not loom large in the minds of those who are most instrumental in the decision, the other parts of the study might be unnecessary unless we are then going to follow it up with some sort of educational program and try to persuade hospitals that costs are important. Now I am <u>hoping</u> that is beyond the scope of our present study.

<u>Dr. Doby</u>: That is one of the things I meant by the causative or objective factors in the situation, when I introduced the topic earlier. We are not claiming to be spelling out the objective factors that should enter

into the equation or decision making system. Now there will be no data generated by this questionnaire that will answer your question in an "alternative cost" sense.

Dr. Miller: What will be generated, John, is something that I think you take into consideration in cost, and that is, all things being equal, cost is determinant. What we are asking is, are all things actually equal?

Dr. Howland: It seems to me that you are trying to get a behavioral reference for the status measurement. Our sociologist tried to do this, but if I read what you're doing, you're trying to add some sort of a cost measurement.

Dr. Hullerman: Let me restate this. I like this discussion, but I don't suppose time would permit, but I was just asking whether or not this is a particular problem in hospitals. We know that status has a lot of weight in anything in a hospital. Is it peculiar to hospitals, or has this been a part of the problem in industry?

Dr. Doby: I think this is a basic human variable that enters any kind of organizational system.

Dr. Hullerman: In industry, they have the opportunity to exert this weighting?

Dr. Doby: I would hypothecate that the weight exerted by this particular factor would vary with the structure, depending upon the value system of the structure. I don't know how much this operates in hospitals. I would suspect, although I don't know, that this thing would vary even with the type of hospital, whether it is a private or public hospital, whether it is state supported, etc.

Dr. Hullerman: There is a status variation in hospitals, I judge it is considerably different from other walks of like. Is that right? You don't think it's any different?

Dr. Howland: To me, any organization that gets anything done would have to have status differences. I would certainly hate to go into a hospital that didn't have any status differences.

Dr. Doby: Why, it couldn't operate without it.

Dr. Howland: You can't operate anything without it.

Dr. Doby: You have to have a hierarchy.

Dr. Howland: It seems to me unimportant whether it is good or bad, but what is it?

Dr. Doby: Yes, and how does it operate?

<u>Dr. Dudek</u>: If I might inject something. I am going to stick my neck out and say that in industry, though, status would take a back seat to cost.

<u>Dr. Doby</u>: I would entertain that idea, but I don't know.

<u>Dr. Dudek</u>: In most companies that want to make money, if it is going to come down to a decision, the decision is for that system that is going to make money.

<u>Dr. Howland</u>: This I don't think is the question here. If I am reading you right, the dependent variable is cost and the independent variable is status. And in industry certainly the guy with the status is the guy who makes the cost decisions. That poor old IE out on the floor doesn't have much to say, he doesn't have much status, but as you go up into the higher group you are able to handle bigger chunks of money.

<u>Dr. Dudek</u>: But, as I understand the question: Is the user really considered, or does the status man just make a decision?

<u>Dr. Doby</u>: That's part of it, yes.

<u>Dr. Dudek</u>: That's right. This is what I thought you were trying to determine, what's the difference between the groups as defined, the administrative group and the user group. Assuming that the administrator group has greater status, do they consider usage or is the decision based on status?

<u>Dr. Doby</u>: That's one way in which we are using status, that's in a unit sense. Now, the other use is in respect to the individual himself. It's an individual reference that is involved. That is, does he, when he makes the decision, entertain the idea of the consequence of the decision to himself. Now I'm not talking about <u>power</u> here in the sense of a hierarchy, I am talking about it now in the sense of his perception of the consequence of the choice to his own welfare and to his own role performance. He does take that into consideration. For instance, if a nurse is already overworked on the floor as they generally are, and if the choice is between a processable or disposable item and she <u>thinks</u> that the reprocessable item is going to necessitate her spending a lot of extra time in cleaning up, she is going to vote against that kind of item. Now that's in the "individual" use of this <u>sense of status</u>.

<u>Dr. Doby</u>: Do you have any other questions on my part of the presentation before I sit down?

<u>Dr. Dudek</u>: This may be jumping way ahead, but I have been glancing at this first page, and I am still bothered by these two <u>groups</u>. May I ask the question, in the questionnaire, I see 15A for users and 15B for administrators. Does the person looking at this questionnaire make the decision whether he is a user or an administrator?

<u>Dr. Miller</u>: No, the person doesn't get his hands on the questionnaire, you have an interviewer.

Dr. Doby: The person never sees it.

Dr. Dudek: Oh, o.k.

The Instrument and Interviews

Dr. Miller: I amy be usurping some of Dr. Doby's and Dr. Emerzian's area here. Primarily, my task is to relate how we are going to find out from these people the things we want to know in order to see if the propositions we have made are substantiated or not.

I suppose that, first, I ought to make an operational link then with what Dr. Doby has said and refer to direct items in the questionnaire which apply or speak to these areas. Dr. Doby mentioned a preference system which implied that we either have one at hand or we're going to ask for some sort of preference statements on the part of the people. Actually, we are going to do both. We have an outline of some of the things which we think enter into the decisions and we also have made provision for the people being interviewed to supply their own systems or their own types of preferences. The factors which we are including can be found beginning on page 2. We are asking which of the two forms of the items are more expensive, safer for the patient, safer for the user, requires more time in preparation, is less messy, causes more patient discomfort. These are items which Dr. Doby, Dr. Emerzian, and I anticipated might be some of the factors that entered into decisions or preferences. In general, we summed them up as being cost, safety, convenience, and discomfort.

In the second part of this, we ask them which do you prefer, a disposable item or a reprocessable one. On page 5, you can see that we are asking this in relation to gloves. And then we ask them to state why they prefer this, with instructions to those who are asking these questions to do a good deal of probing here. If you get an answer such as costs, then get at the phenomenalogical factors involved in costs. Is it money, is it time, or what is it?

We also are trying to get data on the source of the preference. First of all, we are trying to get this in terms of whether the person is an administrator or a user. This would be one of the things that we have noted earlier. We also ask a question on page 5 concerning knowledge of practices in top hospitals or hospitals which they consider to be tops. This speaks to the problem of whether these preference systems are actually following the preference systems of leaders in the field. On page 10, we also ask, "Other things being equal, would you say you have a general preference for reusable, or disposable items?" This tries to see if there is a general frame of reference from which this person is answering.

On page 10, we try to get some idea of how this preference system acts in terms of operation. We ask them to say how they would try to get an item adopted, to respond to how they handle requests for supply items. This will give us, I hope, some insight into the picture of how this actually goes on, whether it is through the formal channels that are set up in the table of organization, or in another direction. This ought to be particularly valuable in terms of the user to see at what point they inject their own preferences into the system. We have data on how long they have been with the hospital, how much under pressure they perceive themselves in terms of work load, their position within the hospital, etc.

The actual interviewing, or the actual administration of this particular instrument is scheduled to take about six weeks starting next week. Pretests have been done and the schedule has been revised. I think this is the third revision. The interviewers are at present being trained through general sessions and practice interviews. We are going to tape the early interviews for reaction. We are in the midst of identifying our universes and also trying to select a sample. As things stand at the present, each hospital will be a sub-sample and within each hospital we will interview all the "administrators" and a systematic or random sample of the "users". This is, at present, about where we stand. Have I left out anything?

Discussion

Dr. Dudek: One quick question on this sample. When you say you are going to sample all administrators, you are using this in the context of ....

Dr. Miller: Yes, in the context of . . . . . Dr. Smalley's previous definition.

Dr. Dudek: Anybody who makes administrative decisions?

Dr. Miller: We have outlined, in the prospectus, a specific group we are talking about, supervisors of central supply and this sort of thing. This is our "sponge" concept.

Miss Belcher: I'm real curious about that too. Who does that include? Does it go down to the head nurse?, the supervisor?

Dr. Doby: We thought of it only as unit heads in terms of the overall administrative hierarchy, but there may be some advantage to think in terms of smaller units within each unit.

Dr. Kuehn: You did include Central Supply, didn't you.

Dr. Miller: Yes.

Dr. Kuehn: Would there be any advantage then in getting at the differences between central supply and the users of these items from central supply. The central supply administrator versus the ward administrator who utilizes what central supply dishes out.

Dr. Dudek: This is just as Dr. Smalley pointed out earlier, some administrative decisions are made at that level.

Dr. Smalley: One reason I think this is a bit nebulous is that you have just caught us at the point where we are at present. Miss Owen, this week, has been compiling rosters from which the samples will be taken. I think Dr. Emerzian could speak to this point better than any of us right now, but my guess is that no only would we want to separate central supply supervision from ward supervision because we suspect there might be different motivations, but in some hospitals they might be entirely different departments and have entirely different organizational reporting patterns. In one hospital, the central supply is under an assistant administrator for professional services or professional relations. In others, it is under the director of nursing. My guess is that there are going to be differences.

Dr. Doby: That could be very easily done. I don't see any reason why we shouldn't do it, and I feel that it would probably provide additional information. From the standpoint of their functions or positions, one might reasonably expect different motivations.

Dr. Kuehn: If you are using the central supply head, I wish you would take a good look at your operating room head, because here is an area in which there are great differences of opinion. I think this should be looked into.

Dr. Doby: I think you are right. One of my propositions hinted at that in terms of the degree of professionalization reflected in the user's activities. I would think that you would find professionalization probably maximum in that particular system.

Dr. Emerzian: For these items that we have in mind, Dean Kuehn?

Dr. Kuehn: For gloves, both at the operating room level and the ward level. You see, your goals are different.

Dr. Hullerman: I'd like to go a little further on this. Actually, the central supply and the nursing units may have different views on this. Also, for these particular items, your system can be made or broken by the people who are actually using these things, dropping them in waste baskets or breaking syringes or something like that. You probably ought to check the correlation between the opinions of the nursing heads and the nurses that are using these items.

Dr. Doby: We have attempted to do that.

Dr. Kuehn: That's your user. Miss Belcher just brought up another good point that the obstetrical head should be involved in that. That's true because you get conflicts between your obstetrical department and your surgical department.

Dr. Doby: That's a very specialized branch in the "administrator" group.

Dr. Kuehn: Do you have definitions for roles?

Dr. Doby: Not yet, but that will be the kind of thing we will come up with.

Dr. Miller: We interviewed, in a pretest, the head of the O.B. section. It was quite interesting, particularly in terms of enemas.

Dr. Dudek: In this selection of sample, a head nurse could be a user in one instance and an administrator in another. When you do get a sample and pick her as an administrator, are you going to exclude her as a user -- so that she doesn't taint the answers of the users, or vice versa?

Dr. Kuehn: She would definitely be an administrator and a staff nurse at the bedside would be a user.

Dr. Dudek: You see, conceivably, the way I understand their definitions now, administrator and user, a head nurse could be both in some instances, couldn't she?

Dr. Miller: She surely can.

Dr. Dudek: And in this sense, they would also use some head nurses as users in their sample, right?

Dr. Doby: That's right. The same thing is true of physicians. You take the man who is chief cancer surgeon and may also be an administrators and users, we fully anticipate the group that has both roles. I am not sure that you got the right answer to your question, that you are going to exclude them from this if they are this. My opinion would be that you might end up with a third category even though you didn't set out to have three categories.

Dr. Dudek: Oh, well, she was selected at random for both roles.

Dr. Smalley: In our selection process, we are going to make some mistakes. We are going to pick people from the roster who look like administrators, but when we interview them, we'll find out that they may be both administrators and users. Now, depending upon what kind of significant differences we find in responses, we might have to form a third category. And since we are going to maintain the identity of the people, we may find that other categories will suit our purposes much better. For example, is he a practicing physician; that might be a more distinguishing characteristic than if he is an administrator or user.

Dr. Dudek: I see.

Dr. Doby: I think too that we ought to allow for that because a man who is an administrator-user seems to me to be operating within the framework of two value systems. He may have a great deal of role conflict here. We ought to allow for its reflection in such a category. I think that categories like this will allow for it.

Dr. Dudek: Well, this is what I was basically trying to get at, the kind of selection technique you are making in your sampling procedure. What you are really going to do is make a fairly selective sample, right?, rather than purely random?

Dr. Doby: As far as the administrative group is concerned, we are going to try to cover them since there are only six hospitals involved anyway, but from the standpoint of the user, we are trying to draw a random sample. But we recognize that in drawing that random sample of users we will unquestionably come up with some people who will also be administrators. We have been discussing it within the framework that we keep them, but we would label them as user-administrators and see if they actually do differ in any significant way from the other two categories. If they don't, then we will lump them into the user category; if they do, then they'll stand as a third category. They very well may be, and I suspect that they will be, significantly different.

Miss Belcher: As I understand your definition of administrator, I think the head nurse group is a terribly important group. The head nurse is the one that orders supplies. She probably cares more about what it costs to run her ward than probably anyone else, because she is in competition with other head nurses to keep her costs down so this disposable versus reprocessed would have a tremendous bearing on her even though she may occasionally use these supplies, I would be willing to wager that she functions more than half the time as an administrator rather than a user.

Dr. Doby: I think you are probably right.

Dr. Emerzian: But does she not, I wonder, reflect the preferences of her staff?

Dr. Kuehn: She probably does, but that's all right.

Dr. Doby: Joe, what they are saying is, that if she does, we will get no different information by including her in that separate category because the information that she would give us would be provided by the random sample of nurses.

Dr. Kuehn: I don't think so?

Dr. Doby: You don't think so?

Dr. Emerzian: I thought the other way around at first, that it would be merely duplication.

Dr. Smalley: The advantage of doing what Miss Belcher and Dean Kuehn suggests would be that if she does mirror the opinion of her subordinants, you haven't lost anything. But suppose her opinions are partially a reflection of them and partially pressure from above, you might end up with a fourth category.

Dr. Emerzian: I think these suggestions are very good. I have a feeling that perhaps we had overlooked some of this. We wanted to get quite detached groups, the director of nursing who was detached some distance from the user.

Dr. Smalley: In a hope that we could have a breakthrough in determining what her decision-making scheme was, not too much influenced by day-to-day preferences on the floor.

Dr. Dudek: You will still get this.

Dr. Smalley: We don't lose anything by this.

Dr. Emerzian: We just lose time!

Dr. Dudek: You may have very tainted opinions in this question, they are more user than administrator, and in another question, they are more administrator than they are user.

Dr. Doby: They may act like Koko, there: "Which role do you want me to answer this from?"

Dr. Hullerman: Are you going to sample staff nurses?

Dr. Miller: Yes, staff nurses and house doctors are the primary user sample.

Miss Belcher: Is this sample going to include all 24 hours? You may get different reactions from people who are permanently on nights and have to clean up some of this.

Dr. Kuehn: That's right.

Miss Belcher: Than from people who are just users, not cleaners.

Dr. Miller: This was a problem which was brought home to me the other day; they are also, to some extent, removed from pressure except from limited points.

Dr. Gilbreth: Is there any attempt to get the patient's reaction.

Dr. Miller: No.

Dr. Doby: Our assumption, Dr. Gilbreth, rightly or wrongly, is that this is to be reflected by the ward nurse; her value system will reflect that. We don't know, of course, but we are not making provision for including patient opinions.

Dr. Miller: Nor have we made any provision for housekeeping personnel.

Dr. Gilbreth: I wasn't thinking so much of getting a direct return from the patient, but will the patients express to you in any way what they feel?

Dr. Smalley: Well, I think our decision there, Dr. Gilbreth, has been cowardice more than anything else. We are reluctant to open up Pandora's box on this thing. I am afraid that we would just be hopelessly lost if we got into the question of the interplay of comfort and care and at what point is the patient satisfied with his care and what influence does bedside manner and report have upon his decision. We felt that we didn't dare get into this area and that we would gamble that the nurse adequately reflects the patient's preference system. Now this may be unwise, but this is what we had planned to do.

Dr. Gilbreth: It may be unwise, I think that's quite right, but I think your assumption is a little broad, don't you, of what the nurse would reflect?

Dr. Kuehn: I do too!

Dr. Gilbreth: I feel cheered. I'm not as ignorant as I thought.

Dr. Doby: I don't see how this patient attitude or feeling actually has any bearing on the hospital decision system. The hospital decision-makers must necessarily take it into account or else it will have no bearing by definition. Now how they take it into account or whether they take it into account, I don't know, but if it is taken into account, then they are the only ones who can take it into account and surely it would be reflected in their preferences.

Dr. Miller: I think also that in "patient discomfort" we have a device to see if the perception of comfort or discomfort that these items produce in a patient is reflected. It may be changed at different levels from the actual people who are, well, sticking reusable or disposable needles into a patient and from the higher level where they probably never see this done. I have the feeling that if there is a relatively common complaint about discomfort that it will be brought out by the people who are using it as to what happens. I am speaking of this in terms of some of the impressionistic data I have from pretesting.

Dr. Smalley: We haven't neglected this entirely. We've got to keep in mind too, what items we are concentrating on right now? Aside from enemas, we do not believe nor does anyone else that we have talked with, that the patient knows much difference in a disposable needle or reprocessed needle. Certainly the OR patient doesn't know the difference in the kind of glove being used on him. We don't really suspect that the patient would have any valid preferences with the kind of items we are talking about.

Dr. Kuehn: I wouldn't buy that on needles. I think you could make a nice little study of patient reaction to needles.

Dr. Smalley: You think that needles might show a difference?

Dr. Kuehn: I sure do!

Dr. Gilbreth: They may not be the only item.

Dr. Dudek: Maybe disposables would come up better because each time they are sharper.

Dr. Kuehn: Right! If you made a study in a controlled situation where you used the reprocessed versus the "control" and more patients complained about needles, what would you conclude?

Dr. Smalley: Are you proposing a study to determine whether burrs on needles hurt, or whether disposable needles have fewer burrs than reusable ones? To me, these would be two different studies; one wouldn't involve the patient at all. You can find out what is the grequency of a burr on a reprocessed needle and the frequency on a disposable and see if you get a significant difference without involving the patient.

Dr. Kuehn: The patient will complain about dull needles if they are not sharpened in reprocessing, if they are not well handled, your patient will complain upon the insertion of the needle.

Dr. Smalley: Then you study would be to determine the extent to which the patient felt it discomfortable to have a burr.

Dr. Kuehn: That's right.

Dr. Miller: Actually, there is a matter of relative discomfort here.

Dr. Kuehn: That's right.

Dr. Emerzian: Nurses have reported this to us quite a lot.

Dr. Gilbreth: I can see a whole group in business and industry, and back of them, Madison Avenue just panting to get at this.

Dr. Hullerman: In talking about disposables, one of the departments that gets concerned about this business is the stores and purchasing department. Are they being questioned?

Dr. Miller: Yes, the purchasing agent is one of the"administrators."

Dr. Hullerman: Also, when a person answers this question, is he answering it from the standpoint of his own narrow point of operation?

Dr. Miller: No, we can't do that. We have discussed this at some length as to whether we would ask each individual to respond in terms of his own narrow operation, and we ran into this problem of the user-administrator. Where does he fit in this? In other words, he may not answer this in terms of his own use. He may give one answer, but in the terms of his broader knowledge as an administrator, he may answer another way.

Dr. Hullerman: Some people will take into consideration the purchasing and the accounting and the central supply and the use and others won't?

Dr. Miller: That's right.

Miss Belcher: I hesitate to mention this but in various hospitals, the Practices in the central supply room differ. In one hospital, you may get a very efficient central supply room that automatically sharpens needles frequently, that has a very good person who checks for burrs and all that. In that kind of hospital, they may prefer conventional reusables. But in a hospital where they don't have good central supply services, where they don't sharpen the needles, they don't remove the ones that have burrs, etc., those nurses will go over to the disposable. How are you going to deal with this?

Dr. Miller: This is why we are taking each single hospital as a subsample.

Miss Belcher: Are you attempting to describe the process?

Dr. Miller: No, we are not. I think that we may have this information available though.

Dr. Emerzian: This information will be available as part of the "Reprocessing Cost" study.

Dr. Dudek: I'd like to raise a question that I think could pose some problems. I see that you are taking into consideration their knowledge. Now, I presume you mean both education and experience. Right?

Dr. Miller: Knowledge here means: do they know of the item, that is have they seen it or seen it used.

Dr. Dudek: O.K. Now I think that the extent of their knowledge will be a factor in their answers. But here's another question, right along these same lines: this questionnaire here is going to determine what the person feels right now. What if a study were made in this hospital and facts were presented to this person that they could save this much or that these were all the advantages that they would have to make the transition to one or the other. If they got these facts to review and you went back and asked them the same thing, how much is it going to affect their decision? In other words, how much does status or feelings really affect their decision when presented with facts?

Dr. Miller: We just have to consider their present frame of reference, their present level of knowledge. I had an administrator admit to me that he read cost studies but actually he wasn't sure whether a cost study could determine whether this was an economical or a noneconomical adaptation. What is "facts" to you may be just a type of data to someone else.

Dr. Dudek: This is what I am interested in. How many of these people in these various status positions or administrative roles are affected by a report that presents facts to them?

Dr. Miller: All right.

<u>Dr. Dudek</u>: It might be a more valid measure of how <u>status</u> is really affecting them, because this question just says, what is their position right now? Most of our assumptions here say that the relative weight of the interest groups are influenced under decisions assumed to be related to relative position and status in the hospital. Wouldn't this comparison possibly give a better indication of how the status itself is affecting the decision.

<u>Dr. Miller</u>: To some extent, though, what you are saying is: "Is this person a type of person who goes through reports and reads these things, and is that what he bases his decision on", and this ought to come out." Why do you base your preference on this." "Well, I looked at a report." And if he has done this in the past, I think it is pretty safe to assume that he will go to the same source of data in the future.

<u>Dr. Emerzian</u>: Dr. Doby may have addressed himself to this question somewhat earlier, and if I interpret you correctly here, this project does not answer the questions that you have in mind, but rather the second stage of research may do this. For example, the nurses may say that disposable needles are safer, and this is what they feel, but an experimental study later on would study the question as to whether disposable needles are safer or not, and with this fact in mind, would this change the preference of the people? Is this what you are raising?

<u>Dr. Dudek</u>: Not completely. This is part of the thing that I'm driving at, but what I'm saying is that if you came to me with this questionnaire, I would answer all of these questions in view of the facts that I now possess, whether I had any experience or any knowledge of this material or not. I may not have ever given any thought to disposable versus reprocessed syringes. So you ask me and I say: Oh, yes, I remember that somebody in one of my classes ten years ago said that this might occur some day, or maybe I was in a hospital where we used these and I liked them a lot. For no other reason but that I liked them, I say, "Yes." I made my decision not on any facts, but just things that I had accumulated from my experience and my education. Now, if somebody came to me with a proposal: "We propose that in this hospital we should use this, and here are the reasons why." And now they present you with all these facts, a study has been done, the costs are thus-and-so, we would save this much, it would be this much easier on patients because of report so-and-so, and I look through all this material. Now, as an administrator, I say, "Gee, I have a lot more background to base my decision on." I would answer that question in an altogether different manner.

<u>Dr. Doby</u>: The basis for your answer is different, but you still use the same concepts in arriving at a decision, but the particular variables expressed by the concepts would be viewed in a different light. You know now what the cost is. You placed cost as the number 1 factor before. You still place cost as the number 1 factor, but heretofore you didn't know exactly what the cost was, cost was rather fuzzy.

<u>Dr. Dudek</u>: What I am saying is: the first time, I may have checked "simplicity of use" as prime, now that I have read all these things, it may be "safety to patient" first and cost second, whereas

they were down the line some place in the earlier decisions. You are saying that my decision is going to be the same the second time it is the first time. I am saying, I don't know.

Dr. Doby: No, I am saying that the basis for it is the same.

Dr. Emerzian: The valve system is stable. We don't know; this would be an assumption here.

Someone: I don't think you can make it here.

Dr. Dudek: I don't think you can make it, not when you are dealing with human beings.

Dr. Doby: We have differences of opinion here.

Someone: It would make a good study.

Several People: Yes.

Dr. Doby: Here's what would happen. If your attitudes and personality changed that fast you would feel like you were a whirling machine. How would you ever get any "integration?"

Dr. Dudek: I think that the good administrator, the guy who is forging ahead, who is really making wise decisions from day to day is the man who does change his value judgments as it is necessary to change them.

Dr. Doby: His value judgments, that's very true, but does he change the principles which he utilizes in arriving at a decision?

Dr. Dudek: Yes, maybe I'm wrong but you understand what I'm saying, don't you, Hal?

Dr. Smalley: Yes, I understand it. I'm just uncertain about how I stand. That's the reason I'm not speaking, that's all, but I'll always jump in.

Dr. Doby: We have been going through that argument for about six months, and we haven't resolved it yet. We can't resolve it without a crucial experiment. It is a very fundamental question.

Dr. Dudek: That is why I say, could you design it into this question right now. Let's resolve it.

Dr. Doby: I think you'd have the design an experiment. I don't think you could answer that question by a survey.

Dr. Kuehn: In making a decision, as Dick brought out here, you have a flexible field and you are interested in the safety to patients, the cost, the method, and the timing, and you are shifting within that framework. I would like to be sure that it wasn't nailed at cost, for example. I don't think it will be.

Dr. Miller: No, at least in terms of a value orientation, you are dealing with humans, so safety to a patient would be probably high on everybody's list.

Dr. Smalley: Let me react this way. Take this question about how important is cost. I think Dick has a point in this respect. We don't want to get too philosophical about this, but one might view education, real education, as an attempt to change a person's value system. This is the thing that Dr. Doby is saying: It's pretty stable; there is a lot of inertia to changing a person's value system, but every now and then we change a bigot into a person who will view objectively. This is a major step. I think what Dr. Doby is saying is that we are not going to take any major steps like this in a survey of this project or even one ten times more comprehensive. But what you might very well find is this: It's sort of like some of the surveys we made some years ago where we get statements like: "The purpose of the hospital is to save the patient's life, not his money." Well, this is a convenient cliche that I think really reveals a lot about his value system. He has cost in it somewhere, maybe reluctantly would he be interested in cost, but he's not really concerned about it at all. I don't much think shedding light on the cost picture is going to change his value system, but I think if you show what the costs are so that he is now talking about something that's within his frame of knowledge, not some hunch or belief he has, he might give more weight to that than he would otherwise.

Dr. Dudek: But you see, I'm not only referring to cost. I'm referring to a study that presents all the facts. If there is any study available like Joe mentioned that "There's less burrs on this needle," O.K., this is one of the facts. "This disposable needle has less burrs." "This disposable needle is going to cost us so much." The cost factor may have gone up, but now, because of all the facts, it still is a better thing to use because of all these other considerations which I, at the time you came to me with this questionnaire, didn't know.

Dr. Smalley: You didn't think of burrs?

Dr. Doby: You can't go into those. It's still a saving in your cost. It simply varies with conditions for which those factors are expressed.

Dr. Smalley: Let me ask one other question in order to probe. Do you mean that he didn't think of burrs before -- it didn't occur to him -- or that it wasn't important to him before?

Dr. Dudek: He may not have had enough knowledge. I think that his first decision is based upon the knowledge that he has. In other words, if you asked many people before the horseless carriage, "Would you like a horseless carriage?" , they might say, "Yeah, maybe so, I don't know."

Dr. Howland: "Would you like tail fins on your horseless carriage?"

Dr. Dudek: Yes.

Dr. Doby: But, the criterion in all probability would still be "speed of movement."

Dr. Smalley: John, you know we will be getting at this to some extent this way: We have one open-end question. "What did you take into account?" And there is where they will name the things they are already familiar with, whether they have all the knowledge or not. Later, we're having a forced choice. There, for the first time, they might be confronted with a criterion they hadn't thought of before, and any difference between the way they handle this would get at what you're talking about.

Dr. Dudek: Yes, or a second questionnaire, after some planned education to a few of these people, would get at this same thing that I am referring to.

Dr. Kuehn: Hal, we have a second little project for you here: to institute an in-service education program after you do this, and see what happens.

Dr. Emerzian: That would be a third project. I would like to raise this question before we terminate this session. Perhaps it has been covered already, but I would appreciate seeing the research group going over it again. That is, what is this going to look like in final form? I say this from my own personal point of view, because somewhere along the line I have the responsibility of putting this thing together - am wondering, "What will this look like, Dr. Doby, in final form? What will it say?

Dr. Doby: Two things, from my point of view, will come out. One is a set of factors for which we show the rank order of the amount of influence they had on a person's decision. Two, we will present either by regression analysis or by variance analysis the way in which different units weight or rank these particular factors. We may find that the particular units do not reflect significant differences in regard to the particular factors of preference.

Dr. Emerzian: Organizational units?

Dr. Doby: Yes. Or we may find they express very significant differences in regard to these factors. And that's all.

Dr. Smalley: That was a good try, Joe, but you didn't get much help on your practical problem. I think you are dead right on that.

Dr. Doby: I am just going in terms of the particular way in which we state the problem and the particular kinds of data which the questionnaire will generate. We won't extrapolate beyond that. The practical application of it would have to be worked out as another project.

<u>Dr. Howland</u>: I'm missing something. I'm still a little confused about what your dependent variable is in your regression expression.

<u>Dr. Doby</u>: The dependent variable is the <u>choice</u> they make.

<u>Dr. Howland</u>: I got that, but I'm still confused. How are you going to do that, operationally?

<u>Dr. Doby</u>: They will give a choice on the basis of the questionnaire. From our point of view that's the variance: disposable, reprocessable. We are trying to see how this choice varies from unit to unit within the hospital and on what preference factors it is based.

<u>Dr. Emerzian</u>: In other words, this is a prediction device?

<u>Dr. Doby</u>: No, it is not a prediction device at this point. It could become a prediction device. At this point it is simply a descriptive device, to determine what actually is happening.

<u>Dr. Emerzian</u>: Can you add these things together in some sort of a model?

<u>Dr. Doby</u>: You will get a number of "F" scores or "F" values. You may get a number of R's, multiple or partial R's showing relationships. Now, in conventional literature, there is no method for handling a multiple regression analysis with a dichotomized dependent variable, although just recently there has been a mathematical device worked out by James Coleman of Johns Hopkins University. It's not in print yet. We plan to use Coleman's model for doing this. He dealt specifically with this type of problem; his paper has been read and criticized and nothing has been found wrong with it so far.

<u>Dr. Smalley</u>: We are not putting all our eggs in one basket. Our project does not rise or fall on the availability of a magic model which will deal with a dichotomized dependent variable either as a descriptive technique or a prediction device. As we get into this further, I think that we may be satisfied to know what these non-monetary factors are and to be able to impute cost to them when a decision is made. But I think we are hopelessly bogged down on the monetary side of the study until we can describe these environmental factors that work in the hospital situation: Just where are the decisions made and what is the value system and what are the relative importances of decision criteria? It won't disappoint me if we can't quantify this. I think we can handle the matter without direct quantification.

<u>Dr. Doby</u>: We can handle it, but I think, if I understand the question correctly, what he (Dr. Howland) is reacting to is the fact that in conventional literature there is no method for this analysis. But the literature I was referring to is not part of the conventional literature.

<u>Dr. Hullerman</u>: I am quite confused as to what you are going to get out

of the other pages as against page 9. Really, I think you could almost predict that, after a little thought, practically every department is going to put "safety" very high. Then "cost" is going to come in as a factor after those things are considered. Now, what are you going to get out of the rest of it that you don't get out of page 9?

Dr. Doby: That's a good question. And this was done as a methodological device. We don't know for sure that this is true, and we did not want to provide them initially with a structured situation which might bias responses.

Dr. Hullerman: One is a check on the other?

Dr. Doby: That's right. We had rather let them generate their own categories and then by a coding device go back and see if any systematic patterns evolved. Also, we want to use this as a check on our own thinking and we have the feeling that what comes up from their description will be the same, but we don't know.

Dr. Hullerman: What's meant by: "All other things being equal?"

Dr. Doby: It's a hypothetical situation you try to put the person in. You never succeed, but you try.

Dr. Smalley: It's an efficiency mechanism, too, to keep from getting the pat answer, "It all depends."

Dr. Doby: Yes, and going off on a tangent.

Dr. Dudek: Now you might get conflicting answers between that item and some of his earlier items, right?

Dr. Miller: Yes, certainly.

Dr. Smalley: Not only that but they just didn't think about it before. It's still important in their value system but it didn't occur to them.

Someone: I'm still bothered.

Dr. Smalley: I would be very disappointed if this group felt good about this area. I don't believe you told us specifically, but you do plan to use punch cards and code the items, don't you Jerry?

Dr. Miller: Yes. At present, the plans are to put the data on punch cards and use machine processing. How far we go along this line will depend on the kind of data we get out in the end. Some of it is already handleable by this method.

Dr. Smalley: I am surprised that someone hasn't been curious as to who are to be the interviewers, since this is such a critical link, where you are going to require them to probe.

Dr. Miller: I think the question has been, up to now, are we asking the right questions, no matter who asks them. The interviewers will be Mr. Hall, Miss Owen, a graduate student at Emory, and myself. The major portion of the work will be divided between Mr. Hall and Mr. Westerman, who is on the Emory Campus. Miss Owen is serving primarily as a liaison personnel to set up the arrangements and I'll be a kind of a stop-gap person and will schedule myself for a few interviews.

Dr. Hullerman: On page 1, this question on "work load." Is that designed to give an opportunity to determine if they have the right kind, or the right quality of people? What is the number in there for?

Dr. Miller: Just, "Do you have bodies to do the work."

Dr. Howland: That is a question for the "empire builder."

Dr. Doby: This deals with their conception of the adequacy of the staff. It may be very crucial there. This is a control factor. If we have their conception of the adequacy of the staff, then we can make some assessment of that in connection with the appraisals or preferences which they give later on.

Dr. Hullerman: I run into this all the time when I say, "All right, here's your budget. Is this what you want?" , and the answer is, "No, this isn't what I want because I can't get the supervisors I want, I can't get the nurses, I have to substitute other personnel, and so forth. Yet they say, "I don't need any more people."

Dr. Doby: Well, that's really a question of efficiency and the quality of performance, one which we will have to control by definition. Really, what we are getting at is: "Do we have enough people," because if they don't, they may become very much concerned about the choice of an item which might increase the amount of work.

Dr. Emerzian: We had one decision, you know, which was made primarily on this basis. There was too much work in the department, and moving to a disposable meant that the amount of work in the department would be reduced, and therefore the supervisor was not very much in favor of it.

Dr. Hullerman: Then you do mean in number, then, that's what you mean?

Dr. Emerzian: That's right. The capacity, really, for completing the work load, whatever it happens to be at the moment.

Dr. Smalley: I am not sure, though, that you are addressing yourself to Dr. Hullerman's question. As I understand it, he is saying it is not unusual for a supervisor to have enough bodies but the wrong kind, which in her mind might influence her answer to other questions more than would be the case if she were shorthanded with the right kind of people. And our purpose here, as I remember, John, was, we are afraid that your feeling about whether you are overstaffed or understaffed would have a significant influence on your decision. The point Dr. Hullerman is making is a good one, because it could have a lot of influence if you pinned them down and required them to answer in terms of quantity and not quality.

Dr. Emerzian: I think we wrestled with this. As a matter of fact, the word "number" was added later, after further thought.

Dr. Doby: Yes, that's right.

Dr. Emerzian: Perhaps what you might be able to do to overcome this is to find this for them, to find out one way or the other what they are talking about.

Dr. Doby: Yes, in the interview.

Dr. Hullerman: All you can ask them is the numbers as of now. I think the numbers are good. It might be a good two words to add in there, because if they could change the character of their help, you could ask them the question again a different basis, but I just wanted to be sure that this was what you meant.

Dr. Howland: The independent variables you are using here are cost, safety, comfort, and convenience?

Dr. Doby: In terms of our rationally conceived system, it is entirely possible that the open-end questions may generate some others in addition to that.

Dr. Howland: O.K. Now, are these going to be binary scales -- it's either safe or it isn't ratio scales or rank scales?

Dr. Doby: It certainly won't be ratio scales, because we have no way of really getting at zero, we don't know what zero is. I see them as rank scales or ordinal scales. That is all that is possible. You can't get a cardinal scale at this point because we don't have sufficient basic concepts to generate that kind of scale.

Dr. Howland: Would the dependent be a nominal scale, disposable or non-disposable?

Dr. Doby: Yes. We could make a chi-square analysis in that sense.

Dr. Howland: Or a contingency table.

Dr. Doby: Yes, that's the first thing we thought of.

Dr. Howland: Why did you throw it out?

Dr. Doby: Chi-square, as you probably know, is very insensitive at the tails, so the size of the sample is very crucial in terms of the type of statistical model you use here. We have to use the statistical model which is most sensitive in terms of the size of sample that makes the same kind of mathematical assumption.

Dr. Smalley: I think we had better break now. We surely do appreciate it, Dr. Doby and Dr. Miller.

MONDAY LUNCHEON SESSION

Brittain Dining Hall

Georgia Institute of Technology

WELCOMING:

Col. F. F. Groseclose

PRESENT:

National Advisory Committee

Dr. Richard A. Dudek
Dr. Lillian M. Gilbreth
Dr. Daniel Howland
Dr. Hugo V. Hullerman
Dr. Ruth P. Kuehn

Cooperating Hospitals

Mr. E. F. C. Fisk (Crawford W. Long)
Mr. Harold Michael (Grady Memorial)
Mr. Robert L. Zwald (Georgia Baptist)

Staff

Dr. A. D. Joseph Emerzian
Mr. Thomas J. Hall
Miss Louelia Owen
Mrs. Mary Kate Rush
Dr. Harold E. Smalley
Mr. Howard W. Woods, Jr.

Guests

Miss Helen Belcher
Col. F. F. Groseclose
Mrs. Blake R. Van Leer

MONDAY AFTERNOON SESSION

Present:

National Advisory Committee

Dr. Richard A. Dudek
Dr. Lillian M. Gilbreth
Dr. Daniel Howland
Dr. Hugo V. Hullerman
Dr. Ruth P. Kuehn

Staff

Dr. A. D. Joseph Emerzian
Mr. Thomas J. Hall
Mr. Tee H. Hiett, Jr.
Miss Louelia Owen
Mrs. Mary Kate Rush
Dr. Harold E. Smalley
Mr. Howard W. Woods, Jr.

Other

Miss Helen Belcher
Mr. E. F. C. Fisk
Mr. Robert L. Zwald

Illustration No. 10

Advertisement Data Sheet

Company Code	Product	Magazine	Date	Page Size	Ad Size	Color No.	Cost	Comfort	Safety	Ease of Use	Saves Time	Easy Disposal	Acceptance (D) (N) (P)	Other

ADVERTISEMENT PROJECT

Miss Owen: This is a disposable items advertising project. It actually has been a survey which was begun in August of this year. The hospital, nursing, medical, and other publications contain many advertisements of disposables: large, small, one-page, two-page, and down to 3-1/2 x 2-1/2 inches in size, both black-and-white and color. We wondered if the decision-making in purchasing was influenced by these ads, and if the ads were different for different users, that is, doctors, nurses, dietitians, hospital administrators, etc. We wanted to find out. We decided to survey some of the publications and determine, if possible, what their purposes were in advertising.

We limited the survey to disposable items and selected ads from medical journals, nursing journals, one dietetic journal, six hospital magazines, and three medical publications. I want to pass out some work sheets that we used in making this survey -- I used -- this is my little project all by myself, except that Dr. Emerzian gave me some wonderful ideas and help in beginning it, but the actual collection has been mostly my efforts. (See Illustration No. 10.)

We decided to list the company under the first column by code, beginning with number 1 and going through to as many companies as we found with advertisements in the magazines that we surveyed. There were 45 companies listed. The second column is a write-in of the name of the magazine, date of issue, next column page size, and if you will follow the columns on through, ad size, number of colors in ad. We defined that as any color other than black-and white. Columns were provided in which we could check off the attributes in the ad that were being stressed by the advertiser. There are seven of them: Cost, comfort, safety, ease of use, saves time, easy disposal, acceptance (doctor, nurse or patient). Now many of the advertising spreads would list one or the other, or two, or maybe all of them as accepting this product. We didn't question the authenticity of this, we merely listed what they had. Three hundred and sixty-seven disposable advertisements were obtained from 121 magazines from 1955 through September 1960.

Our main objectives in making this kind of a survey was, first, to determine, if possible, what attribute of the item was emphasized, and second, to determine what differences there were, if any, in the appeal to the audience. The basic assumption for making such a study is that technical advertising in professional magazines is for an informed audience. What we wanted to find out was what attributes the companies were pushing, also the impact and toward what group. Was it the hospital administrator and his assistants? Was it the medical profession, or was it the nursing profession they were trying to attract?

The result of this survey has been used as the basis for selecting the items and many of the questions in the Human Factors Project which was discussed just before lunch by Dr. Doby and Dr. Miller. Particularly was this true in the product acceptance or the emulation by the user group. (A detailed account of results was given on the blackboard at this point. See Illustration No. 11.)

Illustration No. 11

Advertisement Study Results

Attribute	No. Ads Found	Total Ads	Per Cent
Safety	250	367	68.1
Ease of Use	195	367	53.1
Saves Time	168	367	45.8
Cost	159	367	43.3
Ease of Disposal	149	367	40.6
Comfort (patient)	136	367	37.1
Acceptance	59	367	16.1

Discussion

Dr. Dudek: As a matter of interest, how many different products were involved?

Miss Owen: How many different products? Forty-five.

Dr. Dudek: Was that companies also?

Miss Owen: Yes, there were 45 different companies and 45 products, with a total of 367 ads.

Dr. Emerzian: Wasn't there pretty much of a density on three or four of the items?

Miss Owen: Oh, yes, I'm coming to that. I'll show you. Some of them are listed only once.

Dr. Hullerman: If an ad appeared in three journals, was that three ads, or one?

Miss Owen: We counted them each time as one. Each one was counted as it was found.

Now, this was an interesting finding. If one company rated a certain percentage on my frequency scale, their products tended to be similar. There were six advertisers that appeared only once. Five of these were in magazines dated September 1960. These will probably appear again, because most of them were new products or they were improvements on old products. You can't conclude anything from this; you can only sense trends, I think.

All of this material of itself doesn't mean a lot, but it did give us ideas on what to use for Dr. Doby's and Dr. Miller's study.

Dr. Gilbreth: Do you think this type of thing is going to spread into magazines where the general reader will get some of this feeling of the various things that are involved in hospital care? Do you think that quotations or descriptions of any of this would help to enlighten the general public.

Miss Owen: I hadn't thought about it, truthfully, but it certainly does give you food for thought.

Dr. Gilbreth: There is so much nowadays in so many fields that needs to be translated for others to use. I think that this study is extremely interesting.

Miss Owen: Well, it gave us a lot of clues, and that's what we needed in order to formulate a tool to work with in the human factors study. It has been most helpful for us and it has been most interesting to me. It came to my notice that there was no difference in ads according to whom the advertising was aimed. If you found an advertisement in a hospital journal one month, that advertisement appeared in the nursing journal, the medical journal, in all of them -- the very same ad. There are a few of the advertisements I have found that have not changed over a five-year period; they still have the same format, the same wording, and are the same size.

Dr. Gilbreth: Would it be a public relations officer in a hospital who would decide which magazines to buy?

Miss Owen: I don't know. I think it's the administrator, the nursing director, or the assistant administrators.

Dr. Howland: You were doing this to find out what influence advertising had on purchasing policies?

Miss Owen: Well, no, we wanted to know what the advertiser was emphasizing.

Dr. Howland: Did you relate this to use of these products?

Miss Owen: No, sir, we didn't go into it that deeply.

Dr. Smalley: Joe, you might give us an insight into the motivation behind this survey.

Dr. Emerzian: Well, I would say we started off with the assumption that this is, in effect, "industrial advertising." By "industrial advertising," we would mean advertising to an informed market. Therefore, the claims which would be contained in the ad would be those which, in most cases, should be demonstrable statements, because the informed audience would be able to question them. In other words, it is an intelligent audience. We assume further that the advertiser would be a rational person who would direct his advertising force, if you will, to those segments of the market which would be influential in the purchase of the commodity. What we tried to get out of this were the product attributes which they were stressing in order to form a foundation for the project which we talked about this morning, and also to get some idea as to what the advertisers thought were the people in the hospital complex who were instrumental or influential in purchase decisions. This was not a scientific inquiry, it was just to get some insight into it.

Dr. Hullerman: You know the advertisers are under considerable pressures. Now you take that group of hospital magazines, if an ad appears by one company on one product in one of the journals, the other journals go to the competitor and say, "You're falling behind in your advertising space. So-and-so has this ad. So you will get a piling up of numbers of ads in that group of hospital journals from the influence which is brought to bear.

Miss Owen: I was just trying to get a ranking of the number of times the ad appeared and the ranking also of the attribute they were pushing.

Dr. Smalley: How frequently did you find these ads in "professional" journals? Wasn't this one of the things that you found, that they didn't appear very frequently in professional journals?

Miss Owen: Not too frequently.

Dr. Smalley: This tentative finding would tend to indicate, I think, that if you are to persuade a decision toward your product, you don't deal with the user, that you appeal to the doctor or the surgeon not in his professional journal as a practitioner but in the magazines he is likely to read if he holds an administrative position. This is about what one would guess anyhow, but I believe from what you told me earlier, Miss Owen, you did tend to substantiate this suspicion.

Dr. Emerzian: Another interesting facet of this, although it wasn't explored because we didn't think it would be worth while, was to examine over time the attribute composition of specific commodities, such as a syringe, to see how long they would persist in advertising, say, safety as one of their attributes, or did they discover that perhaps the pressure of inquiry or examination forced them to drop safety out. We wanted to see what happened to attribute composition over time, but this I don't think we can do.

Miss Owen: No.

Miss Belcher: Do you have any indication that as a product becomes generally accepted and used, the advertising drops off so that perhaps the number of advertisements that appear represent what products are being pushed? This might show whether or not disposable products are used widely.

Miss Owen: There was an indication that some items are more widely accepted than others, and therefore, it is not advertised too much except when the company comes out with an improvement in it.

Miss Belcher: That's why I was raising the question. It is a little difficult to interpret.

Miss Owen: It is, it is difficult.

Miss Belcher: Not knowing what motivates the ad.

Dr. Smalley: Yes, that's really putting it mildly. There is so much "noise" "background interference" in this thing, the psychology of advertising, for one thing, is tremendously complex. Consider the apparently irrational motivations of the people who go out and get an advertising agency to do something for them. Then consider the presumed irrationality of some of the advertising agencies, themselves. And who can ever know? For example, I am advertising a certain product, and all of a sudden I wonder if I'm getting anything for my money, so one of the ways I might find out is stop advertising and see if my sales drop off. Well, that can completely mess you up here, because you might attach one meaning to it and all it means is that some fellow wants to see what effect it has. That's just one of many problems in drawing conclusions in this survey. I think the point that Miss. Owen and Dr. Emerzian made is quite appropriate -- that this was to give us an insight to make some fair guesses as to what kind of assumptions we need to make for Dr. Doby's study. Thank you, Miss Owen.

