

AN
INDUSTRIAL DYNAMICS SIMULATION MODEL
FOR
LONG-RANGE PLANNING
AT A
STATE MENTAL HEALTH INSTITUTION

by
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TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS.	iv
LIST OF TABLES	v
LIST OF ILLUSTRATIONS.	vi
SUMMARY.	vii
Chapter	
I. INTRODUCTION	1
Objective	
Problem Background	
The Unit-Area System	
Computer Simulation	
Industrial Dynamics	
DYNAMO: The Modeling Language	
The Systems Approach	
The Nature and Significance of Results	
Scope and Limitations	
II. LITERATURE SURVEY	15
Trends in Mental Health Care	
Long Range Planning	
III. THE MODEL	23
Description of the Patient Flow System	
and Corresponding Mathematical Model	
Computed Constants	
Constants	
IV. DISCUSSION AND ANALYSIS	38
Overview of Simulations	
Simulation One	
Simulation Two	
Simulation Three	
Simulation Four	
Simulation Five	
Simulation Six	

V. RESULTS, CONCLUSIONS AND RECOMMENDATIONS.	43
Results	
Conclusions	
Recommendations	
APPENDICES	48
REFERENCES	71

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LIST OF TABLES

Table	Page
1. Comparison of Actual Versus Simulated Annual Admissions to Central State Hospital	49
2. Population Projections for Counties in Unit 1 1968-1975	50
3. Population Projections by Unit, 1970-1975, Versus Present Available Beds and Occupancy.	51
4. Analysis of Counties with Highest Annual Rates of Admission, 1961-1968	52
5. Patient Population Data - Central State Hospital. . .	53
6. Patient Population Data - Unit I.	54
7. Patient Population Data - Unit I, Powell Building . .	55
8. Patient Population Data - Unit I, Walker Building . .	56
9. Patient Population Data - Unit I, 10th Ward	57
10. Projected Average Unit Occupancy as Unit I Counties are Varied (1967-1970).	58

LIST OF ILLUSTRATIONS

Figure	Page
1. DYNAMO Time Notation.	5
2. Fractional Multiple of Patients in Unit I Placed On Furlough and Escape	25
3. Hypothesized Impact of Unit Occupancy on Patient Transfers to Other Units.	28
4. Conceptual Model, Patient Flow System, CSH.	59
5. Industrial Dynamics Model, Patient Flow System, CSH .	60
6. Definition of Abbreviations in ID Model for Simulation.	61
7. Simulation One Results.	62
8. Simulation Two Results.	63
9. Simulation Three Results.	64
10. Simulation Four Results	65
11. Simulation Five Results	66
12. Simulation Six Results.	67
13. Unit Area Geographical Districts.	68
14. Area Map of Central State Hospital.	69
15. Computer Program Listing.	70

SUMMARY

The objective of this research is to develop a computer model that can be utilized for simulating the time-varying behavior of the Patient Flow System (PFS) at Central State Hospital (CSH). This model is to be utilized as a research tool, enabling the planning authorities at the hospital to study the long-range implications of their policy decisions today.

Specifically, a computer simulation model is developed; programmed with known data regarding such factors as admission, discharge and furlough rates at CSH; checked for validity against known behavioral patterns; and refined until the model is realistic, i.e., performs in accordance with known trends. The model is then programmed to project patient flow trends over a five-year planning horizon. The results are particularly useful in determining: 1. the significant policies affecting unit occupancy levels, 2. in what time span improper utilization of resources under the present Unit-Area organization scheme will occur, and 3. ways planning authorities can exert control in order to alleviate problem areas and "bottlenecks" at the hospital before they occur.

The computer programming language, DYNAMO, (for DYNAMIC Modeling language) is employed herein for its ease both in formulating the model as well as in interpreting the computerized results. Printed and plotted data are "automatically" generated as a product of each simulation run.

A search of relevant information regarding the topic of this the-

sis revealed a paucity of computer applications studies in the mental health field. There is, however, an abundance of information on trends in mental health care, particularly the Community Mental Health Care concept. Since this new trend in mental health care appears to be significantly influencing admission rates in the large state mental health institutions, current thoughts on this subject are reported.

With a precise model developed and defined within a framework of awareness of new and pertinent trends in mental health care, two particular areas of concern regarding the PFS are studied: 1. patient assignments according to the present Unit-Area organization plan (referring to the plan whereby a patient is assigned to a specific unit at CSH according to his county of residence), and 2. various hypothesized "impacts" or effects upon admission rates to CSH as caused by new, decentralized modes of mental health care in Georgia.

Analysis of the results of this study indicates that the planning authority for CSH can utilize the model herein to realign the present Unit-Area organization so as to achieve better balance in the allocation of resources for CSH and, through continual updating of information and simulation of the PFS, refine long-range planning capability as a result of having more thorough understanding of the "impact" of new trends in mental health care upon the unit occupancy levels at the hospital.

CHAPTER I

INTRODUCTION

Objective

The objective for this research is to develop a computer model that can be utilized for simulating the dynamic nature (the time-varying behavior) of the Patient Flow System (PFS) at Central State Hospital (hereafter referred to as CSH). The computer model developed is intended to serve as the primary research "tool" for long-range planning requirements at CSH.

Problem Background

The charge for this thesis study originated with Mr. Rod Clelland, Administrator at CSH, with the following statement:

The imbalance of patient loads in the Psychiatric Units and placement of patients in Units other than their own is largely caused by changes in admissions rates from various counties since the inception of the Unit System.

A study is required to show predictable admissions of the future, added to the present occupancy, compared to predictable departures (deaths, furloughs, discharges), against a background of available conforming bed space in each building. It will be used for a proper distribution of patients. The study recommendations are to include:

1. What counties shall make up what Units; and
2. What buildings shall be in what Units (1).

The Unit-Area System

The Unit-Area System at CSH refers to the organizational plan or scheme whereby a patient is assigned to a specific Unit at CSH (see Maps on pp. 68 according to his county of residence. First men-

tion of this plan is found in MacKinnon's (2) letter to Dr. Addison Duval, Director, Division of Mental Health, Georgia Department of Public Health (July 1, 1965):

In the fall of 1964 comprehensive surveys were made by the Governor's Commission on Efficiency in Government, better known as the Bowdoin Commission, and a survey team from the National Institute of Mental Health which made the study at the request of the Bowdoin Commission. These two surveys resulted in several excellent reports and provided the hospital with much valuable information for future planning and improvement in areas of patient care and treatment, education, and research. While both surveys commended advances that have been made, they also pointed out that if the hospital is to maintain minimal efficiency in its programs, there must be considerable reorganization of the institution, equalization of staffing patterns, additional professional staff in all areas and adequate buildings and equipment.

One of the major recommendations of the survey committees was that the present unit system be reorganized so that the units would be identified with certain geographical areas. Accordingly, this has been done. Patients from the northeastern section of the state to Unit 5, the northwestern section to Unit 4, the southwestern section to Unit 3. A map showing this alignment and the buildings in each unit will be found elsewhere in this report. Assignment to the units is being made irrespective of race, creed, or color, and resident patients have been exchanged between the various hospital units and this regional placement is now complete. No further patient exchange is contemplated.

Computer Simulation

Many considerations affecting patient policy-making at CSH are continuously changing and interacting, to name a few -- admissions rates, furloughs, discharges, the rate of construction of the Regional Mental Health Hospitals, and the county constituency of each Unit-Area at the hospital. In order to comprehend and predict the effects that various alternative policies may have, without having to actually implement them, a computer simulation was developed. Patient flows into and out of CSH are described by a mathematical model, and a computer in turn is used

to calculate the response of the mathematical model to alternative inputs.

The advantage of using a computer is that as alternative management policies are suggested; for example, altering the component counties comprising a unit changes the values in the mathematical model, but the computer can quickly determine the resulting effects. In general, computer simulation is a method of testing management policies before implementing them.

Industrial Dynamics

Industrial Dynamics (ID) is a dynamic feedback systems analysis technique. It is also a managerial philosophy. Since the inception of its use over ten years ago, ID has matured into a logical, scientific approach - applicable for analyzing a multiplicity of behavioral, feedback type systems.

ID considerations are employed in this project for the development of the simulation model. A basic premise of ID is that the dynamic behavior of the institution or enterprise to be modeled is created by an underlying system of information-feedback relationships (3).

An information-feedback system exists whenever the environment leads to a decision that results in action which affects the environment and thereby influences future decisions. Such is the nature of the Patient Flow System at CSH, i.e., the decision making authorities at the hospital act to control the flow of patients to and from CSH in response to predetermined goals of unit balance and occupancy level viewed in contrast to the apparent state of these selected reference criteria at any

point in time, retarding or advancing the flow, reviewing the results of these decisions periodically and, at a later time, repeating the process.

To assist the researcher with details of an ID simulation approach to systems analysis there exists a most useful computer programming language -- DYNAMO, or DYNAmic MOdeling language.

DYNAMO: The Modeling Language

DYNAMO is a computer programming language for translating mathematical models from an easy-to-understand notation into tabulated and plotted results. The models may be of any dynamic feedback system that may arise in business, economics, or engineering. The principal limitation on the model is that it will be a continuous representation of the real world. As DYNAMO does not recognize individual items or events, models of job shops and the like cannot be tested (4).

A model written in DYNAMO consists of a number of algebraic relationships that relate the variables one to another. The notation is very similar to that of a general purpose scientific compiler (for example, FORTRAN). A few of the advantages of using DYNAMO rather than a general purpose compiler are:

1. The time notation greatly aids one in comprehending the order of computation.
2. DYNAMO's output includes graphic results, saving the user time and effort that he would otherwise spend plotting his data.
3. All forms of the output can be specified exactly, even to

the point of not having to supply the scale factors for the tabulated results or the scales for the plotted results.

Explanation of Time Notation and Variable Types

The basis for the time notation is the procedure by which the computer calculates the results, which is to move through TIME in discrete steps and calculate all the variables at each step. Figure 1 illustrates this procedure.

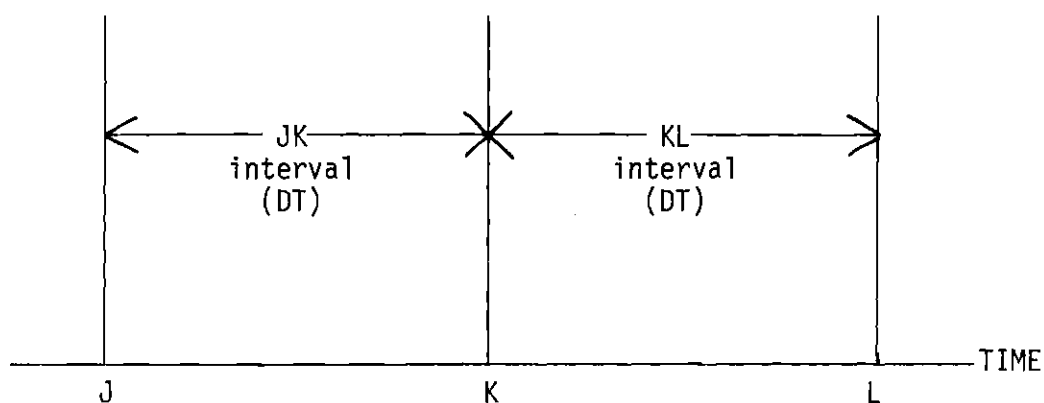


Figure 1

DYNAMO Time Notation

The TIME for which the calculations are currently being made is called TIME K. The previous TIME for which calculations were made is called J, and the next instant for which calculations will be made is L. The intervals between these times are called JK and KL. The length of

these intervals is called DT.

The names of instants and the intervals are used to specify when a quantity is calculated and when the quantities used in the calculations were previously calculated. Once all the variables have been calculated for the instant K and the interval KL, the computer moves forward one time step, and the values that were associated with TIME K are now related to TIME J.

This notation system was chosen in preference to one derived from differential equations because many users unfamiliar with higher mathematics will be able to understand and to use this step-by-step notation.

There are three principal types of variables in DYNAMO: levels, rates, and auxiliaries.

Level. A level, which is calculated at TIME K, is a quantity that depends upon its value at TIME J and on other quantities at that TIME or in the JK interval. Inventory is an example in that the inventory today is equal to the inventory at an earlier time plus what has been received minus what has been shipped during the JK interim (5). Thus the level equation:

$$IAR.K = IAR.J + (DT) (SRR.JK - SSR.JK)$$

IAR	=	Inventory Actual at Retail (Goods)
DT	=	Delta Time (Weeks)
SRR	=	Shipments Received at Retail (Goods/Week)
SSR	=	Shipments Sent from Retail (Goods/Week)

Rate. The decisions in business and economic models are called rates. Rates are the flows of tangible things from one level to the

next. They are computed at TIME K for the interval KL from levels and auxiliaries at TIME K and occasionally from rates in the JK interval (6).