PROCESSING COSTS PROJECT

Dr. Smalley: Let's move right on to the processing costs project. Mr. Hall will carry the ball on that. He has Mr. Hiett and Mr. King, a graduate assistant, who will be helping out. Now, Mr. Hall.

Mr. Hall: This portion of our presentation is concerned with processing costs. I will defer a functional definition of processing for just a little while. The specific aim of this project or study of processing costs is the development of a system whereby any interested hospital can determine for itself the cost of reprocessing supply items. The term "cost," as I am using it here, implies a determination of both the absolute cost of reprocessing an item and the determination of a "differential" cost which we would associate with the alternative of reprocessing or using disposable supplies.

The specific objectives of our processing cost study are, first, the determination and quantification of factors involved in processing costs, for example, direct labor, capital equipment, etc. Second, we want an identification of the differential elements involved in alternative use of the disposable, as opposed to reprocessible supplies. Third, we are aiming toward the development of a standard procedure of evaluating, that is costing and summarizing, these quantified variables. Fourth, of course, will be an evaluation of this standard procedure by application to participating hospitals.

In July of 1960, at a meeting of the Project's Staff, it was decided that processing costs would be approached from the standard data basis, that is to say that detailed time studies would be made of processing operations for the specific supplies that we are interested in at these pilot hospitals. These items, which have been mentioned earlier are, rubber gloves, needles and syringes, and enemas. It was felt that data in this form would best lend itself to generalization in hospitals outside this participating group. This view was taken partly with regard to the many combinations of processing methods which were evidenced by the Atlanta Area hospitals. We further hypothesized that standard data would permit a precise determination of cost in our Atlanta Area hospitals and would provide others with a methodology for their own cost determinations. Insofar as labor costs are concerned, which is what we are primarily interested in right now, since we are so deeply engrossed in work measurement at this time, it is intended that this data will be in such a form that any interested hospital can, by direct comparison or by analogy to its own processing operations, arrive at a normal time per item. We have been handling this study on a "per item" basis, as opposed to most of the in-service studies that we have read of that go by a "per application" basis, for example, most needle and syringe studies have been on the "per injection" basis. Now this "per injection" basis doesn't consider items which are either never used but are reprocessed nor items which are broken, lost, or taken out of the cycle by various means. This procedure, our standard data procedure, is based upon the assumption that processing tasks can be divided into a number of component parts or elements and that these elements will be comparable with elements to be found in the processing operations of all hospitals. If all these processing jobs are regarded as made up of combinations of a limited number of basic tasks, the normal time for each job is then simply determined by adding the previously established standards for each of the elementary tasks which comprise it.

Let's assume we have arrived at a labor cost for processing an item at a particular hospital. It remains for us now to synthesize the method by which this hospital would introduce a disposable into its cycle, and so far as we can determine at this time, this will probably have to be on an "interview-of-users" basis as to just what method they would use in putting disposables through their use cycle, in other words, whether they would completely by-pass central supply and stock their using units, or what have you.

After this method has been synthesized, deletion of non-applicable elements from this reprocessing cycle that we have determined through work measurement will lead us to a differential figure for evaluating labor time associated with the reprocessed item as opposed to that associated with the disposable. We can use an analogous argument on other processing cost factors, such as capital equipment, associated supplies, etc. In the event the differential processing cost at a particular hospital reflects a saving, we have to keep in mind that this saving is strictly of a potential nature; in other words, this saving, in all likelihood, will not be realized in payroll reduction or in immediate decrease of material expense and capital equipment. This saving is real, but the potential worth of it will not be realized unless the individual hospital undergoes a proper re-allocation of personnel time and facilities to accomplish the realization of this potential. It's going to be up to the individual hospital to re-allocate this "dead processing time" perhaps into the quality of their methods for reprocessing items which are left behind.

As a starting point for a more particularized discussion of processing costs, let us consider the functional boundaries of processing. By functional boundaries I mean actually, I guess you would say, a working definition of processing. I refer by this to all operations reflecting on actual reprocessing, either directly or indirectly. We broke this down into four general functions bounding processing, and found them to be: Pick Up, Manufacturing or reprocessing, Distribution, and Use. These major divisions were determined to be common to all the supply items that we are considering in the study. Now it remains to outline the operations necessary for the transition of a particular item through these major divisions, and since our most comprehensive knowledge to date is in relation to processing rubber gloves, I will take this item as an example and outline the operations necessary for its transition through this processing cycle. Later, Don King and I will discuss how and why these operations were categorized into the particular format that we are using for this standard data presentation.

Under the heading, Pick Up, are listed the operations, Load, which is a transfer at the using unit of soiled gloves from a point of temporary storage to a means of transport. In other words, this would be where your orderly or aide or student nurse actually picks up the items at the utility room on the ward floor and loads them on whatever conveyance she is to use to transport them down to the central supply area. Then quite naturally follows Transportation, which is the movement of the gloves from the using unit to the central sterile supply, and third, Unload, which is transfer of these gloves from means of transport to a point of temporary storage in central supply. Of course this elementary breakdown of these operations varies from hospital to hospital according to the operational methods employed by the individual hospital. We will see later that these elemental differences are classified in our standard data system and also just how they are classified.

Under our next general division, Manufacturing, or actually reprocessing, we find the operations of Washing, Drying, Inspection, Sorting, Powdering, Wrapping, Sterilizing and Storing. This division terminates with the storage of the reprocessed glove on the central supply shelves. Distribution which is much the same as Pick Up, consists of the operations Pick and Load, which is selecting the item from the shelf and moving it to the means of transportation, Transportation, which is movement of the gloves from central supply to the using unit, and Unload, which is transfer of the glove from the means of transport to a point of temporary storage at the using unit.

Last in this processing cycle is Use, (at point of use). This term implies all handling necessary to perform some duty requiring the use of gloves, but only the handling peculiar to the use of gloves. This division terminates with the return of the used glove to a point of temporary storage at the using unit, which brings the cycle to its original starting point. Those are more or less the functional limitations we have placed on processing.

As to the status of the study at this time, just as a rough estimate, I would say we are between 65 and 75 per cent of the way through with our work measurement studies, which are the bulk of this study. We hope to have all our work measurements and the format completely done for gloves, needles, and syringes by the end of November. Then we will go into several related items like capital equipment costs, associated supplies, etc.

As Dr. Smalley mentioned earlier, there have been several student studies on this very same thing, but in trying to utilize these to any extent we found that they were heavily loaded with assumptions and guesses, no facts to support some of their figures. We just haven't been able to rely on them at all, so we are really tied up in a lot of "pick and shovel" work right at this time. At this point, I'll let Don King come up and go over with you the format we are using for presenting this data and also carry us through an actual example of how a hospital would go about determining, say, its reprocessing time for gloves. Before Don gets up, are there any questions up to this point?

Discussion

Dr. Emerzian: I have a question. You mentioned two terms, "absolute cost" and "differential cost." What is the difference?

Mr. Hall: By absolute, I mean the cost of actually reprocessing the item, the labor cost in this instance, and by differential we refer to either the positive or negative saving reflected by using the disposable article. In other words the alternative, just the difference between the two forms of an item.

Dr. Emerzian: You really mean a difference in cost.

Mr. Hall: Right.

Dr. Smalley: The implication in this might not be readily discernible. I would want to point out, at the risk of insulting your intelligence, that if we find the differential in cost to be zero, we could pretty much forget about these, because we are only interested in those operations where there is a measurable, discernible, significant difference between the two forms of the item.

Dr. Emerzian: Is the differential cost the difference between the two absolute costs?

Mr. Hall: Right.

Dr. Hullerman: You mean that you might have a cost for disposables, for example, that you wouldn't have in the other and this would be an adjustment factor?

Dr. Smalley: Yes, it's something like this, I think. You have disposables and you have re-usables. There are certain cost items that will not be any different. At the point of use it might take a minute to use either one of them. There might not be any difference whatever in the using of the item, but in the washing, it might take two minutes to wash the reprocessable item, but you don't wash the disposable, you throw it away. The Use operation has a differential of 2 minutes, while the Wash operation has a differential of zero. I think that's all we were saying there.

Standard Data on Processing Costs

Mr. King: Before I begin my presentation, I will hand out to you this summary of the methods classification scheme which we have developed. Before I get into the formal explanation of the methods classification scheme, I would like to tell you briefly how we developed this methods classification scheme, where we now stand in this development, and also what further studies and developments will have to be made before it is completely applicable.

The purpose of this methods classification was to develop a classification scheme whereby the various methods of reprocessing could be associated with the direct labor time involved in reprocessing. In other words, here we are concerned with reprocessing costs associated with the direct labor operations. To state an objective of this methods classification system would be to say that it would provide hospitals with a method for determining the direct labor time necessary for reprocessing operations without actually having to make detailed time studies themselves, in other words, a kind of synthetic system.

The data that we gathered for the basis of this methods classification system was from six hospitals in the Atlanta area and one hospital in Birmingham, Alabama. I have personally been involved for the last eight months in time study work on a part-time basis in these hospitals. In going into the hospitals I consulted with the people in the central supply departments, more specifically the people working in the glove reprocessing operations, made up a flow chart of these operations in each hospital, and then proceeded to take time studies of the methods of reprocessing. It was these times that formed the basis for this methods classification system.

If you will follow along with me, starting on the front page here, I will explain to you just how we developed this system. (See Illustration No. 12.)

The methods for performing each of the "processing" operations are as follows:

I. WASHING: The washing operation consists of all elemental operations involved in cleaning soiled gloves.

Methods of Washing
1. Combination Machine
2. Combination Machine - Add Powder
3. Domestic Machine
4. Commercial Machine
5. Domestic Machine - Add Powder
6. Domestic Machine - Prerinse
7. Hand Method

II. DRYING: The drying operation consists of all elemental operations employed to completely dry the gloves after washing.

Methods of Drying
1. Combination Machine
2. Domestic Machine
3. Bunn Machine
4. Bunn Machine - Predrain
5. Hand Drying

III. INSPECTING: The inspecting operation consists of all elemental operations employed to test gloves for holes, tears, and other defects for the purpose of separating them into their proper quality groupings.

Methods of Inspecting
1. Manual Sound Test
2. Machine-Large Diameter Air-Nozzle Test

Illustration No. 12

Glove Reprocessing Methods Classification

The following is a summary of the various methods of reprocessing gloves. The classification of these methods is based on the direct labor time necessary for performing the operations involved in reprocessing gloves:

I Washing

II Drying

III Inspecting

IV Sorting

V Powdering

VI Wrapping

VII Sterilizing

VIII Storing

IX Distribution

X Point of Use

XI Pick Up

3. Manual Water Test
4. Machine-Large Diameter Air Nozzle, and Twist Fingers Test
5. Manual Trapped-Air Test
6. Machine-Small Diameter Air-Nozzle Test

IV. <u>SORTING</u>: The sorting operation consists of all elemental operations employed to separate gloves into the various size groups.

1. Manual Sorting Into Bins, Drawers, or Groups

V. <u>POWDERING</u>: The powdering operation consists of all elemental operations employed to powder gloves with glove powder prior to packaging.

<u>Methods of Powdering</u>
1. One Side Powdered by Machine
2. One Side Powdered by Hand
3. Both Sides Powdered by Machine (excluding turning inside-out)
4. Both Slides Powdered by Hand
5. Both Sides Powdered by Machine (including turning inside-out)

VI. <u>WRAPPING</u>: The wrapping operation consists of all elemental operations employed to wrap a pair of gloves completely in a wrapper, and to indicate the size on the wrapper and place it with other wrapped gloves.

<u>Methods of Wrapping</u>
1. Cloth Envelope Wrapper, No Wicks Used
2. Crepe Paper Envelope Wrapper, Make & Insert Wick
3. Plain Paper Envelope Wrapper, No Wicks Used
4. Single Cloth Wrapper with Wicks
5. Single Cloth Wrapper, No Wicks, No Wrapper Stacking
6. Sheet Paper Wrapper, Make and Insert Paper Wicks
7. Single Cloth Wrapper, Make & Insert Wicks
8. Double Cloth Wrapper, Insert Wicks

VII. <u>STERILIZING</u>: The sterilization operation consists of all elemental operations necessary for sterilizing packaged gloves.

<u>Methods of Sterilizing</u>
1. Onto Autoclave Cart, Autoclave
2. Into Basket, Onto Autoclave Cart, Autoclave
3. Onto Transfer Cart, Into Baskets, Onto Autoclave Cart, Autoclave
4. Into Basket, Onto Autoclave Cart, Autoclave, Mark "s" on Each Package.
5. Onto Transfer Cart, Into Basket, Onto Autoclave Cart, Autoclave, Mark "s" on Each Package

VIII. <u>STORING</u>: The storing operation consists of all elemental operations necessary for the temporary storage of gloves prior to distribution.

Methods of Storing

1. Store on Shelves by Size from Autoclave Cart
    (a) Gather Gloves by Size Groups
    (b) Place on Shelves
2. Onto Transfer Cart, Store on Shelves by Size From Transfer Cart

Each of these levels represents a specific method of reprocessing gloves, and what you have before you here is just a summary. What would be furnished to the hospitals would be an elemental breakdown of each of these levels so that they could, by observing the operations in their hospitals, associate one of our methods with theirs.

You will see at the bottom of page 3 an outline of a method which people in a hospital could use to determine the direct labor time associated with their own glove reprocessing. (See Illustration No. 13.) They would read the elemental methods descriptions of the eight reprocessing operations and select methods for each operation from our standard data system which most closely corresponded to the methods which they were using in their hospital. Then, after they had done that, they would simply add the elemental times for the particular classifications of the methods which they selected and come up with the total normal time for the direct labor associated with reprocessing. Now, this is represented by a mathematical model here which just simply says to add together the normal times for each level of each operation.

On page 5, you will see a detailed breakdown of the wrapping operation. (See Illustration No. 14.) Now we have one of these breakdowns for each of the reprocessing operations. I included one for this operation to give you an example of what a hospital would be furnished with to determine their direct labor time. You will notice that we have listed the actual work elements which exist for each method level.

Discussion

Dr. Dudek: Are you going to furnish the elemental times also?

Mr. King: No. The total time for all of these elements. We have the data that could be furnished you, but we thought it best to list total time for that operation.

Dr. Smalley: What do you mean, Dick, to furnish to us today, or to the hospitals eventually?

Dr. Dudek: I mean eventually. Somebody in making this analogy might be able to eliminate an element for their total.

Dr. Smalley: I see what you mean. This decision really hasn't been reached yet. We think we are going to play around with this a good deal yet and make it even a little more practical than it appears right now. We just wanted this group to get an insight into our approach and its status now.

Illustration No. 13

Method for Estimating the Normal Time
For Reprocessing Gloves in a Particular Hospital

1. Read the elemental methods descriptions for each of the eight reprocessing operations.

2. Select the method for each operation which has the closest correspondence to the method utilized in the hospital.

3. Compute the total normal time for the eight reprocessing operations according to the formula

$$\text{Total Operation Time} = \sum_{i=I}^{VIII} \sum_{j} O_{ij}$$

where O_{ij} represents the j^{th} method of performing the i^{th} operation.

4. Estimate the total distance traveled between the eight reprocessing operations, and the average lot size transported.

5. Compute total transportation time according to the formula:

$$\text{Total Transportation Time} = \frac{.010D}{T}$$

where D = the total distance between operations

T = the average lot size of gloves transported

6. Compute total reprocessing time as follows:

$$\text{Total Reprocessing Time} = \sum_{i=I}^{VIII} \sum_{j} O_{ij} + \frac{.010D}{T}$$

Illustration No. 14

Breakdown of Wrapping Operation

Wrapping:	Normal Time
1. Cloth Envelope Wrapper, No Wicks Used	0.3051 Min./Glove
2. Crepe Paper Envelope Wrapper, Make and Insert Wicks	0.3489 Min./Glove
3. Plain Paper Envelope Wrapper, No Wicks Used	0.3634 Min./Glove
4. Single Cloth Wrapper with Wicks	0.4036 Min./Glove
5. Single Cloth Wrapper, No Wicks, No Wrapper Stacking	0.4183 Min./Glove
6. Sheet Paper Wrapper, Make and Insert Paper Wicks	0.4291 Min./Glove
7. Single Cloth Wrapper, Make and Insert Wicks	0.4359 Min./Glove
8. Double Cloth Wrapper, Insert Wicks	0.5372 Min./Glove

Dr. Dudek: What about a multi-variable chart and other tools?

Dr. Smalley: I am hopeful we will do that later, but at this stage, we haven't decided.

Dr. Emerzian: Only as a last resort, would we.

Mr. Hall: We have played around with synthesizing operation times for elements that didn't actually occur in these Atlanta hospitals. In other words, a permutation of this operation from the elements that we imagined could take place to see how it worked out, but the bulk of the data that we are accumulating is beginning to get out of hand.

Mr. Hiett: I think, as a sideline, you might mention that Dr. Emerzian wants all of these lumped together into one figure without any breakdown.

Dr. Emerzian: Then we'll work back from there.

Dr. Dudek: Or, you might work forward to "there."

Predicting Reprocessing Times

Mr. King: Now if you will turn with me to page 8 of the summary, we see a tabular record of the actual reprocessing times in the seven hospitals that we visited. The column on the left is the standard normal time which we have determined for each of these method levels. These were arrived at by taking the arithmetic average of like method levels in hospitals and coming up with the standard normal time for that level. Page 9 is a continuation of this. You see that hospitals do vary to some extent from the normal time of that level, but the variation is not too great; for the most part they stay pretty close.

Pick up and distribution consists of the operations utilized in transferring gloves from the reprocessing area to the area of use, prior to use, and the transferring of gloves from the area of use to the reprocessing area after use.

Pick Up of Ward Gloves. - Pick up consists of three major operations which are:

I. Load
II. Transportation
III. Unload

I. LOAD: This operation consists of the elemental operations employed in the transfer of gloves from temporary storage at the area of use onto the vehicle of transportation (cart, dumbwaiter, bucket, person, etc.)

Methods of Loading	Normal Time Per Glove
1. Load Into Bucket	0.014 min./G.
2. Load Onto Cart-Organized	0.022 min./G.
3. Load Onto Cart-Unorganized	0.033 min./G.
4. Load Onto Dumbwaiter	0.085 min./G.

II. TRANSPORTATION: This operation consists of the elemental operations employed in transferring the gloves on the transfer vehicle(s) from the area of use to the reprocessing area. The two major elements of transportation are: 1. Horizontal Travel
2. Vertical Travel and Associated Elements

Methods of Horizontal Travel	Normal Time Per Glove
1. Walk (normal 4 fps)	$\frac{0.004PD}{T}$
2. Walk With Bucket or Bag	$\frac{0.005PD}{T}$
3. Walk With Cart	$\frac{0.007PD}{T}$

Methods of Vertical Travel, Associated Elements	Normal Time Per Glove
1. Elevator Travel (includes wait, onto, out of, and time on the elevator.)	$\frac{P}{T}$ (1.591E + 0.165F)
2. Wait on Dumbwaiter (outside reprocessing area.)	$\frac{0.923EP}{T}$
3. Wait on Dumbwaiter (inside reprocessing area.)	0.000

Symbols: P = per cent of load by volume which is gloves.
D = distance traveled in feet.
T = total number of gloves transferred.
E = total number of elevator entries (and exits.)
F = total number of floors traversed by elevator.

III. UNLOAD: The operation, unload, consists of the elemental operations employed in the transfer of gloves from the vehicle of transportation to the point of temporary storage at the reprocessing area.

Methods of Unloading	Normal Time Per Glove
1. Unload Bucket	0.001 min./G.
2. Unload Cart-Organized	0.004 min./G.
3. Unload Cart-unorganized	0.066 min./G.
4. Unload Dumbwaiter	0.105 min./G.

With regard to the distribution of ward gloves, we have this represented in the tabular form on page 12 and it is very similar to the Pick Up, except what determines how long it takes to distribute a glove is whether the gloves are distributed immediately as needed, or are distributed on a daily basis. (See Illustration No. 15.)

On page 13, the last segment of the processing operations is what we call "point of use." Point of use consists of those activities associated with the actual use of a pair of gloves in the wards (in the patient's room.)

Point of Use Consists of Seven Activities:

1. Get Gloves - Securing the gloves from their storage area.
2. Remove Wrapper - Takes place prior to using the gloves at the point of use.
3. Put on Gloves - Includes powdering the hands before putting on the gloves.
4. Remove gloves - After use.
5. Replace in Wrapper - After removing. May or may not be done.
6. Put Away - Discarding the gloves into buckets, sacks, etc. in a utility room or other point of storage after use.
7. Transportation - To or from the point of usage. Consists either of walking only or walking with a cart.

Refer to Appendix 5 for an analysis of all the following categories:

I. GET GLOVES	
A. Distance Involved	0.073 min/G
B. No Distance Involved	0.034 min/G
II. REMOVE WRAPPER	0.069 min/G
III. PUT ON GLOVES	0.164 min/G
IV. REMOVE GLOVES	0.045 min/G
V. REPLACE IN WRAPPER (if applicable)	0.078 min/G
VI. PUT AWAY	
A. Into Open Area or Container	0.014 min/G
B. On Vehicle	0.025 min/G
C. Into Closed Area or Container	0.045 min/G
VII. TRANSPORTATION	0.002 $\bar{D}$ per G

$\bar{D}$ is a dimensionless number whose value is one-half of the length of the ward in feet.

On page 15, we have an example of how an individual hospital would determine their normal labor times from this classification scheme. (See Illustration No. 16.) Now, the normal time that we determined in this example is the predicted normal time for a hospital which we visited in the Atlanta area. In their washing operation at this hospital, they use

Illustration No. 15

Distribution of Ward Gloves

		Distribution by Cart		Distribution by Dumb Waiter	
		By C. S. Personnel	By O. R. Personnel	Located Inside C.S.	Located Outside C.S.
Pick, Load, Unload, Store, Wait on D. W.	Immed. Dist.	Not Available	Not Available	0.313	Not Available
	Daily Dist.	0.084	0.105	0.071	0.082
Horizontal Transport	Immed. & Daily	$0.008 \frac{PD}{T}$	$0.005 \frac{PD}{T}$	$0.005 \frac{PD}{T}$	$0.004 \frac{PD}{T}$
Wait for Elevator		$1.318 \frac{EP}{T}$	$1.318 \frac{EP}{T}$	NOT APPLICABLE	
Onto Elevator		$0.160 \frac{EP}{T}$	$0.160 \frac{EP}{T}$		
Elevator Time		$0.165 \frac{F}{T}$	$0.165 \frac{F}{T}$		
Out of Elevator		$0.113 \frac{EP}{T}$	$0.113 \frac{EP}{T}$		
TOTAL ELEVATOR TIME		$\frac{P}{T}$ (1.591 E + 0.165 F)			

Illustration No. 16

An Example of the Computation of the Direct Labor Time
Involved in Reprocessing Gloves

I. REPROCESSING

A. Washing: Domestic Machine . . . . 0.0092 min./glove

B. Drying: Domestic Machine . . . . 0.0045 min./glove

C. Inspecting: Machine small diameter
air nozzle test . . . . 0.2699 min./glove

D. Sorting: Manual Sorting into bins . . . . 0.0311 min./glove

E. Powdering: One side powdered by machine . . . 0.0123 min./glove

F. Wrapping: Single cloth wrapper, with wicks . . 0.4036 min./glove

G. Sterilizing: Into basket, onto autoclave
cart, autoclaved . . . . 0.0160 min./glove

H. Storing: Store on shelves, by size,
from autoclave cart . . . . 0.0251 min./glove

I. Transportation between operations: (D = 145 ft.) (T = 150 glv.) $\frac{0.010D}{T}$ . . 0.0097 min./glove

Total Reprocessing Time . . . . 0.7815 min./glove

II. PICK UP

T = 14 gloves
P = 5% by volume
D = 1100 feet
E = 6 elevator entries and exits
F = 10 floors traversed

A. Load: Load onto cart, unorganized . . . . 0.033 min./glove

B. Transportation:

1. Horizontal
Travel: Walk with cart $\frac{0.007PD}{T}$ . . . . . . 0.027 min./glove

2. Vertical Travel and associated elements: $\frac{P}{T}(1.591E + 0.165F)$ . . 0.040 min./glove

C. Unload: Unload cart, unorganized . . . . 0.066 min./glove

Total Pick Up Time . . . . 0.166 min./glove

Illustration No. 16 (continued)

III. DISTRIBUTION

T = 72 gloves
P = 15% by volume
D = 1100 feet
E = 6 elevator entries and exits
F = 10 floors traversed

A. Pick, load, unload, and store:

Daily distribution by cart by Central Supply Personnel . . . . 0.084 min./glove

B. Transportation:

1. Horizontal travel: Daily distribution by Central Supply Personnel: $\frac{0.008PD}{T}$ . . . 0.018 min./glove

2. Vertical travel and assorted elements: $\frac{P}{T}(1.591E + 0.165F)$. . 0.024 min./glove

Total Distribution Time . . . . 0.126 min./glove

IV. POINT OF USE

A. Get gloves, distance involved . . . . 0.034 min./glove

B. Remove wrapper . . . . 0.069 min./glove

C. Put on gloves . . . . 0.164 min./glove

D. Remove gloves . . . . 0.045 min./glove

E. Replace in wrapper . . . . 0.078 min./glove

F. Put away . . . . 0.014 min./glove

G. Transportation, $\overline{D}$ = 150 ft., $(0.002\overline{D})$ . . . . 0.300 min./glove

Total Point of Use Time . . . . 0.704 min./glove

V. SUMMARY

A. Reprocessing . . . . 0.782 min./glove

B. Pick Up . . . . 0.166 min./glove

C. Distribution . . . . 0.126 min./glove

D. Point of Use . . . . 0.704 min./glove

Total Processing Time . . . . 1.778 min./glove a domestic machine, so consulting our table of standard values, we list the value for washing with a domestic machine; we do the same thing for drying. In inspecting, they use a machine which we call a "small-diameter air nozzle test," and we list the normal time for that particular operation. Each of these times is on a "minute per glove" basis. The other times are determined in a similar manner.

Dr. Smalley: Excuse me, Don, but I think it important that we make it clear to everyone that these values are not the actual time values you obtained in this hospital, but are those obtained from the standard data you had previously established.

Mr. King: Right. In the reprocessing of gloves in this hospital, the total distance between all the operations was 145 feet, and we estimated the average lot size of gloves reprocessed to be 150. These values were inserted in the formula, giving us the value 0.0097 minute per glove. Now all that is left to do is to add the estimated normal times and we come up with 0.7815 minute per glove. From our actual data from time studies, the actual time in this hospital, the time for reprocessing gloves, was 0.8115, which is a difference of about 0.03 minute per glove. This is pretty close.

We notice that in a typical pick-up operation, they picked up 14 gloves, or 7 pairs. Observing this operation, we estimated the per cent of the load by volume to be 5 per cent. The total distance traveled in the pick-up operation was 1100 feet. During this pick-up, it was necessary for them to take an elevator to go to the various floors. There were six elevator entries and exits necessary. Also, the elevator traversed the total of 10 floors during the pick-up operation. At the floors, the gloves were loaded onto the cart in an unorganized fashion. Consulting our standard data system for this particular level of Load, we find the value 0.033 minute per glove. In Transportation, the horizontal travel in this hospital was done as they walked and pushed a cart through the various floors to pick up the gloves. The standard data formula for this method of transportation and pick-up was $\frac{0.007PD}{I}$. Inserting the values in this formula we come up 0.027 minute per glove for the horizontal transportation element, and for the vertical transportation and the associated elements we come up with 0.040 minute per glove. Unloading the cart back in central supply: the gloves were loaded on the cart in an unorganized fashion, so the operator in central supply would have to unload the gloves in an unorganized manner. The time for this level is 0.066 minute per glove. Summing up these normal times, we come up with 0.166 minute per glove for Pick-Up.

Discussion

Dr. Dudek: What do you find was the reason for getting a difference in loading the cart in an "unorganized" fashion versus an "organized" fashion? Why is it that "unorganized" is higher than "organized?"

Dr. Smalley: I've heard that question before.

Mr. Hall: What we mean by "unorganized" is the way the gloves are left at the utility room after Use. Maybe they are scrambled up there in several different locations among a variety of items whereby she has to go around and pick up a glove here and a glove there.

Dr. Dudek: This ought to be defined a little bit better then. This is "unorganized" storage.

Dr. Smalley: That's exactly what I told them. It's not the cart that's "unorganized," it's the storage area from which you get the material to put on the cart.

Dr. Dudek: I see, ok, that explains it.

Concluding The Presentation

Mr. King: On page 16 (See Illustration No. 16), we show the computations for computing the normal times per glove for the Distribution phase of reprocessing. The average number of gloves distributed per distribution load was 72 gloves, or 36 pairs, and these comprised 15 per cent of the total load by volume distributed. Again, the total distance traveled was 1100 feet and the total number of elevator entries and exits was 6. The total number of floors which the elevator traversed was 10. Now we have all the data we need to determine the normal time for Distribution in this hospital. For the elements, Pick-Up, Load, Unload, and Store, this was done on a daily basis by cart and by central supply personnel. Consulting the standard data for Distribution, we have a standard normal time of 0.084 minute per glove for these particular operations. On Transportation time, this is determined exactly as it was in Pick-Up. Adding these values, we get a total time for Distribution of 0.126 minute per glove.

The last segment for which we will have to estimate the normal time is the "point of use." We merely go down and put the times on a "minutes per glove" basis with each of the elements of point of use, add these up, and get a total time of 0.704 minute per glove for point of Use. Down at the bottom of the page, we have the summary where I have added our estimated normal times for each of the major segments of operations and have come up with a total reprocessing time of 1.778 minute per glove.

Dr. Hullerman: Is that per glove, or per pair of gloves?

Mr. King: Per glove. You would have to multiply by 2 to get the time "per pair." The cost on a "per glove" basis is one of the further developments that we have to make in this project. We must determine some wage rate scale in the various hospitals so that we can come up with the average labor rate to apply to this particular time to get the labor cost on a "per glove" basis. This would be the labor cost involved in reprocessing reprocessable gloves. To compute the savings in going to disposable gloves would require that for a given hospital, one would have to determine the operations in reprocessing which would be eliminated by going to disposables and subtract this from the total reprocessing time. The difference here, multiplied by the labor rate, would give us the dollar saving on a "per glove" basis. This completes the presentation of the methods classification.

Discussion

Dr. Dudek: What type of performance rating are you using in establishing your normal time?

Mr. King: I just rate the operator with the picture I have in my mind of his doing the operation in a normal manner, under normal conditions.

Dr. Dudek: You use "speed rating," then.

Mr. King: Yes.*

Dr. Emerzian: I have a leading question, Don. On page 10, you have an equation for the normal time per glove for walking. You would presumably associate a cost with this for a reprocessable item. For a disposable item, T in this particular case would be zero, so that the equation would be zero.** Is the difference between these two things the so-called differential cost that you talked about?

Mr. King: In this case, I don't think it would be so, because in picking up gloves from the floor, other items are picked up too, and whether or not disposable or reusable gloves are used is not going to eliminate the necessity of picking up other items from the various nursing units, so this time wouldn't be eliminated.

Dr. Emerzian: So you wouldn't have this term in your equation?

Mr. King: For determining the difference between using reprocessable and disposable?

Dr. Emerzian: First, we get an absolute cost; is that what you're saying?

Dr. Smalley: Are you talking about the P in the walk equation?

Dr. Emerzian: That's right. The value of this would not be a term in your equation, because this term would then contribute to absolute costs.

* Editor's Note: It is more reasonable to assume from the answer given that "effort rating" was used.

** Editor's Note No. 2: It T = 0 in the expression, $\frac{PD}{T}$, then the expression approaches infinity, not zero. Dr. Emerzian's point, otherwise, is true and pertinent since P in the expression would be zero for a disposable item that was not transported.

Mr. King: This sytem determines absolute costs; it doesn't determine the differential costs.

Dr. Hullerman: Are you planning to do this same sort of thing for the disposable glove: You have certain costs there plus the problems of disposing of the disposables. This gets into incineration and housekeeping load and other items. Some of these things are not too easily disposed of.

Mr. King: Yes, we discussed this and we thought, for gloves, that on the floors they would probably be deposited in trash containers or something of this nature.

Dr. Hullerman: Do you have a description of the costs for disposables?

Dr. Emerzian: We have no data with respect to disposables.

Dr. Smalley: The practical answer to your question, Dr. Hullerman, is yes we plan to do that, but haven't yet. As a matter of fact, we anticipate that this will be fairly easy to do because a good number of what is already here would apply to disposables then there would be a few like you mentioned that would be new operations that we don't yet have.

Dr. Hullerman: Yes, you have a different picture, I think, with disposables. This will vary by hospital.

Dr. Smalley: We may not be able to devise a system to deal with all stages of transition from reusable to disposable. We have been assuming that this scheme is only going to work in an early transition stage. It probably is not going to work at the extremes without some major revision. Let's take the example you mentioned, this business of trash disposal. If you're well into disposables, you might have to create a new trash disposal department. Whereas in an early stage, you could handle that as an incidental duty for housekeeping.

Dr. Emerzian: If you are at the disposable extreme, you may have the department already. The incremental cost would be zero.

Dr. Dudek: This has got to be worked in some place.

Dr. Emerzian: You tell us how.

Dr. Smalley: It's hard to deal with this question.

Dr. Dudek: Well, maybe, just for the time being, with three different models. One for that end, one for this end, and one if you are somewhere in the no-man's land.

Dr. Howland: Now, back to why you do all this. Isn't this to make a decision whether to do it with disposable or reusable?

Dr. Smalley: Yes, and you do this one item at a time. If you start now to begin to adopt disposables, you will have one set of circumstances, but the more of these decisions you make, the more atypical each successive decision becomes until such point as your model is obsolete. That's where Dick's point would come in. At some point, you pick up a different model and start using it. I think the methodology is pretty much the same as to how you get these, but my point is that the model is "perishable."

Dr. Dudek: But if you could build in this incremental cost, a hospital at that far end could also determine roughly how many must they adopt before they are at least breaking even.

Dr. Emerzian: You could set it up as a constant, I suppose. Each rejection really has some monetary saving, but it's not sufficient for you to move on, adopting on the basis of adopting that one alone, so you carry it forward to your next decision, so to speak.

Dr. Hullerman: I find this very interesting. These (standard data) tables are fine because they mean that we in the hospital do not have to calculate all of these times. We are not capable of doing it. I was wondering, though, is there much of a range in time values between hospitals for the same method? Some of these are as much as 100 per cent variation or more, where they're using the same method. Are these times good enough that we could use them, the average of them?

Dr. Smalley: I'd say, no, not to use them generally. There are several big limitations here. First, these are bound to be subject to measurement error and also we are not certain that the method classifications we have are sufficiently homogenious and mutually exclusive. We also have a limited number of hospitals. My own opinion would be that this sample would have to be broadened, we would have to get more data, and get a little better statistical significance before we would be ready to say this is it.

Dr. Hullerman: And yet, unless we have some figure like this average figure here, it's impossible for a hospital to apply this system.

Dr. Smalley: That's right. That's something we are very conscious of. We are going to have to compromise between what would be statistically "right up to snuff" as opposed to what is going to be practical enough for hospitals to use.

Dr. Hullerman: This would be very helpful.

Dr. Smalley: I think, right now, the data here would be better than the information you are now making decisions on.

Dr. Hullerman: Better than trying to do it yourself, yes.

Dr. Emerzian: May I ask this, Dr. Hullerman. An example is worked out here. Would this example, in your opinion, be too burdensome for the hospital.

Dr. Hullerman: It wouldn't be so burdensome if we didn't have to measure the number of feet and percentage of load, etc.

Dr. Smalley: We have some suggestions on this. I'm glad you raised that, Joe, because I had made a note to bring it up if you hadn't. Even though, theoretically, an administrator or someone else, whoever is concerned with this, could go around and measure all these distances and count all the elevator floors and entries and all, this is not as practical as we would like to have it.

Dr. Hullerman: You can't trust your figures when you get them unless you have somebody that is awfully close to you making them or somebody that's in a team making studies.

Dr. Smalley: What we have already decided that we wanted to try is to do some correlations between readily available statistics and the parameters that we have in our formulas. For example, instead of dealing with the number of elevator floors, you might find a variable like the number of floors in your hospital or the number of beds or your average census or some other readily available statistic that would correlate well with these parameters, in which case you would have this information. Of course, we have no idea whether we will be successful in this. We are definitely going to try.

Dr. Gilbreth: Do you make comparisons not only within hospitals but on industrial and other activities?

Dr. Smalley: Yes, say, in "walking time." We have used the standard 4 feet per second as the walking time. As a matter of fact, that's where this walking standard came from. Our time studies did not differ enough from the "4 feet per second" standard to warrant a change from it.

Dr. Gilbreth: Pace is so important, though.

Dr. Smalley: Right. Wherever possible, we have tried to tie this back to what we know about manufacturing work that has been done.

Dr. Hullerman: I think that this is very helpful, really. Even though it might be grossly out of line with what eight different hospitals did, it is going to be better than they can do for themselves. I notice you do not have the other cost factors in this. Are you going to get the capital costs and others?

Dr. Smalley: That's coming up soon.

Dr. Dudek: I think Dr. Hullerman pointed out a good discrepancy, earlier. I would like to know, why did such widely diverse times exist in the same method in two different hospitals?

Mr. King: I would think, that being the washing operation, it was probably the quantity of gloves that were washed. We took the time study, and to get the time per glove, we had to divide the quantity of gloves washed into the total time observed, to get a "time per glove."

Dr. Dudek: In your divisions, then, did you use their average load or the load at the time of time study?

Mr. King: The average load that we determined from our observations.

Dr. Dudek: Their average load might be more meaningful and that might get these times in line.

Dr. Smalley: We did make those comparisons when we generated these for that very reason. That is, we took the time per batch in anything that you handle by batch. For example, you are going to put a pile of gloves on a cart. Well, you can probably put 50 up there at once about as quickly as you could put 20 up there at once, but the time per glove would be tremendously different. We looked at that too. There's a good bit more stability in the basic data than there is in this derived figure of "minutes per glove."

Dr. Dudek: What I am saying is, rather than giving this average normal time on this basis, do it on a batch basis. If your batches run between zero and 25 gloves on the average or 24 gloves, your time is thus and so with this method. If your batches run from 25 to 50 on the average, use this time.

Dr. Emerzian: This is merely a statement of the same problem, because you are dealing in intervals.

Dr. Dudek: No, what I am saying is that if this hospital got 0.005 and normally runs bigger batches than another hospital, you should compare times per batch.

Dr. Smalley: What Dick is really saying here is, let batch size be one of the unknowns in this formula and then they can plug in their own values -- the interval, the exact figure, or whatever.

Dr. Hullerman: But, let's not do it unless it helps because we want it simple.

Dr. Dudek: That's true. This is all a question of how much accuracy they want.

Dr. Hullerman: Not too much here, just a good workable basis.

Dr. Dudek: It might be better to start with as fine an accuracy as you can get. In other words, one of the steps -- you remember when we were talking about this at Pittsburgh -- was that we would try to get accuracy first then we would go back and say, "well, now look, it's foolish to ask them to do this, and to do this, and to do this." Now let's see if we can't lump all these things together and get a little average here that one might just plug in an average. We realize that we are definitely using averages and that if we want real accuracy we might go back to the original model that had accuracy and now we are using this wide open one just because it is convenient to us. In other words, we make two models, an accurate model and a convenient one.

Dr. Smalley: Another way of putting this would be that you try to be as accurate and precise as possible and let the burden be upon those who advocate simplicity and pull you as far away from that as they feel they have to in being practical, as opposed to the case where you go out and at all costs make it practical. Then the burden is upon someone to try to tighten up your precision. We recognize that it has to be a practical thing that they would use. We don't care about developing something that somebody will file away on a shelf with all their other studies. On the other hand, we want to give up as little scientific accuracy as we dare in the process of making it practical. I suppose we have a fond hope, too, that out of this we would place a little motivation upon the part of every decision-maker to be more factual in his decisions.

Dr. Dudek: This is what we are trying to do anyway. The more factual we can be, the less "slop" we have, the "slop" comes from subjectivity, and our devisions are going to be better.

Dr. Smalley: There are two or three points in relation to this. I want to make sure we get the Committee's reaction. One of these Don mentioned, one of our next steps here would be to cost out these direct labor times, and obviously one could go out to each individual operation and find out what the hourly rate is of that operation and cost it that way. We doubt that this is going to be practical. We are thinking that maybe some sort of wage survey would be indicated to determine the extent of variability in the going rate of pay for the people who usually perform these kinds of operations and deal with these on some of average rate basis if the variability is not great. Now, I am wondering if you have any ideas or reactions to that plan?

Dr. Dudek: I think that goes hand-in-hand with this that we are talking about. At the same time you are getting your accurate one, you make your decision as to whether you can average it up for your practical one. To be real accurate, you'd have to get all these different wage rates. This is a lot of work, so you get your average for this kind of work in your hospital and plug it in once.

Dr. Hullerman: Could you establish a figure to be used on the average dollar per hour for the entire group of personnel that is used in this process and apply that to your labor?

Dr. Smalley: This is possible particularly since the differential in cost, which will be the most significant part of this, probably occurs at those places where aides do most of the work. Our suspicion is that the variability in hourly rate for aides in any given locality is not great. You wouldn't introduce much of an error if you used average hourly rate for aides to cost out the whole thing. Now where that will bog down I'm afraid, is at the point of use where you will use a professional nurse or a student nurse. The equivalent hourly rate might not be close to that of an aide. I think what we need to do is shed more light on this, to study the wage situation. We frankly don't know what the variabilities are right now.

Now there are other angles to this that I think deserve some attention. One of these is the old question of "phantom savings." Let me refresh you on what we mean. What do you do with time saved? If you follow this through, there is a subtlety about this that's not so obvious on the surface. Here we are saying that these would be the times if these people worked at a normal performance level and if they didn't waste any time and if they didn't divert part of their attention to things that are not technically part of their job and if they do not, through other motivations, go off and help take care of patients a little better. These would be the times. We know all these other things happen, so, what do you do with them? They are obviously a part of the cost of reprocessing and if you didn't reprocess, you wouldn't need the aide in central supply. Therefore, she wouldn't be available to do these things. In effect, this is sort of an overhead figure that you carry, and I'm afraid you undercost reprocessing time if you do not build into your system some burden figure for all this make-work, extra work, unofficial duties, if you will, and so on.

Closely associated with this is another troublesome one. What about lost time? By that I mean this, suppose we come up with a normal time of, say, one minute per glove and all this aide is supposed to do is process gloves. At the end of the day you find out she has done 300 gloves. Well, we say that should have taken 300 minutes, but she works below 100 per cent performance so it actually took 350 minutes, let's say. That still leaves 130 minutes in an eight hour day. What did she do with this time? Well, if you go out and study it, you probably won't find her sitting around doing nothing for 130 minutes, but there will be a difference between the 480 minutes elapsed time and the 350 minutes of work time.

Dr. Hullerman: That's why I am not too concerned about this being terribly accurate as long as it's consistent. One of our residents ran a study on what people were doing, and I think he covered 15 minute periods around the clock on selected units for an interminable length of time. When you get all done, you find that unproductive time ranged, I think, the least was over 20 per cent up to between 45 and 48 per cent, something like that. This unproductive time included coffee breaks, etc., but also a considerable amount of "unaccounted-for" time. This comes back to the matter of supervision, which is a problem. I would think, in most places, the amount of unproductive time is very high in almost any kind of operation. I would think you would have to use something like 25 to possibly 30 per cent of the time as not being productive in keeping with this schedule here, but this might in itself be worth taking a look at in your study.

Dr. Smalley: I think that's a good point. Putting it another way, you might say, why worry about 2 or 3 per cent one way or another in the accuracy, if you are going to have a 30 per cent figure unaccounted for in the whole cost picture. Now Miss Owen and Mr. Newberry did a work sampling study last summer in which we did get some information on what per cent of the time these people devote to this, this, and this, and I forgot the figure off hand, but I would judge it is in the 20 to 30 per cent range for "unaccounted for"time. Part of this is legitimate personal time, running errands somewhere else and you didn't know where they were, and part of it was probably fooling around.

Dr. Hullerman: When we came to the matter of whether to put in glove washing equipment, we also felt first that this large percentage of this "unaccounted for" time was probably not so very productive anyway, and if we could use it, we wouldn't have to find more time, we already had it to be used. Therefore, to obtain the use of the time we might save from the same number of personnel and use that time for other purposes, we said, well what can we do in rescheduling the job and we found that we could cut off two employees in central supply, and by rescheduling the work, do as good or better job than we were doing with the two employees there. Now, on top of that, we took a look at the average number of uses for a reprocessed glove which turned out to be surprisingly low. I won't even give you the figure, I am so ashamed of it. Grossly, we know we can save two employees' time, we know what the cost per disposable is as against reprocessed glove, and we have an idea of the number of uses, it looked like we were safe in at least giving it a trial run, which we are doing. A very interesting thing happened. We found that instead of using the disposable gloves as disposable gloves, we were reprocessing them and probably getting more uses out of them for non-surgical purposes, on the floors, than we got out of reprocessed gloves. So again the model is going to change as your operational method changes.

Dr. Smalley: Yes. We found the disposable gloves being reprocessed and the reprocessable ones being disposed of, both ways. As a matter of fact, I was thinking a moment ago as we were talking, that when you get right down to it, the difference between the disposable and the reprocessed item is more an economic matter than it is any basic characteristic of the product. As a matter of economics, if it costs a lot and its durable, you reuse it. The way you make something disposable is to sacrifice some durability and longevity in the interest of economics, but there is no close dividing line between the two.

Dr. Hullerman: If you can find a hospital or two that is using disposables, what are they doing on reprocessing disposables might be a factor in helping you make a decision about your model.

Dr. Gilbreth: What does it do to labor costs.

Dr. Smalley: The presentation tomorrow morning will speak to this to some extent. We have studied the average life of an item, that is, when it is reprocessable, how many uses can they get out of it. We have a tremendous amount of data on this.

Mr. Hall: Dr. Smalley, while we have our advisors here, would you like to go into this problem now of the marginal versus the prorated basis, or would you like to save that until the very end?

Dr. Smalley: Well, you brought it up now, so go ahead.

Mr. Hall: As you can see in just going through these pages, we have a lot of percentage figures. We have been proceeding on a "prorated" basis for these items. In other words, when a person is pushing a cart loaded with several items, only a percentage of this transportation time is allocated to gloves. We have been kicking this back and forth ever since I have been on the project as to whether this is the correct basis or whether we should go on a "marginal" basis.

Dr. Smalley: Maybe you ought to explain what we mean by the "marginal" basis.

Mr. Hall: I, personally, am not in favor of the marginal basis.

Dr. Smalley: Joe, you are the economist, you tell us what the marginal basis is.

Dr. Emerzian: I tried to get at this question earlier, but no one picked it up. I was looking for help too. A marginal basis in this illustration?

Dr. Smalley: Yes. It has application elsewhere, but let's talk about something like distribution or pick up.

Dr. Emerzian: Why don't we go back to the same example we had before. I think that we might possibly look at it this way. In the case of transportation for disposables, this activity would drop out, but does this mean that you are actually saving the absorbed cost of the transportation, or is the cost still there because the activity is not a marginal activity?

Dr. Dudek: Yes and no. You are saving it, but you aren't. You should show that it is available for saving, you haven't even shown that it is a potential saving. What you are saying then is, when we get to the last item on the cart, we could eliminate it entirely and we have saved all that transportation time.

Dr. Emerzian: You are not, at the moment, saving this at all. You are not at the margin, that's why. The margin merely means that you have a change in behavior; you drop a person or you drop an activity. We don't know in this particular case, unless P happened to be 100 per cent. In that case, yes, it's clear cut. Anything less than 100 per cent is yes and no; it's indeterminant.

Dr. Smalley: Let's take pick-up on reprocessables. Let it be presumed, as is the usual case, that these gloves are picked up along with all other things. They go back to central supply on a cart with everything else and let's say they costs 1¢ per glove to do this. When you go to disposables you don't pick them up, so your cost is zero cents; but with disposables, you must get rid of them and this costs, say, half a cent? One might say, no, if he adheres to the marginal school because he would say even though you eliminate the gloves from this operation, you don't eliminate the cost because you still have to go back with the cart. You can either consider that the cart would have gone anyhow and not charge the gloves with any cost, or you can say everything else on the cart shouldn't get charged, because if the gloves had had to go, it would carry part of the cost. It's really accounting philosophy, isn't it? It's a way of looking at it, there's no scientific answer to it.

Dr. Emerzian: It may depend largely upon whether you are interested in the effect upon the balance sheet.

Dr. Hullerman: You brought this up last year, I believe. What effect does this have on my balance sheet, my operating statement for this particular period? Any effect? Well, no. Then there's no difference in cost.

Dr. Smalley: You're being quoted from what you said 18 months ago.

Dr. Emerzian: This is a practical approach.

Dr. Dudek: What happened to the idea we were tossing around in Pittsburgh when we first talked about this, Hal?

Dr. Smalley: Which one was that, Dick?

Dr. Dudek: You were going to have two figures for your model, one showing those costs that definitely are going to be "in-pocket" savings and the other was going to take up just these kinds of things showing the potential that you are saving but will not be in-pocket right now. In other words, your saving right now is merely theoretical, but if you could eliminate every item from that cart, then you have in-pocket savings.

Dr. Smalley: That's good, Dick. I'm glad you brought that up because it applies to places other than this. Let me give you another example. As you indicated, you made some sort of study and found that you could eliminate two people. Whether you really eliminate these two people or not may be more a matter of supervision than it is methods and workload. So, you would really have two answers: (1) If you operate the way we usually operate, namely, we keep people around whether they are needed or not or we put them on something else that we had been hoping to be able to get done, the saving is "potential"; and the other one would be (2) You really made those savings by either getting rid of those people or putting them on other productive work. I think your suggestion is a distinct possibility.

Dr. Dudek: And in your model, you could take this into consideration. You could split it up, this part gives you the "in-pocket" saving and this part gives you the "potential" that will not be realized until other marginal items are considered.

Dr. Hullerman: If you were going to consider that on the "prorated" basis rather than "marginal," after a while you would get enough of these in some situations to make the decision to add somebody to do the

the job or cut out those things eventually. I would imagine you ought to carry it but not kid ourselves that this is a savings because really it is not a saving, but just a potential saving until you have converted it, isn't it?

Dr. Dudek: Yes, that's right.

Dr. Smalley: This has a relation to this continuum that I drew on the board. Take an extreme example. You gradually get disposables adopted. This pick-up cart is having fewer and fewer items on it. Pretty soon, you've got one item on the cart. If it carries "prorated" cost, it is going to be a tremendous amount of cost. When you consider eliminating it, it may not even be close. You are paying so much to handle just one or a few items that the decision is made for you, once you know what the facts are.

Dr. Emerzian: Let's look, fundamentally, at what happens here. You're talking about an activity. The cost of that activity is the walking and the proration, I say, is irrelevant.

Dr. Smalley: It's not irrelevant with regard to the item to which you attach that cost.

Dr. Emerzian: Well, I say the cost is still there until you reach the margin, then walking drops out.

Dr. Dudek: But if you eliminate it, Joe, how do you let them know when they have reached the margin?

Dr. Emerzian: I've got another approach to this. I have one or two ideas I want to talk about tomorrow, but if I talk now, I may have nothing to say then.

Dr. Smalley: Let me interrupt for a procedural question. Mrs. Gilbreth has a commitment across campus at four o'clock and I have promised to get her there. I would suggest that if you are not completely exhausted by now and if you feel there are other productive things that you want to discuss, please stay and do that.

SUMMARY OF A GENERAL DISCUSSION

(Editor: The following is an edited summary of the points raised in a general discussion from 4:00 to 5:00 p.m. at the conclusion of the Monday afternoon session.)

Several comments were made in relation to the question of "accuracy" versus "simplicity." There seemed to be two schools of thought, one advocating the need for accuracy even though there appeared to be a general lack of adequate theory, and the other advocating simplicity as characterized by gross, "in the ball park" measurements. Dr. Howland appeared to favor the "accuracy" school and Dr. Hullerman the "simplicity" school. A plea was made to consider the cost of gathering data and taking measurements versus the cost of making mistakes based upon the degree of accuracy in such data and measurements, i.e., alpha and beta risks or Type I and Type II errors.

Some doubt was expressed in relation to the soundness of the standard data approach in Processing Costs with respect to statistical reliability of the data, considering the small sample size of seven hospitals. There was some interest for the notion that each hospital should obtain its own measurements rather than use averages of distributions which might contain considerable variability. In this connection, there was a suggestion that a "textbook" or "how to do it" approach might be better than sending out formulas or numerical averages. Dr. Howland appeared to get some support for these notions from Dr. Dudek.

Dr. Kuehn advocated the importance of good work methods and expressed the hope that the research would lead to method consciousness. There seemed to be some doubt that methods improvement *per se* was within the scope of the project as presently conceived.

Dr. Dudek made the interesting suggestion that an effort be made to interest women in the career of hospital industrial engineering and pointed out that this could be a rewarding profession and could satisfy a need in the field.

Some discussion took place in relation to the desires of hospitals for gross answers and the conflict between this desire and the apparent need for sound research methodology. There was a belief that the "theoretical" could be provided along with the "practical"; there was also some doubt that this could be done. Dr. Kuehn advocated that small pieces of results should be supplied as generated and that we should not wait until all the work is finished before making it available to the hospital field.

The remaining part of the hour was devoted to a discussion of the "human factors" project. This discussion was characterized by an admitted lack of understanding about the project, its objectives, and its methods. Among the points covered were the following:

1. The multiple regression approach and its purpose and its limitations.
2. A "rehash" of status, environment, and value systems.
3. A question as to whether the cost of disposables was to be made a function of factors, such as safety, comfort, etc.

4. Was this project to be a "preference survey?"
5. Will it consider non-monetary factors only?
6. Will it result in a device for predicting decisions and if so will one ignore monetary costs if the decision prediction indicates a non-economic course of action?
7. Do you plan to get multiple regression coefficients now and wait to get actual measurements for the unknowns until later?
8. Do you measure safety, comfort, etc., and plug these into the model to generate a decision?
9. Is the forced-choice interview technique good?
10. Would not this be prejudicial? Would not an open-end question as part of a pilot study generate a listing of factors?
11. Why not add a new factor, that of "space availability?"

This general discussion session adjourned without an attempt to formulate conclusions or to reconcile differences.

TUESDAY MORNING SESSION

Present:

National Advisory Committee

Dr. Richard A. Dudek
Dr. Lillian M. Gilbreth
Dr. Daniel Howland
Dr. Hugo V. Hullerman
Dr. Ruth P. Kuehn

Staff

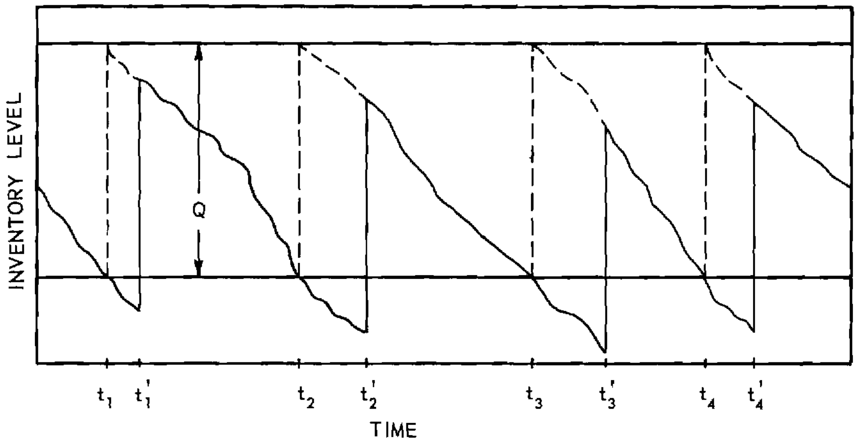
Dr. A. D. Joseph Emerzian
Mr. Thomas J. Hall
Mr. Tee H. Hiett, Jr.
Mr. Thomas L. Newberry, Jr.
Miss Louelia Owen
Mrs. Mary Kate Rush
Dr. Harold E. Smalley
Mr. James W. Standard
Mr. Howard W. Woods, Jr.

Other

Miss Helen Belcher

Illustration No. 17
INVENTORY BALANCES

(a) FOR FIXED-ORDER LOT SYSTEM



LEGEND

——— Quantity on Hand

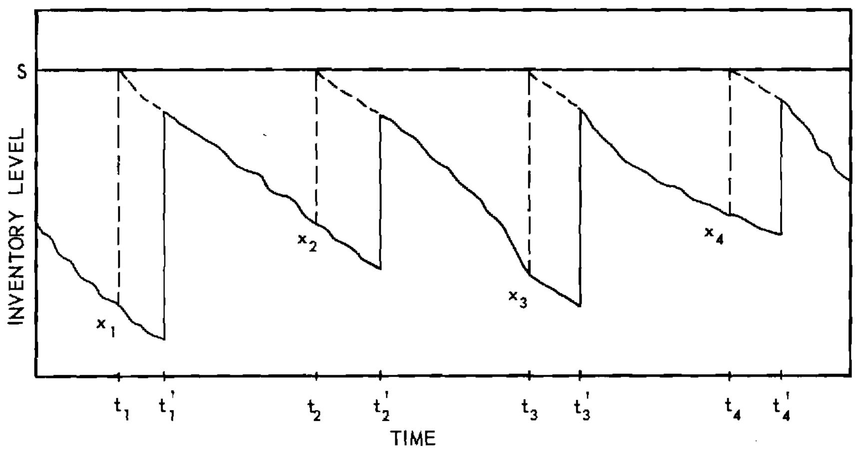
– – – – Quantity on Hand and on Order

t_i is the time when the ith order is placed.

t_i' is the time when the ith order is received.

Q is the fixed order quantity.

(b) FOR FIXED RE-ORDER CYCLE SYSTEM



LEGEND

——— Quantity on Hand

– – – – Quantity on Hand and on Order

t_i is the time when the ith order is placed.

t_i' is the time when the ith order is received.

S is the maximum stock level.

$t_i - t_{i-1}$ is constant.

INVENTORY COSTS

Dr. Smalley: This morning, we will talk about three different projects. But in a sense, they are all one project, dealing with the matter of inventory costs. The first phase of this is what we have termed, "Inventory Policies." This is a broad category to deal with some questions that have an intimate relationship with the project and some that are rather incidental. Then we will be moving into "Carrying Costs," and finally, "Order Costs." First, I'll call on Mr. Newberry, Assistant Research Engineer on our project. He has been with us almost from the very beginning and he will start off by talking about inventory policies. Tom.

Mr. Newberry: Thank you, Doctor Smalley. It's a pleasure to have everyone here today, a captive audience. I have been looking forward to having an opportunity to talk about some of my projects here.

First, I would like to discuss why we are studing inventories in this project. I believe that the chief reason is that when hospitals go to disposable items, undoubtedly there will be more items "running through the mill." Now, we must have at any one time a larger quantity of items on hand, or we must place many times the number of purchase orders with our vendors, either of which will increase the cost of the inventories. Also, with this increased number of items, we must have more storage space.

We found in two studies that the life of gloves is roughly six uses, in other words, you use a glove approximately six times before it will be discarded. We found for needles, and syringes were about 25 to 30 uses. This is for the reprocessed item. If we go to the disposable item, this means that we must have some 25 times the number of needles and syringes coming into a hospital.

Inventory Policies

To get into inventory policies, as Dr. Smalley gave you a preview, I would like to pass out a couple of diagrams which we have worked up, so we can discuss them in relation to that. (See Illustration No. 17.) Now, these inventory systems which are illustrated are policies or systems that are in common usage throughout industry. We made a check at three or four hospitals and found that they were in either the "Fixed Order" or the "Fixed Re-order Cycle" categories. The figure at the top involves ordering a certain amount whenever your level on hand declines below a certain point. The bottom figure says that we will order up to a certain point periodically.

In searching the literature, starting a year and a half or so ago, we found that the conditions of variable demand and variable lead time were passed over very skimpily, and after we got into trying to work up some formulas or equations for these conditions, we realized why they were passed over skimpily. Nevertheless, we have had some success. It was drudgery going through some of the equations, and I don't propose to do that this morning.

What I would like to do is point out, briefly, a couple of things in this figure. First, let me identify these axes. The vertical axis is the inventory level. It is supposed to indicate the number of items that are on hand at any one period of time. The horizontal axis indicates the passage of time. Starting out at the first, you will see a decline in the black line, and as it approaches the horizontal line, you see a dotted line going up, indicating that additional units were ordered at this point; the number of units ordered at this point is "Q". Sometimes this is based on an economic order quantity, other times it is just based on what they would like to order, which may be just as well in some situations. Now, you will notice that the order is not received instantaneously; it is received some time units later. Going on over to the period, t_2, when the second order is placed, you see that t'_2 is not the same distance from t_2 as t'_1 was from t_1. In this system, we believe this to be a realistic representation of what actually happens. This is nothing new, we are just trying to do something with the knowledge that this occurs. Skipping down to the bottom figure, you will note that the periods of time, t_1, t_2, t_3, t_4, are equally spaced, as if the first day of each week or the last day of each month, an equal interval of time apart. Now, the quantity that we order in this fixed re-order cycle system, is determined by the amount on hand at the beginning of the next period, and you order "s minus x." This is what I am going to be talking about, the bottom figure, when I speak of a "fixed order time," and the top figure when I speak of a "fixed order quantity." We did find that the top figure is indicative of the inventory policy now in effect at Emory Hospital. The bottom figure is the type of system used at Grady Hospital.

Three Inventory Costs

There are three main costs that we are interested in when we talk about inventory costs. The first is the one Mr. Hiett will talk about, <u>Ordering Costs</u>. The second one is what is sometimes called <u>Carrying Costs</u>, or investment costs. I am going to make a few comments about that. These comments are going to be incomplete and I hope that we can get some suggestions here that may help us to complete them. The third inventory cost is <u>Cost of Shortage</u>.

Generally speaking, the cost of a shortage is the most difficult cost to measure. I found this to be quite difficult, and I am wondering just how we are going to get at this cost. We know that the cost of a shortage is made up of two or three components, one of which might be the cost of expediting someone to some place to get some item. There is also a cost of administrative effort that goes along with this.

Carrying Costs

A brief listing of some of the items involved in inventory investment are the following: The lost interest on the money value of the items that we have stored in inventory. In private enterprise, if they borrow money at 4%, then this is the cost of the money value of the items stored. There is also another cost, and I am not certain that this other cost is applicable in the hospital situation, and this is the opportunity cost, usually referred to as foregone opportunity. An example of this would be that if a company could obtain capital at 4% and it usually obtained 9% on alternative investments, then this difference of 5% would be the cost of the foregone opportunity. Now, I am not certain that this cost is even pertinent to hospitals. Then we have the costs due to obsolescence, deterioration or spoilage, and some of these may be pertinent. There is possibly the cost of taxes and insurance. You have the cost of storage facilities and the cost of floor space. There are costs involved in handling the items within the storage areas, the physical inventorying cost, and clerical costs.

Demand for Supply Items

In studying any inventory situation, one of the first things we need to concern ourselves with, after the inventory policy has been decided upon, is the nature and quantity of the demand requirements. We have done some work on trying the estimate the demand in various hospitals.

Emory Hospital has seen the most effort, and it was in Bulletin No. 5, authored primarily by Mr. Davis, that the demand for gloves in the hospital was studied. His results were not conclusive. Now, this study was a theoretical one and dealt with two techniques for estimating demand. These techniques were "exponential smoothing" and "regression analysis." The best results were obtained from "exponential smoothing." The new estimate of demand is equal to the old estimate plus some constant, we will call "a", times the difference between new demand and the old estimate. For example, if we want to forecast the demand for gloves in October 1961, we have an old estimate from which to work, and that was our estimate for gloves in October 1960. After October is over, we know the actual demand, and we subtract from the actual demand the old estimate which was made. Now the significance of this is that, varying this value "a" between zero and 1 can give more or less weight to the fluctuation. In his work, Davis found that his "a" should be very small. A very small "a" value implied that there is very little change from month to month and that we are not taking these changes much into account or it does not help much to take these changes into account. A large "a" would be just the opposite.

Dr. Dudek: How do you get that new demand, after the month is over?

Mr. Newberry: The new demand is obtained after the month is over. We made an estimate for October, 1960. Naturally, we didn't hit it on the head, or most likely we did not, and so at the end of October, we know the value for new demand, and we subtract from that what this estimate was. This is a new estimate for October 1961. This terminology is a little awkward.

Now, Davis went further and took into account trend conditions. For example, if 1960 is known to be having more demand every month so far than 1959 did, we take that into account and modify this estimate here even further. This is what Davis did, and he found the best results from this type of analysis, "exponential smoothing." However, these mathematical manipulations are very unwieldy to manipulate. I doubt that it would be practical in a small hospital, at least.

In the regression analysis he tried to determine the demand for gloves in terms of three independent variables.

$$Y_i = b_o + b_1 X_{1ij} + b_2 X_{2ij} + b_3 X_{3ij} + \varepsilon_{ij} ,$$

<u>Dependent Variable</u>

Y_i = the number of pairs of gloves demanded during the i^{th} week.

<u>Independent Variables</u>

X_{1ij} = the sum of the daily hospital census figures for the i^{th} week which started j days before the start of the glove demand week. $(j = 0, 1, 2, 3)$,

X_{2ij} and X_{3ij} are defined as above for daily number of births and daily number of operations, respectively.

where b_i = true regression coefficients for the i^{th} independent variable.

ε_{ij} = random error for the i^{th} week and a lag of j days.

The rationale for using these three factors, census, birth's and operations, was that it was these three items which caused demand to change. In studying the variation of this b_1, b_2, and b_3, we found that b_2 and b_3 were not significantly different from zero. In other words, starting with this equation as our hypothesis, we later found, in this one instance, that births and operations were not significant factors. So we can erase this from our equation. Then we computed a correlation coefficient between <u>demand</u> and <u>census</u>. The best we could do was R equal to 0.80. This regression analysis implies perfect knowledge of the census in advance. While census may be easier to estimate than demand, this, of course, involves an additional consideration, so for the time being, we concluded that the regression analysis was inconclusive. However, we felt that both of these techniques would warrant further study.

Discussion

<u>Dr. Hullerman</u>: Did you find some evidence that <u>census</u> was easy to predict?

<u>Mr. Newberry</u>: We didn't try to predict census.

<u>Dr. Hullerman</u>: Would you predict census on a monthly basis, or an annual basis? What's necessary with respect to demand?

<u>Mr. Newberry</u>: Demand was on a weekly basis.

<u>Dr. Hullerman</u>: And what's your census basis?

<u>Mr. Newberry</u>: Census was on "patient days per week."

<u>Dr. Hullerman</u>: And what figure would you need, a weekly census figure? And, how far ahead?

<u>Mr. Newberry</u>: We were using a weekly cumulative figure as far ahead as we could rely upon, but we didn't get to that stage. We found that R was just 0.80 and we didn't feel that this was high enough.

<u>Dr. Smalley</u>: This was due in retrospect. They took existing census figures and historical figures on glove uses and tried to find a correspondence between them.

<u>Dr. Hullerman</u>: But you might turn this around as a prediction method.

<u>Dr. Smalley</u>: That would have been their hope had they found a good correspondence, but they didn't.

<u>Dr. Hullerman</u>: I think census is about the most unpredictable figure in a hospital, even from year to year.

<u>Dr. Smalley</u>: That is another reason why it was not pursued, because even if there were a close correspondence between census and demand, it might be as difficult to predict census as it is to predict demand.

<u>Mr. Newberry</u>: Doctor Hullerman, this (regression) is the first thing we tried to do, and we found that we couldn't do a very good job of predicting it even indirectly so we tried a direct approach.

<u>Dr. Hullerman</u>: The assumption that you can predict census is a questionable assumption.

<u>Mr. Newberry</u>: We didn't study that one. We were going to do so if we got any good results.

<u>Dr. Smalley</u>: This failure was a Godsend in a way, because it would have taken us off on some more tangents.

Inventory Model

<u>Mr. Newberry</u>: Next I would like to briefly mention Bulletin No. 4. This was the one authored principally by Mr. Talbird. In this

study, Talbird considers demand as being the demand of central supply for items upon the stockroom. Talbird tried to determine some type of frequency distribution that individual sizes of gloves had, taking the $6\frac{1}{2}$, 7, $7\frac{1}{2}$, and 8 sizes. This was to no avail. However, Mr. Talbird had the idea that he would work in terms of proportions of the number of one size to the total number of gloves. We made some "chi-square contingency tests" and found that we were able to estimate the usage of each size of gloves from the knowledge of the total demand, so at least we had progressed one step. If we could somehow forecast the total demand, we could pretty well handle the demand of each size glove.

Talbird made some tests which showed that the demand for gloves over the year was relatively constant at Emory. This is the demand upon the stock room by central supply. In the study, he is concerned with determining re-order point, when to re-order. This is done, taking into account the idea that the demand is variable and the lead time is variable. This was done by the use of some calculus, and the results appeared in a manner such as this: (See Illustration No. 18.) For any set of parameters and for desired probability of a shortage, we can achieve that by re-ordering at a particular point. If we order, and the conditions remain the same, this will be the probability that we had a shortage. In this consideration, we are not implying that we know what the cost of a shortage is. We are saying that, if you will be satisfied with this possibility of being out, regardless of what it costs or what the inconveniences are, then this is how much you should order.

This was done specifically for the glove demand at Emory Hospital, and it was done in the general case with a Poisson distribution, varying the mean values of these distributions. One of the main reasons for using the Poisson distribution is that in the event you have no knowledge of what your distribution is, other than your mean value, the Poisson distribution will fulfill some of the "max-min" concepts of decision theory. You are assuming that your opponent, which is nature, in this case, will do you in as bad as he can. You are going to follow a policy that if he does you in as bad as he can, then you will be the best off you can be.

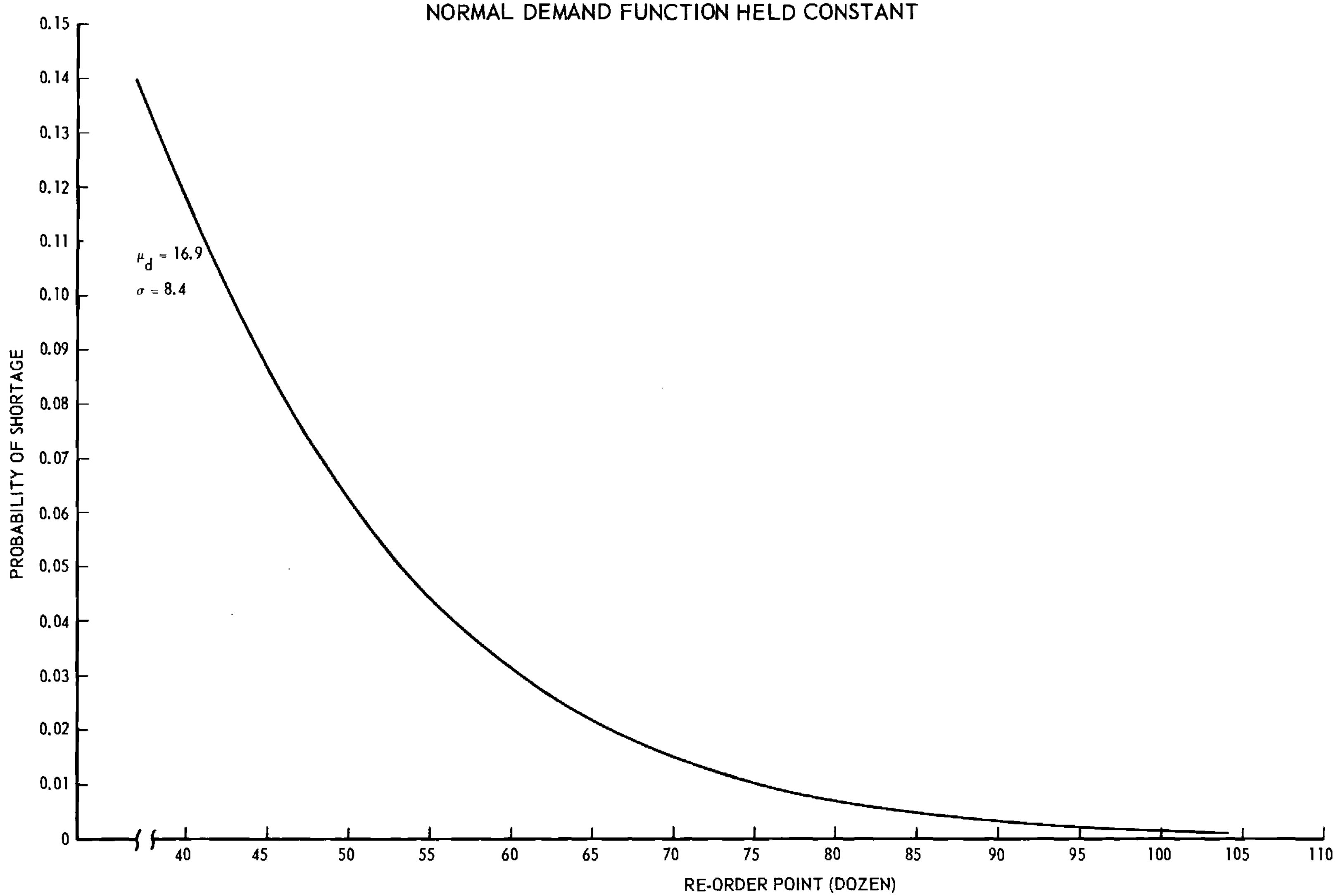
As we decide when to re-order, we want to know how much to re-order, and this is usually designated by "Q", the order quantity. In this study, Mr. Talbird uses an approximation that the demand and the lead time are fixed and known. This is shown in other references to be a very close approximation when it is actually variable.

Investment Costs

I'd like now to go into some of the investment costs. First I would like to give you the criteria that we are going to use in working with inventory costs. We will assume that the stockroom is now operating at capacity and that any reduction in quantity of items will result in a savings and that any increase in the quantity of the items stored will result in a cost. Now, this is not applicable to any specific hospital, although we believe

Illustration No. 18

GRAPH OF TWO VARIABLES; PROBABILITY OF SHORTAGE AND RECORDER POINT WITH THE MEANS OF THE POISSON LEAD TIME FUNCTION AND NORMAL DEMAND FUNCTION HELD CONSTANT



this is the only way we can handle it from a general point of view in the project. For a specific hospital, we should take into account and use as our decision criteria only those costs which represent actual expenditures or foregone opportunities. Out of these costs, we are only interested in those which vary over the inventory decisions that we are interested in. I would specifically ask for any comments on that.

Discussion

Dr. Smalley: The implications of this assumption that a reduction in stock is presumed to be a saving and an increase to be a cost, this is really another way of saying that you are going to use a pro-rated cost rather than a marginal cost basis.

Mr. Newberry: Yes.

The cost of capital is probably one of the biggest items going into what we will call "Carrying Costs." While an industrial concern would probably use about 4%, I am not sure what the proper value would be for a non-profit institution.

Dr. Smalley: What do you do with funds that are not in use? What do you do with your liquid or cash assets? Do you leave them on a checking account balance without drawing interest, or what?

Dr. Hullerman: Our cash requirements are based upon the demand for cash, and this is a result of operational needs as against capital needs. We find that for operating the hospital we need, say, $125,000 in the bank at the end of the month to meet the 5th of the month payroll and the 10th of the month bills. This is our beginning figure. Then there is our "chunk" money, from Blue Cross, drives, or things that come in from the State in large pieces, but you don't always know when or how much. This will replenish the $125,000 at the end of the month. In addition to that, you have going on all the time the purchase of equipment, capital costs rather than operational costs. Here again, you have to have money available on your regular schedule depending upon what's coming due. So you take the two figures together and you find out from month to month how much money you have to have in the form of available cash, and you project this ahead pretty much on an average for the operational $125,000, or whatever it may be, but you have to use judgment on when the others come due. So you try to hold out that much cash in a checking account readily available.

Dr. Smalley: Moneys that you have budgeted for some capital outlays later in the year or any excesses of revenue over expenses or any expenditures that you did not make, this is allowed to stay on a checking account balance. Is that what you are saying?

Dr. Hullerman: No. You know what's coming due this month and next month, as long as you can predict it. Then you buy, with your excess capital, short-term things and you try to re-invest as you anticipate needs for money. If you are just considering operations, you wouldn't have too much of a problem, but when you put operations and capital together, then you get into widely fluctuating amounts. The other day we had $100,000 worth of savings certificates come due, and we expected we would need it to pay contractors, but the thing got into a strike delay, and so we re-invested this for another six month's period, because we recognized that another short-term obligation is coming due in the interim that we aren't going to need these funds for what we thought we might.

Dr. Smalley: So it is a short-term investment where you can liquify rapidly?

Dr. Hullerman: Only for that amount of money that you anticipate that you are going to need, over a fairly short period.

Dr. Smalley: What would be a typical interest earning on such moneys as that?

Dr. Hullerman: Oh, in savings, I'd have to check this, but it seems to me you can get around 2½% on short-term savings.

Dr. Smalley: This is like commercial bank savings?

Dr. Hullerman: About 1% in some situations.

Dr. Smalley: You wouldn't put it building and loan associations at 3 or 4 per cent?

Dr. Hullerman: Probably not.

Dr. Smalley: Or Government paper?

Dr. Hullerman: Oh, yes, Government securities is a common form. But then, over and beyond this predictable need, you then invest your other funds according to your investment program, which is a percentage due on common stocks, preferred bonds, and on a long-term basis. This becomes an investment problem.

Dr. Smalley: Now, these earnings could amount to 8 or 10 per cent, could they not, if they were left for a while, your stocks and securities of that nature?

Dr. Hullerman: Not as income, they can't, but as total increase in value they could, if you were lucky, but hospitals don't usually buy these.

Dr. Smalley: Did you have any GM stock when they split a few years ago?

Well, what we are really getting at is not just a matter of curiosity, of course. It is that we want to tie on to a realistic figure as to what the moneys saved might logically earn if they weren't used for some other purpose. Or, turning it around, if you had to have a larger stock of items in the hospital, if you went to more disposables, you wouldn't have as much of this money to put out at 2-1/2 or 4 or 6 per cent or whatever. Mr. Newberry is interested in knowing what is a realistic way of handling it. We could say, fine, 4 per cent, but if we found that hospitals generally didn't invest their money at 4 per cent, then this is an unfair assumption to make.

Dr. Hullerman: I don't know that it really has too much bearing to the hospital in terms of earnings at 4 or "D" per cent. It could at some hospitals, but you have to start with the assumption that a hospital is going to have more income than it has expenditures, if we are talking about the operations side. I mean, we start the year with, say, $125,000 in the back at the end of the year, that is what we aim for. But during the year we aren't going to pile up $250,000 or $300,000. We are on a hand-to-mouth basis throughout the year and we are lucky if we come up with $125,000 at the end of the next year. So unless you are piling up something you earn interest on, it's a hand-to-mouth deal. I don't think you are going to find, in half the hospitals, that they are going to be able to earn money on this inventory saving. But what it does do, it will help the hospital to keep its cash position good, and this is very important. Half the hospitals in the country won't make a penny.

Dr. Smalley: But, on the other hand, if a hospital did live hand-to-mouth and decided to go substantially to disposables, they would either have to liquidate some of their capital money and invest it in inventory or they would have to conduct a fund drive or get an appropriation or grant or something to do this. And that is what we are interested in. What is the cost of procuring this capital that would be required.

Dr. Hullerman: No, inventory needs would not come out of capital. It would come out of operations.

Dr. Smalley: Well, this is an artificial categorization. I am not interested in what you'd call it in a particular situation, but it's money, it's dollars and it costs something to procure it. Putting it the other way, if you don't have to procure it, you save something, you save the cost of not having to procure it. We consider this a real cost. We don't know yet whether or not it is significant, but we think it is real.

Dr. Hullerman: I don't follow you.

Dr. Smalley: Regardless of the name of the fund or category of this money that is available to the hospital, whether it be from a grant, from Blue Cross, from philanthropy, or from patient collections, whether it is "operating" funds or "capital" funds, it's all money. We are saying, in effect, that we are trying to get at a method of determining what it costs to obtain that money, no matter where it comes from. Or, turning it around, what would you save by not encountering the cost of having to obtain the money.

Dr. Hullerman: What money are you going to obtain?

Dr. Smalley: You are going to obtain enough money to carry a larger inventory. You are going to have to buy more needles, more syringes, more gloves, build a larger stockroom, put on the payroll an additional stockroom clerk, build a new incinerator, whatever is required to go to disposables on an extensive basis. This is an extreme case, but just to point it up. That'll take dollars, and those dollars have to come from somewhere, and you are going to have to pay interest on the dollars, in some form. Or, if you don't do that, if you don't go to that expenditure, you're going to save what it would have cost to obtain those dollars, and it is this cost which Mr. Newberry is calling "investment cost."

Dr. Hullerman: If I hear you correctly, we would not borrow money and have a money cost to do this. We have to have the money because a hospital cannot borrow money. Now you could have the loss of income from funds you use. This would be the reverse of what you're borrowing.

Dr. Smalley: Yes.

Dr. Hullerman: And the costs here, I suppose, would not be determined by either the short range or the long range, it would just have to be a loss income, on the average, of what you would get from everything, I would think.

Dr. Smalley: I think so too, and what we are groping for now is a way of getting at what would be a realistic percentage figure for hospitals.

Dr. Hullerman: You could get a realistic rate.

Dr. Smalley: Yes, that's what I mean.

Dr. Hullerman: Then I don't know, I would really have to take a look at what the average is for all sources. I would say, probably, somewhere in the neighborhood of 4 per cent would be high enough, not counting increases in valuation of stocks and that kind of thing. But, Hal that isn't quite a real picture either, because every piece of cash that you have, except endowment funds, is cash that you expect to use for this equipment or that capital purpose or something else, you don't build it up or hoard it, if you follow me.

Dr. Smalley: Yes.

Dr. Hullerman: And the demands of the hospital to use available funds for X, Y or Z are so great that you seldom if ever build it up. You are using money that you would expect to spend anyway over a fairly short period of time. For example, we have been building up about $200,000 of gift money, because we know we are going to have to use it. We want to buy a number of things -- we build it up and we spend it. It's not held for income purposes unless it's an endowment. You don't borrow from your endowment to build an incinerator.

Dr. Smalley: Yes, I follow you, that's all right, that will bring the point out well. The point at which we are not communicating is this: We are talking about an anstraction here in the sense that you buy an electron microscope for $100,000, or whatever they cost. That's not the only cost of that electron microscope. Also part of the cost is the interest that is lost on the $100,000 had you put that to some purpose other than the electron microscope. It is just an accounting mechanism that says, that's not all it costs you, because if you had taken the $100,000 and put it in a building and loan association at 4%, the total cost of that equipment would be greater than the $100,000. That's what we are saying.

Dr. Hullerman: Wouldn't you say that the electron microscope was another form of income-producing capital?

Dr. Smalley: Right.

Dr. Hullerman: So we are not talking about that kind of expenditure, really, we are talking about the operations cost. But what would this formula save you on inventory? That's not an inventory item, that's a capital item. When I use "inventory," maybe we're using it differently. I'm talking about the inventory of perishable or used-up goods. Now if you are talking about the physical inventory of the plant and all that kind of thing, we really are talking a different language and I have missed your point, but this kind of inventory control is based upon a prediction of used-up items on a short-term basis, not items that are used up only after a period of years. So then you are restricting this to the value it has for your currently usable inventory.

Dr. Smalley: I see the distinction you are making and I agree with you, except that there is a facet of this that you must keep in mind. Let's say that in Mr. Newberry's model he always maintains, as a minimum, $1,000 worth of supplies and never lets the supply stock get below $1,000 value. In effect that $1,000 is as much of a sunk cost as a piece of equipment, in many respects it is even more so because it doesn't wear out but is continually being replenished, so that while you say it is expendable, from now on, you are going to have $1,000 in there as inventory and you have tied up $1,000 worth of money in it. That $1,000 worth of money that is tied up in stock could have earned interest outside, and that's the other phase of it.

Dr. Hullerman: This is true, and on this, I'd say you have maybe 1% to 2½% maximum, depending on the time period.

Dr. Smalley: We are trying to get "in the ball park" on different kinds of costs.

Dr. Hullerman: But what does happen in high inventories is that hospitals can use a high inventory as a cash-conserving deal. I mean, if you get short on cash, you delay orders, you build up your cash. Now, what Newberry is suggestion is that you don't have to go through this frustrating situation. You could order more evenly, and this would be a real advantage, not dollar advantage, but an operating advantage, because some of your cash shortage is created by too-high inventory. I think it has some value, but I don't think it has too much dollar value, but nevertheless a real value.

Dr. Kuehn: Hugo, wouldn't it have some value in the phasing-in process of transition from the reprocessing to disposables. It seems to me it should help there.

Dr. Hullerman: It would have real value with respect to your space requirements for storage, etc. Now you may make a bulk order for a year and you have the question of how much do you stock so as not to be too heavily stocked or too lowly stocked. Well, this helps, it takes some of the guesswork out of it.

Dr. Gilbreth: How does this take into account the change in the price of the things that you are purchasing?

Dr. Smalley: Now, there's a new one for you. You didn't have that on your list, Tom.

Mr. Newberry: No.

Dr. Hullerman: May I come back to one thing"

Mr. Newberry: Yes, Sir.

Dr. Hullerman: If we were building up a lot more income than our expenses, then you could expect to have this saving, and once in a while that happens, but not often.

Dr. Gilbreth: Maybe this price matter isn't appropriate, but....

Dr. Smalley: No, your question's good. We hadn't even thought of that.

Mr. Newberry: Well, if I can twist your question in one way, maybe we can answer it. If you are speaking of "price breaks" on quantity orders, we can deal with that.

Dr. Gilbreth: How can you be sure prices will stay the same?

Dr. Smalley: That's good. This implies that maybe what you need is a probability factor that prices will increase, or decrease, in the foreseeable future and take this into account.

Dr. Gilbreth: I have a question along the same line, and that is how this ties in with your purchasing departments and the people who contact the market and know what is coming, prices in markets and all that.

Dr. Smalley: Yes, suppose that, right now you say to yourself, well, if I invest $1,000 in a stock of items, it might cost me $1,060 because there is $60.00 lost interest on it. You decide not to do it because it is going to cost you this much. Well, the alternative might be to wait. but to get these same items a year later might cost you $1,200 because of a price increase. That's what you are saying. I think that is a pertinent factor. Or it could work the other way. If hospitals began to adopt disposables in great numbers and manufacturers could take advantage of mass production economies, they might cut the price and it might be much less a year from now, so this cost, in comparison with what it would have been, would be a much more significant figure.

Dr. Gilbreth: Yes.

Mr. Newberry: We haven't handled that. It's a real problem.

Dr. Gilbreth: We'll just make a note of it.

Mr. Newberry: Yes. I have seen, in the literature, references to this situation, however these were quite scanty.

Dr. Gilbreth: When you say literature, that would mean hospital literature?

Mr. Newberry: No, I'm speaking of literature on inventory control.

Dr. Gilbreth: This is primarily in industry?

Mr. Newberry: Yes.

Dr. Smalley: It's right out on the frontier, almost into the unknown.

Mr. Newberry: The next factor is that which I mentioned earlier. This was the opportunity cost of having your capital in excess of what you might get at a reasonable rate.

Dr. Hullerman: There will be times when this would make money, and in some hospitals, it would be a continuing process.

Dr. Smalley: I don't want to interrupt you too much, Tom, but this point brings up another question. I think we have to be awfully careful not to get caught up in the subtleties of hospital finance, because it is awfully easy to dismiss a way of analytically thinking about finance under the guise that we are non-profit, or we are not in a liquid position, or we live hand-to-mouth. All of these things may be true, but in a way you do it anyhow. For example, you may say, "We never have any extra money for these things," but in effect you've got an educational program over here, you've got a research program, and you've got a group trying to improve the quality of care or the quality of services. Well, in effect these are all on-going economic projects, they have economic implications, and you've got money and resources tied up in them. Whether you carry it on your books or not, diverting funds to any one of these things has an economic implication, and it's this subtlety of the hospital finance picture that gives us so much trouble, and if we are not careful, we will "miss the boat."

Dr. Hullerman: Oh, I think this should be considered as a potential and probably a very real source of increased income. In many hospitals, it will be. And you do group a lot of these things together and use them as cash that you put out on some kind of earnings basis.

Dr. Smalley: I think your comments are quite helpful.

Dr. Hullerman: This has meaning. And it is true that high inventories especially if they get a little bit higher than they need to be, will tie up money. This can create one of several kinds of problems.

Dr. Dudek: I would like to ask you a question, Hal. In looking at these hospitals do most hospitals use a pretty good cost accounting system?"

Dr. Smalley: I would hesitate to answer that about most hospitals. Our experience and impression is that, by manufacturing standards, they do not. Now I can't pass judgment as to whether they have as good a system as they think they need. I give them credit for being intelligent people, and they must think they have fairly good cost accounting systems, but, by manufacturing standards where the pressure of the profit-and-loss statement is an awfully powerful one, the ones I know anything about do not have them.

Dr. Hullerman: I think they are better than you would expect, but nowhere near as good as you would like to have them. They are not as bad as a lot of people say they are, but they are not as good as you would like to have either.

Dr. Gilbreth: I think this is a very valuable discussion to all of us, because one of the prime topics of discussion everywhere is, how and why do hospital procedures differ from business and industrial procedures?

Dr. Hullerman: Dr. Gilbreth, maybe it would be interesting to mention what Dick and I were talking about last night, because I find this is not widely understood, and again I would like to be sure that you understand it. I don't mean to say that this won't mean income to the hospital. I think that many times it will. The proposition that Dick gave me was that there outght to be a profit motive in hospitals, whether they are non-profit or not, and so we examined the question, "Where is the profit?" You have to apply the figures individually of each hospital, but just take our hospital. Thirty-five per cent of our patient days are on State Aid under the Crippled Children's Act. At one time, two or three years ago, they were paying us $19.00 a day for care that cost $36.00. Now they are paying us $25.00 a day for care that from one year to another will range from $36.00 to $39.00 a day. Well, you don't make any profit on that group, because obviously your costs are much above what the State's paying. So, then, Dick said, what about Blue Cross? Well, Blue Cross will pay us our billings or costs, whichever are lower, and that means our billings have to be higher than our costs or we won't even recover our cost. But suppose we have a cost of $30.00 or $40.00 a day for care, and we save a dollar a day on that. Half of this we don't get right away, because Blue Cross cuts back its payments to us, and 50 per cent of your patients are Blue Cross patients. You can't make a dollar on that, so there is no profit to be obtained here, and any profit you make goes back to the third-party. So you have got 85% of your patient days are immediately shot as "profit days." You're not helping yourself. So you've got the other 15 per cent, and this takes in the other insurance programs. The other insurance programs vary greatly in what they will do, but most of them will pay an indemnity towards the room, which is far below your costing picture for room rates. So you have to charge the difference to your patient. These policies will pay $200 or some figure for extras. On the patients who have $1,000, you have to charge that difference to the patients, and you can't collect $200 for $150 worth of work. You have only a loss proposition. I was trying to convince Dick that the profit motive was wonderful, but everybody else got the profit.

Dr. Dudek: There is a completely different concept of what we have to strive for. It is not the same kind as an industry looking at profit, where we get our costs and add 10 per cent this is what we charge.

Dr. Smalley: I want to make this observation and hope that Mr. Newberry can finish his presentation. I talked with Dick at length about this, not in the last couple of years, but before that. I believe that what he is saying and I believe that most of us could agree, is that it is not so much that you try to operate at a profit but the philosophy of hospital operation would be compatible with the profit motive. Let profit be negative, if it must be, but treat that negative profit figure as religiously as the manufacturer treats his positive profit figure. That is, base recognition, motivation, and all this upon a desire for profit. Don't claim that "the purpose of the hospital is to save the patient's life, not his money," get instilled in everybody in management that we have certain funds that we have been given as trustees and our job is to use it as wisely as possible. Tee said something here not long ago in a program in a hospital that I think is pertinent: "We are really not trying to save money, we are here to spend money as wisely as possible." It's this wisdom that I think is the key to it, and Dick's idea of profit motivation addresses itself to this term, "wisely."