An example of a rate equation follows:

$$PSR.KL = RRR.JK + (1/DIR) (IDR.K - IAR.K)$$

PSR = Purchase orders Sent from Retail (Goods/Week)
 RRR = Requisitions Received at Retail (Goods/Week)
 DIR = Delay in adjusting Inventory at Retail (Weeks)
 IDR = Inventory Desired at Retail (Goods)
 IAR = Inventory Actual at Retail (Goods)

Auxiliary. Auxiliaries are variables that are introduced to simplify the algebraic complexity of rate equations. They generally have some physical meaning and consequently simplify the understanding of the model. They are computed at TIME K from levels and other auxiliaries at the same time and occasionally from rates in the JK interval. By their nature they can be eliminated by substitution into the rate equations (7). Following from the above example, the desired inventory is the number of weeks of averaged sales, implying:

$$IDR.K = (AIR) (RAR.K)$$

IDR = Inventory Desired at Retail (Goods)
 AIR = Constant for Inventory at Retail (Weeks)
 RAR = Requisitions Averaged at Retail (Goods/Week)

Order of Computation. The order of computation at TIME K is:

1. Levels, which are based on quantities from TIME J and the JK interval;
2. Auxiliaries, which are based on levels and auxiliaries computed earlier at TIME K and on rates JK;
3. Rates, which are based on levels and auxiliaries from K and other rates from JK.

The Systems Approach

In formulating and constructing a dynamic model for computer simulation, each of the variables that conceivably demonstrates a meaningful pressure for change on the defined system (the PFS) must initially be considered. Often, too few or too many factors will be included in the initial formulation of a conceptual model, though these errors of omission or commission are usually discovered as one proceeds through an iterative trial and error process in testing the simulation model.

The conceptual model referred to earlier is constructed by synthesizing the relationships between the various levels and rates as shown in Figure 2. Each arrow represents a causal relationship or flow of information from the factor at the tail of the arrow to the factor at the head of the arrow. A feedback loop may be identified as a closed path of causal relationships which passes through each factor along its path exactly one time. The dotted arrows indicate that the system will be affected by certain exogenous factors, but these factors are not affected themselves by the system.

With a feasible conceptual model developed, the next step in deriving a model for simulation is to determine from historical data the weekly distribution of the number of admissions, discharges, deaths, furloughs, escapes, and transfers for the particular unit under investigation. These data assist the researcher in moving from the static conceptual model of the PFS to a dynamic model that will demonstrate meaningful system variation. System variation results from the changing flow rates (considering both people and information) which emanate

from and terminate to the various accumulations (levels) defined with the system.

The new, dynamic model, as illustrated in Figure 3, is checked for validity by comparing simulation results against previously exhibited behavior of the PFS at CSH. As soon as the system elements have been accurately weighted and juxtaposed in the model so as to reflect true causality relationships; application of the model is commenced by hypothesizing future operational policies. Any permutation of the individual element values which might feasibly occur in a "real-world" situation can be tested through the process of computer simulation and corresponding system behavior recorded.

The Nature and Significance of Results

The mathematical model developed in Chapter III should ultimately lead to enhanced understanding of the PFS at the hospital. It should be useful as a guide for establishing policies and developing decision criteria effective in maintaining the established policies. Utilizing the herein developed model incorporates the following assumptions:

We have acquired a basic knowledge regarding the characteristics of the PFS.

These known and assumed facts interact to influence the way in which the system behaves over time.

Constructing the mathematical model and, in turn, simulating the system enables us to achieve better understanding of the system with which we are dealing.

Validity and significance are too often discussed outside the context of model purpose. Usefulness can be judged only in relation to a clear statement of purpose. The goals set the frame for deciding what a model must do. The absolute significance of this research can be no greater than the significance of its goals. The value of goal orientation, translated into purposeful research, transcends all other considerations in determining the *usefulness* of this research.

An elaborate and accurate model can do little if it relates to questions and behavior that are of no consequence to the success of the organization. Note that the results of this particular research assist in determining how the present system can be feasibly altered; the types of information most valuable to the policy makers regarding future admission, discharge and furlough policies; and avenues of action that must be taken to effect desired system characteristics - all important and worthy achievements. Forrester comments that, on the other hand, a

simple and even inaccurate model (since the focus of the *research* is the development of the *model*, the words are used interchangeably) may be tremendously valuable if it yields only a little better understanding of the reasons for major success and failure of the system modeled (8). Enhanced understanding of the system being analyzed enables the planning authorities of the hospital to develop an improved, more effective system. The efforts of this research endeavor become entirely academic if such results are not obtained.

From an operational standpoint, the model herein developed may be used to predict the results that will ensue from a *change* in organizational form or policy. The important consideration is the *direction* of the *major changes* in the system performance that will result from altering a structural relationship or a policy in the system. Second, the approximate *extent* of the system's improvements will also be displayed as a result of the simulation.

Further investigation and experimentation with the model should result in depicting what would happen *if* the real system had characteristics like the model. It is significant that much can be learned by studying the systems that *might* exist. In fact, this is the major reason for model experimentation through simulation.

Experimentation in developing the model centers around plausibility and not absolute numerical accuracy. Defending a one-to-one correspondence of the assumptions to reality is secondary to emphasizing what the model can teach, so long as the model reflects the *kinds* of thing that *might* exist in a real situation. If the model is plausible or possible at the level of elementary actions within the system,

it will serve to teach much about dynamics of large systems (9).

The presumption of model significance rests on two foundations. Primarily, confidence depends on how acceptable the model is as a representation of the separate organizational and decision-making details of the actual system. Secondly, confidence is confirmed by the correspondence of total model behavior to that of the actual system. It will be demonstrated that the model herein developed does, in fact, demonstrate behavior corresponding to actual system behavior as recorded.

ID models are built on the same information and evidence used for the manager's usual mental model of the management process. The power of ID models such as the one developed in this research does not come from access to better information than the manager has. Their power (sic ...ID models), says Forrester, lies in their ability to use more of the same information and to portray more usefully its implications (10). Herein rests the fundamental significance of the results of this research.

Scope and Limitations

As discussed previously, the primary objective of this research is not to predict future events; neither does the computer model thus designed attempt to optimize the system or any part of the system.

Since it is desirable that the model indicate the effect of real system changes, there must be a correspondence between the parameters and the structure that might be changed in the model and the actual parameters and structure of the system. In other words, a proposed model re-design must be meaningful in terms of changes that *can* be accomplished in the real system. Thus, model experimentation will be

limited only to potentially *real* situations. The mechanisms of the model must generate the *nature* of the dynamic characteristics that are of interest; otherwise, it is not a vehicle for detecting how those characteristics can be changed.

There seems to be a general misunderstanding to the effect that a mathematical model cannot be undertaken until every constant and functional relationship is known to high accuracy. This often leads to the omission of admittedly highly significant factors (most of the *intangible* influences on decisions) because these are unmeasured or unmeasurable. To omit such variables is equivalent to saying they have zero effect - probably the only value that is known to be wrong (11)!

In general, the scope of this research endeavor encompasses a fundamental "building upward" from the characteristics of the separate components of the conceptual system and incorporating and estimating the values of all factors that our descriptive familiarity with the system tells us are important. This model will communicate easily with the decision authority at the hospital because it was spawned from the same sources and developed out of the same terminology as their own experience.

The model developed herein for simulation is limited to coverage only of Unit-Area I, inclusive of the buildings presently comprising this unit, the constituent counties (Fulton, Clayton, DeKalb) of this unit, as the boundaries now exist, and the mentally ill portion of the Georgia population in and from these buildings and counties respectively.

The model does not differentiate between male and female patients or among the various age groups or races. Sophistication of a computer

simulation model to the extent of including such comprehensive detail is not warranted in view of the desired usage of this model. Besides, there exists sufficient flexibility in the wards of Unit I buildings to accommodate gradual changes in the gender and age of the patients; the point to be established is that the primary concern of the planning authority (those persons responsible for the admission and welfare of the mentally ill assigned to CSH) is the general occupancy level of the unit (see Tables 5-10).

Since the emphasis in this research is on the development of a useful model, extensive experimentation with alternative permutations of the model are not within the scope of this endeavor.

The simulated system configurations do include: 1. experimentation with three different hypothesized admission rates of the Unit-Area I patients into the regional mental hospital in Atlanta, as opposed to CSH; and 2. experimentation with three alternative reorganizational schemes presented in contrast to the present county constituency of Unit-Area I.

The validated model is presented in detail, and the real-world interpretation of each variable is explained. The actual computer output is shown for various simulation runs. These print-outs show in graphic and tabular form the simultaneous changes in magnitude of the variables of interest (see Figures 1-6).

It is worthwhile to re-emphasize that this model does not delineate any specific course of action by the decision-making body. It is only a device, a tool to aid in the decision-making process.

CHAPTER II

LITERATURE SURVEY

Of prime importance to the overall thesis development is the identification and understanding of those considerations which might affect the behavior of the system that is to be modeled. In this respect, a survey of many current articles and publications related to mental health care in general, long-range planning practices, and computer simulation applications related to this thesis topic are examined. Effectually, this literature survey is intended to serve as a backdrop to set-the-stage, i.e., to add dimension to the research endeavor by casting the system to be modeled within the perspective of modern trends and technological advances related to the planning for and delivery of mental health care in the U.S. today.

Trends in Mental Health Care

Long-term trends in our economy and social structure are radically affecting the supply and demand for mental health resources. Population increases, both generally and in the over-65-year-of-age bracket, growing ratio of nonwhites to whites, increasing proportion of women, increasing urbanization, industrialization, educational levels and per capita income are only some of the major factors affecting the demand for mental health services and facilities.

The mental health field provides a good example of medical progress affecting these resource requirements. This evolutionary tide

is concerned not with specific curative or preventive agents though but rather with a conceptual change that involves reorienting the therapeutic program to hasten the return of the mental patient to the community. This procedure not only affects the rate of patient turnover but also results in a reduction in total bed requirements (12).

In recent years, the mental health field has made substantial gains in the care and treatment of mental disorders. After decades of steadily rising state hospital resident populations, there has been a nationwide decline in spite of sharply increased numbers of admissions (13). After decades of poor prognosis and long institutionalization for state hospital admissions, more and more patients are rapidly returning to their homes and community.

In the 1950's the psychoactive drugs entered the picture. For the first time we had some means for making more accessible other types of treatment for the majority of the patients under our care. Following closely on these developments, the idea of a therapeutic community became more widely recognized (14).

These developments, together with the greater use of new techniques such as group methods, psychodrama, meaningful vocational rehabilitation, and partial hospitalization, have fostered a generally optimistic attitude toward the treatment of the mentally ill. It seems that the majority of our patients can live with their own families and only a minority require some degree of on going agency support to function. Fewer patients appear to need the kind of total institutional support we once associated routinely with the state hospital admission (15).

The very success that modern programs have achieved in returning patients to their communities has made increasingly acute the need for more widely accepted indices of adequate community functioning and has rendered less useful the more traditional measures of program accomplishments such as length of stay, response to treatment, and re-admission rate (16).

Major developments in the science, technology and organization of medical care are and will continue breaking traditional patterns in rendering such care, and definitely point in the direction of multidisciplinary and institutional makeup in the delivery of mental health services (17). The systematic development of the trend toward community-centered medical care, for example, would significantly alter the present balance between inpatient and outpatient requirements, and would probably result in both geographic and administrative decentralization of large medical centers. The organizational framework of medicine is changing continually, reflecting the changes taking place both in medical technology and in the major social movements of our time (18). The community mental health center, geared to the provision of short-term care, is one example of a change that will affect Central State Hospital.

Mentioned above, the community mental health center is geared to the provision of short-term care, and in this respect is very similar to the non-psychiatric services of general hospitals. Short-term care is a key part of the mental health service system. Its availability and use can actually reduce the need for long-term hospitalization, but the problem of chronic mental illness has not been completely eliminated. Chronic conditions exist, and facilities for long-term care are still

essential (19).