Dr. Hullerman: I think they are two different things, Harold, one is profit, one is trusteeship. Now, the trusteeship, of course, is fundamental in hospitals, and this we use all the time. You'll find exceptions, but I'll bet that in your entire set up in Pittsburgh, this trusteeship is the principal part of the fibre of your people, isn't it? And this is forced upon us by our boards, which have this outlook, and also because we have a highly competitive situation in the cost picture that the individual hospitals must give to the public those things that other individual hospitals give. So I agree with you, this is what we have to build on, this is what we are using.

Dr. Smalley: I think I can discern progress in the last ten years; I don't think we are standing still, we are just not going as fast as some people would like.

Dr. Dudek: I would like to make one more observation. I think this whole concept sheds some light on how you have to handle this other matter, though, because all this extra money that you're going to tie up in inventory is not necessarily going to add extra burden.

Dr. Smalley: You mean "burden" in the accounting sense?

Dr. Dudek: That's right. Because of the way some of these things are handled at the present time.

Dr. Kuehn: That's my point too, but I don't think people in business and industry always understand the pattern of buying in hospitals and the way cash is handled. I think you are right there, but I sure would go back and support this need for bringing into the hospitals the fine, high level cost accounting that is required. I challenge a bunch of the cost figures now being used.

Dr. Smalley: Even the most dedicated decision-maker cannot make a decision that is in the interest of the patient and the community and the trustees if he is not operating on facts. Dick, you know the study we made in Pittsburgh in one of the hospitals? Mrs. Kuehn knows about this one too. It grew out of the bed study by Anne Roebuck. We wanted to know how bad it was for a blanket to fall off the bed onto the floor. Well, nurses say you are not supposed to let this happen. Well, there are probably two reasons for this, one is the contamination problem, and the other is that you have to launder them more frequently, and the presumption is that the life of the blanket is thereby reduced and you increase blanket costs. But, when we got into that, we found that nobody in this hospital had any earthly idea how long a blanket lasted, if you laundered it every day versus never laundering it. So, actually, they were making decisions without facts. We are not out to change anybody's value system; we are making a plea, let's operate on facts, you keep your value system.

Dr. Hullerman: That's why I think this thing is very helpful, because it does give you the facts on lag, on minimums, on order points, etc. No, I'm all for this. This is not too gross or too theoretical.

Dr. Smalley: You may decide for some reason that you would not care to divulge that you want to have such a low probability of a shortage you are willing to carry a tremendously large inventory. All we want to do is make sure that you are aware that this is costing you so much; it is up to you to decide whether or not it is worth it to you to do that.

Dr. Kuehn: We do not have the facts.

Dr. Hullerman: That's right.

Dr. Dudek: And, at the same time, I think that the study should be conscious of the fact that it may not be the same kind of carrying charge that would be charged to inventory here as we are used to. You may want to charge them for the space and things of this nature, but the interest rate may not really enter the picture. You could visualize that on Blue Cross-

Blue Shield, for example, you could increase the capital investment in your inventory and if you have a cost accounting procedure where you charge this inventory carrying cost to each item, your cost per day goes up slightly and you get more of your money back from Blue Cross rather than less.

Dr. Smalley: Yes, but from a welfare economic point of view, isn't this bad too? This philosophy departs from the profit motive again, because there you are saying, "Why be frugal, because Blue Cross will pull our chestnuts out of the fire." There's no incentive there to keep your costs low. It's the old profit motive again. In manufacturing, you wouldn't tolerate this, because you can't go to a customer and say, "I'm sorry, we had some waste, or we carried too large an inventory so you are going to have to pay $30 for this radio instead of $20." the customer would say, "Go jump in the lake." But the patient can't say this.

Dr. Kuehn: Human life is precious, and when you have an emergency in the hospital, you don't think about what it's going to do to your inventories and your costs, you move in with whatever equipment and whatever services you need. And that's O.K. But, on the other hand, we ought to know what we are doing, and we do not. That's my point.

Dr. Smalley: That's a good point.

Dr. Dudek: But you missed my point. Because of this, some of these other facets might make you reduce this interest bit, for example, which really may not be of real interest to them.

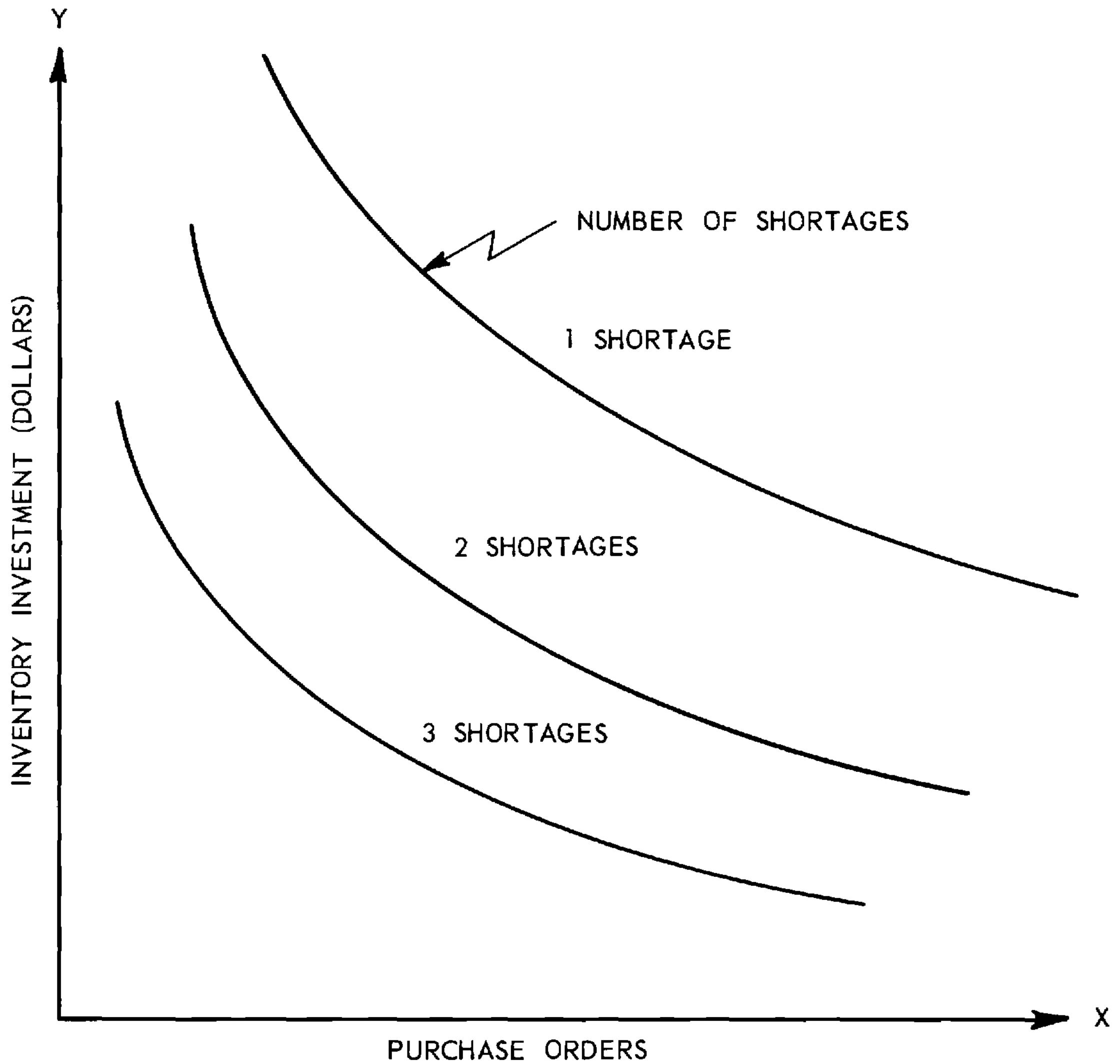
Dr. Smalley: I don't detect any doubt around the table that we need more facts. Now, we may feel that the man who made the decision made an unwise decision, but if he has made it on the basis of facts, we can be encouraged.

Dr. Dudek: Yes.

Frequency of Ordering, Investment, and Shortages

Mr. Newberry: Thank you. I enjoyed those comments. Our time's beginning to run out and I think this graph pertains to what we were just talking about. (See Illustration No. 19.) If we plot on this "Y" axis the total number of purchase orders and if we plot out on this "X" axis your total inventory investment in dollars of investment in inventory. This has nothing to do with what it costs to make a purchase order. This has nothing to do with what inventory investment costs. Well, in any situation, we have a certain amount of uncertainty, and if we were to draw some curves up here and label these curves "number of shortages," the farther out that way you would go, you would expect to have fewer shortages. I'll just label these curves 1, 2, and 3, to give an idea of the magnitude of shortages as you come in toward the origin. For a particular inventory policy, we could draw a set of curves which would be optimum for a range of all possible inventory costs. These curves will have the property that it would be possible to have three shortages with less than "Y" number of

Illustration No. 19
RELATIONSHIP OF NUMBER OF PURCHASE ORDERS, INVENTORY INVESTMENT, AND NUMBER OF SHORTAGES



purchase orders and "X" amount of investment. In other words, this would be the best you could do under your policy. So, what we could do is to show such a chart as this to the decision-maker and he could decide how much investment to have in his inventory, how many purchase orders to write each month or each year. From the point that is selected, there are a set of cost figures that can be assigned to the cost of inventory, to the cost of purchasing (writing each purchase order) and to the cost of shortages that would give you this figure. You can go from this set of curves to an imputed set of costs.

This is one way of imputing cost without actually going out and measuring them. All three of these costs, as I am sure you know, are most difficult to determine uniquely, or even to get a close range.

Discussion

Dr. Hullerman: Mr. Newberry, this kind of thing and what you were talking about before, aside from any interest on money, are of value, because you do take some terrible inventory losses when you get a high inventory, and you find that it becomes difficult to use up that inventory for one reason or another. And this is a valuable approach because you can move over to more purchase orders and lower inventory levels and so avoid shortages if your total inventory investment threatens to include items that you are never going to be able to use because of pattern changes and things like that.

Dr. Smalley: And the reverse is true. There is another point about this that I think would be helpful. The case you described says, in effect: "Well, we have a certain frequency of shortages now, and we are not quite sure this is good, but at least we are now operating that way and presumably taking care of patients all right, so you could vary the frequency of ordering and the investment simply by moving up and down a given risk curve." On the other hand, you might be able to assess, indirectly, what risk you are willing to take, in an implied way, by finding out which one of these curves you are on. The man might say, "I'm willing to run out a little more frequently than that in the interest of bettering my position otherwise." You could move and see just where that would be. Or he may be dissatisfied. He is running out too frequently now, then what do you do about it? This will also tell you about that.

Dr. Hullerman: You can run into such things as your purchasing department wanting to make large purchases, rather than buying frequently. This might be unwise and you have a basis of talking him back into, "Well, let's do it a little more frequently, this is an item that might have a passing phase of interest," or something like that. I think this is quite valuable.

Mr. Newberry: I would like to point out that although this could be used for one item, generally you would use an analysis of this type to include your total inventory investment.

Dr. Hullerman: Yes, but there are certain areas in which you would use it for breakdown, in pharmacy or in linens, for example.

Mr. Newberry: Yes, categorizing.

Dr. Dudek: It may be that if you applied to the total, the risk for different items it is going to change. I would imagine that an individual wouldn't mind running out of gloves five or six or eight times, but with something else, like blood plasma, man, let's not ever run out of that.

Dr. Hullerman: You mean your shortage points are meant for items, not totals.

Dr. Dudek: I would assume that, don't you think? I don't know.

Dr. Kuehn: Let's not run out of gloves.

Dr. Dudek: Well, O.K., something else.

Dr. Kuehn: I was kidding. Yes, that's right.

Dr. Dudek: See, for example, I think that in this disposable picture too, let's say you might be willing to stand a risk of running out of disposable enemas as many as seven times a month, because it puts you to such a good cost advantage; those other seven, you can reprocess. You can have one reprocessible enema kit, for those seven extra times that you need it, because now you put yourself into a good position inventory-wise.

Dr. Smalley: Then the facility of substitution would come in here also.

Dr. Dudek: Right. I think so, especially if you already possess a few of these reprocessed kits, now you could increase the risk of running out of a certain item because you could makeshift for this.

Dr. Smalley: Maybe we ought to let Mr. Hiett tell us about order costs, perhaps some of these same questions will come back to him and we can kick them around some more.

Mr. Hiett: Before Tom leaves, I would like to ask him one question. Since I am working on a small part of this, I would like to know, what do you see as the end product of this study? Is it what is on the board up here?

Mr. Newberry: If we were going to have a chart like this, we wouldn't need the cost studies.

Mr. Hiett: That's right. Therefore, I'm assuming that this won't be the only thing that we get out of the project. So I was wondering if you could tell us how you see the ending of this?

Mr. Newberry: If we can arrive, within a range, at these costs here, we plan on having inventory decision rules for variable demand and lead time for these two policies that we discussed earlier, telling when to order and how much to order for the fixed quantity system and up to what level shall we order for the fixed order cycle system.

Mr. Hiett: Is this intended to guide the people toward how they should order or is it intended to give them an idea of the cost of the present procedure or the cost of the change if they go to disposables?

Mr. Newberry: Probably they will not all follow these analytical procedures that we work out. If they did, and the assumptions that go along with them which are not too strenuous, you would end up with a reasonably small inventory cost. I don't think I really understand your question.

Dr. Smalley: Are you talking about the difference in the role of a minister and a prison warden? In one case, they tell you what ought to be done, and in the other case, they tell you what to do?

Mr. Hiett: No, for instance, we're concerned with ordering costs. Mr. Standard and I started working on this phase, and this is one small part of it. Let me just go through ordering costs and then I can relate this back to the question I had for you.

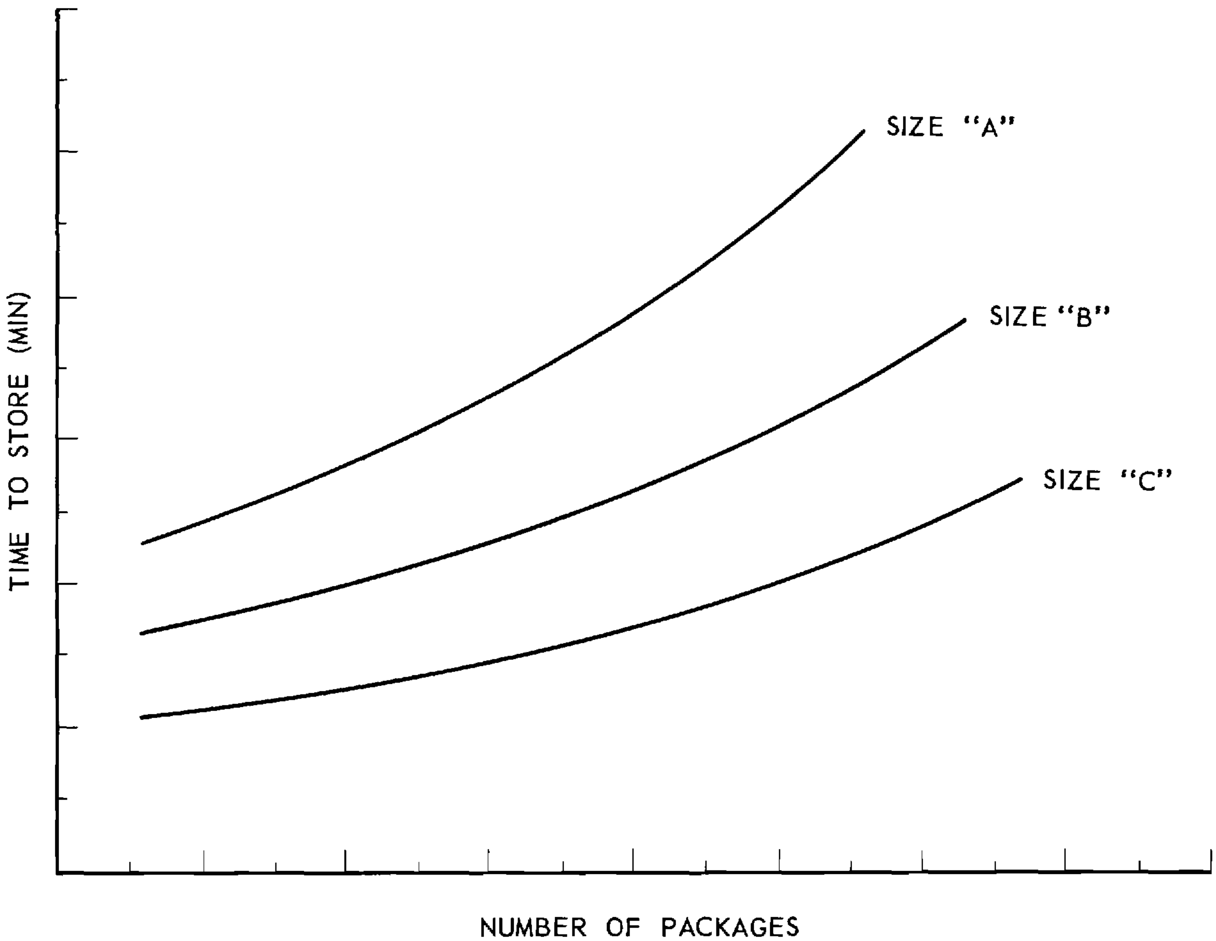
Order Costs

In ordering costs we are concerned with ordering the material, the units of items, and getting them into stock, and we are concerned with the cost of these activities. The remarks that you made yesterday concerning the processing costs apply to the cost of ordering, because we are using the same type of procedure. We are making time studies of the work that is involved in all the elements of processing these orders. Our problem is quite similar to processing costs, but it is uniquely different in that these things will not be discontinued if we go to disposable items; it would appear, in most cases, that it would increase. We would have more of them.

We are looking at "ordering" from your using unit to central supply to stock room and from the vendor. We are concerned with the costs of placing the order, ordering the items, getting them in stock, and getting them delivered to the using unit. In the case of reprocessables, we are interested in getting them into the reprocessing cycle.

We are approaching this from the standpoint of standard data in which we are trying to identify the work that would be involved and the variables or parameters that will be surrounding this work. We have such operations or elements as "check stock," "fill out paper work," "deliver information or material," "file paper," "issue material," "receive material and count," "inspect material," and "store material." These are the basic functions that are used throughout this process. (See Illustration No. 20.) We are trying to build up a standard data basis which can be expanded and, through implication, can be used in other areas. For instance, in the stock room, and this is a commonly accepted procedure, we plot "time" (to store) in this fashion and we plot the "number of packages" in this direction. By the "number of packages" we mean the number of groups of units.

Illustration No. 20
ORDER COSTS, STANDARD DATA GRAPH



Gloves come 12 pairs to a box, and needles come a dozen to a package and syringes a dozen to the package. If we can find a relationship, we may have a family of curves in this form where these would be, perhaps, size. This occurs in a number of different places. If we can find this relationship, and we haven't been able to do it yet, we can predict or specify time.

To date, our work has been principally concerned with finding out what goes on in ordering, what are the factors, what is being done, and we have made some time studies in the storeroom area, checking-in merchandise, getting it into storage, etc. If we can determine these kinds of curves for the activities I have listed, this could be used for other types of areas where similar work is being done. For example, other types of supply items. Given the number of packages, we can get the time required to "store," on a per package basis or a total time basis. In this case, it would be total time because we have the number of packages involved.

If we do this for all the elements, we can have someone in the hospital organization describe what is being done. We could have a standard data table for this, and we could determine the time for that activity. This is true for all of the activities concerned with the cost of ordering. This generally is what we are doing. We were getting to the actual time requirements for all the activities involved in ordering. Are there any comments or questions about this?

Discussion

Dr. Smalley: Tee, isn't it true that a principal difference in the "order cost" phase of this project and the processing cost phase is that, whereas in processing costs we are dealing with just one item at a time, in many phases of ordering, it's the same for all items. For example, where you are talking about a package, you don't care whether it's a package of needles, syringes, or tubing, or whatever.

Mr. Hiett: This is what we hoped to find; this is the true standard data approach, that we find the parameters surrounding all the variables of the situation and we measure these occurrences. If we can describe these "sizes" (or whatever these turn out to be), then it doesn't really matter what the item is. If you have a size for a package and as long as a package falls within that size, then this would be the time to store this many packages, once you get them to the storage area.

Mr. Newberry: Can you use existing synthetic time values such as MTM or BMT for this?

Mr. Hiett: Quite possibly so, but I am not at all enthused about doing it this way. I would prefer to build up the standard data table.

Mr. Newberry: Possibly, if they worked, this might save some time though?

Dr. Howland: The question, though is which one do you pick because they give you different standards.

<u>Mr. Hiett</u>: There is a difference between MTM and BMT. If you use one and then use the other, you may get different answers.

<u>Mr. Newberry</u>: That really was not my question. However, they give close results.

<u>Mr. Hiett</u>: Right.

<u>Mr. Newberry</u>: I was just wondering if this might not give a more easily workable system. I mean, develop your standard data system from BMT rather than from time studies.

<u>Mr. Hiett</u>: I don't think that you would save time, principally because our experience has been that you have got to go find out what people are doing, and in doing this, you might as well make some time studies while you are there.

<u>Dr. Smalley</u>: There is another phase of this that I think is pertinent. Generally speaking, for any predetermined motion time system to be efficient, the method should be relatively standardized and relatively repetitive. You just don't find those things very often in hospitals. So that, rather than write a detailed left-hand, right-hand, classified description of a method that varies so widely from occurrence to occurrence, I think what Tee is saying is that he feels that in timing it, he would still be "in the ball park" and he could do that along with his description. Whereas, if you stop to make a detailed MTM description, it might slow you down. I am not dismissing the possibility that MTM or BMT would be the most feasible way in certain kinds of activity. For example, in writing the purchase order, here is a highly repetitive type of thing. Why not describe the motion pattern of typing a purchase order and apply MTM and not do any timing at all. You might find that feasible, but in something like unloading a truck or putting items on a shelf, I don't know, maybe Tee's suggestion would be better.

<u>Mr. Hiett</u>: I think it's worthy of consideration. Instead of "number of packages," if we are concerned with <u>typing</u> information, then we can build up this same type of chart. This (X) might be the number of lines on a page, or some such variable. We can determine the different times required for these. I think this is different from <u>processing costs</u> in that this activity will be continuous. If we can establish the standard data, then this can be expanded by other people. Where it doesn't fit into their situation, they can use what we have and add to it to get their data. There are a lot of problems associated with this. The basic approach has been used in industry for a number of years, but one problem is, as Dr. Smalley pointed out, these things do not occur continuously and when they do occur, the times required vary considerably because the procedures vary. Even though we are using the same pace, we may vary the procedure slightly from time to time. This gives us a wide range, so we've got a problem of stability of the final figure that we are going to use, but I think we can work on this and come out all right.

Dr. Hullerman: I'm just a little bit lost.

Dr. Gilbreth: Don't you think that one of the problems is trying not only to get the facts but also all that you can about trends, coming trends, and things that are going to happen? That's where I feel that good purchasing procedure can help. The purchasing agent can get knowledge that processes are going to be changed, new products are coming in, there are going to be new possibilities. He can pass up the line the fact that if changes were made affecting size or anything of that sort, it would make the problem easier. I think that, in industry, we are afraid that people who become deeply engrossed in a special part of the total picture will tend to neglect other parts in establishing communications for them in the projects of the future. Also, I think that very often if industry knows of difficulty, or knows that time is being taken on handling various products ahead of time, perhaps they will modify their procedures. Take, for example, ordering large quantities and then having it put into smaller quantities by somebody in the hospital. The moment the pharmaceutical people knew that, they were perfectly willing to take over furnishing it in any form that you want. Of course, you've got your costs to consider, but I think that facilities for getting future trends quickly are awfully important.

Mr. Hiett: We will try to do this insofar as possible. I think this can be illustrated by the procedure for counting needles. If we have reprocessed needles, then it is much more difficult to count, in terms of measuring how much we have in inventory than it is if we have disposables, primarily because you count disposables in terms of thousands -- you get them in boxes of thousands -- and it's easy to look at two boxes and count two thousand in two glances.

Dr. Smalley: Another implication of what Mrs. Gilbreth says is that, suppose as a result of your standard data projections, given the hospital situation, the decision-maker could assess what it is now costing him to receive, store, and issue items. He would be in a much better position to determine the feasibility of introducing automation in his storeroom. Just last week at the AIIE meeting, the man was talking about small plant automation, and I couldn't help thinking, when he talked about small plant automation, he is really talking about hospital automation, because we have a diversified, jobbing-type activity, and in many areas, like storeroom, it would not surprise me in ten years if we found a good number of automated storage areas. Without basic cost information like this, no decision-maker is in a position to determine when it is feasible to automate. He may automate when it becomes fashionable to do so, but here again, you don't have a profit motive when you follow what's in vogue.

Mr. Hiett: If this question did come to pass, he could use this data for evaluating the potential of changing to an automatic storage room. He would have this readily available. It would serve not only to provide information that people could us for other reasons, but would supplement what Mr. Newberry is doing in his part of the inventory project.

Dr. Hullerman: Did you say you would use this for "lines on a purchase order?"

Mr. Hiett: If this was a variable element, you could use it for the number of items on an order to type up. In other words, getting the order blank would be a constant element, but typing it would be a variable, say, a function of the number of lines in the order form.

Dr. Hullerman: Would you limit this to the purchasing department, or any place where typing is done?

Mr. Hiett: This would apply any place that we have typing of this nature.

Dr. Hullerman: Even if it is not as formal as a purchase order blank?

Mr. Hiett: Possibly, now we would probably have to check this to be sure that it would apply to other areas. What I am trying to do really is to break it down into constant and variable elements and examine these.

Miss Belcher: You are doing this work at Emory Hospital? Will this cover just one hospital?

Mr. Hiett: No, this will cover all the hospitals cooperating in the project.

Miss Belcher: All seven?

Mr. Hiett: Yes, and possibly others. We are working so far in Piedmont and Emory. These are the only two that we have covered so far.

Miss Belcher: How much variation in procedures was found? Is there a lot of difference?

Mr. Hiett: These are two different types of hospitals.

Dr. Smalley: Tee, do you have that outline that we made up of the alternative ways of doing the various steps, she might be interested in glancing at that?

Mr. Hiett: Yes, right here. (See Illustration No. 21.)

Dr. Smalley: Those are some of the ways that we anticipate you will have variations from one place to another.

Mr. Hiett: I can give you one illustration. Jim, how do they order items for the stockroom from vendors at Piedmont?

Mr. Standard: At Piedmont, the vendor sends a representative around and the stockroom clerk orders from him, an oral order. The vendor writes it down. At Emory it is done entirely different. They send out the

Illustration No. 21

Order Cost Operations

With Possible Alternative Methods

I. ORDER PREPARATION

A. Supply Request (using unit on central supply)

1. Written

(a) Pre-printed requisition form

(i) Delivered with other forms and messages

(ii) Delivery requires special trip

(b) Form requires writing in items desired

(i) Delivered with other forms and messages

(ii) Delivery requires special trip

2. Verbal

(a) By telephone

(b) By messenger

3. Standing Order

B. Stockroom Order (using unit or central supply on stockroom)

1. Written

(a) Pre-printed requisition form

(i) Delivered with other forms and messages

(ii) Delivery requires special trip

(b) Form requires writing in items desired

(i) Delivered with other forms and messages

(ii) Delivery requires special trip

2. Verbal

(a) By telephone

(b) By messenger

3. Standing Order

C. Requisition (stockroom on purchasing)

1. Written

(a) Pre-printed requisition form

(i) Delivered with other forms and messages

(ii) Delivery requires special trip

Illustration No. 21 (continued)

(b) Form requires writing in items desired

(i) Delivered with other forms and messages

(ii) Delivery requires special trip

2. Verbal

(a) By telephone

(b) By messenger

3. Standing Order

D. Purchase Order (purchasing department on vendor)

1. Review and determine specifications and quantities

2. Obtain Bids

3. Write and send out purchase order

II. RECEIVING

A. Inspect and sign forms

B. Move to storeroom

III. STORE

A. Unpack

B. Complete receiving forms

1. List all items

2. Blind invoice

C. Place on Shelves

IV. STOCK MAINTENANCE

V. ISSUE STOCK

A. Receive stockroom order

B. To shelves

C. Pick

D. To counter

E. Issue

VI. DELIVER TO CENTRAL SUPPLY

VII. KEEP RECORDS

VIII. REMEDIAL SHORTAGE

order to the vendor. At Grady, they send out for bids. There you have three different types. At Piedmont, ordering disposable needles that they use takes about 10 minutes a week, whereas at Emory it would take probably 45 minutes to an hour each week. At Piedmont, they order every week and I think at Emory they order only once a month.

Mr. Hiett: Our study is really independent of the procedure. Once you understand the procedure, you could from these tables get the time for all of the activities. You might come out with a final average that we might use in certain situations, but basically, I want to build up these tables and expand from there.

Mr. Newberry: Grady is the type of hospital that has to have bids, three bids, before a purchase order can be written, and this introduces more lead time, a little more effort involved, so this is even different from the two you mentioned.

Dr. Hullerman: Are there confirming orders on those verbals at Piedmont?

Mr. Standard: That's right. Yes.

Dr. Hüllerman: And this only takes 10 minutes total?

Mr. Standard: Yes, it takes 10 minutes of the clerk's time. The vendor writes it down and later a typewritten order is sent to them. This also takes about 10 minutes to type up.

Dr. Smalley: Are there any other questions or comments about inventory, demand, orders, carrying costs, finance, profits? What's interesting is that we see Parkinson's Law in effect here. They all had their presentations planned where it took two hours, and we made them squeeze it down by all our questions, so we worked out fine.

TUESDAY LUNCHEON SESSION

Food Service Building

Emory University

WELCOMING:

Mr. William E. Lankford
(representing Mr. Humphrey and Miss Graves)

PRESENT:

National Advisory Committee

Dr. Richard A. Dudek
Dr. Lillian M. Gilbreth
Dr. Daniel Howland
Dr. Hugo V. Hullerman
Dr. Ruth P. Kuehn

Staff

Dr. A. D. Joseph Emerzian
Mr. Thomas J. Hall
Mr. Tee H. Hiett, Jr.
Mr. Thomas L. Newberry, Jr.
Miss Louelia Owen
Mrs. Mary Kate Rush
Dr. Harold E. Smalley
Mr. Howard W. Woods, Jr.

Local Steering Committee

Dean Ada Fort
Col. F. F. Groseclose
Mr. Glenn M. Hogan

Other

Miss Helen Belcher
Mr. William E. Lankford

TUESDAY AFTERNOON SESSION

Present:

National Advisory Committee

Dr. Richard A. Dudek
Dr. Lillian M. Gilbreth
Dr. Daniel Howland
Dr. Hugo V. Hullerman
Dr. Ruth P. Kuehn

Staff

Dr. John T. Doby
Dr. A. D. Joseph Emerzian
Mr. Thomas J. Hall
Mr. Tee H. Hiett, Jr.
Dr. Jerry L. L. Miller
Mr. Thomas L. Newberry, Jr.
Miss Louelia Owen
Mrs. Mary Kate Rush
Dr. Harold E. Smalley
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Other

Miss Helen Belcher
Mr. William E. Lankford

DECISION SYSTEM

Dr. Smalley: We have two items on the agenda this afternoon. We want to call on Dr. Emerzian to discuss his conception of the ways that the various pieces of this project might be pulled together into a decision system to satisfy the general objective of the project. As I indicated to some of you first thing yesterday, this is an almost impossible task, and so any ideas that he can throw out to you and any that you have for him certainly will be appreciated. Then, we want to allow the second hour this afternoon for calling on each member of the National Committee particularly and, time permitting, the others of you also, to give us your evaluation of the past two days, your comments, additional questions, suggestions, and reactions. With that, I will call on Dr. Emerzian. Joe.

Dr. Emerzian: Thank you, Harold. I am not at all certain I can do what you set out for me to do, partly because of the nature of the problem and partly because I really haven't spent an awful lot of time wrestling with this. Most of my thoughts are going to be those which I generated within the last couple of days, mostly last night and the night before. I thought perhaps it might be best if I were to start with some system objectives which I jotted down this morning. I have listed here four system objectives for this project and I think that if we can obtain a meeting of the minds with respect to these system objectives or any additions, deletions, or modifications, we then would be in a much better position to implement these objectives as well as to steer our program toward its accomplishment.

Now I must say here also that this is not an official position of the research team as such, because I have not talked to anyone with respect to what I am going to say. So these are just my own opinions at the moment, with the limited thinking I have done. Let's take a look at these and see if these are really appropriate for this project.

System Objectives

1. It should permit the recognition of all variables relevant to supply decisions involving disposable hospital commodities. By all variables, we would mean economic variables as well as environmental variables, psychological variables, all variables which might be relevant to the supply decision. The original objective of the project is as follows: "The specific aim of this project is to develop a practical decision system for determining the relative economic feasibility of disposable and reprocessed supply items for hospitals." This would mean that the type of model which might be used here would be restricted to an economic model, in which, let's say, some objective function is maximized, and in the write-up here, there is a suggested objective function, namely, the maximization of the "quality-cost ratio." Now this would be an OR approach if we could do this. I don't think, frankly, that this is what this project will come out with. At least, at the end of the three years, we will not have strictly an OR approach. We will not have a mathematical model from which objective criteria are maximized or minimized. At least, I can't see it at the moment. In fact, I am not sure what this objective criteria would be. This first system objective recognizes that

these variables here are going to be more than economic variables. Now whether these other variables might be expressed in some common denominator is something else, perhaps you may be able to express them in monetary terms. I don't know. This would be very desirable, if you could. Perhaps we will get some suggestions on that as we go through.

2. It should permit the application of the decision-maker's value system. Now what I mean by this is that the model permit the decision-maker, whoever he happens to be in the instant case (be he here in Atlanta, at Emory Hospital, or wherever you might select), that he is allowed to weight these variables any way he chooses, in accordance with whatever value system he possesses, at this moment in time.

3. It should provide an instrument(s) for ascertaining resource allocations for present supply status. By present supply status I would mean that your decisions here are going to involve some movement. There is always a reference point unless you are starting with a hospital that isn't in existence. You are either moving, as far as your decision is concerned, in one direction or another. You are moving from either disposable to reprocessable, or you are moving from reprocessable to disposable. These are your alternatives. By "present supply status," you would be either in one category or the other. Ascertaining resource allocation would mean, where are your cash outflows or outlays for the behavior or performance involved. In reprocessing reprocessable items, where is your cash flow? Where are your resources allocated? We have got to provide an instrument or some instruments for having these resource allocations ascertained. The discussion with regard to labor time yesterday, that's a resource allocation. The discussion this morning, your ordering costs, your inventory costs, etc., these are all allocations.

4. It should provide an instrument(s) for ascertaining probable shifts in resource allocation resulting from a change in supply status. By this, I mean, what changes are there in cash outflows or outlays which result from this change in supply status, either going from disposable to reprocessable or going from reprocessable to disposable. By this I mean probable shifts in cash outlay. Objectives 3 and 4 really deal with economic factors as such. The only reference we have here to the non-economic, if I may call it that, is up in objective 1. Do we have any questions at this moment?

Discussion

Dr. Hullerman: Why do you exclude 2?

Dr. Emerzian: Yes, 2 also.

Dr. Dudek: No. 1 involves both disposable and reprocessable, does it?

Dr. Emerzian: Yes. The reason I just mentioned disposable is that, in most cases, it's really a decision as to whether you are going to disposables or not. It's just historical. You could have made a general statement here and just talk about supplies.

Dr. Smalley: Distinguish between No. 3 and No. 4, will you please?

Dr. Emerzian: Yes, No. 3 is a measurement of the present cost, with the organizational structure that you have, and what might possibly happen to these organizational alignments expressed in cost if they were to move in one direction or the other. Perhaps I ought to go into that a little bit.*

Time Displacement Matrix

We could say that the decision is a function of economic variables and non-economic variables. We will concentrate here on the economic variables, labor, materials, and capital -- your continuing cash outlays and miscellaneous cash outlays. If we were to concentrate our attention at the moment to labor costs, this would merely be the summation of a lot of labor costs for the various operations. From this, you could get a labor rate. The monetary rate of labor per unit time for this operation times the time for this operation would be the unit labor cost. Now this is just an approach.

Now from this, using the approach which we suggested yesterday, we could determine the present labor cost for reprocessable items. Now, I think in order to conform to objective 4, it is necessary for us to make a subsidiary analysis of these other factors, that is, the department in which the work is performed and the person who does the work and the operation which may be changed. We might develop something that I call a "potential time displacement," a potential time displacement table in which we have the various operations, the departments, and the time required by the person who does this work. All of this may enable us to insert into this table a value indicating "minutes potentially displaced."

(Editor: At this point, Dr. Emerzian developed a table pertaining to "potential time displacement" and inserted hypothetical values in an attempt to show how such a table might be used to summarize the results of time or cost savings. See Appendix A.)

I think that a subsidiary analysis like this is necessary for the administrator to manipulate this matrix. I don't say manipulate in mathematical terms, but rather by inspection. He may be able to re-align this work, which may be saved, in such a way that it can actually be saved. There's a total here of this entire matrix of 150 minutes or some such figure. He may be able, by organizational manipulation, save 50 minutes of this, but if the 150 minutes remain, then there is actually no change in the distribution of resources with respect to the bringing on of disposable items. You can make this same type of analysis on the other side because there may be times in here that you can work additional activities in without bringing on any more resources.

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* Editor's Note: Certain "potent" mathematical symbols and formulas have been deleted here in deference to us peons. See Appendix A.

Discussion

<u>Dr. Smalley</u>: I would be curious as to whether Mrs. Kuehn sees in this kind of approach any value supplemental to your normal staffing studies, that you have made, where you are actually seeing the need of shifting people and positions.

<u>Dr. Kuehn</u>: Yes, I see a value in that when you get your calculations, it gives you a focus and some feeling of confidence as you move into your staffing assignment.

<u>Dr. Smalley</u>: This addresses itself to this old question we have banded about here for so long, what do you do with time saved? Do you do anything with time saved?

<u>Dr. Kuehn</u>: And the cost of the time saved, too.

<u>Dr. Emerzian</u>: You would cost this out, whatever it happened to be in your organization.

<u>Dr. Kuehn</u>: I think, if I were a director of nursing service, I would want to be prepared to defend my position, staffing-wise, in relation to disposables, so that I might answer that question as to whether we should go to disposables.

<u>Dr. Emerzian</u>: The problem you may run into with disposables is that your allocation of resources is fixed because of your organizational structure. There may not be any changes, except as you add those activities associated with disposables which will actually increase the total allocation of resources.

<u>Dr. Kuehn</u>: (Editor: Comments not picked up on tape.)

<u>Dr. Emerzian</u>: This is where the local situation comes in, where I think the administrator has to examine his own organizational work structure and ascertain whether these savings, these minutes that you tell him you might displace, are displaceable, as far as his own situation is concerned <u>at this time</u>. Obviously an accumulation of these is going to have quite an effect. You might have one matrix like this for an analysis which you make today; then you have another disposable item that you want to examine later. These two would have to be added together and then, perhaps, you would have another decision, perhaps a somewhat different decision to make.

<u>Dr. Smalley</u>: I think it might be important too, to recognize that you could have negative values in this table that would represent negative time saved. In effect, this may be what Mrs. Kuehn is implying in her question. In some respects, you might add work to certain positions by the introduction of disposables.

<u>Dr. Emerzian</u>: I didn't go far enough there. My next point was "potential time increment."

Dr. Smalley: That is nothing more than a negative value of what is in the body of this table here.

Dr. Emerzian: You could handle this way, but I prefer to keep them separate. In other words, the time increment associated with bringing on a disposable and then you cost this out. Maybe it won't cost you anything because your organization may be staffed in such a way that it can handle the additional work.

Dr. Kuehn: That goes back to Hugo's statement this morning. This manipulation within the organization comes in at this point. When you move the personnel around, it affects your cost.

Dr. Hullerman: I think that's of definitely value. Also, we've had the experience of not making any change until we had two of these things together because if you let them rest for 15 or 30 minutes, in a week they're doing something else that you may not want them to be doing.

Dr. Emerzian: What we are talking about here is merely one approach. It isn't an official approach of the team, but I do feel, Harold, that this is something that you are going to have to wrestle with fairly shortly and it would be awfully important if this group could give us some good ideas on it.

Dr. Miller: You really have another factor that I think is outside this matrix you have and that is, at what point can you justify upsetting the present organization by the potential saving of time? I think this is where the decision really comes to bear, isn't it?

Dr. Emerzian: If by bringing on disposable items you disrupt your organization, this would be a factor outside of this system, unless you felt that the savings from this was less than the pain of disruption which is created, then you go ahead and bring the thing on.

Dr. Dudek: We have done nothing with our function of beta, or made our decision system a function of both functions. How do we tie that in with this matrix?

Dr. Emerzian: I would say that what you do would be to examine any other factors that you think are pertinent to this decision. There are, presumably, on the basis of some of the work that is being done, disposable items that have certain positive characteristics. These characteristics may be worth something to you, they may not.

Dr. Dudek: Then, are you proposing that we have a matrix like this, this is for labor costs?

Dr. Emerzian: I say this is applicable to all of the monetary costs.

Dr. Dudek: Oh, you're going to have something like this for material and other costs?

Dr. Emerzian: I just used this as an example.

Dr. Dudek: Are you going to have one combined matrix then? Or are you going to have several matrices, one for labor cost, one for material cost, one for environmental costs, etc.

Dr. Emerzian: My preference would be to separate them if at all possible.

Dr. Smalley: I think that there is another implication here, an argument for keeping it separate at this stage. This is that these values in the body of this table presumably would be generated by the application of our other predictive models. These would tell us potentially what kind of saving there would be in moving in one direction or another. Now the change to effect any of that saving would have a nonmonetary effect over in this disruption to organization, "resistance to change," "fear of loss of status," and many other factors. So, only a part of this time is realizable with any given decision and that's the reason for the word potential, I suppose. Only part of this would be realizable in any practical sense. Now that part that's realizable would be the labor saving that is real and immediate. You would add to that the material saving, the overhead saving, and other savings.

Dr. Emerzian: It's the maximum in the table.

Dr. Dudek: That's why I was asking these questions. Joe and I talked about this last night and I think its very valuable to keep them separate for another reason. This way, you are not telling anyone how to combine his functions. You are letting him apply his own values in making this evaluation, because in one hospital the "beta" may be much more important than the "alpha," and vice versa in another one.

Dr. Smalley: I would like to see that issue, combining "alpha" and "beta," opened up as a particular discussion and get some ideas on that. Now we've had a few ourselves, Largely brainstorms, but it's not too late to implement a good, sharp idea, so don't be reluctant to throw it out.

Dr. Doby: Harold, I think Richard put his finger on the crux of the matter in the combination of these considerations. And that is, if you can combine them, then from the point of view of the decision-maker, that means that you are in a sense presenting him with a value system which he must accept.

Dr. Emerzian: That's right. You built it in for him.

Dr. Doby: And it may or may not be acceptable to him and it may or may not be disrupting. I think one would have to examine seriously the consequences of that kind of approach.

Dr. Dudek: However, Dr. Doby, if you recognize this, then the project could go ahead and point the way how you do make combinations of these.

Dr. Doby: And allow for alternatives.

Dr. Dudek: That's right. This is another investigation. There may just be a limited number of logical combinations.

Dr. Doby: Yes, and hence, alternatives.

Dr. Dudek: That's right.

Dr. Smalley: I think it all turns on what you people mean by "combine." I didn't really mean, when I was giving some support to the idea of combining at some stage, that you impose your own value system on the decision-maker.

Dr. Doby: The thing has built into it that aspect of it though, Harold. You can't escape that problem, except by outlining explicitly the alternative situations or approaches, and then on the basis of your personal values or personal situations, choosing the one that will maximize that.

Dr. Smalley: Yes. I would be hesitant as to the advisability of embarking upon a project whereby you attempt to establish monetary equivalent to nonmonetary things. In fact, that's what we're saying. However, I think that we are not taking advantage of the knowledge we are now generating if we don't at least draw up these alternative courses of action and, most importantly, cost them out. Then the decision-maker will know the cost consequences of the courses of action. He must do this subjectively in his own mind anyhow. You don't just use a ouija board. They must have some rationale for this and I think the biggest service we could provide would be to show the cost consequences of various courses of action. Then an administrator or a stockroom clerk or a head nurse or whatever, is in a position then to make a judgment with her own value system, but knowing what the cost consequences are.

Dr. Emerzian: This is a complex question. You will never get all the probable situations which might arise.

Dr. Smalley: You haven't created any problems. You have simply shed light on some of them. You couldn't be any worse off than you are now. You are bound to be better off. I must be an eternal optimist on this because, in the staff meetings and all, I never get any enthusiasm for this point of view. Nobody does handstands when I express this point of view.

Dr. Doby: You have a problem, Hal.

Dr. Smalley: A relatively simple example of this is what Mr. Newberry was doing this morning when he attempted to get around the problem of assessing the risk of running out of an item. If you went to a decision-maker and asked, "How frequently are you willing to run out of morphine?" You will get one answer, "I don't ever want to run out," but strictly speaking the way you never run out is to carry an infinite stock which is infinitely costly and nobody can afford infinity. So, you let him save face and go ahead and let him think that he is perfectly assured of not running out, but you do it in a practical way. You cost out various alternatives with probabilities of shortages. This allows him to keep his own value system and there's nothing beyond our technology that prohibits our costing out alternatives. Now is a real service that I am talking about that we could offer, the matter of giving him a few more facts to work with.

Dr. Dudek: Now that Hal has brought in this risk, I want to throw out one question. How are you going to get this into the model? Right now you are talking about going from reprocessables to disposables, and a potential savings in labor, material, etc. Couldn't we visualize the case where if we can provide it with these risk alternatives, then you might conceive of a situation where the risk might be as great as 50 per cent of the time that I'm going to run out of an item, say 10 times a month. By taking this position of allowing myself to run out 50 per cent of the time of this disposable item, I put myself in a wonderful cost position, and that half the time that I am going to run out, I will keep a few reprocessed items on hand and use them in place of those ten, that's only going to be half the time. Six months out of the year, I would have to use a reprocessed item.

Dr. Smalley: What you are doing here is hedging, I mean, in a technical sense. You are reducing the cost of a shortage by hedging. You are not going completely to disposables, you are going to keep enough reprocessable to dampen the consequences of running out, in the interest of getting a good cost position.

Dr. Dudek: That's right, to get the best economic position for myself, the middle of the road, in other words.

Dr. Emerzian: The fact that you have those available, however, is decreasing one cost and increasing another. It would be the summation of the two because if you reprocess, this would be a higher cost than the disposable.