Specifically, the organizational concept of care known as the community mental health center which embraces the care considerations of caretaker-patient relationship, continuity, accessibility and comprehensiveness is an ideal concept. It does not prescribe how segments of cities, a city, a county, or a combination of counties can achieve comprehensive care in mental health. Neither does it spell out who the partners in the enterprise should be and how they should relate to each other. What the center concept lacks in clarity, though, is by the same token its strength for implementation in varied communities (20).

The National Institute of Mental Health Community Centers Program, initiated in 1963, provides financial assistance for the construction and initial staffing of new services in community mental health facilities. Under this program, approximately 202 grants have been awarded through June 30, 1967, for the construction of center buildings, and 134 grants have been awarded for their staffing (21).

A recent newspaper article brings to light many pertinent facts and figures related to the Regional Mental Health Hospital Program and Community Mental Health Center Movement in the State of Georgia (22). Following are salient, modified highlights of that article.

For years, report after report urged the state to decentralize the Milledgeville institution, which in the early 1960's housed 13,000 patients.

Health officials realized that the crushing load of patients there meant that many received less than adequate treatment, and that real treatment could come only if the population were reduced to reasonable size.

Out of a search for the means to accomplish this reduction came the

Regional Hospital Concept. This concept calls for eight small hospitals, with no more than 1,000 patients each, so that no patient could get lost in the shuffle.

When the regional hospital system is completed, hospital services will be available for each Georgian within 50 to 60 miles of his house.

The score so far on a ten year master plan through 1974 is:

The institution in Augusta is beginning to accept patients and expects to have 300 by July of 1971, in line with current budget appropriations.

In Savannah, an institution is about 50 percent complete.

The legislature this year budgeted \$100,000 for Columbus and Rome to begin planning hospitals. An original timetable anticipated this almost two years earlier but the budget squeeze has been on.

Still on the drawing board are hospitals at Albany, Gainesville, and Macon.

Ironically, just as the general public is growing aware of the regional program, the health department is now calling for a reappraisal of overall mental health priorities.

The first Community Health Center will open its doors shortly and will be an extension of the new Northside Hospital complex in Atlanta. It is anticipated that this occurrence will ultimately have a significant bearing on the admissions to CSH from the Fulton County area. Obviously though, a period of several months from the opening date of the new complex must transpire before an accurate evaluation of patient admissions to the respective hospitals can be assessed.

Long Range Planning

Definition

Long range planning, for purposes of this thesis study, shall be defined simply as the forward planning of the institution's (CSH's) ac-

tivities from the present into the future as far as it is practical to plan. G. A. Steiner defines planning as "the conscious determination of courses of action to achieve preconceived objectives. It is deciding in advance what is to be done, when it is to be done, and how it is to be done. It can range from the detailed, specific and rigid to the broad, general and flexible design" (23).

Steiner also says,

Long-range planning does this for extended periods of time. Long-range planning is a process of establishing long-range goals; working out strategies, programs, and policies to achieve those goals; and setting up the necessary machinery to insure that the company gets where it wants to go.

The length of time for long-range planning varies from industry to industry and from company to company. The length of the planning period should be determined by:

1. time it takes to prepare for the decision
2. time it takes to implement the plan in light of
3. the time when implementation must be completed.

Examples of the length of long-range planning are 40 years for the pulp and paper products industry and only two years in industries where rapid style changes occur, such as in clothing. Most organizations and institutions seem to have decided on a five year plan.

Purpose of Long-Range Planning

The real purpose of long-range planning is not so much having a plan as it is developing the processes, attitudes and perspective which make planning possible. It is a teaching process to help members of the organization stand back and look at the past, present, and future and to use the past to plan for the future and realize that today's decisions

cause tomorrow's decisions. It is a means to an end. Management must recognize the possible implications of long term commitments made today and prepare now for commitments which will have to be made rapidly, economically, and with as little shake-up of the organization as possible (24).

Long range planning desires to accomplish the following:

1. Raise the sights of the executives who make commitment decisions today, by bringing more awareness of possible changes in the future on decisions involving long term commitments
2. Make the executives aware of future decisions which will have to be made; when and in what magnitude
3. Anticipation of problem areas and potential profit opportunities
4. Increase the speed of relevant information flow
5. Foster and provide for less disruptive implementation of future decisions.

To reiterate on the focal point of this thesis project, long-range planning in the delivery of Mental Health care must allow for the introduction of new concepts. Certainly the Georgia Department of Health is making strides in the direction of developing and implementing new concepts for the delivery of such care.

Careful planning then, necessarily should include consideration of the impact of the system of mental health care in Georgia resulting from these new concepts; especially with respect to projected future utilization of large scale institutional care as administered through CSH.

A sharp decline in admissions to CSH could ameliorate many of

the problems associated with the extremely high patient load per bed now found at the hospital. In time, the actual impact of the new programs on the admissions rate to CSH will be realized, but through the use of computer simulation of plausible hypothesized "admissions impacts" - much insight into future admissions behavior can now be derived. This idea encapsulates the rationale for simulations tests I, II, and III where various situations specifically regarding the implications of opening new Mental Health Care facilities upon admission to CSH are studied.

In this regard, i.e., predicting admissions, we note a method of prediction suggested by the public health service. This method, which uses present utilization rates in making projections, is now being tested and evaluated by several hospital planning councils (25). It has an advantage over the other methods of predicting future use in that changes in two very important factors, age and sex, are incorporated in the analysis. Projections are made of age and sex distributions in the area, and utilization rates are then calculated separately for each age-sex category.

To be sure though, in studies of factors affecting use, it is not so important to develop a list of the many factors which may influence demand as it is to learn the weights or the relative importance of each factor. For only by learning the relative importance of these factors can proper mechanisms be developed for translating need into demand and, conversely, to reduce the demand that is not expressive of need (26).

CHAPTER III

THE MODEL

Verbal and Mathematical Description of PFS

Population Growth

The three counties of Unit I had a total population of 1,100,000 in 1967 and have a forecasted population of 1,497,771 for 1975. (From Table 2). To derive the population for any period between 1967 and 1975 (416 weeks), it is assumed that the population will increase uniformly to the 1975 projected figure.

Computer Equation

Equation Number

$$\text{UAPIF.KL} = (1/\text{LENGTH}) (\text{UAP75}-\text{UAP67}) \quad (1)$$

$$\text{LENGTH} = 416$$

$$\text{UAP75} = 1,497,771$$

$$\text{UAP67} = 1,100,000$$

Explanation of "Computer" Abbreviations

UAPIF	=	Unit County Population Increase Factor (People/Week)
LENGTH	=	Length of Time Over Which Model is Simulated (weeks)
UAP67	=	Unit County Population 1967
UAP75	=	Unit County Population 1975

Admissions Rate

The number of candidates for admission is assumed to be directly

proportional to the total population. This figure is adjusted by a factor that reflects the impact of the Atlanta Regional Mental Health Hospitals upon the admissions candidates to CSH.

$$ROA.KL = (UAPF) (UAP.K) (ROAAF.K) \quad (2)$$

$$ROAAF.K = TABHL (MULT, TIME.K, 0,416,26) \quad (3)$$

$$MULT = 1.0/.95/.90/.83/.72/.72/.72/.72/.75/.72/.72/.72/.72/.72/.72/.72/.72/.72$$

ROA = Rate of Admission
(Patients/Week)

UAPF = Unit County Population Admission

UAP = Unit County Population (People)

ROAAF = Rate of Admissions Percentage
Adjustment Factor (Dimensionless)

TIME = The Week During Which Each Indicated
Percentage Applies

Placing Candidates

It is assumed that all candidates for placement into Unit I will be allowed to enter.

$$ROP.KL = CFP.K \quad (4)$$

$$CFP.K = (\text{Described later in Equation 23})$$

ROP = Rate of Placement (Patients/Week)

CFP = Candidates for Placement into Unit I (Patients)

Furloughs and Escapes

As the occupancy rate approaches 100 percent, it is assumed that there is increasing pressure to furlough more patients. Graphically

this is shown as follows:

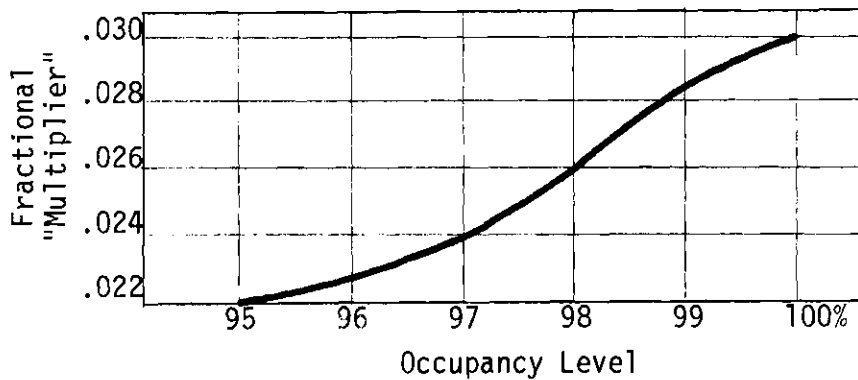


Figure 2.

Fractional Multiple of Patients in Unit 1 Placed on Furlough and Escape...Function of Unit Occupancy Level

$$PFE.KL = (PFEF.K) (PU.K) \quad (5)$$

$$PFEF.K = TABHL (PFET, OCP.K, 95, 100, 1) \quad (6)$$

$$PFET^* = .022/.023/.024/.026/.029/.030$$

PFE = Patients Placed on Furlough and Escape (Patients/Week)

PFEF = Patients Placed on Furlough and Escape Factor (1/Week)

PU = Patients in Unit I (Patients)

PFET = Fraction of Patients in Unit I Placed on Furlough and Escape Versus the Occupancy Level of that Unit

Returns from Furlough

Over time, about 50 percent of the patients placed on furlough or escape return to the hospital. These patients are assigned to a building as new admissions according to the Unit-Area Organizational Policy.

Historical data collected for the years 1967 and 1968 indicates that six weeks is the average length of time that a patient stays on leave or remains escaped before returning or being returned to the hospital.

$$RTN.KL = \text{DELAY } 3 \text{ (PFEFR.K,6)} \quad (7)$$

$$PFEFR.K = (PFE.K) (.50) \quad (8)$$

PFE.K = (from Equation 5)

RTN = Returns from Furlough and
Escape (Patients/Week)

PFEFR = Patients on Furlough and Escape -
Fraction Returning to Unit Over Time

PFE = Patients Placed on Furlough and Escape
(Patients/Week)

Transfers Into Unit I

There are patients at CSH residing in Units other than the one that the present Unit-Area Organizational scheme would indicate. Although relatively small, there is a continuing effort to relocate these patients in their proper Unit. A major consideration is the availability of beds in the "proper" Unit. Experience indicates that a reasonable policy for a Unit to maintain is to accept an average of three persons per week (some weeks more, some less) transferring into that Unit as long as there is ample bed space. An arbitrary decision rule for Unit I is suggested here allowing approximately three transfers-in per week if the Unit occupancy is below 99.0% (about 13 to 15 beds available), otherwise allow no transfers-in per week.

$$TI.KL = \text{CLIP } (P.K, Q.K, R.K, S.K) \quad (9)$$

$$P.K = 0$$

$Q.K = (1) \text{ NORMRN } (3,1)$

$R.K = OCP.K$

$S.K = 99.0$

$OCP.K = (\text{Described later in Equation 23})$

TI = Transfers-into proper Unit
(Patients/Week)

$(X) \text{ NORMRN } (Y,Z)$ = X times a normally distributed
random number (mean-Y, standard
deviation-Z)

OCP = Occupancy of Unit (Percentage)

Transfers Out of Unit I

There is a moderate but continuous flow of patients out of Unit I to other Units where they belong under Unit-Area guidelines. It seems plausible to transfer-out approximately three patients per week, recalling that this was approximately the number transferred into the Unit. It is also reasonable to assume that as the occupancy level of the Unit climbs above 95-96 percent, there is increased pressure to transfer-out patients that do not belong in Unit I so as to provide adequately for the influx of patients that do belong in the Unit. The simulation model is designed to accommodate twice the pressure to transfer-out the "non-belongers" when the occupancy reaches 100 percent as compared to the 'pressure' at the 95 percent occupancy level (See Figure 3).

Besides the transfers to other Units, there also exists a category of transfers to other mental health institutions. For purposes of simulation (in accordance with reality, though relative data is quite scanty due to the recency of the Regional Mental Health Hospital Program) transfers to these institutions will be represented as a sudden

or "pulse" outflow from the Unit occurring at the completion or opening of each new regional center. It is further assumed that these centers will be opened at the rate of one center every two and a half years and that approximately 20 persons will be transferred to the new institution at those times.