Dr. Dudek: No, because your inventory goes way down.

Dr. Emerzian: But your reprocessing costs go up.

Dr. Dudek: But only half the time. You're adding only a small increment there for a large increment on the saving. You see, it's this idea of risk. The other alternative, to go to a disposable entirely, you may want a 0.999 per cent probability that you will never run out or that you will have only one shortage, right? This is what they might tell you they want. But, in order to achieve this 0.999, you have got to have this big an inventory, so I'm going to cut back my inventory to this position, because now I have a 50 per cent risk, or let's make it 60 or 80 per cent risk, of running out only 10 times. So only 40 or 50 per cent of the time do I have to reprocess these ten items in that month. Do you see what I'm driving at?

Dr. Emerzian: I'm not sure I agree with it, but that's all right.

Dr. Smalley: You (Dr. Emerzian) can't disagree with what he says. I believe when you say you disagree that you think it might cost more to have a product mix between disposable and reprocessed. He's (Dr. Dudek) guessing that this mix would be less costly, but what he said will stand or fall depending on how it costs out.

Dr. Dudek: That's right, I'm not saying that this is going to be the best situation in all instances, but I think you should guard against this possibility, because when you start using the Poisson distribution for probability of a shortage, it is asymptotic toward zero and you could get way out here with an inventory that's so costly to have a 0.9 per cent probability of not running out, that your inventory cost would be prohibitive, so you would consider disposables.

Dr. Emerzian: You will have to remember here that your reprocessables are also part of your inventory, that's part of your safety stock.

Dr. Dudek: But, just a minor amount.

Dr. Hullerman: I can see some possible applications of this, for example, it might be shown that half a dozen hospitals could join up in some way so that a pool might furnish disposable items. This would reduce carrying costs. You might even purchase your reprocessed items in this way, too. It does suggest a method of reducing the risk within a given institution without necessarily establishing a fixed increased reprocessing cost in any great amount.

Dr. Smalley: This is really a first cousin to substitutability, which is the old argument that we have had in manufacturing for many years. We try to standardize on sizes, so that the same nut that fits the wheel of this car . . . will fit another one, and so on. Dr. Dudek is suggesting here, it seems to me, that by having a few reusable items on hand, though this has a cost consequence, you increase the substitutability and therefore reduce the cost consequences of a shortage. Now it remains to be seen whether such a course of action as this would be more or less costly than some alternative.

Dr. Dudek: Right, but I can conceive of some situations where it would be, depending on what the distribution is, what the probability of risk of running out is, and how much inventory you need to guard against that probability.

Mr. Hiett: Or, we could reprocess disposable items.

Dr. Dudek: Well, this is all right. If this is the case, then let's be sure we get into the risk picture, as Hal points out, so that he can say that if 50 per cent of the time gives him the best cost picture and he can reprocess those items, only the increment of cost of reprocessing that disposable. I'm with Hal now. I think you have to provide this risk decision, in the model somehow.

Dr. Kuehn: Wouldn't you have to look at your environmental factors, what are you doing to your labor situation when you introduce these reprocessed materials into your program where you have everybody trained on disposables, you have x number of items down here someplace and you can't locate them when you want them, what's the cost there?

Dr. Dudek: This is all a part of good management.

Dr. Emerzian: This is something I would prefer to avoid for it's a headache. You will have to have the capacity to reprocess when you have to. This is a cost, a stand-by cost.

Dr. Kuehn: It's going to run your labor cost up, too.

Dr. Emerzian: Of course it will. In fact, you have to staff in such a way that excess is there because you don't know when you will need it.

Dr. Hullerman: I'm not sure you do, Joe.

Dr. Emerzian: Then you'd have to be able to predict what it might be.

Dr. Hullerman: No, you might use related hospitals that can absorb a larger load or get along on a smaller load. I'm not sure you'd have that problem. This would have to be determined, but it certainly has a possibility of success.

Dr. Emerzian: You mean another hospital?

Dr. Hullerman: If we run out of something now, we lean on each other.

Dr. Emerzian: Well, that's the risk. There's no risk associated with the run out then, if there are five or six hospitals in the area.

Dr. Hullerman: No, it might be on a purely disposable item. If the others weren't using disposables or if they were cutting very narrowly on their margins too, if one of them was still reprocessing, you might be all right on this.

Dr. Dudek: You can look at it like this, too, Joe. You don't have to stick to the original method of reprocessing either. You can develop one that is a one-shot affair for reprocessing that they could do with existing equipment. In many instances, you're right, this possibility may not exist, but in many other instances, I think it's going to exist.

Dr. Howland: I agree with what you are saying, but it seems to me this is a different question from what you were asking in the first place. Is the question here, what proportion of disposable versus reusable, where do we want to be on this continuum? Or how do we get to disposables? Has this decision been made? These are two different questions.

Dr. Dudek: Yes, but I think that the best way to get there would be to get to the best position on your first try, wouldn't it?

Dr. Howland: So you've made the decision that this is what you want to do, or is this the question you are asking in your research?

Dr. Dudek: I am saying that this is the question we should be answering. Get to the best position for us on the first try and if we have this all built in, maybe we can.

Dr. Howland: In other words, where on this continuum do we want to be?

Dr. Dudek: Right. This is the question I am posing now.

Dr. Howland: It seems to me to be different from what Joe says. Is it or isn't it?

Dr. Emerzian: The reason why it may be different is that I frankly hadn't thought of mixture. In other words, where might this be optimized, what combination of the two. I hadn't thought about it, but it certainly is a legitimate question.

Dr. Howland: I think it would make a difference in what you do, what you do in your study. If you've made up your mind that you want to get everything disposable, then how you do it is one kind of question. The other question is where do you want to be on this continuum?

Dr. Dudek: Frankly, I didn't think about it until this morning either. If you could get to this position on your continuum on your first try, then you are achieving the best situation.

Dr. Howland: Are you suggesting that you "crank up" so that you have some "feed-back" loops to tell you what kind of corrections to make?

Dr. Dudek: Right.

Dr. Howland: I think this is what you want. This also takes care of the environment in a sense.

Dr. Dudek: Right. After you get to this point, it changes this; now let's go back and try it again.

Dr. Smalley: Some phase of this has come up earlier in this respect. We might look at a continuum as exclusively reusable on one end and exclusively disposable on the other and all sorts of mixes in between. Or we might look at a continuum that was related to cost or efficiency or some concept thereof, which wouldn't necessarily put disposables at one end and reusables at the other, though this might happen. I had been assuming all along that this would probably be a by-product or ancillary benefit of this and not really at the main stream of our objective. It would be a mechanism whereby you could show a hospital or a department or an area where on this efficiency continuum you now fall. Then you could cost out alternative movements in one direction or the other, whether it be for increased mechanization and automation or decreased mechanization and automation or different kinds of staffing patterns or a different kind of product use or a different concept of patient care. I had been assuming all along that these would be by-products but the way you are talking now, about where you ought to be the first time and judging where you are on the continuum, you are suggesting that this might be something that you would do rightaway.

Dr. Dudek: I think that you yourself more or less have underwritten this when you start saying that "risk" should be included.

Dr. Smalley: Yes, but you can include risk, Dick, in the sense that you recognize it and cost out consequences of risk without really coming to grips with the substantive nature of risk. You can leave the man with his own value system, his own way of looking at the problem, and you simple tell him consequences, and that's the way I had assumed we were going to deal with it, but I would certainly not be opposed to getting into it more deeply than that.

Dr. Emerzian: What is this risk that you are assessing? I thought we talked earlier about the risk of run-out; now I think we are talking about a different type of risk. Is it the risk associated with the selection of an alternative.

Dr. Smalley: The risks that generate cost, as applicable to the items. I'm not talking about the hesitancy of a decision-maker to take a course of action for fear of his own personal position and this sort of thing. What other kind of risk did you have in mind besides the risk of run-out?

Dr. Emerzian: The risk associated with making a decision.

Dr. Smalley: What's the consequence of your risk?

Dr. Emerzian: Bad decision, loss of job.

Dr. Smalley: That's what I thought, personal consequences. I wasn't talking about that kind of risk.

Dr. Emerzian: We are in this market and devote most of our resources to it; there's a change in the demand for our product and there are consequences.

Dr. Dudek: You have these kinds of risks whether or not you are going to decide how good your model is on "alpha" and "beta" decision errors. I was primarily referring to getting the risk of run-out in here because I think this would help them make a decision to get in a good cost position.

Dr. Smalley: Before we run out of time, let's not leave the impression or pass up the chance of getting a reaction to a much less sophisticated approach to this question and one that may even hold more promise for practical results, come a year from now, namely, the one that we have discussed so often. You would compile, in effect, some sort of a manual that would be something like a Federal Income Tax Form and you didn't understand all the steps and what lay behind it, but it's fairly simple to follow through the instructions and come up with some answers with some interpretations of what those answers mean.

Dr. Emerzian: I left that open. All I talked about was an instrument and I had no definition of what this instrument is going to be.

Dr. Dudek: But even in that instrument you could build a little of this in. You're doing it already.

Dr. Smalley: You can do it, but what I'm afraid of is that there are people in this room now who are going to say, "What in the world are they going to do with the alphas and betas and j^{th} and k^{th} departments and the i^{th} case and the probability of a run-out and value systems? Let's get down to earth on some of this. We've talked about this, and now, I'm saying, why don't we talk about some of the less sophisticated possibilities. We are not committed to these either.

Dr. Howland: It seems to me, Hal, that what you are saying in a sense is that in this regression framework, we are going to assign zero weights to more factors and you can simplify yourself right out of the world doing this. Sure it's simple, and it may work for some hospitals on Mars, but I don't think we are in any position to do this kind of simplifying until you have had a good look at what's there. Then you are in a position to start simplifying, but I wouldn't assign zero regression weights before. you have been through the drill.

Dr. Smalley: Here I think we have semantics problems on the word, simplify. I think you can simplify the format without doing anything about the technology or the scientific procedure.

Dr. Howland: A packaging problem, then?

Dr. Smalley: I am saying that you can express, in a schedule, the same ideas that you express mathematically, and if this makes it simpler for the devision-maker to use, then adopt this format.

Dr. Howland: I don't think anybody would argue this point.

Dr. Smalley: No, I'm sure they don't and that's the reason I am wondering.

Dr. Howland: It seems to me what you are saying is that you may simplify the results. I thought that you wanted to expedite by simplifying the analysis and I think this could be dangerous.

Dr. Smalley: I think we have got to do scientific work to generate what is important and what isn't, and if internally, we can do this mathematically better than we can descriptively, fine; but I am saying and I was hopeful that this afternoon, we could get some insight into how this final package might look. I am afraid we were leaving the impression that this final package might be a set of complicated multiple regression equations, and I don't want to leave that erroneous impression.

Dr. Howland: It seems to me you are a brave man if you are going to talk about what the final package is going to look like, now.

Dr. Dudek: I think you had some indication of this yesterday, possibly making multi-variable charts and things of this nature. I think we are all in agreement that what you want the ultimate thing to look like is something that's going to be fairly easy to use. Dr. Hullerman pointed out, you don't want mathematics, because as soon as they see alpha and beta, that scares them off right away. They will say, "I don't understand alpha and beta, so I can't use this." Maybe Dan's statement is it, that's the package you are going to put it in.

Dr. Howland: Transmitting information requires some effort on the part of the receiver, too. It can't all be done by the transmitter. I recognize that the practical problems of running a hospital are tremendous, but I worry about making it so simple that it doesn't do anybody any good.

Mr. Hogan: That's not what you mean, is it, Hal? You're not going to sacrifice scientific method.

Dr. Smalley: It would certainly not be my intention, though I may be obliged to do some of this. Dr. Howland, I am sure, in his own group occasionally has to do this. What he is warning against, and I think quite legitimately, is that you shouldn't make this sacrifice in the process. Certainly, Glenn, I don't think any of us would want to.

Dr. Howland: What I am saying is that this is not a simple problem and you can only go so far before the people who are going to use it will have to pick up their end of the load.

Dr. Smalley: As industrial engineers, we are continually warned that you've got to keep everything simple, don't get above arithmetic or the workers won't understand it. This is almost as silly as telling the civil engineer that you can't use calculus or section modulus or strength of materials in designing any of our bridges around here because the politicians won't understand it. You've got to draw a line somewhere, that you are not going to simplify it at the risk of validity and reliability. I just didn't want the people to get away thinking that this is it. I didn't want Dr. Hullerman, for example, to expect to get a decision system that is wrought with this kind of sophistication. I'm afraid he would be a little disappointed.

Dr. Doby: Harold, simplification of the explanation of the basic variables involved is one thing, but simplification of procedures for applying these very same variables is something else. I would consider that a problem of technology, rather than a problem in explanation or validation. The two things, while they go hand-in-hand, I think they can be separated and can be dealt with in that manner.

Dr. Smalley: We would like to give each person an opportunity to give his own reaction and perhaps we ought to move on into that. Thanks so much, Joe.

EVALUATION SESSION

Dr. Smalley: We invited the Public Health Service to send a representative as an observer, and before we go around the table to get official reactions, I wonder, Miss Belcher, if you would like to give us any of your reactions or comments at this time.

Miss Belcher: First of all, I would like to thank you very much for inviting us to come down. This has been a very interesting two days, a very full one, and I feel it is a real privilege to hear all the discussions that have been going on. I think you can't help sitting through two days of this kind of thing without becoming impressed with the complexity of the problem and all that it involves. It seems to me that it is a very important problem and that it has all kinds of ramifications. The difficulty seems to be, at the moment, to identify which parts of it will be approached on a research basis, and perhaps, which aspects of it may have to be left for some other time. We seem to get back to the discussion of how simple should the outcome of it be, yesterday and today, and I'll just add my two cents to it. I think it's quite important, since this is supported as a research project, that it stand up as good basic research. It may be that a secondary part of it might be making some applications or developing something which would be more usable by a lay person, a person who was not trained in calculus or something of that sort. I think this should not, in any way, limit the sophistication or the way the thing stands up in the research field. I think it is always nice to meet so many people on a team of researchers and I think those of us who are in nursing or have something to do with hospitals are very happy to know of the interest of other fields in helping to solve the many problems that we have. I think the other thing I would like to comment on is that it's always nice to see so many of the young people coming along, getting Master's degrees or doing Ph.D. dissertations which feed into this kind of research design, for I think this helps in the problem of research training. I have enjoyed it very much and I thank you all very much for letting me be here. I don't think I have anything more to offer at this point.

Dr. Smalley: We certainly enjoyed having you, and as I have indicated to some of the people already, we got a windfall. We just expected you to listen, but you have made a constructive contribution as well. Dr. Howland, how about giving us your reactions?

National Advisory Committee Remarks

Dr. Howland: Do you want the short version or the long version?

This business of integrating all these parts is one that I have a great deal of sympathy for, and the only thing I can think of is that somehow you've got to get the integration built in. It's almost impossible to go back and, after the fact, integrate component studies. This is where we have gotten in trouble in our work, if it is going to be integrated, it has to be integrated before you do them and not afterwards. This just leads to a mess. If you are really interested in integration, which I think we all should be, then the kind of component research that has been badgering the psychologists, particularly in the human engineering area, I think this is a horrible example, we can turn out nice neat little papers, but after you got them, you don't have very much except a summary with the conclusion that we should have done something different. This is a good place to start on the next investigation and I don't think people are going to stand for this, indefinitely. What this adds up to is that it takes time to do this. It takes three or four years to know enough about a problem to write a good proposal, really, realistically. I think there is a growing recognition of this fact and if you don't have this kind of integration before you start, the decision to study gloves or needles or blood may be questionable. I don't know why you picked gloves. You could have picked lots of other things; you could have picked blood the way we did. We chose it because we thought it was pretty tough and it is. Unless you have this integrating something or other to play these things back and forth against, from our experience you get into trouble.

Another thing that I think is important that Dr. Gilbreth raised this morning is the applicability of these industrial models to this kind of system. I think one reason they don't work very well is that you just don't have the volume and this seems to make a big difference. I think that people who are fooling with these should make a concerted effort to keep tract of the failures, and somebody should be picking up these failures and seeing why they don't work, what's wrong with an inventory model in the hospital? Out of this kind of information, if you can get it together, if people will admit that the models don't work, perhaps we can develop some better ways of looking at them. I remember seeing at an AHA meeting a few years back -- that's the last meeting they ever invited me to -- where some administrators were discussing the applicability of the business organization's rules of management to a hospital. The consensus was that there were some real fundamental difficulties here because of hospital systems. We hear this kicked around: Is a hospital like an industry? Isn't it? You can argue all kinds of ways around this, but I think somebody should really go to bat with this. When you are using industrial models in a hospital situation, try to find out why they don't work if they don't.

One other general complaint that I think has also been touched on is, after we have gotten the studies done, how do we get the results somehow ground back into a curriculum. You do it, in part, through your graduate students. They get training not only in research procedures but some of this business about being in a hospital. We have a tremendous difficulty in convincing our young engineers that the hospital field is one that has any interest or promise or anything else. The need for people who can handle these problems seems to be growing. There are two or three people from our department who have gathered up their courage and taken the "plunge." They have been extremely happy with this. But, there is a real gap here, it seems to me, that somehow that ought to be filled by research teams like yours and mine and the others. I think that the Public Health Service and the government in general -- it's even more of a problem in military research -- are overlooking what probably could be the greatest benefit to them in getting their people trained by being associated with these teams. We have finally gotten a gal who is a NIH scholar to work for her degree in our group and the Army is beginning to send people to work in our Army project. These are career military people. I think this kind of movement ought to be encouraged, but how do you go about encouraging it? I don't really know, but the training aspect of these projects sometimes gets lost in the shuffle.

I had some other specific comments which I don't think are worth boring you with. It will probably be better to jot them down on a piece of paper and send them back.*

One other thing, though, that I would like to mention in passing. It seems to me this is a question of whether you provide "point" answers, or "functions." The operations researcher provides an optimal solution; this is a point answer. It doesn't often get used, not as often as it should, because when the poor decision-maker, whoever he is, looks at it he recognizes that some things are left out. This is due to the assigning of regression weights of zero, and he doesn't buy it. And then the OR type typically stomps out in a rage because this guy is so stupid. He's not being stupid; he's being smart. He could, perhaps, work with functional relationships where the point basis folds. I think our final product in these projects ought to be some kind of functions, rather than optimums or points.

Dr. Smalley: Thanks, Dan. Dr. Kuehn.

Dr. Kuehn: I feel that I have learned a great deal and have very little to give. It's always nice to be with Mrs. Gilbreth and you know we've been carrying the torch on this project.

I keep asking myself about non-economic factors entering into decision-making and wonder if we really don't have to come to grips with a deeper definition of roles with relation to the administrators and users. That's bothering me.

Then I find myself getting a little bothered about introducing this aspect of reprocessing disposables. We're talking about the disposables and the reprocessing, and then we get into this reprocessing the disposable. Are we muddying design here? Is this another study, or do we want to get into this here in this particular outcome?

The conversation we had this afternoon doesn't bother me at all. It seems to me that what we are saying supports the position that Dr. Gilbreth and I took a long time ago that we must get engineers into the hospital field in the interest of hospital costs, and it seems to me that the more research we get and the farther along we get, the clearer becomes the case of the engineer in the hospital or the engineer for a group of hospitals. I would not be in favor of diluting the quality of the research in any aspect. It seems to me that the research is helping us focus on what we believe to be a good movement within the health field. I would urge that we stay with this and then sell engineering service to the hospital. I was quite concerned in the Bibliography, for example, the number of "how we do it" items.

*See Appendix B.

Let's not confuse the field into thinking that this is easy and that there are a lot of easy answers because that is not true. Let's use our power where it's going to be most effective.

Dr. Smalley: Thank you. Dr. Hullerman.

Dr. Hullerman: I am reminded of a story here. * It seems to me we may be having different "prayers" because I must confess that we should not overlook the possibility of getting some practical benefits from this at a much earlier time than we might expect to get through the widespread introduction of industrial engineers into hospitals. I did ask myself, though, what values I could see in what has been done so far, and I have four or five of those here.

One, I think that if what we have seen here could be given to hospitals in a way that could be used would help the administrator to demonstrate how he arrives at estimates and thus his decisions; this reduces the consideration of how he got there to the level of how effective is the formula he is using. When I say "administrator," I'm talking about any decision-maker. If the formula is furnished by a research group such as this, then the administrator isn't defending his own prediction nor is anybody challenging him when they disagree with him. I think this is the kind of situation that contributes to good sound decisions in a hospital, because it removes the necessity of choosing between two opinions. They are really choosing between two alternatives that are backed up by something that is fairly factual and understandable and can be analyzed. This is a big factor in the good operation of an institution. The worst thing I think you can do is have to say, "I believe x and I don't believe y. All you have done is reach a decision, but you haven't convinced anybody of anything.

A second value is that some of the things we have seen this two days furnish a breakdown in detail of the elements that must be given numbers if the hospital elects to do its own detail work. One of those that Hiett discussed and the glove reprocessing report (Hall and King) did that thinking for a hospital, in just listing the things. And also, it provides figures that could be used if the hospital isn't going to do all its own detail work and wishes to use these figures as a step toward improvement. I am not wishing to upset any research approach, because I think it should be research and done in a scientific manner. I do think that you will find plenty of opportunity in hospitals to use figures that are "averages." Maybe they can be spot-checked to see if there is any reason to think they would not apply to a hospital, and you could make better decisions in a hospital with such figures. I think they would have to be extended and made a little more detailed than the ones we have here. I think those figures could be an advantage in a hospital.

Another value is this: What we have seen here so far and what we could see at the end of the study would help us in hospitals to obtain a more factual level towards decision making, whether it's an accurate listing of facts, I don't know, but at least it would be more factual than what we do now in many instances.

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* Editor: Story deleted through it had pertinent moral.

I am rather impressed too with the feeling that the formulas that we have seen so far presented are going to bring many people in hospitals to realizing that the decisions they make are very frequently -- pehaps in the majority of instances -- based upon beta, upon the intangibles, upon which they have to fix values and that cost is probably fourth or fifth down the list. I think that hospital decision-makers are bound to realize that they must get to using this kind of formula approach, which would be a rather worthwhile thing for them to realize.

Now there's one other thing that bothers me about this project. Hospitals along with industry, have seen certain things in the administrative and operational fields emphasized from period to period. I've no idea whether this is complete, but we have work simplification, we have had ideas about dictatorships as administration, authoritative versus democratic, we've had group dynamics and human relations, administration by committee, methods improvement where everybody is brought into the act, the suggestion that industrial engineers ought to be in hospitals. Maybe we're coming back to the idea of communication which is tied up in some of these others. And now we have operations research, and if you will look at these others, they have fallen by the wayside. They really are not in operation in hospitals very effectively, I don't think yet. I'd like to think that operations research could come up with something that would be of practical use, and I can assure you, that if you come up with a lot of Greek letters, you had better concentrate on putting industrial engineers in hospitals, because I don't think you are going to find very many hospitals are going to be able to use that. You're going to have to simplify what you give them even though you might not simplify what goes into those formulas. Why don't they come up with something that we could use?

Now this is an extremely well staffed project. I think it's wonderful the objective analysis and views that have gone into what we've had so far, but I'd like to leave this word. In hospitals we are just not comfortable with ourselves. We'd like to be able to do better. I think the point that I wish to make is: don't wait for three, four, five or six years to give us something we can use, because waiting can sometimes be uncomfortable.

Dr. Smalley: Thank you, Dr. Hullerman. Dr. Dudek.

Dr. Dudek: Many of the items that I had in mind have already been said. We've already talked about risk, and I want to add only one thing, the problem of an existing method versus the "best" method that I think you guys are going to have to wrestle with a little bit in constructing this decision system, or this model. I think these are going to be some hard problems here, I don't know. Maybe it can be resolved real easy though. Other than that, I think we've had a real fine time these two days. I think you have progressed well since the last time we were here.

Dr. Smalley: Thank you, Dick. Dr. Gilbreth.

Dr. Gilbreth: I have, as I think all of us have, had a most enjoyable time and I am very grateful for it. I do want to see our findings go on along the lines you suggested, but also to have them as quickly as possible, put in simple, easily available, understandable form so that we can try them out in the field.

I feel very strongly that we are over-emphasizing, perhaps, the difference between hospitals and so-called "non-profit" business and industry, rather than the likenesses. Very often, it's a kind of defense mechanism on both sides for not doing anything. I think this challenge to business and industry to try to understand the problems of the hospital field is just as great as the challenge in the hospital field to try to find out what in business is useful in hospitals, including what is motivating and carrying people through. I think what we really want to know from all these groups is: "Why do you do what you are doing," and "Why don't you do what you are not doing?" I think you could have answers to these problems if both groups were better understood.

I think also that, on both sides, we are a little inclined to generalize, to talk about business as though all business was alike, and to talk about hospitals as if all hospitals are alike. Hospitals aren't alike in size, in problems, in goals. And neither is industry. We seem to be talking at cross-purposes. First we talk about likenesses and then we talk about differences. I think <u>size</u> has a good deal to do with the fact that people in hospitals very often say: "We can't do this in the hospital field." They are thinking of such a place as General Electric or General Motors or something enormous, while as a matter of fact, small industry is, of course, the most challenging field of all these days. Perhaps a closer study is needed so that you can find the most similar comparisons with business and industry.

Now of course, I think we are all impressed with the factual material that has been presented to us, including this fine bibliography which I think is a real step forward. There is so much talk in the business and industrial world these days about communication and participation, sometimes without trying to find out if we really have anything to communicate.

It seems to me that the emphasis you have all put on <u>fact finding</u> and getting the facts to us <u>as soon as you can</u> is extremely important, much more important than perhaps the speed of pushing ahead in the interpretation of all the facts before bringing the facts to us. Because, limited as our experience may be, we may have certain slants of looking at these which, if you could get them and look back on them, it would be a great help. I think that we have to go back to fundamentals and remember that, after all, science is largely <u>asking questions</u> and <u>accumulating facts</u> and then going at them very carefully in order to <u>analyze</u> them.

I too feel very happy that so many young people are coming into the hospital field as they are also in business and industry. The young executives and the Jaycees and the Under Forty group and so forth, not only nationally but internationally, are coming into the picture and showing that they can take responsibility.

I feel very strongly that perhaps it would help in hospitals if they really utilized all that the young industrial engineer might have to give. I sometimes feel that they are assigned projects more or less without any consideration as to the demands on the project. They may assume that the engineer has less to give than the project demands, when as a matter of fact he may have more to give than the project demands. It seems to me that if young engineers go into the hospital field, either in research or taking permanent or temporary jobs, at the present at least, they are making very definite sacrifices to do that, it's the service motive, certainly, that would take them in rather than anything financial that they would get. It seems to me, that, in compensation for that, they should have all the challenge you can give them; they should have an opportunity to keep very closely in touch with what is going on in their professional field. If they see any parallels between industry and what happens in hospitals, and I think they will, they should be allowed to go freely on their project, out of the hospital and wherever the information is to be had, in order that they may bring back this information. You can always cut it down, you can always say this is extraneous, but just looking at that material may give some of you who have had wide experience just the opportunity to say, "Well, you've put your finger on something there that perhaps can be developed." I hope we are going to have more and more young engineers to give you and that we are going to try to put more and more into their training.

I think also that, looking toward the future, it would be a great contribution if you would think of the service you can provide hospitals in other lands, some of which are really very advanced, I think, though they probably don't get credit for it. And some of them, of course, are very, very far behind. This is partly because they can't help it, because of the terrific demands upon them, but partly also because <u>we</u> haven't thought through very carefully the types of things <u>we</u> can do.

Now, when you remember that these young engineers have been very carefully brought up to believe in a code of ethics, to believe that they are to utilize resources of nature and human nature for the benefit of mankind, when you think that we tell them very definitely from the beginning that they are to have these values in mind, we might go back over their background and experience and say, "They haven't had all the courses we wish." I wouldn't worry about that. They are working in an interdisciplinary group, just as you are doing here. They know where to go and I think they <u>will</u> go to get that sort of thing. They will try to find out what is going to be done, why, who is going to do it, and where, when, and how. But above all we should say to them: "You must have your standards based on policy and procedures, based on principles, based on beliefs. It seems to me that we can utilize this group better and this will be fine. Thank you.

Local Steering Committee Remarks

<u>Dr. Smalley:</u> Thank you, Dr. Gilbreth. I want to acknowledge again that we are awfully happy to have had all of the out-of-towners with us and also our Local Steering Committee people. Mr. Hogan, would you like to make any comment as a member of the Local Steering Committee?

Mr. Hogan: Thank you, Harold. Briefly, I appreciate the chance of being with you all for this two-hour session. Harold was very kind to let me sit in. My comment would be the comment made by someone earlier, and he stated it so much better than I could state it. My inclinations are in the direction of his remarks. The average size hospital, certainly in the South, is less than a hundred beds and nationwide it's a relatively small institution. Dr. Gilbreth touched on this too. Are we talking about a tool for management, or are we talking about a tool for the engineer who is part of a larger picture? To us in the field, it's a little impractical with us if you don't have a system that's workable for the typical hospital, and the discussion that I have heard seems to presuppose that all hospitals are large. To me, when you say your objective is "relative economic feasibility," you are immediately saying that you're talking about something that you want to see applied. To me this is not basic research. It is inherent that it has to have applicability as part of its product. You're talking about devising a system, not the finding of eternal new truths. It can be as sophisticated as you like, but the system has to have this element of applicability, as one of the most important elements. I think you are on the road to something, I just hope this final phase is what you, Hal, have already expressed, that it will indeed be a thing that is unsophisticated, but still a thing that the manager of a typical hospital can use who has not the resources of an engineer. You expected me to comment this way, didn't you, Harold?

Dr. Smalley: Well, it doesn't surprise me. We appreciate it. Another member of our Local Steering Committee, Dean Fort. We catch you at a disadvantage since you have been away, but would you care to make any remarks?

Dean Fort: I don't have anything to add to all of these comments. I really am more anxious now than I was to find out what went on while I was away. This has certainly whetted my appetite and, as you and I were saying ahead of time, we do need to get together very soon and renew the relationships on what nursing education can contribute to this project on the local scene.

Discussion

Dr. Howland: Hal, at the risk of using up time, I think there is a very important issue that has been raised here that I am not going to settle but that people should be aware of and be worrying about. It seems to me that the basic issue is the difference, or lack of understanding about the difference, between what an engineer does and what a scientist does, what the inputs are to engineering, what they are to science, and what the outputs are. I think that what is happening here, not just here but in general, is as a world or certainly as a country, we are getting into the position where we have got to have some basic theoretical formulations to make things work or we are going to go broke. You look at the difference between a modern weapon system and a weapon system of World War II. You just can't build airplanes and evaluate them in the good old way. You've got to know what you are doing before you build these things. It seems to me that engineering is the application of theoretical formulation which includes the value system of the user and that science is the business of getting something for the engineer to use. A lot of the difficulty and confusion and unhappiness that surrounds this stems from lack of understanding of just what the expectations are on the part of the user. I think part of the job here is to point out what one can expect, and what it takes to get data, and what you can do with data after you have got them. We have been working with a truck line in Columbus for seven years. We've been working with a small profit-making organization who is shocked to find out how many dollars it took to get results. We've had some really horrible staff meetings with this guy who is saying essentially what Hugo says but not anywhere near as delicately. The "parakeets" have been screaming, and finally at long last, we have been able to devise a theory that fits his organization and now he is getting his pay-off. But we didn't understand this when we started, and I think this distinction between science and engineering is something that is generating "noise" in all of these studies and is something that we have just got to keep educating the people who pay for this. Fortunately, I think in the Division of Nursing Resources this is not a problem, but among sponsors, they are pretty atypical. As a matter of just talking it up and explaining this, I think everybody that hires a research group ought to read books like "Common Sense of Science" and "On Understanding Science," things like this, to find out what in the world they are buying. This is my sermon for the day.

Dr. Smalley: Thanks, Dan. Will, as sort of a substitute for both Mr. Humphrey and Miss Graves, do you have any comment?

Mr. Lankford: No, other than the fact that this brief session that I have attended has whetted my appetite and I wish I had been here for the rest of the sessions. This has been very enlightening.

Dr. Smalley: Again, let me express appreciation on behalf of our staff.

Dr. Hullerman: Harold, could we have some remarks from you?

Finale

Dr. Smalley: I'm overwhelmed by it all. Actually, I am not really surprised, knowing this group. After all, we selected you because we knew you were the people who would tell us what you thought. Naturally, we are impatient to get on with the work and are never satisfied with what has been done. I do feel that in the last two days, we have learned a lot. We have about seven tapes over here, that we will review, and transcribe and study and digest and try to implement the wisdom that you have given us. It is with a good deal of gratitude that I adjourn the second meeting of the National Advisory Committee. Thanks for coming.

* * *

APPENDIX A

COMMENTS FROM DR. EMERZIAN

I. Objectives of System

1. Should permit the recognition of all variables relevant to supply decisions involving disposable and reprocessable supply commodities. (Variables might include economic, organizational, sociological, etc.)

2. Should permit the application of the decision makers value system. (Variables are subjectively weighted in accordance with the importance the local decision maker assigns to them.)

3. Should provide an instrument(s) for ascertaining resource allocations for present supply status.

   (a) This instrument (these instruments) should be sufficiently simple to permit local application by persons without professional training (industrial engineer) and without special training.

   (b) This instrument should include methods for ascertaining probable errors in the estimate of resource allocations.

4. Should provide an instrument(s) for ascertaining probable shifts in resource allocations resulting from a change in supply status as well as changes in non-economic variables. (In an existing hospital, the shift in supply status would generally move symbolically as follows:

$$R^{100\%}_{1\%} \longrightarrow R^{100-D\%}_{1\%} \; D^{100-R\%}_{1\%} \longrightarrow D^{100\%}_{1\%}$$

. The instrument should be capable of predicting the effects of economic variables at any point within the interval $R^{100\%}_{1\%} - D^{100\%}_{1\%}$. On the other hand, functions of non-economic variables at best will be "discontinuous" so that all that can be expected are three point estimates around the supply states R, RD, and D.

II. Conceptual Model

$$D = f(\alpha), (\beta)$$

Where:

α = economic variables L (labor), M (materials), C (capital)

β = non-economic variables (safety, acceptability, etc.)

Using (L) as an example:

L = labor cost $= \sum_{c=1} L_1 \; L_2 \ldots L_N$ $\qquad$ i = 1, 2, ...N operations

$L_1 = R_j Y_{ik}$ $\qquad$ R_j = monetary rate of labor /t for the jth occupation (nurse, aide, etc.)

Y_{ik} = standard min. (t) for the ith operation performed by the kth organizational component (central supply, nursing, etc.)

Implementing objective (3), we should have a Labor Cost Matrix

	K_1			K_2		
i	R_1Y	R_2Y	R_3Y	R_1Y	R_2Y	R_3Y
1		xx				
2			xx			
3					xx	

Implementing objective (4), we should have a Potential Time Displacement Matrix and a Potential Time Increment Matrix. The PTDM is a schedule which contains the amount of work by organizational unit (K), occupation (j) and operation (i) under the present supply state. When a change in state is made, it identifies the amount of work which is potentially displaced. It remains for the local decision maker to reorganize his work system to take advantage of the potential contained in the matrix. The extent to which he is able to realize this potential constitutes the positive profit from the change in state. On the other hand, the PTIM contains the amount of work which is added to the hospital's work system. It also remains for the local decision maker to reorganize his work system to minimize the addition of resources due to the change in state. The extent to which additional resources are necessary constitutes the negative profit from the change. The net effect of the two matrices is the conditional profit from the change in state.

Note: The unit used in these matrices is time, which must be costed before the conditional profit is determined.

APPENDIX B

COMMENTS FROM DR. HOWLAND

1. The problem of integrating the substudies, to which Joe addressed himself on the last day, is an extremely difficult one. It has been our experience that unless the integration problem is solved prior to conducting the individual component studies, so that they fit in an integrated framework, it is very, very difficult to impose integration later.

2. Dr. Gilbreth and others have touched on the applicability of industrial models to hospital problems. I am becoming increasingly skeptical that they fit as well as we would like. What is needed here, I think, is some concrete data on where they fit, where they do not, and why. It seems to me that exploration of this problem would be very useful to the whole field, and that you are probably in a better position to examine the problem than any of us working in this area.

3. The problem of what happens to the research findings, in addition to their presentation to hospital management, I think, should be integrated as rapidly as possible into engineering, nursing and administrative curricula at the local and national level. We attempt to do it through our courses in the Industrial Engineering Department. I think, however, that a good deal more work should be done on this.

4. The question of providing point versus functional solutions. The operations research models normally provide point solutions and I think what we need is function. This is what the administrator must have if he is to utilize his background experience in the solution of practical managerial problems. This is an acquirement imposed by the fact that no model can handle all the detail of the real world situations.

5. Definition of the administrator. I think that you are going to have to adopt a behavioral definition which is divorced from the administrator as a human being. Defined in terms of a behavioral vector, it is possible to do something research-wise, which becomes very sticky if we think of the administrator as a human. Ashby's <u>Introduction to Cybernetics</u> discusses this point.

Moving on to the specific areas, I would like to throw out the following:

1. <u>Non-economic factors and decisions</u>: I am still a little confused about what is being attempted here, and the use to which the item analysis will be put. It would seem to me that the first step would be to look for items, and that this could best be done by open ended interviews and an item analysis of the recordings. Weights could then be determined. If, then, a multiple regression analysis is intended, the question of predictor variable is raised. What is to be predicted? The cost of operating

a hospital? Probability of a decision as to usable or disposable supply, or what? In spite of the discussion this was not completely clear to me. Do you see as the ultimate outcome of this study: a prediction about operating cost based on usable versus disposable supplies? I think the outcome should be clarified before the item analysis is developed too far.

2. Advertising projects: It seems to me that the critical question here is how does advertising influence the purchasing decision. If this is so, then some data appear to be necessary on sales and purchases. Relationship between characteristics of the ad and its effectiveness would be useful.

3. Methods Engineering Studies: The fundamental difficulties of small volume output are present here, as well as the difficulties of standard data systems. We also run into the question of the relative cost of estimation and evaluation which Abruzzi talks about in his *Work, Workers, and Work Measurement*, and the cost of Type 1 and Type 2 errors. This is basically the cost of gathering evidence as against the cost of making mistakes. It also seems that some sort of variance estimates is necessary in addition to the length of time. Perhaps the end product might be the development of a procedure so that a hospital could make its own estimate, rather than standard estimates as presently envisioned. Included in this area is the work on pace. The work of Conrad at the Applied Psychology Unit, Cambridge University, Cambridge, England, might be of interest.

4. I am glad to see the increased emphasis on function, not "optimal" solutions in this area and I feel that this is on the right track. This allows the decision maker to develop solutions using his own changing value systems. I would disagree with Joe, that the value system of the decision maker is constant. Some references which you are probably familiar with, but which might help are *Naval Logistics Quarterly*, and the work of Bill Marlow on the ONR Logistics Project at George Washington University in Washington. Bill Morris's recent book on *Engineering Economy*, and the work on Value Theory of Nicolas Smith at ORO.

I hope these brief comments will be of some assistance to you.

B-158 & B-178

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PROGRESS REPORT

(January 1, 1959 - December 31, 1960)

By

Harold E. Smalley, Ph.D.
Principal Investigator

January 1, 1961

"Disposable Versus Reprocessed Hospital Supplies"

USPHS GRANT #GN-5968

PROJECT BULLETIN NO. 9

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia

9

GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION
ATLANTA 13, GEORGIA

January 1, 1961

Department of Health, Education, and Welfare
Public Health Service
National Institutes of Health
Division of Research Grants
Bethseda 14, Maryland

Gentlemen:

Under this cover is a progress report on GN-5968, "Disposable Versus Reprocessed Hospital Supplies," for the period, January 1, 1959 through December 31, 1960. For the convenience of the sponsoring institution, this report is referred to as Project Bulletin No. 9.

This report has been prepared in accordance with the specifications contained in Part IV of your "Instructions for Preparing Research Grant Applications on Form PHS-398 (Revised December 1959)."

The reader will be best informed by reviewing pertinent sections of eight Project Bulletins previously submitted to the Division of Research Grants. References to these bulletins are given throughout the present report.

To facilitate ease in reading this report, numerous details contained in internal reports have been deleted. These reports are available upon request, as indicated in the footnotes.

I am happy to make this report and wish to reaffirm my sincere appreciation for your continuing confidence and support. We can all be proud of the ability and willingness of the American people to encourage and support quests for better utilization of the resources of nature for the benefit of mankind.

Respectfully submitted,

Harold E. Smalley
Principal Investigator

"Disposable Versus Reprocessed Hospital Supplies"

P R O G R E S S   R E P O R T

(January 1, 1959 - December 31, 1960)

By

Harold E. Smalley, Ph.D.

Project Bulletin No. 9

Engineering Experiment Station Project No. B-158 and B-178

This investigation is supported in part by a PHS research grant #GN-5968 from the Division of General Medical Sciences and the Division of Nursing Resources, Public Health Service; Harold E. Smalley, Ph.D., Principal Investigator.

January 1, 1961

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   GN-5968, "Disposable Versus Reprocessed Hospital Supplies."

2. Principal Investigator:

   Harold E. Smalley, P.E., Ph.D.
   Professor of Industrial Engineering
   Research Associate, Engg Exp. Sta.
   Georgia Institute of Technology

3. Sponsoring Institution:

   Georgia Institute of Technology
   (Engineering Experiment Station)

4. Period Covered by Report:

   January 1, 1959 through December 31, 1960

   (This is a complete report in the sense that it covers the first two years of the grant period. However, frequent references are made herein to eight Project Bulletins previously submitted to the Division of Research Grants.)

5. Date of Preparation of Report:

   January 1, 1961

II. Summary Statement

The specific aim of this project is to develop a practical decision system for determining the relative economic feasibility of disposable and reprocessed supply items for hospitals.

Progress with respect to the four major parts of the research approach outlined in Project Bulletin No. 1 may be reported as follows:

1. Most of the significant cost factors which influence rational decision making have been identified, isolated, and defined. Both monetary and non-monetary factors are being measured.

2. The relationship of cost factors to the two alternative forms of supply items has been ascertained by development of a cost structure for monetary factors. The significant non-monetary factors, including environmental and behavioral considerations, are being determined through the Human Factors study.

3. The determination of a hypothetical decision system is being pursued under the title, Decision System. As results from current studies become available, an attempt is being made to integrate findings. This will constitute a major portion of GN-5968(C2) in 1961.

4. The fourth major part of the research approach, "Test the hypothetical decision system. . . .", has not been attempted, but a limited amount of testing may be done in 1961.

III. Full Statement of Progress

1. List of Publications:

Davis, Edward W., Thomas L. Newberry, Jr., Joseph J. Moder, Jr., and Harold E. Smalley, "Forecasting the Demand for Hospital Supply Items," Project Bulletin No. 5, E.E.S., Georgia Institute of Technology, Atlanta, March 1960.

Davis, Edward W., "Forecasting the Demand for Hospital Supply Items," Georgia Institute of Technology, Atlanta, June 1960 (Master's thesis).

Emerzian, A. D. Joseph, "An Evaluation of the Relative Unit Value System for Pricing Pathology Tests," Operations Research Report No. 3, University of Connecticut, Storrs, March 23, 1959.*

Emerzian, A. D. Joseph, "Hospital Laundry Operating Models," Operations Research Report No. 4, University of Connecticut, Storrs, June 12, 1960.*

Emerzian, A. D. Joseph, "A Model for Predicting Transcription Service Requirements for Medical Records," Operations Research Report No. 5, University of Connecticut, Storrs, June 28, 1960.*

Emerzian, A. D. Joseph, "Housekeeping Labor Time Models for Medical and Surgical Nursing Centers," Operations Research Report No. 6, University of Connecticut, Storrs, July, 1960.*

Ore, Ike I. and Harold E. Smalley, "Bibliography," Project Bulletin No. 3, E.E.S., Georgia Institute of Technology, Atlanta, August, 1959.

Owen, Louelia, Thomas J. Hall, Tee H. Hiett, Jr., and Harold E. Smalley, "Bibliography, Comprehensive Through 1959," Project Bulletin No. 7, E.E.S., Georgia Institute of Technology, Atlanta, November, 1960.

Smalley, Harold E., "Tentative Plans for a Study of Hospital Cost Systems," Project Bulletin No. 1, E.E.S., Georgia Institute of Technology, Atlanta, January, 1959.

Smalley, Harold E., Richard A. Dudek, and Edward J. Gerner, Jr., "How Methods Engineering Gets Results," The Modern Hospital, May, 1959, pp. 93-96.*

Smalley, Harold E. (Editor), "Proceedings of National Advisory Committee Meeting," Project Bulletin No. 2, E.E.S., Georgia Institute of Technology, Atlanta, May 16, 1959.

Smalley, Harold E., "Industrial Engineering in Hospitals," The Journal of Industrial Engineering, May-June 1959, Vol. 4, No. 3, pp. 171-175.*

Smalley, Harold E., Richard A. Dudek, and Edward J. Gerner, Jr., "Practice is the Test of Methods Engineering," The Modern Hospital, September, 1959, pp. 79-81.*

Smalley, Harold E., "Organized Methods Improvement," The Yearbook of Modern Nursing, G. P. Putnam's Sons, New York, 1959, pp. 32-40.*

Smalley, Harold E., "Progress Report (January 1959-June 1960)," Project Bulletin No. 6, E.E.S., Georgia Institute of Technology, Atlanta, June, 1960.

Smalley, Harold E. (Editor), "Proceedings of National Advisory Committee Meeting," Project Bulletin No. 8, E.E.S., Georgia Institute of Technology, Atlanta, December, 1960.

Smalley, Harold E., "To Buy or Not to Buy?", The Research Engineer December, 1960, Vol. 15, No. 5, pp. 20-23.

Smalley, Harold E., "The Professional Administrator's Tools," The Profession of Hospital Administration, The Georgia Hospital Association, Atlanta, 1960, pp. 51-66.*

Talbird, Joseph B., Jr., Thomas L. Newberry, Jr., David C. Ekey, and Harold E. Smalley, "Development of an Inventory Model for Hospital Supplies," Project Bulletin No. 4, E.E.S., Georgia Institute of Technology, Atlanta, March, 1960.

Talbird, Joseph B., Jr., "Development of an Inventory Model for Hospital Supplies," Georgia Institute of Technology, Atlanta, June, 1960 (Master's thesis).

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* Ancillary to GN-5968.