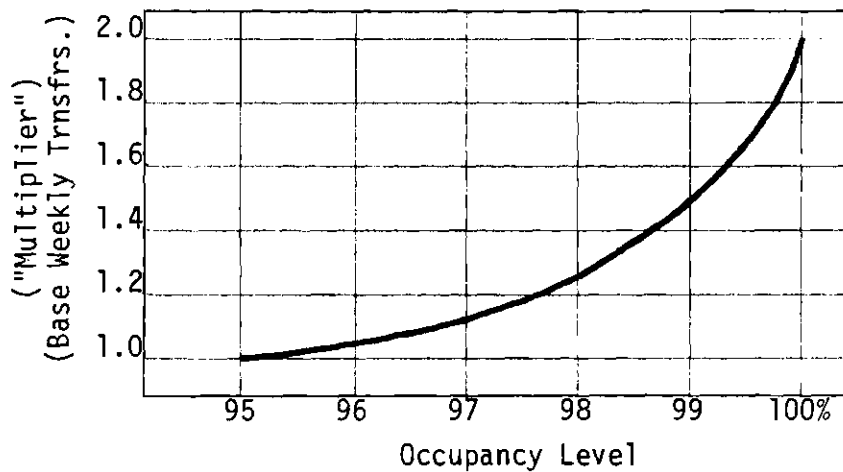


Figure 3.

Hypothesized Impact of Unit Occupancy
on Patient Transfers to Other Units

$$TO.KL = TOOU.K + TPULS.K \quad (10)$$

$$TOOU.K = (TNOS.K) (IOCP)$$

$$TNOS.K = (1) \text{ NORMRN } (3,2)$$

$$IOCP.K = \text{TABHL } (OCPI, OCP.K, 95, 100, 1) \quad (11)$$

$$OCPI* = 1.00/1.05/1.10/1.20/1.50/2.0$$

$$TPULS.K = \text{PULSE } (20, 78, 130)$$

TO = Transfers-Out to Other Units and Institutions
(Patients/Week)

TOOU	=	Transfers-Out to Other Units (Patients/Week)
TNOS	=	Transfers-Out to Other Units: Base Weekly Rate (Patients/Week)
IOCP	=	Impact of Occupancy on Transfers-Out: Base Weekly Rate (Dimensionless)
OCPI	=	Dependent Variable: Occupancy Impact
TPULS	=	Transfers-Out to the Regional Mental Health Hospital Represented as PULSE Function (Patients/Week)

Death Rate

The death rate of patients in Unit I, or any of the five geographical Units, is assumed to be a constant fraction of the total number of patients in that Unit.

$$DRPU.KL = (DRPUF) (PU.K) \quad (12)$$

$$DRPOUT.KL = (DRPUF) (POUN.K) \quad (13)$$

DRPU	=	Death rate of Patients in Unit I (Patients/Week)
DRPUF	=	Death Rate of Patients in Unit I Adjustment Factor (Patients/Week)
PU	=	Patients in Unit I (Patients)
DRPOUT	=	Death Rate of Patients in Other Units
POUN	=	Patients in other Units Belonging in Unit I (Patients)

Discharged Patients

The number of patients from Unit I and the number of Unit I patients housed in other units discharged per week is represented as a constant fraction of the patients comprising these two categories respectively.

$$DPU.LK = (RODF) (PU.K) \quad (14)$$

$$DOU.KL = (RODF) (POUT.K) \quad (15)$$

DPU = Discharges, Patients in Unit I (Patients/Week)

RODF = Rate of Discharge Factor (1/Week)

Discharges from Furlough and Escape

The number of Unit I patients discharged from furlough and escape on a weekly basis is represented as a constant fraction of the patients in this category.

$$DFE.KL = (DFEF) (FE.K) \quad (16)$$

DFE = Discharges, Patients on Furlough and Escape (Patients/Week)

DFEF = Discharges, Patients on Furlough and Escape Factor (1/Week)

Total Patient Gains

The total patient gains for Unit I per week is equal to the weekly rate of placing patients in that Unit.

$$TGU.K = ROP.JK \quad (17)$$

TGU = Total Weekly Gains for Unit I (Patients)

ROP = Rate of Placement (Patients/Week)

Total Patient Losses

The total patient losses for Unit I per week is equal to the weekly number of transfers-out to other Units and institutions plus patients placed on furlough and escape plus the number of patients who died or were discharged during the week.

$$TLU.K = TO.JK + PFE.JK + DRPU.JK + DPU.JK \quad (18)$$

TLU	=	Total Weekly Losses for Unit I (Patients)
TO	=	Transfer-Out to Other Units and Institutions (Patients/Week)
PFE	=	Patients Placed on Furlough and Escape (Patients/Week)
DRPU	=	Death Rate of Patients in Unit I (Patients/Week)

Gains from Furlough and Escape

The total patient gains on furlough and escape per week from Unit I is equal to the number of patients placed in that category on a weekly basis.

$$TGFE.K = PFE.JK \quad (19)$$

TGFE	=	Total Weekly Losses on Furlough and Escape (Patients)
PFE	=	Discharges, Patients on Furlough and Escape (Patients/Week)

Losses from Furlough and Escape

The total patient losses on furlough and escape per week from Unit I is equal to the number of patients who were either discharged or returned to their Unit during the week.

$$TLFE.K = DFE.JK + RTN.JK \quad (20)$$

TLFE	=	Total Weekly Losses on Furlough and Escape (Patients)
DFE	=	Discharges, Patients on Furlough and Escape (Patients/Week)
RTN	=	Returns from Furlough and Escape (Patients/Week)

Relocations of Patients from Incorrect Unit

Analysis of historical data pertinent to patients in Units other than the one in which they would ordinarily be assigned under the Unit-Area organizational concept indicates that there are very few Inter-Unit (Unit I through Unit V) transfers per week, and that transfers-out of the "proper" Unit to another geographical Unit are even more rare. A decision rule suggested for future operations of the Unit-Area system, and incorporated into this model for simulation purposes, was discussed under the section "Transfers Into Unit I." Adherence to strict Unit-Area doctrine will of course limit future increments to the level of patients in other "wrong" Units, thus it is anticipated that this level will be decreasing over time as the patients presently housed in other Units will gradually be transferred-into their proper Unit. In short, there will be no gains to the level of patients in other Units, only losses.

$$TLPOUT.K = TI.JK + DOU.JK + DRPOUT.JK \quad (21)$$

TLPOUT	=	Total Weekly Losses of Patients in Other Units belonging in Unit I (Patients)
TI	=	Transfers-Into Proper Unit (Patients/Week)
DOU	=	Discharges, Unit I Patients in Other Units (Patients/Week)
DRPOUT	=	Death Rate of Patients in Other Units (Patients/Week)

Unit Population

The weekly Unit population is equal to the starting population in 1967 plus the sum of the weekly increments to that population.

$$UAP.K = UAP.J + (DT) (UAPIF.JK) \quad (22)$$

UAP	=	Unit Population (People)
DT	=	Incremental Division of Time (1 Week)
UAPIF	=	Unit Population Increase Factor (People/Week)

Candidates for Placement

The candidates for placement into Unit I each week is equal to the sum of the admissions, the returns, and the transfers-into that Unit per week.

$$CFP.K = (DT) (ROA.JK + RTN.JK + TI.JK) \quad (23)$$

CFP	=	Candidates for Placement Into Unit I (Patients)
DT	=	Incremental Division of Time (1 Week)
ROA	=	Rate of Admission (Patients/Week)
RTN	=	Returns from Furlough and Escape (Patients/Week)
TI	=	Transfers-Into Unit I (Patients/Week)

Patients Per Week

The number of patients in Unit I each week is equal to the number of patients in that Unit from the previous week plus the total weekly gains minus the total weekly losses to the Unit.

$$PU.K = PU.J + (DT) (TGU.JK - TLU.JK) \quad (24)$$

PU	=	Patient Level in Unit I (Patients)
DT	=	Incremental Division of Time (1 Week)
TGU	=	Total Weekly Gains for Unit I (Patients/Week)
TLU	=	Total Weekly Losses for Unit I (Patients/Week)

Patients Furloughed and Escaped

The total number of patients on furlough or escape in any week equals the number of patients in this category the previous week plus the total weekly increase minus the total weekly decrease to this level.

$$FE.K = FE.J + (DT) (TGFE.JK - TLFE.JK) \quad (25)$$

FE	=	Furloughs and Escapees from Unit I (Patients)
DT	=	Incremental Division of Time (1 Week)
TGFE	=	Total Weekly Gains on Furlough and Escape (Patients/Week)
TLFE	=	Total Weekly Losses on Furlough and Escape (Patients/Week)

Patients in Incorrect Units

The number of patients in other Units belonging in Unit I is equal to the number of patients in that category the previous week minus the total weekly losses of patients. This level is never allowed below 10 patients since it is probable that there will always be some patients in the "wrong" Unit.

$$POUN.K = \text{MAX} (10, POUT.K) \quad (26)$$

$$POUT.K = POUT.J - (DT) (TLPOUT) \quad (27)$$

POUN	=	Patients in Other Units Belonging in Unit I (Patients)
POUT	=	Patients in Other Units Belonging in Unit I (Patients)
DT	=	Incremental Division of Time (1 Week)
TLPOUT	=	Total Losses of Patients in Other Units Belonging in Unit I (Patients/Week)

MAX(X,Y) = The Value of This Function of the Maximum of X
or Y.

Measure of Effectiveness -- Occupancy

When analyzing different management policies, it is desirable to introduce a measure of effectiveness. Simply, such a formulation tells how well the model performed over some period of time with given alternative policies. Experience indicates that a proper measure of effectiveness is the occupancy level of the various Units averaged over the planning horizon; more specifically-average bed utilization over the time 1967 to 1975.

The occupancy level of Unit I is a function of the number of patients in Unit I versus the available beds. This measure should prove adequate as a device for comparing different policies in planning for an equitable patient distribution among the psychiatric Units at CSH.

$$OCP.K = (100) (PU.K)/BEDS \quad (28)$$

$$BEDS = 1300$$

$$CUMOCP.K = CUMOCP.J + (DT) (OCCP.JK) \quad (\text{See Table 11}) \quad (29)$$

$$OCCP.KL = OCP.K$$

$$AVGOCP.K = CUMOCP.K/TIME.K \quad (30)$$

OCP = Occupancy Level of Unit I (Percentage)

BEDS = Number of BEDS Available in Unit I.

CUMOCP = Cumulative Occupancy of Unit I (Percentage)

OCCP = Occupancy Rate of Unit I (Percentage)

OCP = Occupancy Level of Unit (Percentage)

AVGOCP = Average Occupancy of Unit I through Most Current Point
in TIME (Percentage)

Computed Constants

$$UAPF = ADM / ((52) (UAP67)) \quad (31)$$

UAPF = Unit Population Admissions Factor Calculated as a Constant Fraction of the Average Weekly Admissions to Unit I for 1967 Divided by the Unit Population Over This Same Period (1 Week)

ADM = Explained Previously

UAP67 = Explained Previously

$$DRPUF = DTH / ((52) (PUI)) \quad (32)$$

DRPUF = Death Rate of Patients in Unit I Factor; Calculated as a Constant Fraction of the Weekly Deaths for 1967 Divided by the Average Patient Level for the Same Period (1/Week)

DTH = Explained Previously

PUI = Explained Previously

$$RODF = DISPU / ((52) (PUI)) \quad (33)$$

RODF = Rate of Discharge Factor for Unit I, Calculated as a Constant Fraction of the Weekly Discharges from Unit I for 1967 Divided by the Average Patient Level During the Same Period (1/Week)

DISPU = Explained Previously

PUI = Explained Previously

$$DFEF = DISFE / ((52) FEI)) \quad (34)$$

DFEF = Discharges, Patients on Furlough and Escape Factor Calculated as a Constant Fraction of the Weekly Discharges from Furlough and Escape from Unit I for 1967 Divided by the Average Level of Patients in That Category Over the Same Period (1/Week)

DISFE = Explained Previously

FEI = Explained Previously

Constants

PU	=	1250	=	Patients in Unit I (Patients)
CFP	=	40	=	Candidates for Placement in Unit I (Patients)
POUT	=	300	=	Patients in Other Units Belonging in Unit I (Patients)
FE	=	1600	=	Patients on Furlough and Escape (Patients)
UAP	=	UAP70	=	Unit Total Population Initially Equals the 1967 Population Total for the Counties Comprising Unit-Area I
ADM	=	1346	=	Yearly Admissions to Unit I, 1967 (Patients)
DTH	=	160	=	Yearly Deaths from Unit I, 1967 (Patients)
DISPU	=	321	=	Yearly Discharge of Patients from Unit I, 1967 (Patients)
DISFE	=	845	=	Yearly Discharge of Patients on Furlough and Escape Assigned from Unit I, 1967 (Patients)
PUI	=	1250	=	Yearly Level of Patients in Unit I, 1967 (Patients)
FEI	=	1600	=	Yearly Level of Patients on Furlough and Escape from Unit I, 1967 (Patients)

CHAPTER IV

DISCUSSION AND ANALYSIS

Overview of Simulations

The DYNAMO model, or slight permutation of same, presented in the preceding chapter was submitted to the Georgia Institute of Technology Computer Center for simulation in excess of 200 times over the course of many months. Six of these simulation runs have been selected for analysis and presentation in the pages to follow.

Simulation One is a representation of the patient flow dynamics as would be realized under the system explained in Chapter III: the Model.

Simulations Two, Three, and Four relate specifically to the various feasible arrangements (feasible in terms of practical for a "real world" situation) of the counties comprising Unit-Area I other than the existing arrangement as presented in Simulation One. For instance, a Clayton and Fulton or Clayton and Dekalb County combination can reasonably be assumed a feasible arrangement, but it is infeasible, with the present bed allotment to Unit I, to permit Clayton County to solely comprise Unit-Area I; beds would simply be wasted under such an arrangement.

Simulations Five and Six are essentially identical to that of Simulation One regarding Unit-Area constituency. These models explore various credible but as yet uncertain impacts (or siphoning effect of

patients formerly sent directly to CSH) of the Atlanta Regional Mental Health Hospital upon the admissions rate to Unit-Area I at CSH.

Simulation One

In the first simulation, the county constituency of Unit I was kept as it currently exists -- that is, Fulton, Dekalb, and Clayton counties.

In programming this model for simulation, the coverage of the computer run was initiated on July 1, 1967, and terminated on June 30, 1975, a period of eight years or 416 weeks. Note that inclusion of the two years (July, 1967 through June, 1969) for which accurate data has been compiled enables verification of simulated against actual results. Accordingly, with the results obtained from Simulation One, the mathematical model was judged to be realistic (See Table 1, p. 49).

It was hypothesized that the opening of the Atlanta RMHH would significantly affect the admissions to CSH. There is strong evidence in support of this theory as it is concluded at this time that the following observations are related, i.e., (a) there is noted an approximate 22 percent reduction in Unit-Area I patients admitted in 1969 versus the number of admissions for 1967 (See Table 1) occurring coincident with (b) the incipiancy of the Atlanta RMHH program. There can be found no other rationale for this phenomenal decline in admissions other than the Atlanta RMHH explanation.

The above noted reduction in admissions, in view of a continued three percent per annum population increase, yields a net "real" decline of approximately 28 ($22 + 3 + 3$) percent and is translated into the

DYNAMO simulation language in the form of a multiplier (percentage reduction) effect on the 1967 admissions rate to CSH (see Figure 1, Column C, p. 54). In addition, from discussions with health officials in Atlanta, it was estimated that increased bed capacity in Atlanta's Regional Mental Health Hospital would become available in 1971. Should this increased bed capacity become a reality and too, exert a similar depression on admissions to CSH, another 12 percent estimated reduction in Unit I's 1967 (40 percent total: $28 + 12 = 40\%$) admission rate would prevail. This assumption was incorporated into the model and also utilized in Simulation Two, and Simulation Three and Four.

Simulation Two

Simulation Two is essentially the same configuration as that of Simulation One excepting the fact that Clayton County has been deleted from consideration, leaving Fulton and DeKalb Counties as the constituent counties of Unit-Area I. Since the actual future impact of the Atlanta RMHH upon admissions to CSH is not accurately known at this time, it is reasonable to accept the hypothesis of Simulation One as a plausible formulation since the main concern is that of studying the behavior of the defined system under various county combinations as input to the model. In fact, the goal of this simulation run - and of all similar trials where the variable input to the model concerns only what counties comprised Unit-Area I - is to derive a qualitative view of the admissions rate and consequential patient level in Unit I. In other words, it is not of major concern to know accurately all the ramifications of each policy consideration upon the system. But, once a basic feasible model

has been selected and tested, it is desirable to be consistent in employing policy considerations when comparing alternative Unit-Area reorganization plans. (see Figure 2)

Simulation Three

Simulation Three, again, is identical to Simulation One excepting that Dekalb County has been deleted leaving Fulton and Clayton Counties as the constituent counties of Unit-Area I. (see Figure 3)

Simulation Four

Simulation Four is designed to portray Fulton County as the sole county in Unit-Area I. All other considerations appear exactly as in Simulation One. (see Figure 4)

Simulation Five

Simulation Five retains the county composition of Unit I as it currently exists and seeks to examine the possible effects associated with one of the major uncertainties bearing upon Unit occupancy. Quantitatively, the impact of the Atlanta RMHH in Simulation Five accounts for approximately a 22 percent reduction in patients admitted to CSH in 1969 as compared to 1967. From Figure 5 it is seen that after the initial drop in admissions there is no further decreasing effect on admissions other than that already realized, i.e., the 28 percent decline. In this particular Simulation, admissions begin to rise beginning in 1970 only because of, and coincident with, the general population trend. This is because the incidence of mental illness has been defined in this study to be a constant percentage of the population of the counties for

each unit.

Simulation Six

Simulation Six examines yet another possible direction that the RMHH's may take. In Simulation Six it is assumed that the regional hospitals are successful and that funds for their continued growth become available at a steady rate through 1975. Thus, the actual admissions decrease rate experienced from 1967-69 continues at the same rate through 1975. Again, the only factor causing the net increase in admissions is a general growth in the population. (see Figure 6)

CHAPTER V

RESULTS, CONCLUSIONS AND RECOMMENDATIONS

Results

The simulation model has been designed, programmed in DYNAMO language, debugged, and validated with test data. Further, several alternative computer simulations have been programmed and results compiled. Analysis of this data indicates that the model provides the desired output in terms of estimates of approximate occupancy levels for various input parameters. In other words, the herein presented material represents a successful attempt at developing a model for simulation of the Patient Flow System at Central State Hospital.

Conclusions

Data on Patient Flow System

The development of a computer simulation model for any system invariably reveals the lack of basic data about the system (27). The system must be completely described in data form. In the case of the Patient Flow System at CSH, data are often sparse and when available are usually incomplete. The fact of the matter is, until recently most of the required data regarding patient flow statistics was not available at all in meaningful form.

Accordingly, there was no central location or unified body of data to which one could turn in this research effort. Nevertheless, the fragmented data available were organized, reviewed, and augmented by pro-

fessional estimates to provide a workable framework from which to develop the conceptual model and ultimately evolve a validated model. Lack of adequate data or a simulation of inaccurate data about the Patient Flow System at CSH will provide continuing problems for any future studies attempted in this field.

Accuracy Required in the Data

Many questions about the PFS can be studied with less than perfect data. It will be recalled from Chapter I that precision, not numerical accuracy, is the basic requirement for the structuring of the model. Many, many simulation runs of the model were undertaken for debugging purposes, and it is believed that the herein presented model is a precise description of the PFS.

Auxiliary Studies

The computer simulation model herein developed provides available means for conducting auxiliary studies of CSH operations. Such important factors as patient admission policies, furlough policies, discharge policies as well as building sizes and demographic factors can be varied systematically and the effect noted through computer simulation. Systematic variation of such factors as these should provide insight into arrangements which are dominate from a standpoint of both greater effectiveness and lower costs.

Flexibility of the Model

The same model developed herein might well be applied for a wide variety of institutional situations by virtue of their generally similar input orientation. It is thus possible to simulate almost any institution, whether privately owned, publicly operated, profit or non-profit

motivated in structure. There is virtually no upper limit on the size of the institution that might be studied in terms of number of beds, staffing requirements or geographic location. Since much of the model logic revolves around *policy formulation* generated by governing bodies of the institutions studied, herein is the area where the research must necessarily focus attention.

Recommendations

Evaluation of Unit Area Organization

It is deemed by the author that the present unit area organizational scheme is not properly designed to accommodate the needs of the patient population, both now and in the future, at Central State Hospital. *It is recommended that immediate attention be devoted to the overcrowding conditions found particularly in Unit 1 and that adjustments be made to reduce the patient load in the unit or to allocate more bed space for patients assigned to this unit.*

Evaluation of the Community and Regional Mental Health Programs in Georgia

With the advent of the regional and community mental health programs being established in the State of Georgia, there is noticed a reduction in the patient population assigned to Central State Hospital. *It is deemed by the author that the implications of these new programs upon the relative magnitude of the patient population at CSH is extraordinarily significant and should be carefully analyzed in the future as more meaningful and relevant data become available over the course of operating these new programs.*

The Systematic Formulation of Requirements for PFS Data at CSH

There is neither uniformity nor completeness in the currently available data concerning the Patient Flow System at CSH. *A systematic formulation of the data required to study and plan future CSH operations should be made.* Since the number of and need for mental health care facilities in Georgia is growing rapidly along with population increases, it is important to plan now for future data needs. *Insofar as possible, all data that would likely be useful in the future should be identified and procedures established for capturing and storing this information in a form which can easily be updated and retrieved.* A detailed analysis of these data requirements, identification of sources for obtaining the data, and specifications for storage and retrieval of this information would constitute a significant contribution for better mental health care in the future in the State of Georgia. Following are some of the areas in which these data would be useful:

(1) Needs of the simulation models: Because of the limitations discussed above, it is likely that the data available lacks accuracy, completeness or both. Since a model will perform no better than the input data provided, it is important that the scope and variety of the model be upgraded.

(2) Requirements for mental health care facilities: Another use of this data is to support analyses to determine further requirements for mental health care facilities, possibly by regions of the country or by urban-rural classifications. With sufficient historic data, it would be possible to identify the factors which affect the number of mental health care beds required for a given area. These values might then be

extrapolated to provide framing guides for determining where new facilities should be constructed and in what quantity; further, this data could be extended to estimate resource allocation requirements for the needed facilities.

The Exploration of Alternative Uses of the Simulation Model

Every effort has been made to assure that the model is free of unnecessary constraints. This ensures a high degree of flexibility which in turn expands the potential uses of the model. It is proposed that alternatives are available for using the model to solve existing problems other than those previously described. One area might be the adaptation of the model to be provided as a training device for persons concerned with other problems encountered in the operation of state mental health care institutions, or for that matter any institution. Properly packaged, including background material and other educational tools, the simulated operation of the institution would provide valuable "experience" to the personnel in charge -- an opportunity not limited to these individuals, but equally valuable to educators, researchers, and key officials of regulatory agencies.

APPENDIX

Table 1
Comparison of Actual Versus Simulated Annual Admissions to CSH

	S I M U L A T I O N											
	One		Two		Three		Four		Five		Six	
	<u>Actual</u>	<u>Simu- lated</u>	<u>Actual</u>	<u>Simu- lated</u>	<u>Actual</u>	<u>Simu- lated</u>	<u>Actual</u>	<u>Simu- lated</u>	<u>Actual</u>	<u>Simu- lated</u>	<u>Actual</u>	<u>Simu- lated</u>
July 1, 1966												
June 30, 1967	1,346	1,346	1,265	1,265	1,068	1,068	987	987	1,346	1,346	1,346	1,346
July 1, 1967												
June 30, 1968	1,261	1,284	1,173	1,282	961	1,273	873	1,265	1,261	1,308	1,261	1,308
July 1, 1968												
June 30, 1969	1,050	1,075	979	1,067	787	1,045	716	1,027	1,050	1,180	1,050	1,180
Percent error after 2 Years*	1.31		5.76		20.2		27.2		4.85		4.85	

$$*\left(\frac{\text{Actual}-\text{Simulated}}{\text{Actual}}\right) \times 100 = \text{Percent Error}$$

Table 2.
Population Projections* for Counties in Unit 1 -- 1968-1975

COUNTY	YEAR							
	1968	1969	1970	1971	1972	1973	1974	1975
DeKalb	77,876	85,692	93,508	100,270	107,032	113,793	120,555	127,317
Clayton	376,412	421,812	467,212	496,243	525,273	554,304	585,334	612,365
Fulton	603,317	645,166	687,015	701,230	715,445	729,659	743,874	758,089

*Source: (Population Projections for Georgia Counties 1970-1975). University of Georgia

Table 3.