2. Staffing: The following is a complete listing of staff, personnel, consultants and others who have been associated with GN-5968. The names of currently employed professional personnel are marked with a single asterisk. Biographical sketches for these people are shown in Appendix A. The names of those whose association with the project terminated prior to January 1, 1961 are followed by two asterisks.

Acuff, Robert L., Jr., B.I.E., student assistant.**

Davis, Edward W., M.S.I.E., graduate research assistant.**

*Doby, John T., Ph.D., special consultant; Director of Graduate Studies in Sociology, Emory University.

Dudek, Richard A., Ph.D., National Advisory Committee; Professor and Head of Industrial Engineering, Texas Technological College.

Duncan, Harold O., M.A., Local Steering Committee; Area Director, Administrative Services, Veterans Administration Area Medical Office.

Ekey, David C., Ph.D., thesis advisor; Professor of Industrial Engineering.**

*Emerzian, A. D. Joseph, Ph.D., special consultant; Professor of Industrial Administration, University of Connecticut.

Flagle, Charles, D. Eng., National Advisory Committee; Director, Operations Research, Johns Hopkins Hospital.

Floyd, Montyne, project secretary.**

Fort, Ada, R. N., Ed. D., Local Steering Committee; Dean, School of Nursing, Emory University.

Franklin, Edward C., B.S., special problem advisor; Associate Professor of Industrial Engineering.**

Freeman, John R., student assistant.

Gilbreth, Lillian M., Ph.D., National Advisory Committee; Management Consultant.

Graves, Helen G., R. N., M.A., consultant (nursing service) and Local Steering Committee; Director of the Division of Nursing Service, Emory University Hospital.

Groseclose, Frank F., P.E., M.S., Local Steering Committee; Director, School of Industrial Engineering.

*Hall, Thomas J., M.S.I.E., Research Assistant, Engineering Experiment Station.

Hammacher, Paul D., Jr., M.S.I.E., M.S.I.M., graduate research assistant.**

*Hendrix, Pamela M., R.N., B.S., nurse consultant; Administrative Supervisor, Division of Nursing, Emory University Hospital.

Hiett, Tee H., Jr., M.S., research associate; Assistant Professor of Industrial Engineering.**

Hogan, Glenn M., LL.B., Local Steering Committee; Executive Secretary, Georgia Hospital Association.

Hullerman, Hugo V., M.D., National Advisory Committee; Executive Vice-President, Children's Hospital of Michigan.

Humphrey, Burwell W., LL.B., Local Steering Committee; Administrator, Emory University Hospital.

Johnson, Cecil G., M.S., term project advisor; Assistant Professor of Industrial Engineering. **

Kilgore, Joe A., B.I.E., special problem assignment.**

King, Donald M., B.I.E., student assistant, graduate research assistant.**

Klein, Roger, M.B.A., Local Steering Committee; Director, Graduate Program in Hospital Administration, Emory University.**

Kuehn, Ruth P., R.N., Ph.D., National Advisory Committee; Dean, School of Nursing, University of Pittsburgh.

Loveland, Edward H., Ph.D., Local Steering Committee; Director, School of Applied Psychology.

McNulty, Matthew F., Jr., M.H.A., M.P.H., National Advisory Committee; Administrator, University Hospital and Hillman Clinic.

*Miller, Jerry L. L., Ph.D., consultant (interviewing); Instructor in Sociology, Emory University.

Moder, Joseph J., Jr., Ph.D., consultant (methodology) and Local Steering Committee; Professor of Industrial Engineering.**

*Newberry, Thomas L., Jr., P.E., M.S.I.E., Assistant Research Engineer, Engineering Experiment Station.

Ore, Ike I., B.I.E. (formerly Isaac Ifrach), student assistant, graduate research assistant.

*Owen, Louelia, R.N., M.S., special nurse consultant; Administrative Supervisor, Division of Nursing, Emory University Hospital; Associate Professor of Nursing, Emory University.

Phillips, Cecil R., Jr., M.S.I.E., graduate research assistant; Assistant Head, Publications, Engineering Experiment Station.**

Rowe, Evelyn P., R.N., M.N., consultant (nursing education); Coordinator of Nursing Fundamentals, Emory University.

Rush, Mary Kate, project secretary.

*Smalley, Harold E., P.E., Ph.D., principal investigator and project director; Professor of Industrial Engineering and Research Associate, E.E.S.

Standard, James W., student assistant.

Staton, Rocker T., D. Eng., Local Steering Committee; Assistant Dean, College of Engineering.

Talbird, Joseph B., Jr., M.S.I.E., graduate research assistant.**

Taylor, Dorothy, project secretary.**

Westermann, Ted D., B.A., B.D., graduate research assistant; graduate student in sociology at Emory University.

Williams, Mary M., R.N., Ph.D., consultant (nursing research); Director of Master of Nursing Program, Emory University.

*Woods, Howard W., Jr., B.I.E., Research Assistant, Engineering Experiment Station.

3. Foreign Travel: None

4. Specific Aims:

The specific aim of this project is to develop a practical decision system for determining the relative economic feasibility of disposable and reprocessed supply items for hospitals.

This study constitutes the first phase of a general study of decision making. Upon completion of the present study, the general study will be devoted to an investigation of extensions of the decision system to include application to other supply items, as well as other important hospital resources, such as materials, equipment, and labor.

The present study is part of an integrated program in the application of physical and social sciences to administrative problems in the health services industry. The purpose of this total effort is to assist hospital, medical, and nursing administration achieve high levels of patient care at relatively low costs in material and human resources.

5. Research Approach:

The four major parts of the research approach as outlined in Project Bulletin No. 1, pp. 2-5, are as follows:

(a) Determine the cost factors which govern the two types of supply items.

(b) Determine the relationship of cost factors to the two types of supply items.

(c) Determine a hypothetical decision system.

(d) Test the hypothetical decision system through evaluation and revise system as required.

6. Assumptions:

The following assumptions were made in the original research design and are reaffirmed now:

(a) An investigation of alternatives and their relation to hospital costs is best approached by an analysis of the <u>specific</u> as a means of promoting understanding of the <u>general</u>.

(b) Decisions should be based upon an objective comparison of alternatives.

(c) Cost factors exist and can be segregated, identified, and measured. Cost factors are considered to be those interacting elements of a total fiscal structure that contribute to bring about the outlay or expenditure of resources.

(d) There is a relation between cost factors and a measure upon which alternative decisions can be made.

The following additional assumptions have been made during the conduct of the research:

(e) Cost factors are of two types, <u>monetary</u> and <u>non-monetary</u>. Monetary costs equal the money value of the material resources consumed. Non-monetary costs relate to the consumption of human and aesthetic resources.

(f) Non-monetary cost factors have interacting <u>primary</u> and <u>secondary</u> effects upon achievement or accomplishment. The primary effects are changes in negative values, such as fear, anxiety, obnoxiousness, and frustration, and address themselves to the <u>ends</u> of happiness and satisfaction. The secondary effects are changes in monetary factors accruing from changes in non-monetary factors and address themselves to happiness and satisfaction as <u>means</u> to fiscal ends.

(g) A decision is rational when the ratio of "magnitude and quality of results" to "monetary and non-monetary costs" is greater under conditions of the course of action taken than that of the courses of action rejected.

(h) The specification of a value system for decision makers would require an understanding of the substantive nature and interactions of, and the assignment of relative weights of importance to, "magnitude of results," "quality of results," "monetary costs," and "non-monetary costs." This is beyond the scope of the present study.

(i) Unit costs may be determined logically by prorating total costs, joint costs, or imputed costs according to an a priori estimate of the contribution which each supply unit makes toward the appropriate gross cost.

(j) Theoretical or potential savings in cost, may be either positive or negative and are instantaneously realized. In the case of "labor," time saved is immediately devoted to other productive activities. (This assumption eliminates the need to deal with "phantom savings.")

7. Organization:

Upon notification of the GN-5968 grant award, specific steps were taken to implement the research plans. A major effort was directed toward the recruitment of staff and personnel and the establishment of a research organization.

Original plans were built upon the concept of a multi-disciplinary research team headed by a full time leader responsible to the principal investigator who was to devote twenty-five per cent time to the project. Attempts to obtain the services of a suitable team leader, a nurse, and other team members continued throughout 1959. The nurse member reported in September of 1959, but no other full time members were obtained until July of 1960. As a temporary arrangement, considerable use was made of graduate and student assistants and part of the time of certain faculty members.

When it became evident that the original staffing plan could not be put into effect soon enough to achieve project objectives within the grant period, a modified plan was adopted early in 1960. The principal investigator increased his time allocation to about fifty per cent and assumed the duties of team leader, several consultants were retained to conduct important parts of the research, and two full time engineers were recruited to replace faculty members and students. One engineer reported in July and the other in November of 1960. This modified plan is currently in effect.

Long range plans include a return to the original concept of a nucleus of full time professionals augmented by selected consultants and assisted by graduate assistants and non-professional personnel.

8. Project Resources:

The research is presently organized as a project (B-158 in 1959 and B-178 in 1960) of the Chemical Sciences Division, Engineering Experiment Station, Georgia Institute of Technology. The project functions in cooperation with the School of Industrial Engineering, the Emory University Medical Center, cooperating hospitals in the Atlanta area, the Georgia Hospital Association, and certain other groups of health-oriented people.

The research is being done by a team composed of the principal investigator, a project staff, and a select group of active consultants. Assisting the research team are student assistants, clerical workers, and a project secretary. Some use has been made of graduate students in the School of Nursing at Emory University.

Participating intermittently are other consultants, faculty members of Georgia Tech and Emory, and representatives of appropriate societies and associations. Certain phases of the project have been tied in with work of the Committee on Methods Improvement of the American Hospital Association. Manufacturers and distributors of hospital supply items have extended willingness to cooperate in the study, but this resource has not been used to any significant extent.

The Local Steering Committee, representing cooperating institutions, meets occasionally to review progress and to assist in carrying out experiments and surveys. Disciplines represented by this committee are hospital administration, industrial engineering, law, nursing, psychology, and public administration.

An indispensable resource for the project are the cooperating hospitals. Crawford Long, Emory, Georgia Baptist, Grady, Piedmont, St. Joseph's, and

V.A. in Atlanta and University Hospital and Hillman Clinic in Birmingham have cooperated fully by serving as sample hospitals--laboratories and sources of information.

The National Advisory Committee consists of recognized authorities and meets annually to evaluate the research and to offer counsel on future studies and programs. Members of this committee come from several parts of the country and represent hospital administration, industrial engineering, management, medicine, nursing, operations research, public health, and systems research.

Frequent contacts are made with other investigators engaged in similar research and with the rapidly increasing number of industrial engineers and methods practitioners in American hospitals throughout the country.

Situated in Atlanta, the Project has been able to benefit from excellent transportation and supply facilities. This geographical location will be of even more advantage as the research moves into closer cooperation with manufacturers and distributors of supply items and into regional and national field testing.

This location also offers distinct advantages by virtue of the excellent educational and research facilities found in the City. Of particular value to the Project are the services of Georgia Tech's School of Industrial Engineering, Photographic Laboratory, Price Gilbert Library, Rich Electronic Computer Center, Technical Information Section, and the Georgia Tech Research Institute; also the faculties, libraries, and services of the Emory University Medical Center.

Unstinting support has been received from the School of Industrial Engineering, the Engineering Experiment Station, and the Georgia Tech administration. A project office was provided by the School until July 1, 1960 when a suite of seven offices was assigned to the Project by the Georgia Tech administration. Branch offices have been provided by the School of Nursing and Emory University Hospital for use by staff and consultants on the Emory campus.

For more information, see Project Bulletin No. 8, pp. 7-10, 14.

9. Division of Responsibility:

In consideration of the magnitude and complexity of the research problem being pursued, the total study has been divided into several projects. An attempt has been made to define projects such that each is a homogeneous entity requiring limited domains of skill and knowledge and such that results from each will lead sequentially into other studies pointing toward the ultimate objective of the total study. Relative competence and interest have been the chief criteria for assigning available personnel to the various projects of GN-5968. While this division of responsibility is in effect at the present time, it took approximately eighteen months to learn enough about the research problem and about research team management to structure assignments in a meaningful way.

In addition to the projects of limited scope requiring rather routine approaches, it has been necessary to deal with issues and problems requiring deeper understandings, broader perspectives, and keener insights. At times, it has been necessary to work at, near or beyond the boundaries of existing knowledge and theory. Fortunately, individuals with the requisite abilities have been available for specific assignment to a technical problem or for assuming responsibility for a broad area involving more than one scholarly discipline.

10. Project Assignments:

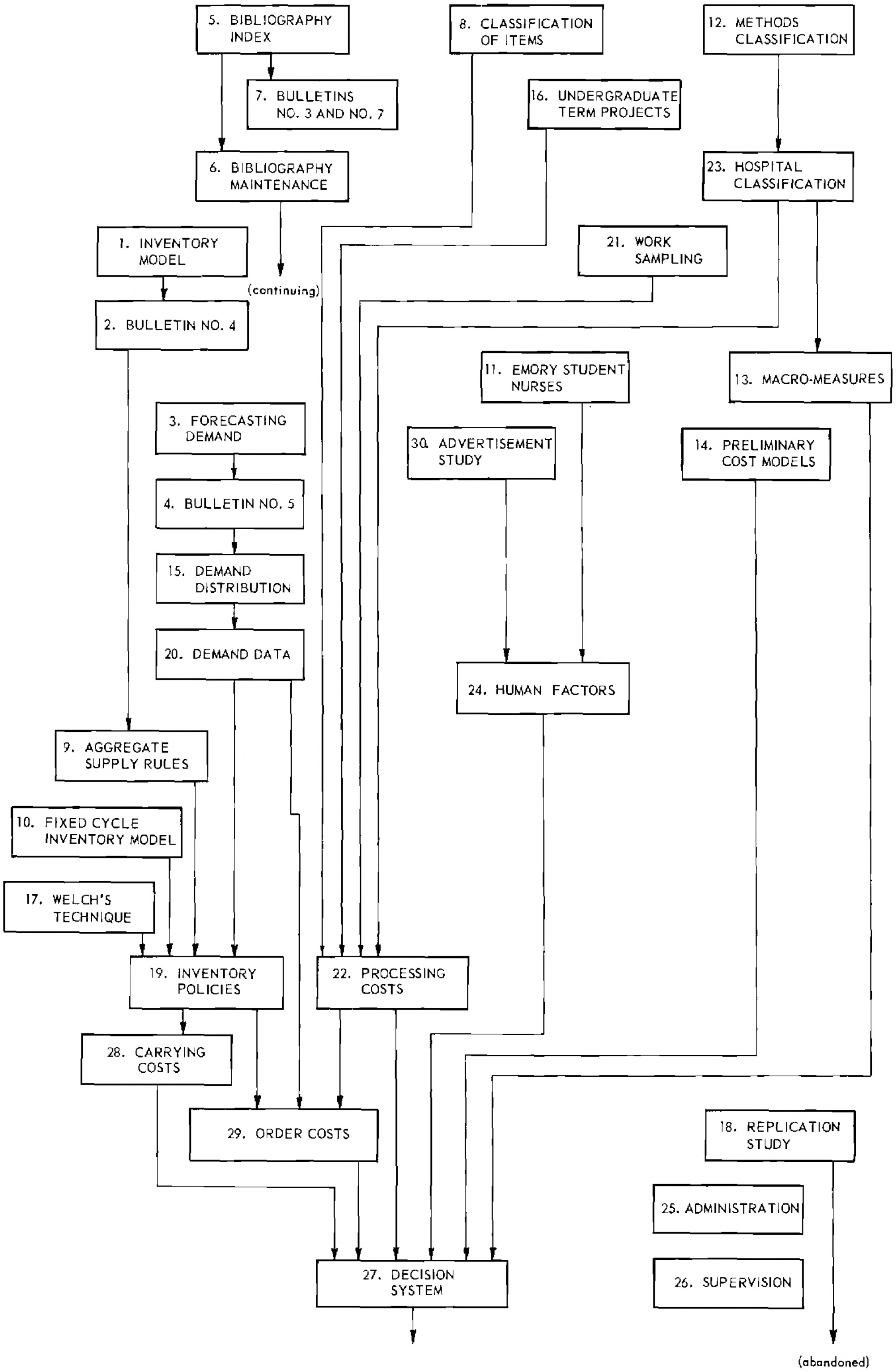
During the early months of the grant period with so many matters requiring exploration, studies were authorized largely on the basis of expressed interest by the few people affiliated with GN-5968 at that time. Nevertheless, most of the early projects have proved to be useful. Some have been continued, some have led to other projects, some have been incorporated in larger projects, and one project was abandoned. The inter-relationships of projects is shown in the Schematic Diagram on the next page.

Since this investigation was initiated January 1, 1959, thirty projects have been authorized, each under the supervision of a project leader. Project leaders are responsible to the Project Director (principal investigator) and are customarily assigned part of the time of other personnel as collaborators, consultants, or assistants. Included in the authorization for a project are approved estimates of needs which will encumber the GN-5968 budget. Time allocations to current projects are made four times a year for all personnel, i.e., at the beginning of each academic quarter.

Before a new project is authorized, the proposal is discussed by the staff and with appropriate consultants. Weekly oral progress reports, staff discussions, and a final written report are required for each project. These final reports are evaluated by staff and consultants.

During the summer of 1960, considerable progress was made in consolidating projects and planning new projects for approaching the research objective. As of December 31, 1960, studies under five major headings were in progress.

(Schematic Diagram of Projects)



11. Current Projects:

The five major headings of seven currently active projects are as follows:

(a) Bibliography -
Project 6, Bibliography Maintenance

(b) Inventory Costs -
Project 19, Inventory Policies
Project 28, Carrying Costs
Project 29, Order Costs

(c) Processing Costs -
Project 22, Processing Costs

(d) Non-Monetary Costs -
Project 24, Human Factors

(e) Decision System -
Project 27, Decision System

The bibliography project is a continuing effort to compile and maintain a listing of appropriate references relating to hospital methods improvement, with emphasis upon patient-care supply decisions.

Inventory costs relate to the need for ordering, receiving, storing, holding, issuing, and handling supply items; to the necessity of investing in supply stocks and facilities; to the execution of inventory policies; and to the risks of encountering shortages.

Processing costs relate to the operations of pick-up, cleaning, assembly, sterilization, storage, distribution, make-ready and put-away at the point of use, and dispose-of supply items.

Non-monetary costs relate to certain human behavioral factors and environmental influences having effects upon decision making. (See "Assumptions" on pages 9 and 10.)

The study, "Decision System," is an attempt to integrate and consolidate findings from all projects so as to achieve the research objective.

A listing of all thirty projects is shown below, and summary reports on the seven active projects are given on the pages to follow. Summary reports on the remaining projects are given in Appendix B. For more information, see Project Bulletin No. 8, pp. 10-13.

(Listing of Projects)

Project Number	Title of Project	Status	Completion Date
1.	Inventory Model	Completed	
2.	Bulletin No. 4	Published	
3.	Forecasting Demand	Completed	
4.	Bulletin No. 5	Published	
5.	Bibliography Index	Completed	
6.	Bibliography Maintenance	*In Progress	12-31-61
7.	Bulletins No. 3 and No. 7	Published	
8.	Classification of Items	Completed	
9.	Aggregate Supply Rules	See Project 19	
10.	Fixed Cycle Inventory Model	See Project 19	
11.	Emory Student Nurses	See Project 24	
12.	Methods Classification	Completed	
13.	Macro-Measures	See Project 27	
14.	Preliminary Cost Models	Completed	
15.	Demand Distribution	See Project 19	
16.	Undergraduate Term Projects	See Project 22	
17.	Welch's Technique	Completed	
18.	Replication Study	Abandoned	
19.	Inventory Policies	*In Progress	7-1-61
20.	Demand Data	See Project 19	
21.	Work Sampling	See Project 22	
22.	Processing Costs	*In Progress	5-1-61
23.	Hospital Classification	Completed	
24.	Human Factors	*In Progress	7-1-61
25.	Administration	(accounting convenience)	
26.	Supervision	(accounting convenience)	
27.	Decision System	*In Progress	9-1-61
28.	Carrying Costs	*In Progress	5-1-61
29.	Order Costs	*In Progress	4-1-61
30.	Advertisement Study	Completed	

*Progress reports are given on the pages to follow.

(Project 6, BIBLIOGRAPHY MAINTENANCE)

This portion of GN-5968 has been pursued principally by Miss Owen, Mr. Hall, Mr. Hiett, and Mr. Ore.

Objective. The objectives of this project are: (1) to compile, classify, and annotate publications pertinent to the research, (2) to maintain the bibliography index for use by the research team, and (3) to make these materials available for distribution to interested parties upon request.

Procedure. A systematic search of pertinent literature was undertaken to obtain references not covered by previous listings. In addition, references compiled and published in Project Bulletin No. 3 were included. References from hospital, nursing, and engineering journals, hospital and nursing abstracts, theses, and related material were obtained. To facilitate the location of reference material, the McBee Keysort system was utilized. There are approximately one thousand index cards in the bibliography file. The bibliography index is maintained in the Project Office at Georgia Institute of Technology.

The bibliography index was classified as follows:

I. Disposable and Reprocessed Hospital Supplies
Sub-classified by supply item

II. Industrial Engineering Applications
Sub-classified by I.E. technique
Cross-classified by hospital department

III. In-Service Methods Improvement
Sub-classified by hospital department

IV. Hospital and Medical Administration

Results: Project Bulletins No. 3 and No. 7.

Status. The plan for maintaining the index includes a supplemental bulletin at the end of each successive year for the duration of GN-5968. A project bulletin covering additions for 1960 and omissions in years prior to 1960 will be published early in 1961. Problems associated with continuing this project beyond 1961 are discussed on pp. 24-27 of Project Bulletin No. 8.

For more information, see Project Bulletin No. 3, Project Bulletin No. 7, and pp. 17-24 of Project Bulletin No. 8.

(Project 19, Inventory Policies)

This portion of GN-5968 is being conducted principally by Mr. Newberry.

Objective. The objective of this study is to determine under what conditions certain standard inventory policies should be used in hospitals, under various objective criteria.

Procedure. Describe the inventory policies in effect in the sample hospitals by interview and observation. Determine the extent of conformity of each existing hospital policy to certain standard policies, such as:

(1) Fixed cycle

(2) (s, S)

(3) Fixed quantity

Specify means of optimizing various objective criteria which conform to the value system of the hospital decision maker.

Status. Interviews and observations have been completed in four sample hospitals. The three policies cited above appear to be characteristic generally of the inventory policies in use in sample hospitals.

This study is presently under way and is scheduled for completion July 1, 1961. For more information, see pp. 96-98, 114-118 of Project Bulletin No. 8.

(Project 28, CARRYING COSTS)

This portion of GN-5968 is being conducted principally by Mr. Newberry.

Objective. The objective of this project is to develop a procedure for determining and predicting the investment costs associated with "carrying" supply items.

Procedure. Isolate the components of the carrying costs, determine methods for measurement, and develop an estimating procedure.

Status. Carrying costs may be determined in two ways: (1) through a measurement process and (2) by imputing cost values from the inventory objectives as specified by the decision maker. The components of the cost of inventory investment are:

(a) The lost interest on the money value of stored items

(b) The foregone opportunity cost; i.e., the difference between the cost of capital (a. above) and the return realizable on alternative investments

(c) Obsolescence, deterioration, and spoilage

(d) Taxes and insurance

(e) Cost of storage facilities (including depreciation)

(f) Handling within the storage facilities

(g) Physical inventorying

(h) Clerical costs

This study is presently being conducted with an effort to become better acquainted with the relationship of the above components and the philosophy of the hospital decision maker toward costs. The results are due May 1, 1961.

For more information, see pp. 98-114 of Project Bulletin No. 8.

(Project 29, ORDER COSTS)

This portion of GN-5968 is the outgrowth of Project 19 relating to inventory policies. The early part of the project was headed by Mr. Hiett. On November 1, 1960, the project was taken over by Mr. Woods, who is assisted by Mr. Standard and Mr. Freeman.

Objective. The objective of this project is to develop a procedure for determining and predicting the costs involved in ordering supply items.

Procedure.

(1) Define the scope and content of the ordering function in terms of operations and work elements.

(2) Identify the operations which create the difference in order cost between disposable and reprocessed forms of items.

(3) Measure the work content of elements of all operations.

(4) Develop a standard procedure for determining and predicting a hospital's order costs.

Conventional industrial engineering techniques are being utilized.

Status. The scope of the ordering function in each sample hospital has been defined through the use of flow process charts developed from direct observation of the currently used methods of ordering. From this information, it was decided that a standard data procedure would be developed.

Operations within the ordering function have been defined. Methods of data collection have been established and the collection of data initiated. At present, the data collection is approximately 50 per cent complete. A tentative proposal for a standard data evaluation system has been prepared.* The project is scheduled for completion on April 1, 1961.

For more information, see Project Bulletin No. 8, pp. 118-125.

*Available upon request.

(Project 22, PROCESSING COSTS)

This portion of GN-5968 is the culmination of several smaller projects engaged in by a number of students and several staff members and assistants. (See Schematic Diagram on page 16 of this report.) In the early stages of this project, most of the data gathering was done by Mr. King under the supervision of Mr. Hiett. Since its consolidation in July 1960, the project has been headed by Mr. Hall, with assistance from Mr. Woods and Mr. Freeman.

Objective. The objective of this project is to develop a procedure for determining and predicting the costs involved in processing supply items.

Procedure.

(1) Determine and quantify the cost factors involved in processing.

(2) Identify the work elements which create the difference in processing cost between disposable and reprocessed forms of items.

(3) Measure the work content of all elements of all operations.

(4) Develop a standard procedure for determining and predicting a hospital's processing costs.

Status. Conventional industrial engineering techniques are being utilized with emphasis upon work measurement. Direct observation of actual processing operations at the seven cooperating hospitals are being made. A proposal for a standard data procedure has been prepared.* This will permit a hospital to determine its direct labor costs for processing.

Functional boundaries of processing have been defined and the contributing cost factors identified, e.g., direct labor, capital equipment, materials, associated supplies, etc. Data collection is approximately 75 per cent complete for gloves, syringes, and needles. Summarization and integration of the data are approximately one-half completed.

A procedure for determining and predicting demand rates for supply items has been developed.*

For more information, see Project Bulletin No. 8, pp. 63-91.

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*Available upon request.

(Project 24, HUMAN FACTORS)

This portion of GN-5968 was designed by Dr. Doby, Dr. Emerzian, and Dr. Smalley and is being pursued principally by Dr. Miller and Miss Owen. Mr. Hall, Miss Hendrix, and Mr. Westermann are assisting with interviews. Dr. Doby has general direction of the project.

Objective. The objectives of this study are:

(1) to identify the preference system which affects supply decisions of members of different organizational components, and

(2) to determine the relative weight which each organizational component assigns to each factor.

This research postulates that the basis for supply decisions in a preference system of "administrators" and "users" and that the preference systems are principally determined by the position and role which the chooser occupies within the hospital system.* Assuming constancy of position, the preference system is assumed to be stable although the intensity of any of its factor components may change with new acquired knowledge or technological innovation. This study does not involve an evaluation of the rationality or validity of the preference factors.

The general argument assumes that: (1) the preference for a supply item is primarily determined by the perceived differential consequences to self and to others of the adoption of the item relative to other alternatives; (2) these consequences are weighted according to the role of the person expressing the preference; (3) accordingly, a person's preference will change as his role changes; (4) the assumption of similar preference of different people through time assumes constancy and equivalency of role; and (5) for a given item, the relative influence of a preference upon a supply decision is a function of organizational position.

Procedure. An interview instrument was designed, pre-tested, and revised for use in gathering data for this study.** Interviews were conducted in five sample hospitals for members of the general administration, purchasing agent, director of nursing, head nurses, supervisors of central supply, operating room and obstetrics, medical administrators, and a random sample of staff nurses and residents.

Status. Interviews are expected to be completed during January of 1961. Results are being coded for punched cards and will be treated mathematically and statistically.

This study is scheduled for completion on July 1, 1961. For more information, see Project Bulletin No. 8, pp. 29-52, 93-94.

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*An "administrator," as used in this study, is any person within the hospital organization who exercises a significant influence in decision making with respect to choices between supply alternatives. "Users" are those people who order, receive, handle, process, use, and discard supply items. Combination "administrator-users" are anticipated. See Project Bulletin No. 8, p. 16.

**Available upon request.

(Project 27, DECISION SYSTEM)

This portion of GN-5968 is being pursued, in a sense, by all staff members, though the major responsibility is assigned to Dr. Emerzian and Dr. Smalley.

Objective. The objective of this study is to devise ways and means of integrating the several projects of GN-5968 into a decision system. In the final analysis, this study attempts to satisfy the total research aim.

Procedure

(1) "Brainstorming"
(2) Deliberation
(3) Discussions
(4) Consultation
(5) Adaptations of approaches and techniques of industrial engineering and operations research
(6) Adaptations of approaches and techniques of other disciplines
(7) Initiative and ingenuity
(8) Possibly more research

Status. During the preparation of the original research proposal and throughout the first two years of GN-5968, the project staff has considered numerous aspects of this problem. Some promising approaches are related in the following sources:

Project Bulletin No. 1, pp. 1-5
Project Bulletin No. 2, pp. 7-8, 11, 13-17, 19-20, 22-24, 24-30, 36-37, 41-42, 43-44, 45-46, 49-50, 52-53, 58, 67-68.
Project Bulletin No. 3, p. 10.
Project Bulletin No. 4, pp. xii-xiii, 1-7, 10, 35, 79-80.
Project Bulletin No. 5, pp. v-vi, 1-4, 9, 15, 28-29, 30-31.
Project Bulletin No. 6, pp. 1-2, 7-8.
Project Bulletin No. 7, pp. 5-6, 11-14, 15.
Project Bulletin No. 8, pp. 93, 131-144, 145-153, 155-158.
Macro-Measures, Project 13, Appendix B.
Preliminary Cost Models, Project 14, Appendix B.

This study is scheduled for completion on September 1, 1961.

12. Present Status:

As was indicated previously, there are seven currently active projects under five headings. Scheduled completion dates have been established for each of these projects as shown on the Schedule Chart (next page).

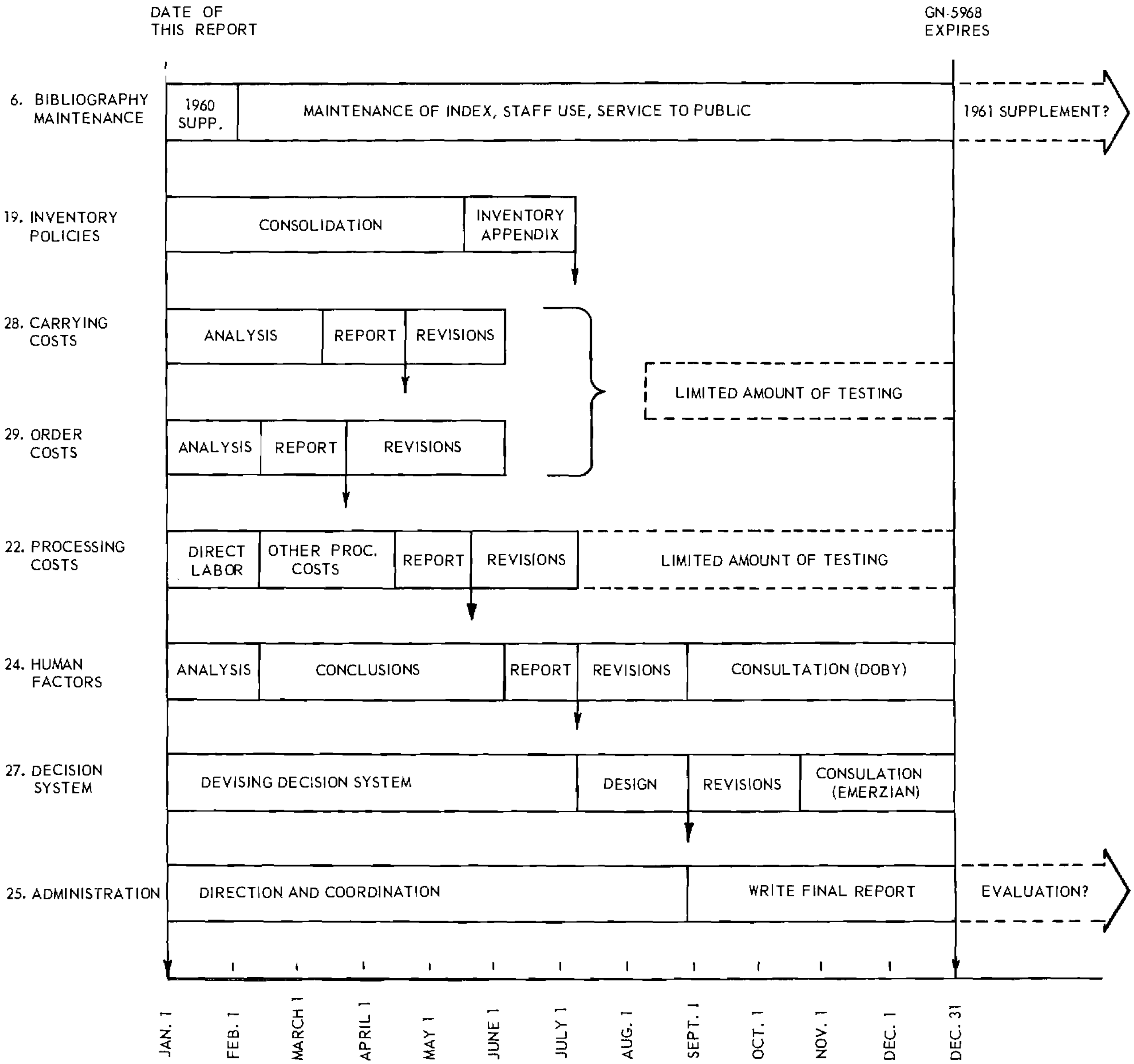
Most of the significant cost factors which influence rational decision making have been identified, isolated, and defined. Both monetary and non-monetary factors are being measured.

The relationship of cost factors to the two alternative forms of supply items has been ascertained by development of a cost structure for monetary factors. The significant non-monetary factors, including environmental and behavioral considerations, are being determined through the Human Factors study.

The determination of a hypothetical decision system is being pursued under the heading, Decision System. As results from current projects become available, an attempt is being made to integrate findings.

Two publications have come from the Bibliography Project, a partial listing in August 1959 and a comprehensive listing through 1959. Currently, preparations are being made to publish a 1960 supplement.

(Schedule Chart)



13. Plans for 1961

The Schedule Chart on the preceding page indicates, in graphical form, projected plans for GN-5968(C2) during 1961.

Project 6 - A bibliography supplement will be published early in the year. The index will be maintained for staff use, and requests for bibliographic information from the scientific public will be served throughout the year. Plans for maintaining the bibliography beyond December 31, 1961 must await action on a pending Renewal Application to the Division of Research Grants.

Projects 19, 28, 29 - Relevant findings from the Inventory Policies Project will be fed into other inventory studies; the remaining materials and conclusions will be included in an Inventory Appendix for the final report. Findings from the projects on Carrying Costs and Order Costs will be incorporated in the project on Decision System. A limited amount of testing of inventory cost models may be attempted.

Project 22 - A standard data system for establishing direct labor times for all processing operations on gloves, needles, and syringes will be completed about February 1, 1961. This will be followed by the determination of direct labor rates and other processing costs, e.g., equipment amortization, materials, and associated supplies. Findings will be incorporated in the project on Decision System. A limited amount of testing of the standard data models may be attempted.

Project 24 - All interviews should be completed during January of 1961. The analysis of results is scheduled for completion on March 1st, and conclusions will be drawn during the spring of 1961. Findings will be incorporated in the project on Decision System.

Project 27 - Attempts to devise a practical decision system will continue for the first six months of 1961, during which time findings from other studies will be incorporated and integrated. The final design will be done during the summer months.

Project 25 - This category includes both administrative duties (planning, staffing, reporting) and research duties (directing and coordinating investigations). The final report for GN-5968 will be written during the fall for submission to the Division of Research Grants early in 1962.

A major problem during 1961 will result from the uncertainties of continuing support for the hospital research program at Georgia Tech. It may be quite difficult to hold key staff members and consultants unless commitments to them can be made early in 1961. For a better insight into this problem, which appears to be commonplace among research groups, please refer to a discussion by members of the National Advisory Committee on pages 24 to 27 of Project Bulletin No. 8.

The fourth major part of the research approach, "Test the hypothetical decision system ....", has not been attempted, but a limited amount of evaluation planning and pre-tests are scheduled for late 1961.

Given reasonable success in carrying out projected plans for 1961 and favorable action on a pending Renewal Application, the research team will be ready to embark upon a continuation of GN-5968 starting January 1, 1962.

A P P E N D I X   A

Currently Employed Professional Personnel

Name: HAROLD E. SMALLEY (principal investigator and project director)

Titles: Professor of Industrial Engineering and Research Associate, E.E.S., Georgia Institute of Technology.

Periods of Employment: January 1, 1959 - December 31, 1960
(committed to December 31, 1961)

Per Cent of Time: 25% during academic year; 100% during summer.

Biographical Sketch:

Born April 9, 1921 near Birmingham, Alabama
American male
Registered Professional Engineer
B.S.I.E., (with honors), University of Alabama (industrial engineering) 1946
M.S.I.E, Purdue University, (industrial engineering) 1947
Ph.D., University of Pittsburgh, (industrial economics) 1957
Formerly: Industrial Engineer at Stockham Valves and Fittings, Inc. (1941-43), Ground School Instructor in U.S. Naval Reserve (1943-44), Graduate Research Assistant at Purdue University (1946-47), Assistant Professor of Industrial Engineering at University of Alabama, (1947-50), Associate Professor of Industrial Administration at University of Connecticut (1950-55), Research Associate in School of Nursing, University of Pittsburgh (1955), Assistant to Vice Chancellor, Health Professions, University of Pittsburgh (1955-58), present position since 1958.
Fields of Major Interest: industrial engineering in hospitals, operations research, methods and standards, interdisciplinary research.
Supplemental Information: Did doctoral dissertation on work simplification in hospitals; has served as consultant to business, industry, labor unions, hospitals, retail stores, and government agencies; member of the A.H.A. Committee on Methods Improvement since 1955; served as principal investigator for USPHS research grant GN-4792 (1956-58); and has served on Industry's Advisory Board for Hospitals.

Name: JOHN T. DOBY (special consultant)

Titles: Director of Graduate Studies in Sociology and Acting Chairman of the Department, Emory University.

Periods of Employment: January 1, 1960 - December 31, 1960
(committed to December 31, 1961)

Per Cent of Time: 10%

Biographical Sketch:

Born May 29, 1920 in Gray, Kentucky
American male
M.S., University of Wisconsin (social psychology) 1950
Ph.D., University of Wisconsin (social psychology) 1956
Formerly: Associate Professor of Statistics and Sociology at Wofford College (1950-58); Associate Professor of Statistics and Social Psychology, Graduate School, Emory University (1958-60).
Fields of Major Interest: social psychology (learning theory, behavior, small group interactions) and methodology (parametric and non-parametric variance models, qualitative and quantitative correlation models).
Supplemental Information: Co-author and editor of text, "Methods of Research in Social Behavior," Stackpole Co., 1954.

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Name: A. D. JOSEPH EMERZIAN (special consultant)

Titles: Professor of Industrial Administration and Supervisor of Motion and Time Study Laboratory, University of Connecticut.

Periods of Employment: January 1, 1959 - December 31, 1960
(committed to December 31, 1961)

Per Cent of Time: 5% during academic year; 75% during summer.

Biographical Sketch:

Born August 10, 1921 in Meriden, Connecticut
American male
B.S. (Magna cum laude), Bridgewater College (economics) 1942
M.B.A., Wharton School of Finance, University of Pennsylvania (industrial administration) 1947
Ph.D., Graduate School of Business, New York University (industrial administration) 1955
Formerly: Industrial Engineer for Connecticut Telephone and Electric Co. (1942-45), Cost Accountant for same company (1946), part time Chief Industrial Engineer, William Brand Co. (1954-60), faculty of University of Connecticut since 1948.
Fields of Major Interest: Administration, managerial economics, statistics.
Supplemental Information: Has served as arbitrator and management consultant, has done research in management and in hospitals, and has served as consultant to Manchester Memorial Hospital, Middlesex Memorial Hospital, Windham Community Memorial Hospital, and to PHS Project GN-4792 at the University of Pittsburgh.

Name: THOMAS J. HALL (Research Assistant)

Titles: Research Assistant, Engineering Experiment Station, Georgia Institute of Technology.

Periods of Employment: July 1, 1960 - December 31, 1960
(committed to December 31, 1961)

Per Cent of Time: 100%

Biographical Sketch:

Born September 14, 1931 in Atlanta, Georgia
American male
B.I.E., Georgia Institute of Technology (industrial engineering) 1959
M.S.I.E., Georgia Institute of Technology (industrial engineering) 1961
(enrolled in Ph.D. program at Georgia Institute of Technology)
Formerly: Various assignments including U.S. Air Force (1949-55), Methods Engineer, Brookley AFB, Mobile, Alabama (1958-59).
Fields of Major Interest: human engineering, aero-space technology.

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Name: PAMELA M. HENDRIX (nurse consultant)

Titles: Administrative Supervisor, Division of Nursing, Emory University Hospital.

Periods of Employment: November 1, 1960 - December 31, 1960
(committed to December 31, 1961)

Per Cent of Time: 10% (to be increased in 1961)

Biographical Sketch:

Born May 15, 1930 in Atlanta, Georgia
American female
Registered Nurse
B.S., Emory University (nursing) 1951
Formerly: Staff Nurse and Head Nurse, medical and surgical units (1951-56); Head Nurse, Central Supply (1956-58); Chairman of Procedure Committee (1958-60); all at Emory University Hospital.
Fields of Major Interest: clinical nursing, facilities evaluation.
Supplemental Information: In work as supervisor, assisted with planning facilities for new service areas for nursing units.

Name: JERRY L. L. MILLER (consultant, interviewing)

Titles: Instructor in Sociology, Emory University.

Periods of Employment: September 1, 1960 - December 31, 1960
(committed to March 1, 1961)

Per Cent of Time: 20%

Biographical Sketch:

Born September 6, 1931 in Webster City, Iowa
American male
B.A., University of Oklahoma (sociology) 1953
M.A., University of Oklahoma (sociology) 1954
Ph.D., Florida State University (sociology) 1959
Formerly: Interviewer with Louis Harris and Associates (1958),
Supervisor of Interviewers with Center for Social Research (1958).
Fields of Major Interest: sociology of formal organizations,
sociology of education and adult socialization.
Supplemental Information: Participation on various levels of
planning and execution of several studies in the Center for
Social Research, F.S.U. (1959).

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Name: THOMAS L. NEWBERRY, JR. (Assistant Research Engineer)

Titles: Assistant Research Engineer, Engineering Experiment Station,
Georgia Institute of Technology.

Periods of Employment: July 1, 1959 - December 31, 1960
(committed to June 30, 1961)

Per Cent of Time: 50% to 6/30/60; 25% since 7/1/60.

Biographical Sketch:

Born January 23, 1933 in Glasgow Kentucky
American male
Registered Professional Engineer
B.I.E., Georgia Institute of Technology (industrial engineering) 1954
M.S.I.E., Georgia Institute of Technology (industrial engineering) 1958
(has been admitted to candidacy for Ph.D. at Georgia Institute of
Technology)
Formerly: Industrial Engineer for Phillips Petroleum Co. (1954)
Scheduling Officer in U. S. Air Force (1954-57), Instructor in
Industrial Engineering at Georgia Institute of Technology (1959-60).
Fields of Major Interest: industrial engineering, operations research,
electronic computer applications, inventory control theory.
Supplemental Information: Has served as consultant in business and in
hospitals, e.g., Emory University Hospital (1958-59).

Name: LOUELIA OWEN (special nurse consultant)

Titles: Administrative Supervisor, Division of Nursing, Emory University Hospital and Associate Professor of Nursing, Emory University.

Periods of Employment: September 1, 1959 - December 31, 1960.

Per Cent of Time: 100% to 8/31/60; 20% since 9/1/60.

Biographical Sketch:

Born March 14, 1909 in Athens, Texas
American Female
Registered Nurse
B.S., University of Indiana (nursing administration in School of Education) 1951
M.S., University of Minnesota (nursing administration) 1954
Formerly: Nursing Methods Analyst, U. S. Army Hospital, Tripler Army Hospital, Honolulu, Hawaii (1954-57), Dewitt Army Hospital, Ft. Belvoir, Virginia (1957-59).
Fields of Major Interest: Improvement in nursing service and improvement in techniques and methods used in taking care of patients.
Supplemental Information: 7-1/2 years as a teacher in public schools of Texas before becoming a nurse. One year's experience with National Youth Administration (health field).

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Name: HOWARD W. WOODS, JR. (Research Assistant)

Titles: Research Assistant, Engineering Experiment Station, Georgia Institute of Technology.

Periods of Employment: November 1, 1960 - December 31, 1960
(committed to December 31, 1961)

Per Cent of Time: 100%

Biographical Sketch:

Born August 17, 1932 in Dallas, Texas
American male
B.I.E., Georgia Institute of Technology (industrial engineering) 1955
Formerly: Part time Traffic Engineering Assistant for City of Atlanta (1950-54), Methods and Standards Engineer for E.I. duPont deNemours and Co., Inc. (1955-59), Methods and Standards Engineer for Lockheed Aircraft Corp. (1959 - 60).
Fields of Major Interest: systems analysis, cost control, methods improvement, human relations.

A P P E N D I X   B

Summary Reports of Inactive Projects

(Project 1, INVENTORY MODEL)

This portion of GN-5968 has been completed and is described in the summary report for Project 2 (below)

(Project 2, BULLETIN No. 4)

This portion of GN-5968 was conducted principally by Mr. Talbird with assistance by Mr. Newberry, Dr. Ekey, and Dr. Smalley. Mr. Newberry was the Project Leader.

Objective. The objective of this study was to provide decision rules for determining optimal reorder points for hospital supplies. This study was restricted to the class of inventory policies in which a fixed quantity of replenishment items are ordered whenever the quantity of items on hand decreases to or below reorder point. The time between successive replenishment orders being placed is not necessarily a constant.

Procedure.
(1) The analysis of one hospital supply item, rubber gloves, was selected as a typical supply item. The analysis of data included 170 weeks of data collected at Emory University Hospital. The data pertained to the period, January 2, 1956 to March 30, 1959. Various statistical tests were performed in an effort to fit a theoretical probability distribution to the demand data, considering gloves in size classifications.