Population Projections* by Unit, 1970-1975, Versus Present Available Beds and Occupancy

Unit	Population Projections* (Number of Persons)		Population Change (1970 to 1975)	Beds available As Of March, 1969	Patients in Unit As Of March, 1969	Occupancy Rate
	1970	1975				
I	1,247,735	1,497,771	+20%	1299	1236	95%
II	1,107,579	1,210,137	+ 9%	1591	1411	89%
III	928,205	980,118	+ 6%	1463	1328	91%
IV	859,518	931,339	+ 8%	1700	1553	91.5%
V	658,193	681,485	+ 4%	1344	1250	93%

*Source: (Population Projections for Georgia Counties 1970-1975). University of Georgia.

Table 4.
Analysis of Counties with Highest Annual Rates of Admission, 1961-1968

County	1961	1962	1963	1964	1965	1966	1967	1968	Average	Interval
BALDWIN	68	70	70	92	114	157	119	144	104	
CHATHAM	111	122	135	167	143	162	154	161	144	100-149 Admissions
FLOYD	86	108	135	152	141	113	106	101	118	
COBB	145	134	202	217	206	218	196	237	194	
MUSCOGEE	98	125	144	175	153	139	196	166	150	150-199 Admissions
RICHMOND	102	135	193	212	175	212	241	248	190	
BIBB	146	187	198	258	268	236	256	273	228	
DEKALB	201	288	303	334	349	325	278	300	297	200 and Above Admissions
FULTON	783	897	915	972	956	922	987	873	913	

Table 5.

Patient Population Data* - Central State Hosp.** March, 1969

Patient Classification	Total Number of Patients
1. Male Patients	4,519
2. Female Patients	5,064
3. Continent Patients	7,247
a. Male	3,522
b. Female	3,725
4. Incontinent Patients	2,336
a. Male	997
b. Female	1,339
5. Ambulatory Patients	8,658
a. Male	4,160
b. Female	4,498
6. Non-ambulatory Patients	925
a. Male	359
b. Female	566
7. Continent, Ambulatory Patients	7,117
a. Male	3,470
b. Female	3,647
8. Incontinent, Ambulatory Patients	1,541
a. Male	690
b. Female	851
9. Continent, Non-ambulatory Patients	130
a. Male	52
b. Female	78
10. Incontinent, Non-ambulatory Patients	795
a. Male	307
b. Female	488

*Total Number of Patients = 9,583.

**Includes Units I-X, River Bldg., and Jones Bldg.

Table 6.
Patient Population Data* - Unit I. March 26, 1969

Patient Classification	Total Number of Patients
1. Male Patients	441
2. Female Patients	835
3. Continent Patients	1,074
a. Male	400
b. Female	674
4. Incontinent Patients	202
a. Male	41
b. Female	161
5. Ambulatory Patients	1,161
a. Male	422
b. Female	739
6. Non-ambulatory Patients	115
a. Male	19
b. Female	96
7. Continent, Ambulatory Patients	1,042
a. Male	393
b. Female	649
8. Incontinent, Ambulatory Patients	119
a. Male	29
b. Female	90
9. Continent, Non-Ambulatory Patients	32
a. Male	7
b. Female	25
10. Incontinent, Non-Ambulatory Patients	83
a. Male	12
b. Female	71

*Total Number of Patients = 1,276

Table 7.
Patient Population Data --- Unit I., Powell Building March 26, 1969

Ward	Sex	Total No. Beds	Total No. Patients	Continent Patients		Incontinent Patients	
				Number Ambulatory	No. Non- ambulatory	Number Ambulatory	No. Non- ambulatory
1W	F	50	40	40	0	0	0
2W	F	64	71	62	0	5	4
3W	F	75	74	51	10	1	12
1E	M	60	63	63	0	0	0
2E	M	75	88	84	4	0	0
3D	M	83	89	48	3	26	12
Totals	3F 3M	407*	425*	348	17	32	28

* Some of the patients have to sleep on mattresses placed on the floor.

Table 8.
Patient Population Data --- Unit I., Walker Building March 26, 1969

Ward	Sex	Total No. Beds	Total No. Patients	<u>Continent Patients</u>		<u>Incontinent Patients</u>	
				Number Ambulatory	No. Non- ambulatory	Number Ambulatory	No. Non- ambulatory
1	F	100	92	31	7	0	54
2	F	120	111	63	0	48	0
3	F	120	112	95	1	16	0
Totals	All F	340	315	189	8	64	54

Table 9.
Patient Population Data --- Unit I., 10th Ward March 26, 1969

Ward	Sex	Total No. Beds	Total No. Patients	Continent Patients		Incontinent Patients	
				Number Ambulatory	No. Non- ambulatory	Number Ambulatory	No. Non- ambulatory
10th	M	206	201	198	0	3	0
Totals	M	206	201	198	0	3	0

Table 10
 Projected Average Unit Occupancy as Unit 1
 Counties Are Varied (1967-1970)

DESCRIPTION	Projected Average Occupancy of Units I Through V				
	I	II	III	IV	V
Present System	92.7	94.9	95.9	93.1	95.3
<u>Alternative 1</u> delete County from add to DeKalb Unit I Unit V	88.5	94.9	95.9	93.1	95.7
<u>Alternative 2</u> delete County from add to Clayton Unit I Unit V	92.0	94.9	95.9	93.1	95.7
<u>Alternative 3</u> delete County from add to Clayton Unit I Unit V DeKalb Unit I Unit IV	85.6	94.9	95.9	95.2	95.7