(2) An alternative procedure was tested to determine if the proportion of each size of glove requested would vary significantly from week to week. A chi square contingency table test was used.

Results.
(1) An inventory model was developed which would enable a decision maker to select reorder points for an item when the demand and replinishment lead time for the item was from a Poisson distribution class.

(2) It was found that the demand data for the gloves when classified by size did not conform to any "simple" probability distribution.

(3) It was found that the proportion of each size glove demanded from week to week did not vary significantly.

(4) A set of reorder tables was developed for the special class of Poisson demand and replenishment lead time functions which would enable a decision maker to select a reorder point on the basis of a desired probability of shortage. These tables range in value from the mean value of demand per period from one to eleven units and the replenishment lead time varies from one period to seven periods.

Conclusions.
(1) Characteristics of the demand for supply items can be estimated which will enable a decision maker to better control his inventory.

(2) Reorder points can be established for hospital supply items by the statistical evaluation of demand and replenishment lead time distributions for any desired probability of a shortage.

This study resulted in Project Bulletin No. 4, dated March, 1960.

(Project 3, FORECASTING DEMAND)

This portion of GN-5968 has been completed and is described in the summary report for Project 4 (below).

(Project 4, BULLETIN No. 5)

This portion of GN-5968 was conducted principally by Mr. Davis with assistance by Mr. Newberry, Dr. Moder, and Dr. Smalley. Mr. Newberry was the Project Leader.

Objective. The objective of this study was to develop a practical forecast model for use by hospital administrators in estimating the future demand for a hospital supply item.

Procedure. Two general forecasting methods were attempted in forecasting the demand for rubber gloves. The data pertains to the period, January 21, 1957 to June 30, 1959. Data was collected at Emory University Hospital. Forecasting was first attempted by regression analysis using certain causal variables as dependent variables in the regression equation. These variables were hospital census, number of births, and total surgical operations.

The second general method for forecasting is known as "exponential smoothing." This method utilizes no causal variables, merely extrapolating on the basis of trends and history.

Results. Statistical data. (See Project Bulletin No. 5)

Conclusions. Rubber gloves at Emory University Hospital could not be forecast with a high degree of reliability. Of the two general methods utilized, the best predictions were obtained from exponential smoothing. This study resulted in Project Bulletin No. 5, dated March 1960.

(Project 5, BIBLIOGRAPHY INDEX)

This portion of GN-5968 has been completed and is described in the summary report for Project 6 (see page 19).

(Project 6, BIBLIOGRAPHY MAINTENANCE)

Summary report given on page 19 of this report.

(Project 7, BULLETINS No. 3 and No. 7)

This portion of GN-5968 is described in the summary report for Project 6 (see page 19). Both bulletins have been published.

(Project 8, CLASSIFICATION OF ITEMS)

This portion of GN-5968 was done principally by Mr. Phillips and Miss Owen.

Objective. The objectives of this study were (1) to determine which hospital supply items are generally available as disposable products, (2) to classify these items in some useful manner, (3) to determine in a qualitative manner which supply items deserve first consideration in GN-5968, and (4) to suggest which items or classes of items deserve eventual consideration.

Procedure. The approach was qualitative and utilized the stated opinions of experts in the hospital field, primarily personnel in hospitals who are responsible for the use, processing and purchasing of supplies. About 20 interviews were made with hospital personnel in the Atlanta area.

Results. The following definitions were stated as a result of this study:

Disposable Supply Item - Any item of supply that is customarily discarded after a single use.

Semi-Disposable Supply Item - An inexpensive item that is subject to disposal if it presents any individual reprocessing problem.

Reprocessable Supply Item - Any relatively expensive item of supply that is durable enough to permit repeated use following a series of processing steps.

Many disposable items are of no interest to GN-5968 because there is no corresponding reusable item for comparison. Typical prices for pertinent items were compiled.

Conclusions. It is suggested that a natural and useful way to classify hospital supplies is by the department responsible for their use and/or processing. Each department, or category, uses different criteria when selecting supplies. These various criteria may be used to identify the items of greatest importance to GN-5968. This reasoning, plus the results of interviews with hospital personnel, leads to the selection of central supply as the most important category, and needles, syringes, and gloves as the items deserving the greatest effort. Other departments and items were listed in approximate order of decreasing importance.

This study resulted in an internal report* which has served as a guide to other studies, particularly Project 22.

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*Available upon request.

(Project 9, AGGREGATE SUPPLY RULES)

This portion of GN-5968 was incorporated in Project 19 described on page 20 of this report.

(Project 10, FIXED CYCLE INVENTORY MODEL)

This portion of GN-5968 was done as an undergraduate special problem by Messrs. Acuff, Elderd, and MacGregor under the supervision of Mr. Newberry and Professor Hiett of the School of Industrial Engineering. GN-5968 cooperated in this study but did not support the work in any substantial way.

Objective. The objective of this study was to determine the results of various constants on a fixed cycle inventory model for data previously obtained on gloves, syringes, and needles at Emory University Hospital.

Procedure.

(1) Evaluate demand data for the three hospital supply items and determine the best theoretical distribution for each item. Consideration was given five distributions: Normal, Poisson, Gamma, Log Normal, and Erlang.

(2) Determine the lead time distributions in the same manner.

(3) Develop a Monte Carlo simulation technique for the inventory model. Program this model on the IBM 650 computer and, using the demand and lead time distributions, determine the results of varying different constants in this model to the two supply items, e.g., how often a shortage of the items will occur.

Status. This study was not completed, but tentative findings were reviewed by the project staff and referred for incorporation in Project 19.

(Project 11, EMORY STUDENT NURSES)

This portion of GN-5968 was done principally by Miss Owen and Dr. Doby.

Objective. The objectives of this project were (1) to establish and maintain liaison with the School of Nursing and with Emory University Hospital; (2) to cooperate in studies by graduate students in nursing and by staff nurses in the Hospital; and (3) to coordinate the use of School of Nursing faculty in the pursuit of GN-5968 objectives.

Procedure. Miss Owen was recruited and employed as a full time nurse member of the research team in close collaboration with the School of Nursing and the Hospital. Miss Owen was given a joint appointment as Research Assistant at Georgia Tech and Associate Professor of Nursing at Emory, though she worked virtually full time on the Project. Her assignments have included attendance at Emory faculty meetings, working with graduate students on required research problems, and acting as liaison person for cooperative projects with Emory.

Status.

(1) Relations with the School of Nursing and with Emory University Hospital have been and remain close and cordial. Miss Owen's status changed September 1, 1960 when she began to share her time between Georgia Tech and the Hospital while maintaining her faculty status in the School of Nursing.

(2) Several graduate student problems were explored with a view toward using results in GN-5968. Dr. Doby assisted in this phase. None of the problems materialized with respect to Project objectives and this phase was abandoned.

(3) Faculty interest in the School of Nursing for cooperative projects with GN-5968 has been expressed and faculty members are serving on the Local Steering Committee and acting as nurse consultants. Several studies have been done in the Hospital with helpful cooperation from the Division of Nursing. Some of Miss Hendrix's time has been made available for GN-5968 research, including some interviewing and some procedures and facilities surveys.

(4) Plans call for arrangements with the Dean of the School of Nursing for further uses of School resources in the Project.

All three objectives of this project (as stated above) should be continued and implemented.

(Project 12, METHODS CLASSIFICATION)

This portion of GN-5968 was done principally by Mr. Hammacher and Miss Owen. As Project 12 proceeded, sample hospitals in the Atlanta area were classified according to existing work methods. This subsequent classification of hospitals was done under Project 23 but is described here.

Objective. The objective of this study was to determine the type of basic functions that have to be performed on needles, gloves, and syringes in various hospitals.

Procedure. Develop definitions of basic types of functions for each item. Classify methods in the sample hospitals according to the derived definitions. Determine standard times for these functions. Derive cost equations.

Status. The following is a list of functions or activities that are performed in connection with reprocessing rubber gloves: Pick-up, Cleaning, Assembly, Sterilization, Storage, and Distribution.

Definition sheets were developed; these describe the types of functions and who performs them.* This classification scheme of "methods levels" for the various "functions" (operations) was applied to all sample hospitals, and a summary of findings was made.* Upon completion of this work, results were referred for incorporation in Project 22.

(Project 13, MACRO-MEASURES)

This portion of GN-5968 was done principally by Mr. Hammacher.

Objective. The objective of this study was to establish empirical relationships between time, cost, and other factors versus readily available hospital data.

Procedure. "Brainstorming."

Status. This study never emerged from the "brainstorming" stage, but it did generate many potentially useful ideas. Results of this study were discussed by the project staff and were referred for incorporation in Project 27.

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*Available upon request.

(Project 14, PRELIMINARY COST MODELS)

This portion of GN-5968 was done principally by Mr. Phillips.

Objective. The objective of this study was to consider various methods of determining total costs associated with hospital supplies, with a view toward proposing the type of model that will provide the most suitable comparisons of disposable and reusable supplies.

Procedure. Deliberation, discussion, consultation.

Status. Ideas flowing from this project include:

(1) Any serious effort to quantify intangible factors in this supply problem may prove to be unprofitable.

(2) The total cost is simply the sum of all the elemental costs. But it is clear that major difficulties will arise in practice. Hospital administrators cannot be expected to make time studies, for example. We must present the cost information to the administrator in a simple format, such as a set of curves or tables. But any such format will necessarily introduce some loss of accuracy and limitations on applicability.

(3) A method of presentation that seems most likely to be useful is indicated on the Cost Catalog.* The columns correspond to the functional classification scheme of Projects 12 and 23. The rows represent the items by type and use rate. (See Project 8.) The individual cells would contain standard costs. The total unit cost for any item would then be the sum of all the appropriate standard costs plus the unit cost of the item.

(4) Another format possibly of value is illustrated on the Cost Curves.* Such curves may be drawn if it is found that costs are generally dependent upon the use rate.

(5) It is recommended that no further effort be expended in the study of costs models until more information is obtained.

This study resulted in an internal report.* Results have been referred for incorporation in Project 27.

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*Available upon request.

(Project 15, DEMAND DISTRIBUTION)

This portion of GN-5968 was incorporated into Project 20.

(Project 16, UNDERGRADUATE TERM PROJECTS)

This portion of GN-5968 was done during several academic quarters of 1959 and 1960 by undergraduate students in the School of Industrial Engineering under the direction of Professors Hiett and Johnson. GN-5968 cooperated in the term projects but did not support the work in any substantial way.

Objective. The objective of these term projects was to generate methods descriptions (including motion pictures)* and work measurements of processing operations in several sample hospitals.

Procedure. Conventional industrial engineering approaches with emphasis on motion and time study.

Results. Several term project reports.*

Status. Term project reports were referred to staff members for incorporation into other phases of GN-5968, particularly Project 22.

*Available upon request.

(Project 17, WELCH'S TECHNIQUE)

This portion of GN-5968 was done as an undergraduate special problem by Mr. Kilgore under the supervision of Professor Franklin of the School of Industrial Engineering. GN-5968 cooperated in this study but did not support the work in any substantial way.

Objective. The objective of this study was to apply Welch's technique of inventory control to a hospital supply problem.

Procedure. The procedure consisted of sampling a category of supplies at Emory University Hospital and applying the techniques of "Tested Scientific Inventory Control" as described in detail by W. Evert Welch.

A random sample of 200 medical supply items was taken from a category of 1100 items. Fifteen of the 200 items were found inactive and were eliminated. The analysis was based on the remaining 185 items.

Results. A "Distribution By Value" analysis tended to conform to Pareto's Law and showed that:

(1) 61% of the dollar investment was included in 10% of the items.

(2) 34.5% of the investment was included in 35% of the items, and

(3) 4.5% of the investment was included in 55% of the items.

"K" factors were computed to calculate the reduction in average inventory investment that would result if the same number of purchase orders were placed in the future as in the past and the number of orders placed per year for each item were optimal rather than arbitrary, or established by "rule of thumb."

Conclusions. The calculated reduction resulting from this analysis would allow cutting in half the present average inventory carried. Also, holding the average inventory constant in the future would allow cutting in half the load on purchasing personnel, i.e., reducing orders placed per year by about 50%.

To complete this study, an "efficient surface" should be plotted from the data collected to give hospital management a guide for establishment of future inventory policy.

Status. A report* of this study was reviewed by the project staff and referred for incorporation in Project 19.

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*Available upon request.

(Project 18, REPLICATION STUDY)

The original plan was to have Dr. Emerzian repeat experiments and, in some cases, carry out concurrent, duplicated studies at the University of Connecticut and at Manchester Memorial Hospital. These were to be replications of Projects 12 and 23. Due to the pressure of other duties in Connecticut and unforeseen delays in the Atlanta studies, this study was abandoned.

(Project 19, INVENTORY POLICIES)

Summary report given on page 20 of this report.

(Project 20, DEMAND DATA)

This portion of GN-5968 was conducted principally by Mr. Standard. Mr. Newberry was the Project Leader.

Objective. The objective of this study was (1) to determine the nature of the demand for hospital supply items at Grady Memorial Hospital and (2) to determine the life (i.e., number of uses per item) of certain hospital supply items.

Procedure. The daily demand for the items was summarized from a collection of the actual requisitions for the supply items. The data collected covered the period, January 1, 1960 through May 31, 1960. The items studied were: tubercular syringes, insulin syringes, 2 cc syringes, 5 cc syringes, 10 cc syringes, 20 cc syringes, 30 cc syringes, 50 cc syringes, gloves, needles (20 gauge and over), needles (19 gauge and under), Baxter blood administration sets.

Results. The average life of each of the above listed items was determined. The analysis of the demand data has not been completed.

Conclusions. The life of hospital supply items can be obtained from (1) the knowledge of the total number of uses of the item during an extended period and (2) the number of the items introduced into the system properly adjusted for a change in beginning and ending inventory.

Status. The study resulted in an interim report dated July 8, 1960,* which was referred to Project 19.

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*Available upon request.

(Project 21, WORK SAMPLING)

This portion of GN-5968 was conducted principally by Miss Owen, Mr. Moore (I.E. student assistant), Mr. Hall, and Mr. Newberry, the latter serving as Project Leader.

Objective. The objective of this study was to obtain time values for processing hospital supply items.

Procedure. A work sampling study extended over the time period, May 17, 1960 through July 2, 1960, at Emory University Hospital. The main observation categories were cleaning, assembly, sterilizing, and storage. The items which were sampled were rectal gloves; surgical gloves; 2 cc, 5 cc, 10 cc, 20 cc, and 50 cc syringes; aesepto syringes; special syringes of all sizes; catheters; and tubing.

Results. Time values were obtained as a result of this study for the items studied under the classifications listed above. This study resulted in the development of charts and tables.*

Status. It was concluded that further studies of this type would be postponed. Results were referred to Project 22.

(Project 22, PROCESSING COSTS)

Summary report given on page 23 of this report.

(Project 23, HOSPITAL CLASSIFICATION)

This portion of GN-5968 has been completed and is described in the summary report for Project 12.

(Project 24, HUMAN FACTORS)

Summary report given on page 24 of this report.

(Project 25, ADMINISTRATION)

This "project number" is being used as an internal accounting convenience in allocating staff and personnel time devoted to administrative matters, staff meetings, and bona fide research activities not associated with any one on-going project.

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*Available upon request.

(Project 26, SUPERVISION)

This "project number" is being used as an internal accounting convenience in allocating staff and personnel time devoted to activities associated with supervising non-professional personnel and general office management for GN-5968.

(Project 27, DECISION SYSTEM)

Summary report given on page 25 of this report.

(Project 28, CARRYING COSTS)

Summary report given on page 21 of this report.

(Project 29, ORDER COSTS)

Summary report given on page 22 of this report.

(Project 30, ADVERTISEMENT STUDY)

This portion of GN-5968 was done principally by Miss Owen.

Objective. The objectives of this study were (1) to determine which attributes of hospital supply items are emphasized in advertisements, and (2) to determine what differences, if any, there are in appeals to readers of such advertisements.

An assumption here is that advertising in professional magazines contain verifiable statements to an informed audience, and hence, are true statements. This study had as its purpose the gaining of some insights for subsequent use in the "Human Factors" project.

Procedure. Six hospital journals, four medical journals, two nursing journals, and one dietetic journal were selected and surveyed for advertisements on hospital supply items. Worksheets were used to record the company, by code number, followed by five columns in which were written the name, date of issue, page size, advertisement size and number of colors. Seven attribute columns were added: Cost, Comfort, Safety, Ease of Use, Saves Time, Easy Disposal, and Acceptance (D) (N) (P). The letters in parenthesis following Acceptance indicated whether it was accepted by doctors, nurses, patients, or all three.

Results. Specific results from this survey are contained in an internal report.* Findings from this survey were of most value to the sociological-psychological consultants on the project team by pointing up the relative weights hospital people assign to uses of disposable items where vested interest categories control purchasing.

For more information, see Project Bulletin No. 8, pp. 58-64.

*Available upon request.

B I B L I O G R A P H Y

1960 Supplement

Pamela M. Hendrix, R.N., B.S.
Ike I. Ore, M.S.I.E.
Louelia Owen, R.N., M.S.
Harold E. Smalley, Ph.D.

March, 1961

"Disposable Versus Reprocessed Hospital Supplies"

USPHS GRANT #GN-5968

REVIEW
PATENT 4-7 19 61 BY
FORMAT ✓ 19 BY

Project Bulletin No. 10

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia

1D

"Disposable Versus Reprocessed Hospital Supplies"

BIBLIOGRAPHY

1960 Supplement

By

Pamela M. Hendrix, R.N., B.S.
Ike I. Ore, M.S.I.E.
Louelia Owen, R.N., M.S.
Harold E. Smalley, Ph.D.

Project Bulletin No. 10

Engineering Experiment Station Project No. B-203

This investigation is supported in part by a PHS research grant #GN-5968 from the Division of General Medical Sciences and the Division of Nursing Resources, Public Health Service; Harold E. Smalley, Ph.D., Principal Investigator.

March, 1961

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PROJECT BULLETINS PUBLISHED

Bulletin Number	Description	Number of Pages
* 1.	"Tentative Plans for a Study of Hospital Cost Systems," published January, 1959. Edited by Harold E. Smalley, Principal Investigator.	7
* 2.	"Proceedings of National Advisory Committee Meeting," published May, 1959. Edited by Harold E. Smalley, Principal Investigator.	69
* 3.	"Bibliography," published August, 1959. Compiled by Ike I. Ore, Graduate Research Assistant; edited by Harold E. Smalley, Principal Investigator.	10
4.	"Development of an Inventory Model for Hospital Supplies," published March, 1960. By Joseph B. Talbird, Jr.	85
5.	"Forecasting the Demand for Hospital Supply Items," published March, 1960. By Edward W. Davis.	61
* 6.	"Progress Report (January 1959 - June 1960)," published June, 1960. By Harold E. Smalley, Principal Investigator.	8
7.	"Bibliography, Comprehensive Through 1959," published November, 1960. By Louelia Owen, Thomas J. Hall, Tee H. Hiett, Jr., and Harold E. Smalley.	56
8.	"Proceedings of National Advisory Committee Meeting, October 31 and November 1, 1960," published December, 1960. Edited by Harold E. Smalley, Principal Investigator.	158
9.	"Progress Report (January 1, 1959 - December 31, 1960)," published January, 1961. By Harold E. Smalley, Principal Investigator.	48

* Limited Supply. Available only for emergency requirements, on loan basis, or by special order for reprinting.

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OBJECTIVES

This Bibliography Supplement is made available as a continuing resource of references pertaining to disposable and reprocessed hospital supply items and applications of industrial engineering in hospitals. The present report, Project Bulletin No. 10, comes from one of several concurrent projects supported by USPHS Grant #GN-5968.

The objectives of this portion of the total study are: (1) to compile, classify, and annotate publications pertinent to the research, (2) to maintain the bibliography index for use by the research team, and (3) to make these materials available for distribution to interested parties upon request.

A comprehensive bibliography was published as Project Bulletin No. 7 in November, 1960; this covered references through 1959. Project Bulletin No. 10 contains pertinent references for the calendar year 1960 and also additions and corrections for the years prior to 1960. Thus, Bulletins 7 and 10 represent a comprehensive listing through 1960.

The specific aim of the total study, of which this bibliography project is a part, is "to develop a practical decision system for determining the relative economic feasibility of disposable and reprocessed supply items for hospitals."

PROCEDURE

A systematic search of pertinent literature was undertaken to obtain 1960 references of interest to the research team. References from hospital, nursing, and engineering journals, hospital and nursing abstracts, theses, and related material were compiled, annotated, and inserted into the bibliography index. The classification scheme described in Project Bulletin No. 7 was maintained for 1960 additions.

The 1960 listing is shown under four major classifications as follows:

I. Disposable and Reprocessed Hospital Supplies
Sub-classified by supply item

II. Industrial Engineering Applications
Sub-classified by I. E. technique

III. In-Service Methods Improvement
Sub-classified by hospital department

IV. Hospital and Medical Administration

Immediately following the 1960 supplement are two sections intended to add to and correct Bulletin No. 7. The first of these sections contains additions to be made to the listings in Bulletin No. 7 and the second section contains references which should be deleted from Bulletin No. 7. These two sections will add previously omitted materials and will correct certain mis-classifications in Bulletin No. 7.

It is suggested that the reader refer to the table of contents on page iv for a specific listing of the materials contained herein.

1960 SUPPLEMENT

Classification I; Disposable and Reprocessed Hospital Supplies

References in this classification relate to the use of disposable hospital supply items, the use of reprocessed items for which comparable disposable items are feasible, and comparisons between disposable and reprocessed items.

The classification contains an itemized sub-division of references relating to specific supply items. Two additional sub-classes list general and unclassified references to literature regarding hospital supplies.

1. General

This section contains references on the use of disposable and reprocessed items in general, without specific reference to any one supply item.

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Marshall, Kenneth, "Single-Use Packaging," Hospital Management, July, 1960, Vol. 90, No. 1, p. 39.

Owen, Louelia, Thomas J. Hall, Tee H. Hiett, Jr., and Harold E. Smalley, "Bibliography, Comprehensive Through 1959," Project Bulletin No. 7, USPHS #GN-5968, Engineering Experiment Station, Georgia Institute of Technology, Atlanta, November, 1960, 56 pp.

Scates, Robert F., "Hospital Disposable Items: Some Pros and Cons," Southern Hospitals, February, 1960, Vol. 28, No. 2, pp. 30-34, 36.

Smalley, Harold E., "Proceedings of National Advisory Committee Meeting," Project Bulletin No. 8, USPHS #GN-5968, Engineering Experiment Station, Georgia Institute of Technology, Atlanta, December, 1960, 158 pp.

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Stickney, David W., "Better Cost Studies," Hospital Management, March, 1960, Vol. 89, No. 3, pp. 64-66, 119.

The Modern Hospital, "Disposables Change Hospital's Buying Habits," December, 1960, Vol. 95, No. 6, pp. 100, 142.

Title, Monroe M., "Disposables up to Date," Hospitals, December 16, 1960, Vol. 34, No. 24, pp. 73, 76, 78.

2. Unclassified

This section contains references relating to specific supply items not otherwise classified.

Hagerman, Jack R., "Disposable Medicine Droppers Save More Than They Cost, Children's Hospital Finds," The Modern Hospital, December, 1960, Vol. 95, No. 6, p. 106.

Southern Hospitals, "Plastic Oxygen Masks," June, 1960, Vol. 28, No. 6, p. 73.

Zahodiakin, Reba, "Disposable Dusters Wipe off Infection," The Modern Hospital, April, 1960, Vol. 94, No. 4, p. 184.

3. Syringes and Needles

Findley, Julia M., "Disposable Syringes and Needles," Hospital Management, July, 1960, Vol. 90, No. 1, p. 93.

Hospital Topics, "Buyers Guide: Syringe," March, 1960, Vol. 38, No. 3, p. 119.

Melland, Harriett, "Use of Disposable Syringes," Hospital Management, December, 1960, Vol. 90, No. 6, p. 94.

Preston, John P., "Should the Purchasing Agent be a Part of Administration?" Hospital Topics, August, 1960, Vol. 38, No. 8, pp. 26-27.

4. Enemas

No Additions

5. Containers

Ginsberg, Frances, "Plastic Bags are Modern Way to Transport O.R. Specimens," The Modern Hospital, September, 1960, Vol. 95, No. 3, p. 133.

Hospital Topics, "Buyer's Guide: Insert Bag," March, 1960, Vol. 38, No. 3, p. 119.

Hospitals, "Disposable Urinalysis System," December 16, 1960, Vol. 34, No. 24, p. 90.

6. Wearing Apparel

No Additions

7. Packs and Wraps

Southern Hospitals, "News of Supplier Products: Sterile Wrap Rolls," December, 1960, Vol. 28, No. 12, p. 69.

8. Food Service Items

Bussart, Joan P., "Paper Products in the Dietary Department," Southern Hospitals, January, 1960, Vol. 28, No. 1, pp. 49, 51, 52.

9. Sheets and Drapings

Hospital Topics, "Buyer's Guide: Utility Protector," March, 1960, Vol. 38, No. 3, p. 121.

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Grant, E. Dean and Ruth Scofield, "Preassembled Perineal Kits," Hospitals, June 1, 1960, Vol. 34, No. 11, pp. 48-49.

11. Gloves

Davis, Edward W., "Forecasting the Demand for Hospital Supply Items," Georgia Institute of Technology, Atlanta, June, 1960 (Master's Thesis).

Davis, Edward W., Thomas L. Newberry, Jr., Joseph J. Moder, Jr., and Harold E. Smalley, "Forecasting the Demand for Hospital Supply Items," Project Bulletin No. 5, USPHS #GN-5968, Engineering Experiment Station, Georgia Institute of Technology, Atlanta, March, 1960, 61 pp.

Manderson, Rufus W., "Disposable and Reusable Gloves: A Cost Comparison," Hospitals, August 16, 1960, Vol. 34, No. 16, pp. 65-68.

Talbird, Joseph B., Jr., "Development of an Inventory Model for Hospital Supplies," Georgia Institute of Technology, Atlanta, June, 1960 (Master's Thesis).

Talbird, Joseph B., Jr., Thomas L. Newberry, Jr., David C. Ekey, and Harold E. Smalley, "Development of an Inventory Model for Hospital Supplies," Project Bulletin No. 4, USPHS #GN-5968, Engineering Experiment Station, Georgia Institute of Technology, Atlanta, March, 1960, 85 pp.

Classification II: Industrial Engineering Applications

References in this classification deal with illustrations of the specific application of industrial engineering principles and techniques to the solution of hospital problems. Specifically excluded from this classification are examples of methods improvements directly related to the use of disposable or reprocessed hospital supply items (see Classification I), as well as examples of methods improvement not utilizing industrial engineering techniques (see Classification III).

Classification II is sub-divided according to the specific industrial engineering principle or technique employed in the improvement. In order to gain comprehensiveness, certain management functions not normally considered an integral part of industrial engineering *per se* are shown as sub-divisions.

1. General

This section contains references pertaining to the application of industrial engineering and management principles and practices in the health field generally, without specific reference to a particular tool or technique.

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Hofmann, R. E., "Efficient Methods for Central Service Procedures," *Hospital Management*, May, 1960, Vol. 89, No. 5, pp. 107, 110.

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McKenna, J. V., "The Standardization of Surgical Services," The Journal of Industrial Engineering, January-February, 1960, Vol. 11, No. 1, p. 3.

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Schlotfeldt, Rozella M., "Reflections on Nursing Research," The American Journal of Nursing, April, 1960, Vol. 60, No. 4, pp. 492-494.

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Smith, George A., "All Electric Hospital," Hospitals, November 16, 1960, Vol. 34, No. 22, p. 51.

Witmer, Melvin R., "Industrial Engineering and Mathematics at the Department Head Level," The Journal of Industrial Engineering, March-April, 1960, Vol. 11, No. 2, p. 111.

2. Unclassified

This section contains examples of specific industrial engineering applications not otherwise classified.

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Blumberg, Mark S., "Hospital Automation--Needs and Prospects." (An address delivered to the annual meeting of the California Hospital Association, Santa Barbara, California, October, 1960.)

Safren, Miriam Aronstein and Alphonse Chapanis, "A Critical Incident Study of Hospital Medication Errors," Part I, Hospitals, May 1, 1960, Vol. 34, No. 9, pp. 32-34, 57, 62-66.

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Wren, William J., "Preventive Maintenance for Your Air-Conditioning," Hospital Topics, December, 1960, pp. 43-46, 60.

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Riddle, Dallas E., "Charting a Course for the Business Functions," Hospitals, July 1, 1960, Vol. 34, No. 13, pp. 54-56.

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Blumenkranz, Joseph, "Architectural Planning for Control of Nosocomial Infections," Hospital Management, June, 1960, Vol. 89, No. 6, pp. 49-51.

Johnson, Dorothy E., "New System is Fast and Efficient," Hospital Management, January, 1960, Vol. 89, No. 1, pp. 48-51.

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No Additions

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The Modern Hospital, "Three Ways to Plan for Progressive Care," December, 1960, Vol. 95, No. 6, pp. 82-85.

8. Materials Handling

No Additions

9. Motion Economy and Methods

Harpur, Ernest, "New System to Simplify All Lab Reports," Hospital Management, June, 1960, Vol. 89, No. 6, pp. 28-29.

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Wear, Millard L., "Part-Time Industrial Engineer is a Full-Scale Success," Hospitals, June 16, 1960, Vol. 34, No. 12, pp. 48-50, 114-115.

Womer, Charles B., "Methods Improvement," Hospitals, April 16, 1960, Vol. 34, No. 8, pp. 106, 108-109.

10. Personnel

Frey, Mary, "A Look at Job Descriptions," The American Journal of Nursing, December, 1960, Vol. 60, No. 12, pp. 1782-1783.

Gordon, Phoebe, "Evaluation: A Tool in Nursing Service," The American Journal of Nursing, March, 1960, Vol. 60, No. 3, pp. 364-366.

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Jaye, David R., Jr., "Personnel Policies Fit Into Five Forms," The Modern Hospital, November, 1960, Vol. 95, No. 5, pp. 92-94.

Jensen, Alfred C., "Determining Critical Requirements for Nurses," Nursing Research, Winter, 1960, Vol. 9, No. 1, pp. 8-11.

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Moses, Evelyn B., "The Profile of a Professional Nurse," The American Journal of Nursing, March, 1960, Vol. 60, No. 3, pp. 368-370.

Robinson, Edward P., "Determining Nursing Staffing Patterns for an Intensive Care Unit," Part I, Hospital Topics, October, 1960, Vol. 38, No. 10, p. 45.

Robinson, Edward P., "Determining Staffing Patterns for an Intensive Care Unit," Part II - The Work-Study Sample, Hospital Topics, November, 1960, Vol. 38, No. 11, pp. 30-34.

11. Production Control

Hospitals, "Editorial Notes - Research: Spur to Progress," July 16, 1960, Vol. 34, No. 14, p. 41.

Safford, Beverly J. and Rozella M. Schlotfeldt, "Nursing Service Staffing and Quality of Nursing Care," Nursing Research, Summer, 1960, Vol. 9, No. 3, pp. 149-154.

Thompson, John B., Oscar Wade Avant, and Ellawyne D. Spiker, "How Queuing Theory Works for the Hospital," The Modern Hospital, March, 1960, Vol. 94, No. 3, pp. 75-78.

Williams, Mary Edna, "The Patient Profile," Nursing Research, Summer, 1960, Vol. 9, No. 3, p. 122.

12. Purchasing

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Wheeler, D. L., "Purchasing Procedures and Inventory Control," Hospital Management, May, 1960, Vol. 89, No. 5, pp. 127-128.

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No Additions

14. Statistics

No Additions

15. Wage Administration

No Additions

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Emerzian, A. D. Joseph, "Hospital Laundry Operating Models," Operations Research Report No. 4, University of Connecticut, Storrs, June 12, 1960.

Emerzian, A. D. Joseph, "Housekeeping Labor Time Models for Medical and Surgical Nursing Centers," Operations Research Report No. 6, University of Connecticut, Storrs, June 28, 1960.

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17. Work Sampling

No Additions

18. Work Simplification

Hankins, John W., "Work Simplification Applied to Hospitals," Hospital Progress, March, 1960, Vol. 41, No. 3, pp. 133-134, 136, 138, 140.

Jordan, L. R. and Robert G. Hoffmann, "Machines Make Light Work of Medical Data," The Modern Hospital, December, 1960, Vol. 95, No. 6, pp. 67-71.

Stanley, Claude B., "Longhand Messages," Hospital Management, June, 1960, Vol. 89, No. 6, pp. 68, 70.

Classification III; In-Service Methods Improvement

References in this classification deal with examples of methods improvements in specific hospital situations using the in-service, or "do-it-yourself," approach. Specifically excluded are examples of improvements based upon industrial engineering approaches (see Classification II), as well as examples of methods improvements directly related to the use of disposable or reprocessed hospital supply items (see Classification I). Classification III is sub-divided into sixteen sections according to the hospital department, division, or area in which the improvement was made.

1. General

This section contains references relating to in-service methods improvements generally without specific reference to any department, division, or area of the hospital.

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2. Unclassified

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Preference Factors
And
Supply Decisions In Hospitals

By

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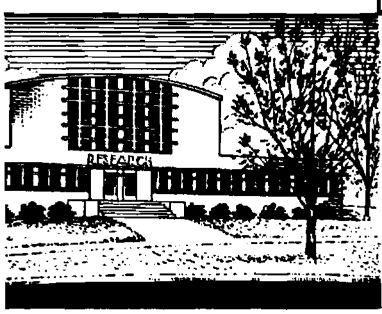

Engineering Experiment Station

Georgia Institute of Technology

Atlanta, Georgia

11

PREFERENCE FACTORS AND SUPPLY DECISIONS IN HOSPITALS

By

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Bulletin Number	Description	Number of Pages
* 1.	"Tentative Plans for a Study of Hospital Cost Systems," published January, 1959. By Harold E. Smalley.	7
* 2.	"Proceedings of National Advisory Committee Meeting," published May, 1959. Edited by Harold E. Smalley.	69
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4.	"Development of an Inventory Model for Hospital Supplies," published March, 1960. By Joseph B. Talbird, Jr.	85
5.	"Forecasting the Demand for Hospital Supply Items," published March, 1960. By Edward W. Davis.	61
* 6.	"Progress Report (January 1959 - June 1960)," published June, 1960. By Harold E. Smalley.	8
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PREFACE

The original aim of Project GN-5968 was to develop a practical decision system for determining the relative economic feasibility of disposable and reusable supply items for hospitals. In the course of the research, the original aim was broadened to include the development of a theory for hospital decision behavior involving a choice from among measured alternatives. Another revision was to limit the application of the study to the two alternative forms of those supply items used in direct patient care.

The major emphasis during the early phases of the Project was upon economic factors in the decision-making process. Recognizing that a decision theory must describe, and perhaps explain, the value systems of decision-makers, the research group faced the necessity of dealing with all significant factors, economic and non-economic, involved in supply decisions. This led to a study of the role of preference factors and their effects upon the decision system. The report to follow describes research efforts to gain an understanding of the preference systems that are related to hospital supply decisions.

TABLE OF CONTENTS

LIST OF TABLES

PREFERENCE FACTORS AND SUPPLY DECISIONS IN HOSPITALS

INTRODUCTION

The purpose of this study is to gain an understanding of the preference systems[1] that are related to hospital supply decisions. In developing a decision model for alternative forms of supply items,[2] it is necessary to know what preference factors enter into the decision process. It sometimes is assumed that supply decisions are based primarily on rationally conceived cost factors. If this assumption is true, the development of a decision model for supply items can be restricted to monetary considerations. If, however, non-monetary considerations are significant in supply decisions, the identification and treatment of non-monetary factors will become necessary. The need to ascertain the role of non-monetary (or human) factors in hospital supply decisions motivates this research.

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[1] Preference system--a set of ordered goals and related value-attitudes used as the basis for a determination of the relative desirability or worth of a proposed course of action. Factor--a component of the preference system referring to a specific goal or value-attitude. In this study such factors as patient safety, cost, and patient comfort constitute components of the preference system.

[2] This study is concerned with two alternative forms of supply items, disposable and reusable. The disposable form is discarded after a single use, whereas the reusable form is retained for repeated use. The term, item-form, is used herein to denote either the disposable or reusable alternative of a given product.

Organizational Components

Since this study is concerned with hospitals, it is necessary to identify and classify components normally found in this kind of complex organization. For purposes of this study, the following operational definition is used:

> Organizational Component--a group of persons with similar professional or technical orientation whose responsibilities require involvement with hospital supply items.

The nature of the involvement mentioned in this definition is the basis for the following classification of organizational components:

Component Code	Organizational Component
1.00	Administrators--persons who by virtue of position or office exercise authority in the determination of choice or supply items and who are not principally users or consumers of the supply items. Administrators may be classified as follows:
1.10	Business Administrators
1.11	Hospital Administrators
1.12	Assistant Administrators
1.13	Purchasing Officers
1.20	Medical Administrators*
1.21	Chiefs of Surgery
1.22	Chiefs of Medicine
1.23	Chiefs of Other Services
1.30	Nursing Administrators
1.31	Directors of Nursing
1.32	Administrative Nurses
2.00	Administrator-Users--persons who by virtue of position or office exercise authority in the determination of choice of supply items and also make applications of supply items in direct patient care. Administrator-users may be classified as follows:
2.10	Central Supply Supervisors
2.20	Operating Room Supervisors
2.30	Obstetrical Supervisors
2.40	Nursing Supervisors
2.50	Head Nurses
2.60	*Medical Administrators (principally gloves)
3.00	Users--doctors or nurses who by virtue of position make applications of supply items in direct patient care and have no formal authority in the determination of choice of supply items. Users may be classified as follows:
3.10	Staff Nurses
3.20	Residents

Objectives

The objectives of this study are:

(1) To identify the preference factors and to describe the preference systems of hospital organizational components;

(2) To determine the relative weight which organizational components place upon the factors in their preference systems; and

(3) To ascertain the effects of the preference systems of organizational components upon supply decisions.

Assumptions

The following assumptions are made concerning the nature of decision-making and of complex organization:

(A) The basis for supply decisions is a preference system consisting of factors which are perceptual and cognitive;

(B) The preference system of an individual functions to connect past experience in a situation with perceived present and future demands of a similar situation;

(C) Experience within a complex organization is conditioned by the role of the individual in the organization and will change as his role changes;

(D) This role experience modifies preference through the perception of consequences upon factors in the preference system; and

(E) Similar weights of a given preference factor by members of an organizational component for different supply items and for different forms of the same item indicate that their use has the same perceived consequences upon the factor involved.

Dissimilar rankings imply differentially perceived consequences upon the factor involved. It follows that the preference of one form of a supply item over the other form of the same item occurs only if a significant effect upon the preference factors is perceived.

Hypotheses

The following hypotheses are tested in this study:

I. Hospital supply decisions are based on the user's judgment of the differential value of the two alternative forms of supply items as reflected by the user's preference system;

II. The members of a given organizational component apply the same factors as a basis for choice and assign similar weights to these factors; and

III. Factors vary in their capacity to predict choice of item-form among organizational components.

METHOD

A questionnaire (see Appendix A) was designed on an *a priori* basis to obtain data to test the three hypotheses. This questionnaire was pre-tested and was revised on the basis of pre-test experiences. The major revision made was the insertion of a set of open-end questions to serve as a reliability check against the forced-choice questions originally included.

Participation was solicited from six hospitals; four of these agreed, one partially cooperated, and one refused. From the participating hospitals, lists were secured of administrative personnel, doctors, and nurses. A stratified sample in each hospital was drawn, randomly where applicable. The sampling proportions were governed by two considerations; first, they had to be large enough to include a sufficient number of respondents; and second, they had to be small enough to keep the total sample to a manageable size. The strata and sampling proportions of the total sample of 140 subjects are shown in Table I.

Interviews were conducted with 123 individuals on the sample lists. The sampling plan was followed except in two situations. In the first case, a high rate of turnover among staff nurses necessitated drawing alternates for those who had left the employ of the hospital. In the second case, permission to interview the residents in one hospital could not be obtained, and they were eliminated. There were no refusals, but some difficulty occurred in locating various individuals.

Responses were recorded on the questionnaire and subsequently were coded for machine tabulation.

TABLE I
STRATA AND SAMPLING PROPORTIONS

STRATA	COMPOSITION	SAMPLING PROPORTION	SAMPLE SIZE
Hospital Administration	Hospital Administrators	100%	5
	Assistant Administrators	20%	5
	Purchasing Officers	100%	4
Doctors	Chiefs of Surgery	100%	5
	Chiefs of Medicine	100%	5
	Residents	20%	34
Nurses	Directors of Nursing	100%	5
	Central Supply Supervisors	100%	5
	Operating Room Supervisors	100%	5
	Obstretical Supervisors	100%	5
	Administrative and Head Nurses	20%	26
	Staff Nurses	10%	36
			140

ANALYSIS

Component Preferences and Supply Practices

Hypothesis I implies that supply decisions should be acceptable to users; therefore, congruence should exist between user preferences and the form of items actually used in the hospital. Tables II through V show the percentages of various components whose preferences agree, disagree, or indicate indifference[3] with the form of item currently in use in their hospital. These tables were derived by comparing the recorded preferences with the actual supply situation existing in the hospitals.

The subjects were not asked directly whether or not they agree with the decision; therefore, the indifference category reflects a lack of preference for the form of supply items and not necessarily indifference to hospital supply decisions. With respect to changes in the form of items used, the amount of disagreement probably is more critical than the amount of agreement, because agreement and indifference indicate,at least, a lack of dissatisfaction with present supply conditions.

It can be seen from the tables that where the reusable form of items is found, relatively high levels of disagreement with the supply decision exist among the users; where the disposable form of items is found, there are relatively low levels of disagreement among the users. If Hypothesis I be true, i.e., if user preference determines supply decisions, one would expect to find a uniformly low level of disagreement among the users. Hypothesis I apparently is not true. In fact, it is the administrators

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[3]Throughout this study, no distinction was made between "indifference" and "no opinion".

TABLE II
DEGREE OF AGREEMENT WITH FORM OF GLOVES PRESENTLY USED
(in per cent of N)

Organizational Component	Code	All are Reusable			
		Agree	Indifferent	Disagree	N
Administrators	1.00	26.1	39.1	34.8	23
Administrator-Users	2.00	30.8	15.4	53.8	13
Staff Nurses	3.10	15.4	15.4	69.2	13
Residents	3.20	46.1	23.1	30.8	13

TABLE III
DEGREE OF AGREEMENT WITH FORM OF NEEDLES PRESENTLY USED
(in per cent of N)

Organizational Component	Code	Hospitals Use Disposable				Hospitals Use Reusable			
		Agree	Indifferent	Disagree	N	Agree	Indifferent	Disagree	N
Administrators	1.00	69.2	19.2	11.5	26	22.2	33.3	44.4	9
Administrator-Users	2.00	100.0	0.0	0.0	15	11.1	33.3	55.6	9
Staff Nurses	3.10	92.3	0.0	7.7	13	25.0	16.7	58.3	12
Residents	3.20	71.4	14.3	14.3	7	9.1	0.0	90.9	11

TABLE IV
DEGREE OF AGREEMENT WITH FORM OF SYRINGES PRESENTLY USED
(in per cent of N)

Organizational Component	Code	Hospitals Use Disposable				Hospitals Use Reusable			
		Agree	Indifferent	Disagree	N	Agree	Indifferent	Disagree	N
Administrators	1.00	68.7	18.8	12.5	16	43.8	27.8	33.3	18
Administrator-Users	2.00	90.0	0.0	10.0	10	33.3	25.0	41.7	12
Staff Nurses	3.10	60.0	40.0	0.0	5	29.4	11.8	58.8	17
Residents	3.20	0.0	0.0	0.0	0	31.2	18.8	50.0	16

TABLE V
DEGREE OF AGREEMENT WITH FORM OF ENEMAS PRESENTLY USED
(in per cent of N)

Organizational Component	Code	All are Reusable			
		Agree	Indifferent	Disagree	N
Administrators	1.00	60.0	33.3	6.7	30
Administrator-Users	2.00	75.0	20.8	4.2	24
Staff Nurses	3.10	93.1	6.9	0.0	29
Residents	3.20	64.7	29.4	5.9	17

whose level of disagreement is uniformly less than fifty per cent for reusable items; and for disposables, it drops to a maximum of 12.5 per cent. If the nursing administrators are eliminated from the administrator category, the disagreement falls below thirty per cent for both forms of supply items. Apparently, supply decisions are controlled by the preferences of business administrators and medical administrators, and not by the preferences of users.

Components' Rankings of Factors

Hypothesis II states that members of given organizational components apply the same factors as a basis for choice and assign similar weights to these factors.

Concordance Analysis

To test this hypothesis, the subjects were asked to rank the influence of eleven factors[4] upon their preferences for four supply items: gloves, needles, syringes, and enemas. Coefficients of concordance, a measure of similarity of rankings, were computed for each component as well as for the total sample of subjects. Table VI contains these coefficients.

These coefficients disclose, first, that there is within most components a tendency for agreement with respect to the ranking of factors; and second, that in general there is more agreement within the components as to how factors should be ranked than there is for the sample as a whole. This follows from the fact that at least two-thirds of the component coefficients are larger than those of the entire sample.

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[4] These factors were chosen on an *a priori* basis and are found in Table VII.

TABLE VI
COEFFICIENTS OF CONCORDANCE FOR RANKINGS OF FACTORS*

ORGANIZATIONAL COMPONENT	CODE	SUPPLY ITEM				COMBINED STANDARD RANKING
		GLOVES	NEEDLES	SYRINGES	ENEMAS	
Business Administrators	1.10	.426	.490	.555	.414	.884
Medical Administrators	1.20	.405	.318	.321	.253	.944
Nursing Administrators	1.30	–	.536	.583	.588	.892
Administrator-Users	2.00	.404	.438	.401	.400	.881
Staff Nurses	3.10	.405	.354	.299	.557	.940
Residents	3.20	.356	.428	.431	.412	.953
Totals		.316	.370	.369	.298	.877

*All coefficients in this table are significant at or beyond the .05 level.

The combined standard ranking column shows that there is a relatively high stability in ranking factors from item to item. The values in this column were derived by computing a coefficient of concordance using the standardized rankings by each component for each item.[5]

The high stability in ranking factors has important implications for the larger study of which the present study is a part. Since the ultimate objective of the larger study is to develop a decision system for various hospital supply items, it is necessary to know whether the weights of factors are relatively stable for all items or vary from item to item. The finding here means that factors included as variables in the decision model may be assigned weights each of which are relatively constant as the model is applied item by item. (See conceptual model in the discussion to follow.)