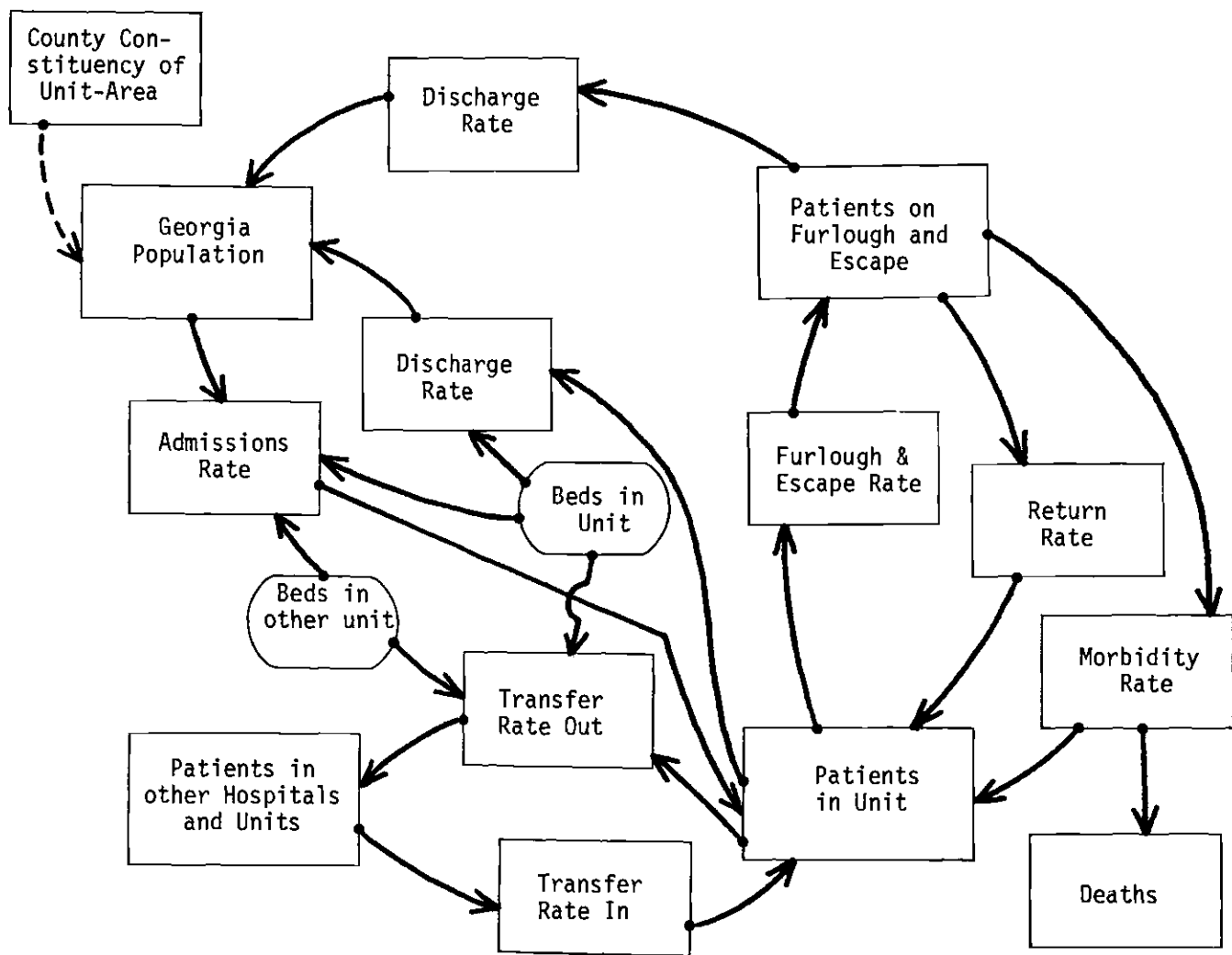


Figure 4
Conceptual Model, Patient Flow System, CHS

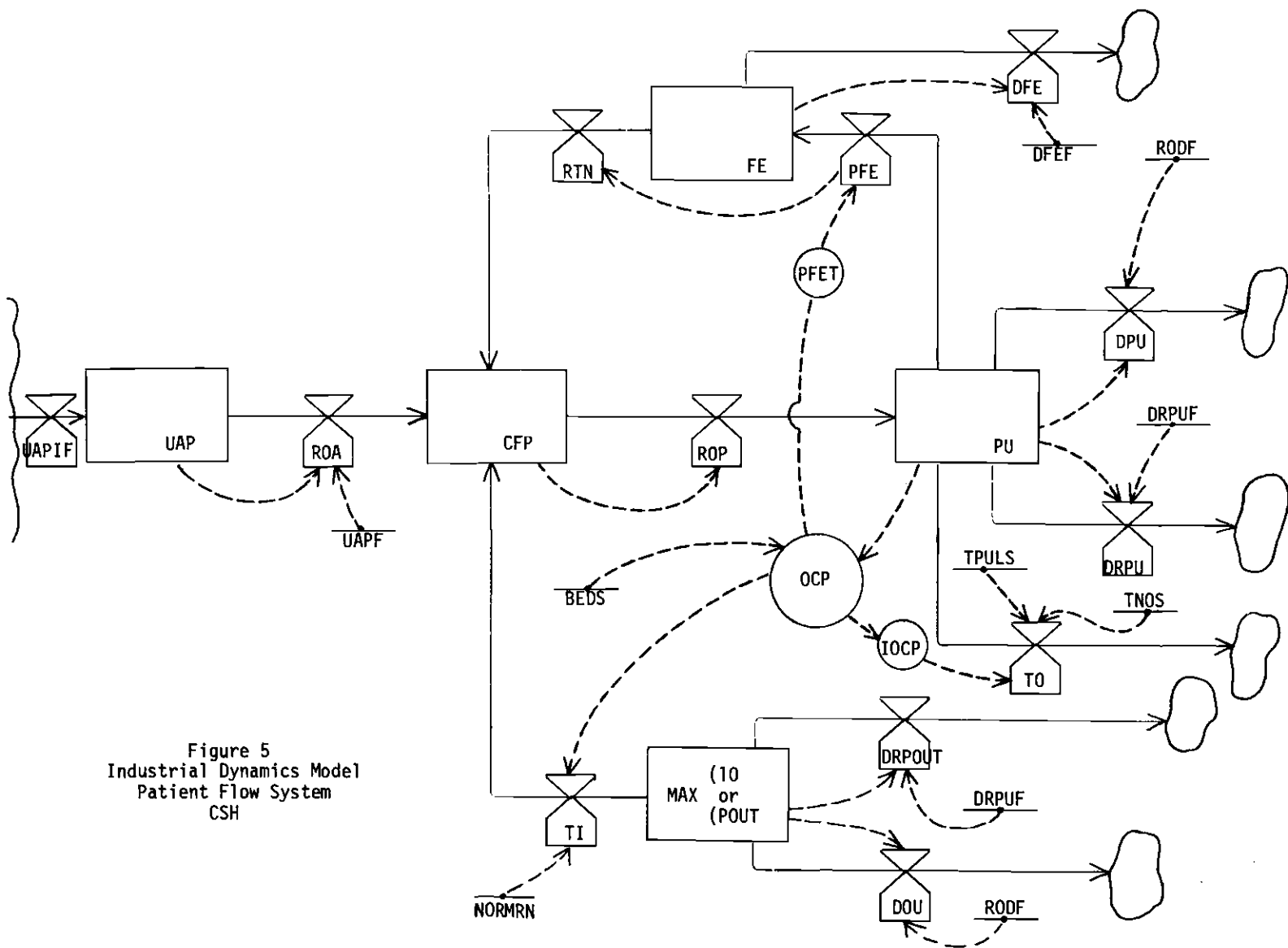


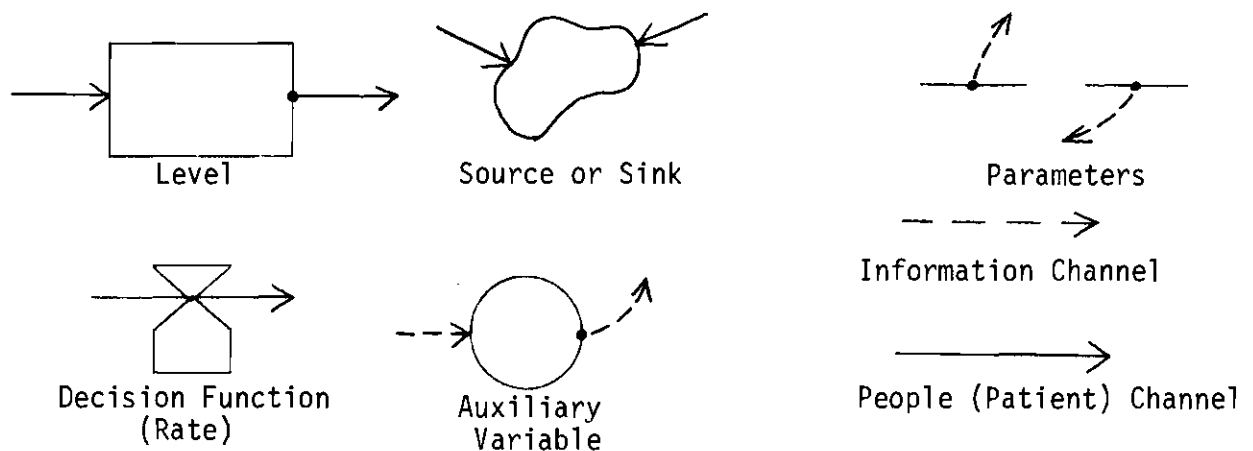
Figure 5
Industrial Dynamics Model
Patient Flow System
CSH

BEDS	Number of available beds in Unit 1
CFP	Candidates For Placement into unit
DFE	Discharges - patients on Furlough and Escape
DFEF	Discharges - patients on Furlough and Escape Factor
DPU	Discharges - Patients in Unit I
DOU	Discharges - Unit I patients in Other Units
DRPOUT	Death Rate of Patients in other units
DRPU	Death Rate of Patients in Unit I
DRPUF	Death Rate of Patients in Unit I Factor
FE	Furloughs and Escapees from Unit I
IOCP	Impact of Unit I Occupancy level on transfers-out
NORMRN	Normally distributed Random Number
OCP	Occupancy of Unit I
PFE	Patients placed on Furlough and Escape
PFET	Fraction of Patients in Unit I placed on Furlough and Escape versus the occupancy level of that unit
POUN	Patients in Other Units belonging in Unit I
PU	Patients in Unit I
ROA	Rate of Admission
RODF	Rate of Discharge Factor for Unit I
ROP	Rate of Placement in Unit I
TI	Transfers-Into proper unit
TNOS	Transfers-Out to other units
TPULS	Transfers-Out to Regional Mental Hospitals
TO	Transfers-Out to other units and hospitals
UAP	Unit-Area Population
UAPF	Unit-Area Population Factor
UAPIF	Unit-Area Population Increase Factor

Figure 6

Definition of Abbreviations in ID Model for Simulation

Definition of Symbols in Figure 5



<u>County Constituency</u>	<u>Year</u>	<u>A Simulated Annual Admissions</u>	<u>B Simulated Year Ending Occupancy</u>	<u>C Admissions Adjustment Factor¹</u>
Fulton	1967	1346	96.2	100%
Clayton	1968	1308	96.4	90
DeKalb	1969	1180	89.1	72
	1970	1078	87.9	72
	1971	1123	89.4	60
	1972	1165	91.6	60
	1973	1210	95.0	60
	1974	1253	96.4	60
	1975	1298	97.1	60

(Note 1: Admission rate is calculated as a function of the 1967 admissions rate, e.g. 1973 Admissions Rate Equals 60% of 1967 admissions rate).

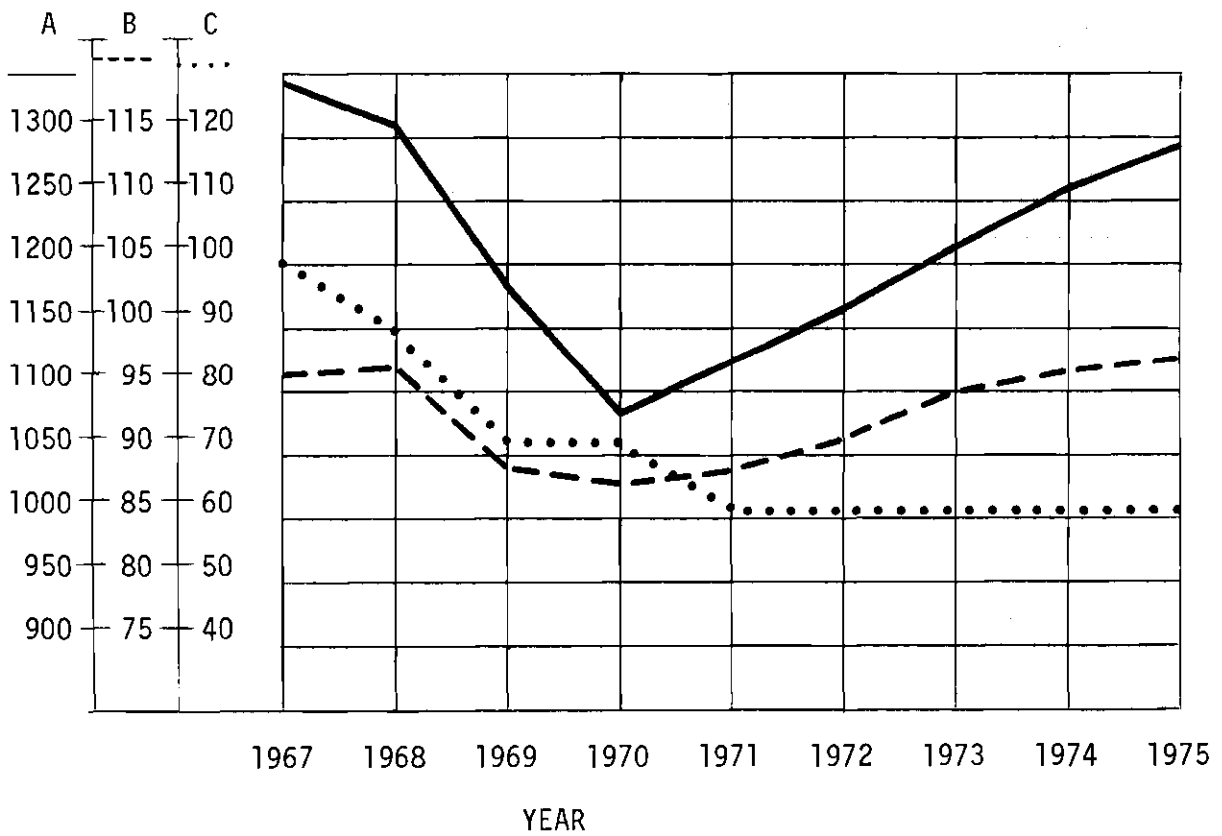


Figure 7

Simulation One Condensed Results

County Constituency	Year	A Simulated Annual Admissions	B Simulated Year Ending Occupancy	C Admissions Adjustment Factor*
Fulton	1967	1265	96.2	100%
DeKalb	1968	1282	96.0	83
	1969	1967	89.0	72
	1970	1066	87.5	72
	1971	1106	88.6	60
	1972	1144	90.1	60
	1973	1183	93.7	60
	1974	1222	95.4	60
	1975	1262	96.9	60

(*See Note 1, Figure 7)

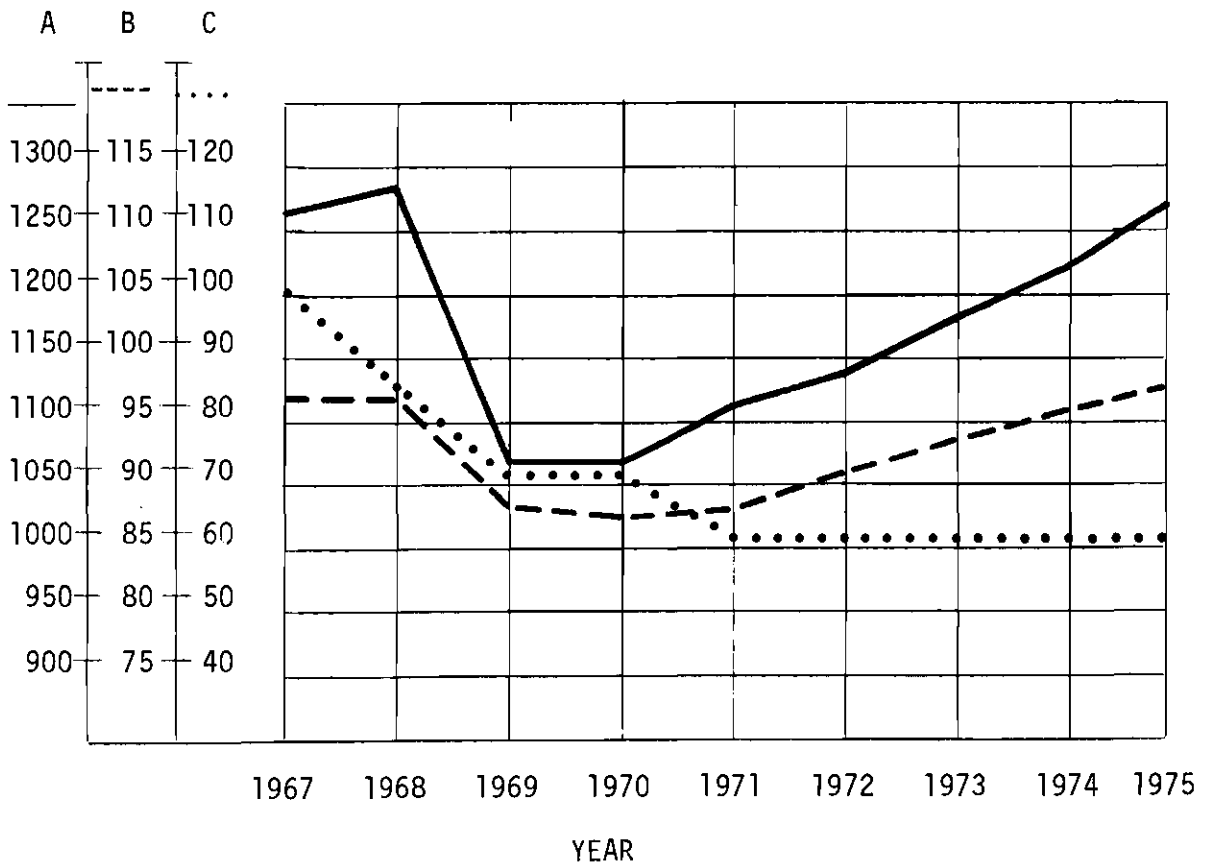


Figure 8

Simulation Two Condensed Results

County Constituency	Year	A Simulated Annual Admissions	B Simulated Year Ending Occupancy	C Admissions Adjustment Factor*
Fulton Clayton	1967	1068	96.2	100%
	1968	1273	96.0	83
	1969	1045	87.8	72
	1970	1031	84.5	72
	1971	1055	84.1	60
	1972	1179	85.1	60
	1973	1104	87.2	60
	1974	1128	88.7	60
	1975	1152	91.3	60

(*See Note 1, Figure 7)