Having established that rankings by components are reasonably similar, the distribution of factor rankings for the several components requires description. Table VII presents the combined standarized rankings for all items.[6] It appears that considerable agreement exists. All components ranked safety to patient first, with simplicity, cleanliness, and user-safety also ranking high. Practice of other hospitals, preference of others, and work load were uniformly ranked low with the exception of the nursing administrators who ranked work load as fifth. Cost was ranked second by business administrators, but this factor received an intermediate ranking by all other components.

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[5]Each respondent was asked to rank the factors which he felt were important for his preference, the rank order being from 1 to n, with 1 indicating first or highest rank. Factors in the a priori list which were not ranked by the respondents were arbitrarily ranked as least important. Standarized rankings then were derived according to the procedure outlined in Siegel, Sidney, Non-Parametric Statistics, McGraw-Hill Book Company, New York, 1956, pp. 237-238.

[6]The distribution of rankings for each of the four items is found in Appendix B.

TABLE VII
COMBINED STANDARDIZED RANKINGS OF FACTORS

Preference Factor	Business Administrators	Medical Administrators	Nursing Administrators	Administrator Users	Staff Nurses	Residents
Code	1.10	1.20	1.30	2.00	3.10	3.20
Cost	2	4.5	6.5	6	5	5
User Safety	4	4.5	2	2	4	4
Patient Safety	1	1	1	1	1	1
Practice of Other Hospitals	9	8	8	9	9	7
Simplicity	3	2	3	4	2	3
Cleanliness	5	3	4	3	3	2
Patient Comfort	6	6	6.5	5	6	6
Preference of Others	7	7	9	8	8	9
Work Load	8	9	5	7	7	8
Advertising (Salesmen or Magazines)*	–	–	–	–	–	–

*These were omitted from analysis because they were ranked by only two people and received ranks of 10 and 11.

From these data it appears reasonable to conclude that there is a similarity of rankings of factors within components but a difference in rankings among components; both the similarities and differences remain stable in the evaluation of these supply items. This finding appears to be reasonable grounds for accepting Hypothesis II.

Secondary Analyses of Rankings

In order to study these rankings further, two types of secondary analyses were made. First, for each component, a ranking of open-end responses was compared with the ranking of the forced-choice responses by use of a rank-order correlation coefficient; and second, the components were compared with each other in terms of the open-end responses.[7]

A comparison of the results of the forced-choice and open-end rankings showed little stability except for the high-ranked and low-ranked factors. A factor dealing with the functional quality of the item was found, but this factor was not included in the *a priori* schedule. This factor seemed to be important to some of the respondents, and its omission may account for the relatively low stability between the two sets of rankings.

In order to explore these data further, the first-mentioned open-end responses were grouped into three classes:

(1) Patient-centered responses--those responses relating to patient safety and patient comfort;

(2) User-centered responses--those responses relating to work saving, time saving, user safety, and simplicity of operation; and

(3) Other--those responses which included cost and quality of the items and a few responses such as product familiarity.

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[7]The rank of a factor was inferred from the order in which it was stated by the respondent, i.e., the first-mentioned factor was ranked most important.

Since patient safety was mentioned first by all components, little difference should be expected between the various components in respect to relative frequency of mentioning patient-centered factors, but in respect to user-centered and other factors, significant differences in relative frequency should be expected. To test these differences statistically, the subjects were divided into two groups as shown in Tables VIII through XI. The expected differences were confirmed for needles and syringes, but not for gloves and enemas.

In view of the high rank given patient safety on the *a priori* list, it would be expected that a large proportion of responses would occur in the patient-centered category, assuming that the first-mentioned factor is *most* important to the respondent. It can be seen from Tables VIII through XI that this is true of needles and syringes, but not of gloves and enemas. This response pattern is consistent with Assumption E and may be explained by the belief of respondents that chances of jeopardizing patient safety are greater for needles and syringes than for gloves and enemas. This pattern also may account for a diffusion of responses among other categories causing the lack of significance in Tables VIII and XI. Some of the results from these secondary analyses appear not to be totally consonant with the results from the concordance analysis; however, the techniques for obtaining the rank order of the *a priori* list of factors and the rank order from open-end questions are not comparable. These differences in interview techniques could account for some of the discrepancies in the two sets of ranks. Therefore, a continuation of the acceptance of Hypothesis II is justified.

TABLE VIII
FREQUENCY OF OPEN-END RESPONSES--GLOVES

Organizational Component	Code	Patient-Centered	User-Centered	Other	Total*
Administrators	1.00	4	7	6	17
Others	{2.00 3.00	7	22	6	35
Totals		11	29	12	52

$\chi^2 = 0.599$; df = 2; $P > .05$

TABLE IX
FREQUENCY OF OPEN-END RESPONSES--NEEDLES

Organizational Component	Code	Patient-Centered	User-Centered	Other	Total*
Administrators	1.00	16	4	7	27
Others	{2.00 3.00	30	28	5	63
Totals		46	32	12	90

$\chi^2 = 7.506$; df = 2; $P < .05$

TABLE X
FREQUENCY OF OPEN-END RESPONSES--SYRINGES

Organizational Component	Code	Patient-Centered	User-Centered	Other	Total*
Administrators	1.00	8	8	13	29
Others	{2.00 3.00	17	32	3	52
Totals		25	40	16	81

$\chi^2 = 19.016$; df = 2; $P < .001$

TABLE XI
FREQUENCY OF OPEN-END RESPONSES--ENEMAS

Organizational Component	Code	Patient-Centered	User-Centered	Other	Total*
Administrators	1.00	6	11	3	20
Others	{2.00 3.00	11	46	0	57
Totals		17	57	3	77

$\chi^2 = 3.040$; df = 2; $P > .05$

*This total refers only to those respondents who had had experience with the supply item.

Prediction of Item-Form Choice

Hypothesis III implies that different organizational components will give different weights to the various factors in forming their preferences for disposable or reusable items. That is, different factors will vary in their ability to predict choice of item-form among the components. The foregoing analysis has shown that, with respect to importance of the factors in their preferences, different components rank the factors differently. The present problem is to determine whether or not the factors, in fact, do receive different weights by different components. In order to do this, the responses of individuals were classified according to the trichotomy (disposable is better, reusable is better, or no opinion) and according to their preferences for the item-form.

The purpose of this classification is to determine whether or not a knowledge of preference will allow one to predict choice of supply item-form. For example, if a subject said he thought disposable needles were safer than reusable ones, and if safety is important to him, he will prefer disposable needles. Or, suppose that cost is a factor which contributes to one's decision to adopt one form of supply item over the other; then, other things being equal, if one believes that one form of the item is more expensive than its alternative, he should be expected to choose the alternative. Table XII is an illustration of user's responses with respect to their estimates of the relative costs of the item-form and their item-form preferences. For example, twenty of the forty respondents believed that the disposable form was less costly, and sixteen of these preferred the disposable form.

TABLE XII
USERS' BELIEFS ABOUT COST OF FORM OF NEEDLES
AND CHOICES OF NEEDLE FORM
(frequency)

PREFERENCE	NUMBER OF USERS ESTIMATING FORM TO BE LESS COSTLY			
	DISPOSABLE ITEM	REUSABLE ITEM	NO OPINION	TOTAL
Disposables	16	6	12	34
Reusables	3	1	1	5
Indifferent	1	0	0	1
Totals	20	7	13	40

Analysis Technique

To find the degree to which choice of item-form is determined by preference factors, McCormick's Kappas were computed.[8] In this study the K coefficient indicates the degree of ability to predict preference for item-form from a knowledge of the subjects' beliefs about cost or about some other specified factor.[9]

The data in Table XII and similar data on administrators and administrator-users for additional preference factors were used in the computation of four K's, one for each column and one for the total table. In treating the data of Table XII, the K's for reusable and for indifference were not significant. However, the K for disposable was significant. This

[8] McCormick, T. C., "Toward Causal Analysis in the Prediction of Attributes," American Sociological Review, Vol. 17, No. 1, February, 1952, pp. 35-44. Since this is a directional test, assuming one variable to be independent and the other dependent, it is preferable to other measures of contingency which measure degree of two-way association, i.e., those which do not discriminate between dependent and independent variables. The essential derivations are presented in Appendix C of the present paper.

[9] Throughout this study, the K values were computed in the K' (corrected) form, i.e., corrected for disporportionality of column frequencies.

means that belief about cost will predict choice of disposable needles, within confidence limits, at seventy per cent of maximum effectiveness, but it will not predict choice in the case of reusable needles or indifference.

The K values for each factor in relation to choice of item-form for the four products, by administrators, users, and administrator-users are summarized in Tables XIII through XVI. Each of these tables is divided into three sections, one for each component.

Needles.--Table XIII reveals that all six factors are effective in predicting choice of disposable needles, but none is effective in predicting reusable needles. This holds for all three organizational components. It is interesting to note the variation in the K_d values among the three components. This is presumably a function of the differing role orientations of the members of the three organizational components.

TABLE XIII
SUMMARY OF THE CAPACITY OF THE SIX FACTORS TO PREDICT CHOICE OF NEEDLE FORM, BY ORGANIZATIONAL COMPONENTS

FACTOR	ADMINISTRATORS				ADMINISTRATOR-USERS				USERS			
	K*	K_d	K_r	K_i	K*	K_d	K_r	K_i	K*	K_d	K_r	K_i
Cost	–	.750	–	–	–	.900	–	–	–	.700	–	–
Patient Safety	–	.654	–	.334	.125	1.0	–	–	–	.766	–	–
User Safety	–	.606	–	–	.125	1.0	–	–	–	.820	–	–
Time	–	.580	–	–	–	.925	–	–	–	.834	–	–
Messiness	–	.625	–	.181	–	.842	–	–	–	.829	–	–
Patient Comfort	–	.606	–	–	.166	1.0	–	–	–	.928	–	–

*K is the predictive effectiveness of a given factor for each separate row within a given section of the summary table. When the column K's are very unlike in value the K's will obscure the true picture of causal relationships in a section and will prove less fruitful than a comparative study of the column K's. K_d is for those individuals within a given component who prefer disposable needles, K_r is for those preferring reusable needles, and K_i is for those who were indifferent to needle form. All K's shown are significant at or beyond the .05 level. Dashes (–) are inserted where the values were not significant.

Syringes.--The results shown in Table XIV are similar to those in Table XIII except for three factors which are predictive of reusables. There is a tendency for the factors patient safety, user safety, messiness, and patient comfort to predict the choice of both disposables and reusables. This tendency is stronger in the case of disposable needles than for disposable syringes.

TABLE XIV
SUMMARY OF THE CAPACITY OF THE SIX FACTORS TO PREDICT CHOICE OF SYRINGE FORM, BY ORGANIZATIONAL COMPONENTS

FACTOR	ADMINISTRATORS				ADMINISTRATOR-USERS				USERS			
	K*	K_d	K_r	K_i	K*	K_d	K_r	K_i	K*	K_d	K_r	K_i
Cost	–	.625	–	–	–	.600	–	–	–	.307	–	–
Patient Safety	.438	.479	.500	.334	.649	.884	1.0	–	.495	.556	1.0	–
User Safety	.493	.416	1.0	–	–	.700	–	–	–	.736	–	–
Time	–	.280	–	–	–	.526	–	–	–	.571	–	–
Messiness	–	.366	–	.250	–	.448	–	–	.464	.464	1.0	–
Patient Comfort	.462	.500	1.0	–	–	1.0	–	–	–	.625	–	–

*Notation is the same as Table XIII.

Enemas.--Table XV contains information on enemas. The results of this table are similar to those for needles in that all factors predict choice of disposables. This table shows that no factors are significant in preference for reusable enemas, and a few factors are significant in leading to the prediction of indifference.

For administrators, factors favoring disposables are cost, patient safety, and user safety. For administrator-users, preference for disposables seems to be based on a belief that the product is safer for the user, the time for preparation and use is less, and safety to the patient is enhanced. All factors seem to predict user preference for disposable enemas.

TABLE XV
SUMMARY OF THE CAPACITY OF THE SIX FACTORS TO PREDICT CHOICE
OF ENEMA FORM, BY ORGANIZATIONAL COMPONENTS

FACTOR	ADMINISTRATORS				ADMINISTRATOR-USERS				USERS			
	K*	K_d	K_r	K_i	K*	K_d	K_r	K_i	K*	K_d	K_r	K_i
Cost	.255	1.0	–	–	–	.700	–	.250	.212	1.0	–	–
Patient Safety	.202	.800	–	.307	–	.700	–	–	–	.910	–	–
User Safety	.180	.884	–	.142	–	.727	–	1.0	–	.700	–	–
Time	.364	.590	–	1.0	.365	.595	–	1.0	–	.820	–	–
Messiness	–	.608	–	.625	–	.460	–	–	–	.760	–	–
Patient Comfort	–	1.0	–	–	–	.250	–	–	–	.880	–	–

*Notation is the same as Table XIII.

Gloves.--Table XVI contains information on gloves. This table discloses a different pattern. Here the same factor often underlies different preferences for item-form by different respondents.

TABLE XVI
SUMMARY OF THE CAPACITY OF THE SIX FACTORS TO PREDICT CHOICE
OF GLOVE FORM, BY ORGANIZATIONAL COMPONENTS

FACTOR	ADMINISTRATORS				ADMINISTRATOR-USERS				USERS			
	K*	K_d	K_r	K_i	K*	K_d	K_r	K_i	K*	K_d	K_r	K_i
Cost	–	–	–	.400	–	.400	.505	–	–	–	–	.166
Patient Safety	.422	.318	1.0	–	.444	.505	1.0	–	.472	.250	1.0	.166
User Safety	–	.181	–	.347	.625	1.0	1.0	–	–	.250	–	.181
Time	.526	.142	1.0	.438	–	.550	–	–	–	–	–	–
Messiness	–	.157	–	.571	–	.307	–	–	–	.200	–	–
Patient Comfort	–	–	–	–	–	–	.625	–	–	–	–	–

*Notation is the same as Table XIII.

It can be seen from Table XVI that, in general, where the same factor is underlying different component preferences, K for a row in a section is significant. In other words, where a factor is important, different conclusions as to whether the factor points toward the disposable form or toward the reusable form of an item can lead to different choices.

Evaluation

Attention now is directed to the meaning of results from the tables for individual supply items. Hypothesis III states that preference factors vary in their capacity to predict item-form among organizational components.

All factors are predictive of choice of disposable items in all three components, except for the factors cost, time, and patient comfort in the case of gloves. However, there is substantial variation among components in respect to the capacity of a factor to predict choice. (See Tables XIII through XVI). For example, patient comfort varies among components from .250 to 1.000 effectiveness in predicting preference for disposable enemas. (See Table XV).[10] This means that different components place different weights on the same factor.

Patient safety is the only factor which is predictive of choice of reusable items in all three components, and this applies only to gloves and syringes. The variation in range among components for this factor is .500 to 1.000 for syringes and no variation for gloves. (See Tables XIV and XVI).

In the case of indifference, significant coefficients (k_i) are to be found most frequently among administrators for all four supply items. For users, significant coefficients of indifference appear only in the case of

[10]The critical values for differences between Kappa coefficients are presently unknown. Therefore tests for significant differences between K's were not made.

gloves, and for administrator-users, only in the case of enemas.

The capacities of factors to predict choice, without regard to item-form were estimated by weighting factors by the number of total choices each factor would predict. Factors were ranked in descending order according to their ability to predict choice. Results for each item by component are shown in Table XVII. The variations in rankings within each component of this table reflect the effect of <u>supply item</u> on the relative weight of factors. Likewise, the variations among components indicate the effects of <u>component</u> on the rank order of factors, by supply item. Both results appear to be consistent with Assumption E.

These observations, together with the considerable range of differences between coefficients for different components for a given factor, lead to an acceptance, within the limitations of sample size, of Hypothesis III.

TABLE XVII
RANKINGS OF FACTORS WITH RESPECT TO ABILITY TO PREDICT CHOICE*

RANK	ADMINISTRATORS				ADMINISTRATOR-USERS				USERS			
	Needles	Syringes	Enemas	Gloves	Needles	Syringes	Enemas	Gloves	Needles	Syringes	Enemas	Gloves
1	Cost	User Safety	Time	Time	Patient Comfort**	Patient Safety	Time	User Safety	Patient Comfort	Patient Safety	Cost	Patient Safety
2	Patient Safety	Patient Comfort	Cost	Patient Safety	Patient Safety**	Patient Comfort	Patient Safety	Patient Safety	Time	Messiness	Patient Safety	User Safety
3	Messiness	Patient Safety	User Safety	User Safety	User Safety**	User Safety	User Safety	Cost	Messiness	User Safety	Patient Comfort	Messiness
4	User Safety**	Cost	Patient Comfort	Messiness	Time	Cost	Cost	Time	User Safety	Patient Comfort	Time	Cost
5	Patient Comfort**	Messiness	Patient Safety	Cost	Cost	Messiness	Messiness	Messiness	Patient Safety	Time	Messiness	***
6	Time	Time	Messiness	***	Messiness	Time	Patient Comfort	Patient Comfort	Cost	Cost	User Safety	***

*Rank order of factors is determined by the capacities of the factors to predict the largest number of total choices, regardless of item-form chosen.

**Tie.

***Missing factors do not predict.

SUMMARY AND CONCLUSIONS

This study tested three hypotheses regarding the relationship of role values (preference systems) to hospital supply decisions. The conclusions which follow are limited by sample size and type of supply item considered.

Hypothesis I

Hospital supply decisions are based on the user's judgment of the differential value of the two alternative forms of supply items to the user's preference system. The findings indicated that, where the reusable form of items is found, relatively high levels of disagreement with the supply decision exists among the users. On the other hand, where the disposable form of items is used, relatively low levels of disagreement exist among the users. User preference does not appear to be the basis for the decision to use the hospital supply items studied, therefore, Hypothesis I is rejected.

Hypothesis II

The members of a given organizational component apply the same factors as a basis for choice and assign similar weights to these factors. From a determination of coefficients of concordance for forced-choice rankings of factors, it appears reasonable to conclude that a similarity of factor rankings exists within organizational components, but a difference exists among components. Both of these conditions remained stable in the evaluation of the supply items included in this study. A comparison of the results of the forced-choice and open-end rankings showed little stability except for the high-ranked and low-ranked preference factors. The components were compared with each other; responses being classified as patient-centered, user-centered, and other. Findings here were similar to those from the concordance analysis in the cases of needles and syringes, but not in the cases of gloves and enemas. There is a tendency for agreement within most organizational components with respect to a ranking of preference factors, and in general, there is more agreement within the components than within the organization. Therefore, Hypothesis II is accepted.

Hypothesis III

Factors vary in their capacity to predict choice of item-form among organizational components. Both supply item and organizational component were found to have an effect upon the rankings of preference factors. The variation in relative weights of factors to predict choice was found to be greater among components than among items within a component. Thus, Hypothesis III is accepted.

DISCUSSION

The discussion to follow is an attempt to relate to the reader some of the insights and impressions acquired in the course of this study on preference factors and supply decisions. This discussion explores the reasons for certain findings, examines the forces which influence the nature of preference systems, and relates study findings to the hospital supply decision process.

It is interesting to note the magnitude of indifference to prevailing item-form in those hospitals using reusable products. This indifference was much less in those hospitals using disposable items.

In speculating on the source of this indifference, several explanations can be offered. It is possible that the respondents were actually indifferent to the choice. If this were the case, however, indifference would be found in all hospitals and not just in those using reusable items. Another explanation might be the lack of sufficient information with which to appraise the merits of the item-forms. For users, the type of information upon which preference is determined is obtained primarily through using the item, primary information. On the other hand, the preference system for administrators requires the accumulation and analysis of various kinds of data from many sources, secondary information. The elapsed time for analyzing secondary information is greater than that for primary information. Thus, more time is required for the disappearance of indifference among administrators than for other components.

Another possible explanation for the difference in time required for the disappearance of indifference relates to the contrasting conceptions of the members of different components in regard to the nature of the preference factors and the relative importance they attach to these factors. Administrators may conceive of cost as being a rather definitive enumeration of specific monetary cost figures, whereas users may conceive of cost as an unstructured generality. Even if cost were regarded by both components as having equal importance, administrators require more time to generate and analyze specific cost figures than do users whose judgment on cost as a generality may be made almost instantaneously. The fact that administrators tend to assign more importance to cost than do users may reinforce the tendency to create a time lag. The case for differing effects by virtue of differing conceptions of factors may be seen also if one considers patient safety, the first-ranked factor by administrators and users. Even when factor importance is comparable, differences in the time required for the disappearance of indifference still obtains. Differing concepts of the meaning of patient safety among components must account for part of this time lag.

Users and administrator-users may shorten the time required for the disappearance of indifference by becoming aware of, and by appealing to, the preference system of the administrator. This practice may be used to manipulate decisions. For example, one respondent in the study revealed that when a new supply item required justification, her strategy was to convince the administrator that the item was either less expensive than the product in use or safer for the patient.

In the present study, general disagreement was found with the prevailing use of reusable items. The indifference and disagreement of business administrators was affected less than that of other types of administrators in those hospitals which made a change from reusables to disposables. Since supply decisions are dominated by business and medical administrators and since medical administrators disagree less with decisions to change to disposable items, one is led to believe that the balance of power in hospital supply decisions lies with medical administrators. It may be that differences in the perceptions of the nature of decision information and subtle variations in preference systems cause doctors and hospital administrators to react differently to the same information.

Having established that different organizational components have different preference systems, we now examine the forces which influence the nature of these systems. One logical approach for initiating this examination is an analysis of the hospital as an organization.

The organizational goals of the modern hospital include patient care, education, and research. Of these goals, patient care is of particular interest in this study because of the heavy emphasis placed on the quality of patient care and the impact of this emphasis upon supply decisions.

Although most hospitals are not expected to show a profit, there is some pressure for controlling the cost of operation. Almost all hospitals face some kind of pressure to reduce non-essential expenditures which could inflate the cost of patient care. Pressures such as these require that the cost factor be given consideration.

Since the values on patient care often are in opposition to those of economy, exchanges between quality and cost are required. Obviously, when alternatives result in the same level of care, other criteria will dominate the decision. Findings of the present study emphasize the primacy of patient-care goals over fiscal goals, but trade-offs of care and cost are always present.

If these were the only values which had to be taken into consideration, the problem of human factors in decision-making might be relatively simple.

However, the hospital is not only an organization of individuals, it is a collection of groups. Some of these groups are professional and have ethics, standards, and mores, which temper definitions of what is basic and necessary, and what is luxurious or supplemental in patient care.

There are at least two readily apparent professional groups in hospitals--doctors and nurses. Of particular interest here is the priority of goals within the hospital, that is, the relative attachment to goals of a profession compared with the attachment to goals of the hospital as an organization.

As one might expect, most doctors and nurses give primacy to basic patient care. The goals of economy and of supplementary, luxurious care have little relation to professional orientation. Doctors are concerned primarily with the patient as a person to heal and as a case to treat; economy and frills are not necessary to achieve this. Nurses are concerned primarily with the care and comfort of the patient, and again, economy and frills are not essential. When doctors and nurses are functioning as users and a preference is to be advanced for a particular procedure, piece of equipment, or item of supply, they consider patient care first, then they consider criteria which are self-oriented; i.e., "how much easier does this make my job?" or "how much more convenient is this?"

When these professionals become involved in the administration of the organization, it becomes necessary for them to adopt organizational points of view in addition to professional points of view. The further they are removed from direct patient care or the higher they go in the organization, the more important organizational goals become. This results in more willingness to consider the interaction of quality and economy in decision-making.

Another professional group is found in the hospital administration. The hospital administrator is responsible for the welfare of the organization in general, including patient care, public image, and the business aspect of the organization's activities. The primary values of the hospital administrator are organizationally oriented, because his security and satisfaction are derived from the success of the organization.

The following outline summarizes fundamental responses of three professional groups involved in supply decisions. These responses emanate from applications of their value systems to care levels and economy.

Doctors:	Basic Patient Care--	Does this item do the best job of performing the functions desired?
	Economy or Cost--	Indifferent.
	Luxury of Care--	Indifferent.
Nurses:	Basic Patient Care--	Does this item perform its functions as conveniently and as well as other items?
	Economy or Cost--	Indifferent, as long as it is not directly more expensive to patient.
	Luxury of Care--	Indifferent.
Administration:	Basic Patient Care--	Will the item perform its functions?
	Economy or Cost--	Is there a significant enough improvement in safety or quality to justify the expense?
	Luxury of Care--	Are there valid benefits to the organization or to the patient?

From the viewpoint of an administrator, advantages of shifting to disposable items may be chiefly economic. Other important factors may become recessive in this context because the administrator has reason to believe that patient safety and welfare will be protected by the standards of doctors, nurses, manufacturers, and perhaps government. User-oriented factors are satisfied because users tend to prefer disposables. Indeed, the administrator may even be willing to make an uneconomic decision in order to capitalize upon this preference for disposables.

There are two essential questions to be answered in considering disposable versus reusable supply items: Are the items functionally equivalent with respect to patient care? And if so, is there any economic advantage to be gained from making a change from reusable to disposable. Since this is a two-fold decision, one part of which may be beyond the administrator's competence, there has to be some delegation of responsibility for evaluation of the relative functional equivalence of the item-form.

The evaluation of functional equivalence usually involves some sort of test of the product under consideration. Presumably, information from the test becomes an important part of the data upon which the administrator bases his decision.

Those who participate in product tests tend to evaluate the product on the basis of their own value systems. In effect, they significantly influence the opinion of the administrator by their reports on the item. The objectivity of the tests and of the reports are most crucial. But, the biases of those participating in tests, if not controlled, enter into the evaluations. To some extent, if the item interferes with or eliminates duties which the evaluators regard as prerogatives, or if the item tends to degradate skill, they may resist the adoption of the item, perhaps subconsciously, perhaps consciously, by citing spurious objections to the item. On the other hand, if the item tends to make work more pleasant or enhances self-esteem, bias may well be positive in favor of the product.

There are additional complications when the test reports have to go through several organizational levels to reach the administrator, because bias can be introduced all along the lines of communication. This additional bias may be partially a position-bias by administrator-users and partially a categorical bias toward disposable items as a class.

Two determinants of hospital supply decision, patient care and monetary cost, have been emphasized in this discussion. It may well be that the hospital decision system contains four major determinants. These determinants and their modes of measurement are as follows:

Major Determinant	Mode of Measurement
Patient-centered	Medical opinion and tests
User-centered	User preference and tests
Organizationally-centered	Policy makers' judgments and tests
Economic	Cost measurements and estimates

The patient-centered determinant is a composite of the whole complex of care, comfort, safety, and welfare. The user-centered determinant includes safety of use, convenience, time, simplicity, and messiness. The organizationally-centered determinant relates to the welfare of the hospital as an institution striving for certain goals. The economic determinant contains monetary values measuring the consumption of resources.

Since it has been determined that preference factors and weights are stable among supply items, it is possible to conceptualize a structure for decision-making which is applicable to supply items generally. The following conceptual model of the decision system observed in the present study initially excludes user-centered and organizationally-centered determinants:

DETERMINANTS

Patient-centered	Economic	Decision
Superior	Cheaper	Accept
	Equal	Accept
	More Expensive	Indeterminant
Equal	Cheaper	Accept
	Equal	Indeterminant
	More Expensive	Reject
Inferior	Irrelevant	Reject

The three terms (superior, equal, and inferior) in the patient-centered column are values of a discrete variable which measures differences in patient-centered attributes between the proposed item-form and the existing item-form. The three terms--cheaper, equal, and more expensive-in the economic column are values of a discrete form of the cost variable which measures monetary differences between the item-forms. The term, irrelevant, indicates that, for this condition, the cost variable does not affect the decision. In the decision column, the alternative courses of action are indicated by the terms, accept and reject. *Accept* means that a change in product form will be made, whereas *reject* means that the existing product form will be retained. In this *closed* decision system, there are two types of indeterminateness. When the proposed product is superior but is less economic, consideration will be given both other determinants and trade-offs between care and cost; when the alternative item-forms are equal in regard to both care and cost, other determinants become the discriminant in the decision.

The trade-offs required for certain conditions of the decision system described above involve exchanges of values among major determinants along a line of indifference (state of equal values). This rate of substitution is based upon the administrator's value system. When all determinants become a part of the decision system, including user-centered considerations, trade-offs may be made among some or all system components.

Organizationally-centered determinants are value components of the environment within which the decision system functions. These determinants assume many forms and manifest their effect upon the decision in accordance with their relative importance in the administrator's value system. The following is a partial list of such determinants:

(1) Conflicts between the value system of the administrator and the value systems of others within the organization affected by the decision.

(2) Conflicts among goals--organizational goals, professional goals, personal goals.

(3) Uncertainties associated with the accuracy of product evaluations, including measurement errors and bias.

(4) Risks of encountering serious, irrevocable, adverse consequences to the organization arising from the decision.

The challenge which lies ahead for the total study is the development of a procedure for measuring the economic determinant and the synthesis of research findings into an operational procedure for supply decisions.

SUGGESTIONS FOR FURTHER RESEARCH

A number of questions arose from the present research which, if answered by further research, would give more insight into the decision-making process for hospital supply items.

One of these questions is whether or not there is a limiting case such that a decision-maker would disregard monetary costs in order to achieve organizational or professional goals. This question is related to the more general question of whether or not preference factor weights assigned to decision determinants change in any given role for different types of supply items. In addition to questions related to preferences, more knowledge will be required as to the relative effectiveness of organizational positions and roles in decision-making.

This research has indicated that the order of values which orients an individual's role performance varies among organizational components within the hospital. There is also significant variation within the component. These external and internal variations should be explored by further research.

Since this study is a pilot study it should be replicated using a larger sample and should include identification of the origin and flow of decision information to determine the empirical relation between such information and the preference systems derived in this study.

There are at least three areas of research suggested by the conceptual model developed in this report. First, it will be necessary to conceptualize a decision system which includes all relevant determinants. Second, it will be necessary to structure practical measurement procedures for the decision determinants. Perhaps continuous variables will be more useful than the presently suggested discrete variables. Finally, the conceptual model should be field tested by use of a representative, stratified sample of hospitals across the nation.

APPENDIX A

HOSPITAL SUPPLY DECISION QUESTIONNAIRE

APPENDIX A

Hospital Supply Decision Questionnaire

Card I

_____ 1. - 3. ________________ (Identification number)

_____ 4. - 5. ______ (Age)

_____ 6. ______ 1) Male ______ 2) Female

_____ 7. ______________________ (Hospital)

_____ 8. - 9. ______________________ (Unit of Hospital)

_____ 10. - 11. ____________________ (Job Title)

_____ 12. __________________________ (Location of Hospital)

_____ 13. - 14. How many years have you worked at this hospital? _________.

_____ 15. A. For Users - Do you believe a shortage of personnel exists in your department? ____ 1) Yes ____ 2) No ____ 3) Uncertain

B. For Administrators - Do you believe that your department or organization is adequately staffed in number? ____ 1) Yes ____ 2) No ____ 3) Uncertain

Do you have knowledge of the following disposable <u>and</u> re-usable supply items?

			(1) Yes	(2) No
_____	16.	Gloves	___	___
_____	17.	Needles	___	___
_____	18.	Syringes	___	___
_____	19.	Fleets-type enemas and re-usable enemas	___	___

Have you had experience with the use of the following disposable and reprocessable supply items? How long? How frequently?

20. - 35.

	Disposable						Reprocessable					
	Yes	No	Yrs	Daily	Wkly	Monthly	Yes	No	Yrs	Daily	Wkly	Monthly
Gloves	___	___	___	___	___	___	___	___	___	___	___	___
Needles	___	___	___	___	___	___	___	___	___	___	___	___
Syringes	___	___	___	___	___	___	___	___	___	___	___	___
Enemas	___	___	___	___	___	___	___	___	___	___	___	___

Which of the following, in your opinion, is more expensive to the hospital over a period of time?

_____ 36. Gloves
- _____ 1. Disposable is more expensive
- _____ 2. Re-usable is more expensive
- _____ 3. No difference in cost
- _____ 4. Uncertain

_____ 37. Needles
- _____ 1. Disposable is more expensive
- _____ 2. Re-usable is more expensive
- _____ 3. No difference in cost
- _____ 4. Uncertain

_____ 38. Syringes
- _____ 1. Disposable is more expensive
- _____ 2. Re-usable is more expensive
- _____ 3. No difference in cost
- _____ 4. Uncertain

_____ 39. Enemas
- _____ 1. Disposable is more expensive
- _____ 2. Re-usable is more expensive
- _____ 3. No difference in cost
- _____ 4. Uncertain

Which of the following is, in your opinion, safer for the patient?

_____ 40. Gloves
- _____ 1. Disposable is safer
- _____ 2. Re-usable is safer
- _____ 3. No difference in safety
- _____ 4. Uncertain

_____ 41. Needles
- _____ 1. Disposable is safer
- _____ 2. Re-usable is safer
- _____ 3. No difference in safety
- _____ 4. Uncertain

_____ 42. Syringes
- _____ 1. Disposable is safer
- _____ 2. Re-usable is safer
- _____ 3. No difference in safety
- _____ 4. Uncertain

_____ 43. Enemas
- _____ 1. Disposable is safer
- _____ 2. Re-usable is safer
- _____ 3. No difference in safety
- _____ 4. Uncertain

Which of the following is, in your opinion, safer for the user?

_____ 44. Gloves
- _____ 1. Disposable is safer
- _____ 2. Re-usable is safer
- _____ 3. No difference in safety
- _____ 4. Uncertain

_____ 45. Needles
- _____ 1. Disposable is safer
- _____ 2. Re-usable is safer
- _____ 3. No difference in safety
- _____ 4. Uncertain

_____ 46. Syringes

_____ 1. Disposable is safer
_____ 2. Re-usable is safer
_____ 3. No difference in safety
_____ 4. Uncertain

_____ 47. Enemas

_____ 1. Disposable is safer
_____ 2. Re-usable is safer
_____ 3. No difference in safety
_____ 4. Uncertain

Which of the following, in your opinion, requires more time to prepare and administer?

_____ 48. Gloves

_____ 1. Disposable requires more time
_____ 2. Re-usable requires more time
_____ 3. No difference in time
_____ 4. Uncertain

_____ 49. Needles

_____ 1. Disposable requires more time
_____ 2. Re-usable requires more time
_____ 3. No difference in time
_____ 4. Uncertain

_____ 50. Syringes

_____ 1. Disposable requires more time
_____ 2. Re-usable requires more time
_____ 3. No difference in time
_____ 4. Uncertain

_____ 51. Enemas

_____ 1. Disposable requires more time
_____ 2. Re-usable requires more time
_____ 3. No difference in time
_____ 4. Uncertain

Which of the following lends itself to less "messiness" in its preparation and use?

_____ 52. Gloves

_____ 1. Disposable is cleaner
_____ 2. Re-usable is cleaner
_____ 3. No difference in cleanliness
_____ 4. Uncertain

_____ 53. Needles

_____ 1. Disposable is cleaner
_____ 2. Re-usable is cleaner
_____ 3. No difference in cleanliness
_____ 4. Uncertain

_____ 54. Syringes

_____ 1. Disposable is cleaner
_____ 2. Re-usable is cleaner
_____ 3. No difference in cleanliness
_____ 4. Uncertain

_____ 55. Enemas

_____ 1. Disposable is cleaner
_____ 2. Re-usable is cleaner
_____ 3. No difference in cleanliness
_____ 4. Uncertain

Which of the following, in your opinion, causes the patient more discomfort?

_____ 56. Gloves
- _____ 1. Disposable causes more discomfort
- _____ 2. Re-usable causes more discomfort
- _____ 3. No difference in discomfort
- _____ 4. Uncertain

_____ 57. Needles
- _____ 1. Disposable causes more discomfort
- _____ 2. Re-usable causes more discomfort
- _____ 3. No difference in discomfort
- _____ 4. Uncertain

_____ 58. Syringes
- _____ 1. Disposable causes more discomfort
- _____ 2. Re-usable causes more discomfort
- _____ 3. No difference in discomfort
- _____ 4. Uncertain

_____ 59. Enemas
- _____ 1. Disposable causes more discomfort
- _____ 2. Re-usable causes more discomfort
- _____ 3. No difference in discomfort
- _____ 4. Uncertain

What hospitals do you think are the top three or four in the country?

____

____

____

____

_____ 60. Do they use disposable gloves? ___ 1) Yes ___ 2) No ___ 3) Uncertain ___ 4) Some do, some don't

_____ 61. Do they use disposable needles? ___ 1) Yes ___ 2) No ___ 3) Uncertain ___ 4) Some do, some don't

_____ 62. Do they use disposable syringes? ___ 1) Yes ___ 2) No ___ 3) Uncertain ___ 4) Some do, some don't

_____ 63. Do they use disposable enemas? ___ 1) Yes ___ 2) No ___ 3) Uncertain ___ 4) Some do, some don't

Which do you prefer?

_____ 64. 1) Disposable gloves ____

2) Reprocessable gloves ____

3) No preference ____

65. - 75. Why do you prefer (disposable, re-usable) gloves?

Card II

Which do you prefer?

_____ 15. 1) Reprocessable needles ____

2) Disposable needles ____

3) No preference ____

Why do you prefer (disposable, re-usable) needles?

16. - 26.

Which do you prefer?

_____ 27. 1) Disposable syringes ____

2) Reprocessable syringes ____

3) No preference____

Why do you prefer (disposable, re-usable) syringes?

28. - 38.

Which do you prefer?

_____ 39. 1) Disposable enemas ____

2) Reprocessable enemas ____

3) No preference ____

Why do you prefer (disposable, re-usable) enemas?

40. - 50.

Of the following factors (hand card to respondent) plus the ones you mentioned in arriving at your preference, carefully rank the influence of each upon your preference or choice. You need not rank all of the factors.

51. - 62.

Factors	Gloves	Needles	Syringes	Enemas
A. Cost	____	____	____	____
B. Safety to User	____	____	____	____
C. Safety to Patient	____	____	____	____
D. The Practice of Important Hospitals	____	____	____	____
E. Simplicity of Use	____	____	____	____
F. Cleanliness of Use	____	____	____	____
G. Patient Comfort	____	____	____	____
H. Preferences of Others in Your Hospital	____	____	____	____
I. 1) The pressure of work upon you	____	____	____	____
2) Adequacy of your staff	____	____	____	____
J. Advertising Messages	____	____	____	____
K. Salesmen's Arguments	____	____	____	____
____________	____	____	____	____
____________	____	____	____	____
____________	____	____	____	____
____________	____	____	____	____

In what way did you first become acquainted with:

_____ 63. Disposable gloves ______________________________

_____ 64. Disposable needles ______________________________

_____ 65. Disposable syringes ______________________________

_____ 66. Disposable enemas ______________________________

67. - 72. (Users only) If you knew of an item which you thought would be of real value in your service, how would you go about trying to get this item in use here? How frequently have you done this? How successful have you been?

(Administrators) How do you handle requests for new supply items? How do these requests usually come to you (formal channels, informally, how?) How much weight do your opinions of the worth of the items carry in the final decision whether to use or not use an item?

73. - 79. All other things being equal, would you say that you generally preferred re-usable items to disposable items?

APPENDIX B

STANDARDIZED RANKINGS OF PREFERENCE FACTORS

APPENDIX B

STANDARDIZED RANKINGS OF PREFERENCE FACTORS

1. Enemas

Preference Factor	Business Adminis-trators	Medical Adminis-trators	Nursing Adminis-trators	Adminis-trator Users	Staff Nurses	Residents
Code	1.10	1.20	1.30	2.00	3.10	3.20
Cost	2	4	5	6	5	5
User Safety	5.5	5	2	4	4	4
Patient Safety	1	3	1	1	1	1
Practice of Other Hospitals	8	8.5	8	9	9	7
Simplicity of Use	4	1	3	3	2	2
Lack of Messiness	3	2	4	2	3	3
Patient Comfort	7	7	7	5	6	6
Preference of Others	9	6	9	8	7	9
Pressure of Work Load	5.5	8.5	6	7	8	8

2. Needles

Preference Factor	Business Adminis-trators	Medical Adminis-trators	Nursing Adminis-trators	Adminis-trator Users	Staff Nurses	Residents
Code	1.10	1.20	1.30	2.00	3.10	3.20
Cost	2	5	7	4	6	5
User Safety	3	4	3.5	3	4	4
Patient Safety	1	1	1	1	1	1
Practice of Other Hospitals	8	7	8	9	9	7
Simplicity of Use	4	2	3.5	6	3	3
Lack of Messiness	5	3	5	5	2	2
Patient Comfort	6	6	2	2	5	6
Preference of Others	7	8	9	8	8	9
Pressure of Work Load	9	9	6	7	7	8

APPENDIX B (Cont'd)

3. Gloves

Preference Factor	Business Adminis- trators	Medical Adminis- trators	Nursing Adminis- trators	Adminis- trator Users	Staff Nurses	Residents
Code	1.10	1.20	1.30	2.00	3.10	3.20
Cost	2	5	3	2	4	4
User Safety	4	4	2	5	3	2
Patient Safety	1	3	1	1	1	1
Practice of Other Hospitals	9	8.5	9	8	7	9
Simplicity of Use	3	2	5	3	5	3
Lack of Messiness	6	1	4	4	2	5
Patient Comfort	8	7	6	6	6	6
Preference of Others	5	6	8	9	8.5	7.5
Pressure of Work Load	7	8.5	7	7	8.5	7.5

4. Syringes

Preference Factor	Business Adminis- trators	Medical Adminis- trators	Nursing Adminis- trators	Adminis- trator Users	Staff Nurses	Residents
Code	1.10	1.20	1.30	2.00	3.10	3.20
Cost	2	4	5	6	5	5
User Safety	3	5	2	2	4	4
Patient Safety	1	1	1	1	1	1
Practice of Other Hospitals	8	8	8	8.5	9	7
Simplicity of Use	4	2	3	3	2	2
Lack of Messiness	5	3	4	4	3	3
Patient Comfort	6	6	7	5	6	6
Preference of Others	7	7	9	8.5	8	9
Pressure of Work Load	9	9	6	7	7	8

APPENDIX C

McCORMICK'S KAPPA

APPENDIX C

McCormick's Kappa[1]

Where data can be arranged in a square experience table, and interest is in predicting one response from the presence of another, one can theoretically set up two situations: 1) a situation of maximum efficiency, where all responses fall on a diagonal; and 2) a situation of minimum efficiency, where the cases in the column to be predicted are evenly distributed. Tables 1 and 2 illustrate this:

Tables Adjusted to Maximum and Minimum Predictive Efficiency

Table 1

Maximum Predictive Efficiency

	Cause 1	Cause 2	Cause 3
Effect 1	60	0	0
Effect 2	0	60	0
Effect 3	0	0	60

Table 2

Minimum Predictive Efficiency

	Cause 1	Cause 2	Cause 3
Effect 1	20	20	20
Effect 2	20	20	20
Effect 3	20	20	20

The absolute sum of the differences between the cell frequencies in Tables 1 and 2 represents the departure of the minimum model from the maximum. We next obtain the absolute sum of the differences between the cell frequencies of a set of original observations from the cell values in the table of maximum efficiency. The ratio of the two absolute sums of differences will be an index of the relative departure of the table of raw data from maximum predictive efficiency. K then is a measure of this efficiency. For any table of the same column totals and same number of rows and columns, K means the percentage of approach to the maximum predictive efficiency. When there is a difference in the column populations, another measure, K' (the one used in this study), eliminates the effects of the column totals by making an unweighted estimate.

The computational formulas for K, K', and K_j and the formulas for their standard errors are as follows:

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[1]McCormick, Thomas C., "Causal Analysis in the Prediction of Attributes," American Sociological Review, Vol. 17, No. 1, February, 1952, pp. 40-41.

f_d = frequency in main diagonal from upper left to lower right

${}_if_j$ = cell frequency of i th row and j th column

ℓ = number of rows

m = number of columns

N = total table frequency

n_j = sum of frequency of j th column

p_d = proportion of column total in main diagonal from upper left to lower right

For any column, j:

$$K_j = (\ell f_d - n_j)/(\ell - 1)n_j \text{ , and} \tag{1}$$

for the entire table:

$$K = (\ell \overset{m}{\Sigma} f_d - N)/(\ell - 1)N \text{ .} \tag{2}$$

Formula (2) is affected by differences in the column populations of the experience table. A formula which gives equal weight to each column is:

$$K' = (\ell \Sigma p_d - m)/(\ell - 1)m. \tag{3}$$

For any column:

$$K'_j = (\ell p_d - 1)/(\ell - 1). \tag{4}$$

In a 2 x 2 table, the cell frequency is ${}_if_j$, and ${}_ip_j = {}_if_j/n_j$; for a column:

$$K_j = ({}_1f_j - {}_2f_j)/n_j = K'_j = {}_1p_j - {}_2p_j. \tag{5}$$

For the whole table:

$$K = 1 - 2({}_2f_1 + {}_1f_2)/N, \text{ and} \tag{6}$$

$$K' = ({}_1f_1/n_1) - ({}_1f_2/n_2) = {}_1p_1 - {}_1p_2 \text{ .} \tag{7}$$

Approximate standard errors of sampling squared of K and K', where i and j refer to different possible column combinations, and C_2^m is the number of combinations of m columns taken 2 at a time, are:

$$\epsilon_K^2 = \left(\frac{\ell}{N(\ell - 1)}\right)^2 \left[\sum^m n_j p_d q_d + 2K \sum^{C_2^m} \sqrt{(n_i p_{di} q_{di})(n_j p_{dj} q_{dj})}\right] \quad (8)$$

$$\epsilon_{K'}^2 = \frac{1}{(\ell - 1)_2} \left[\sum^m \frac{p_d q_d}{n_j} + 2K' \sum^{C_2^m} \sqrt{\frac{(p_{di} q_{di})}{n_i} \frac{(p_{dj} q_{dj})}{n_j}}\right] \quad (9)$$

For any column:

$$\epsilon_{K_j}^2 = \left(\frac{\ell}{\ell - 1}\right)^2 p_d q_d / n_j \quad (10)$$

For a 2 x 2 table:

$$\epsilon_{K'}^2 = \sum^2 \frac{p_d q_d}{n_j} + 2K' \sqrt{\frac{p_{d1} q_{d1} p_{d2} q_{d2}}{n_1 \quad n_2}} \; . \quad (11)$$