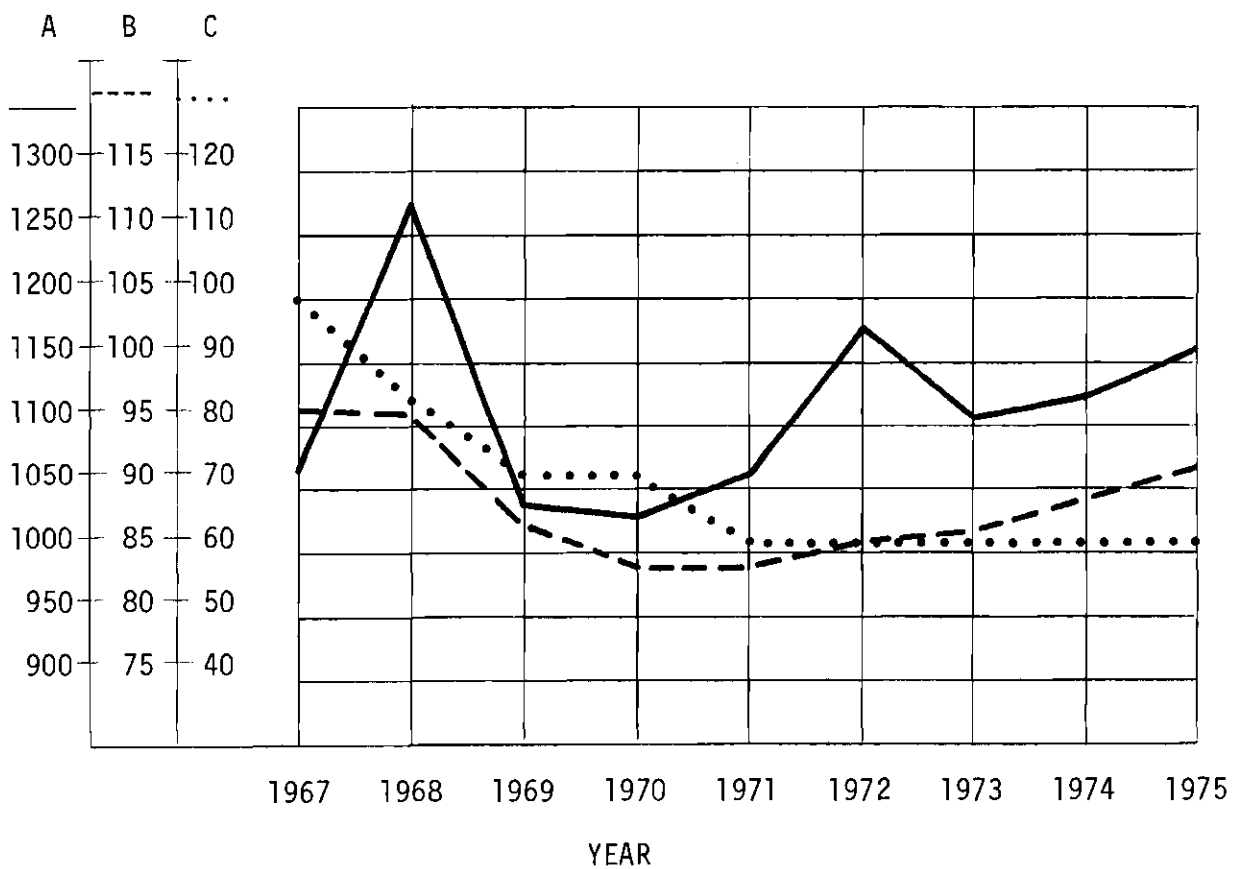


Figure 9

Simulation Three Condensed Results

<u>County Constituency</u>	<u>Year</u>	<u>A Simulated Annual Admissions</u>	<u>B Simulated Year Ending Occupancy</u>	<u>C Admissions Adjustment Factor*</u>
Fulton	1967	987	96.2	100%
	1968	1265	95.5	83
	1969	1027	86.3	72
	1970	1000	82.4	72
	1971	1013	81.3	60
	1972	1026	81.9	60
	1973	1037	83.6	60
	1974	1050	84.9	60
	1975	1063	84.2	60

(*See Note 1, Figure 7)

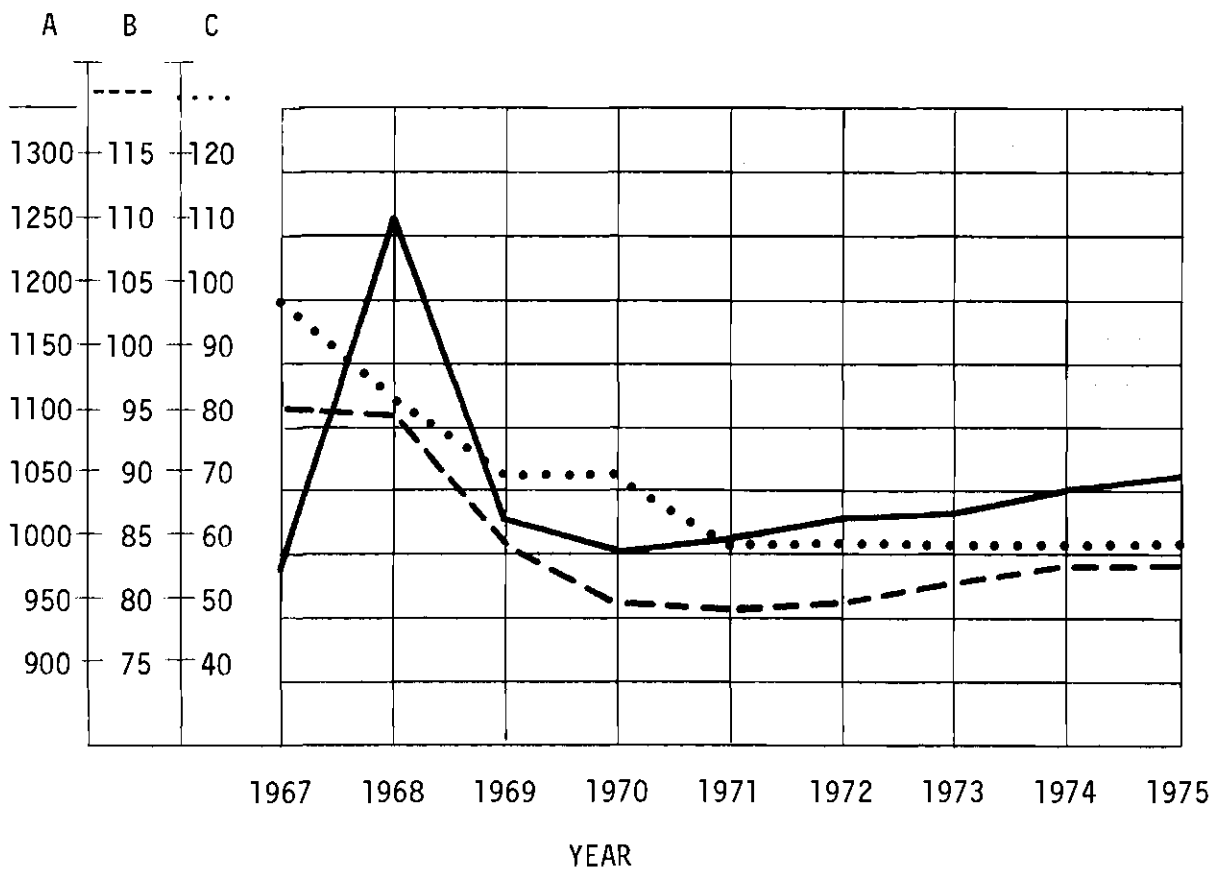


Figure 10
Simulation Four Condensed Results

<u>County Constituency</u>	<u>Year</u>	<u>A</u> <u>Simulated</u> <u>Annual</u> <u>Admissions</u>	<u>B</u> <u>Simulated</u> <u>Year Ending</u> <u>Occupancy</u>	<u>C</u> <u>Admissions</u> <u>Adjustment</u> <u>Factor*</u>
Fulton	1967	1346	96.2	100%
Clayton	1968	1308	97.1	90
DeKalb	1969	1180	93.3	72
	1970	1078	89.6	72
	1971	1122	90.1	72
	1972	1166	91.9	72
	1973	1209	95.1	72
	1974	1254	96.4	72
	1975	1297	97.1	72

(*See Note 1, Figure 7)

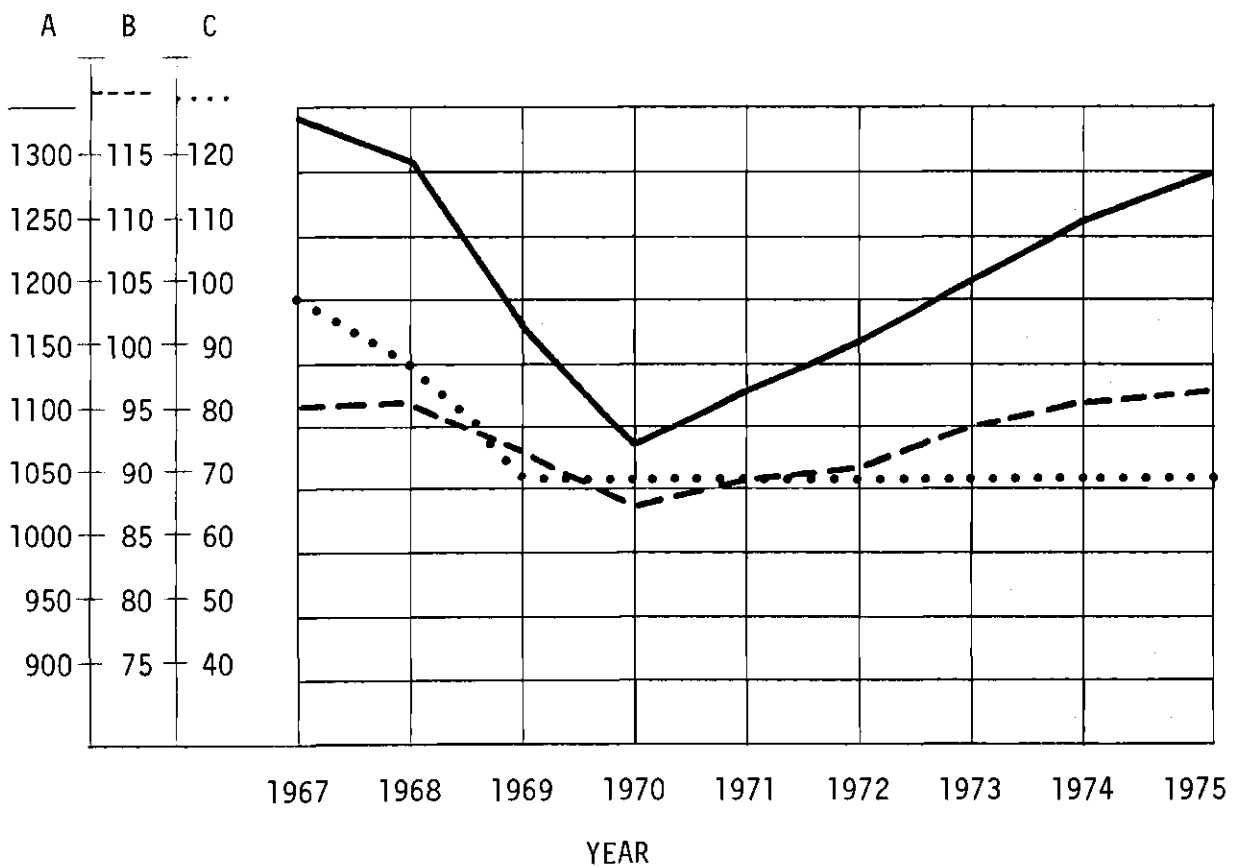


Figure 11
Simulation Five Condensed Results

<u>County Constituency</u>	<u>Year</u>	<u>A</u> <u>Simulated</u> <u>Annual</u> <u>Admissions</u>	<u>B</u> <u>Simulated</u> <u>Year Ending</u> <u>Occupancy</u>	<u>C</u> <u>Admissions</u> <u>Adjustment</u> <u>Factor*</u>
Fulton	1967	1346	96.2	100%
Clayton	1968	1308	97.1	90
DeKalb	1969	1180	93.3	72
	1970	1033	87.3	65
	1971	1060	86.2	59
	1972	1101	87.2	52
	1973	1142	90.1	50
	1974	1184	92.1	41
	1975	1225	95.5	41

(*See Note 1, Figure 7)

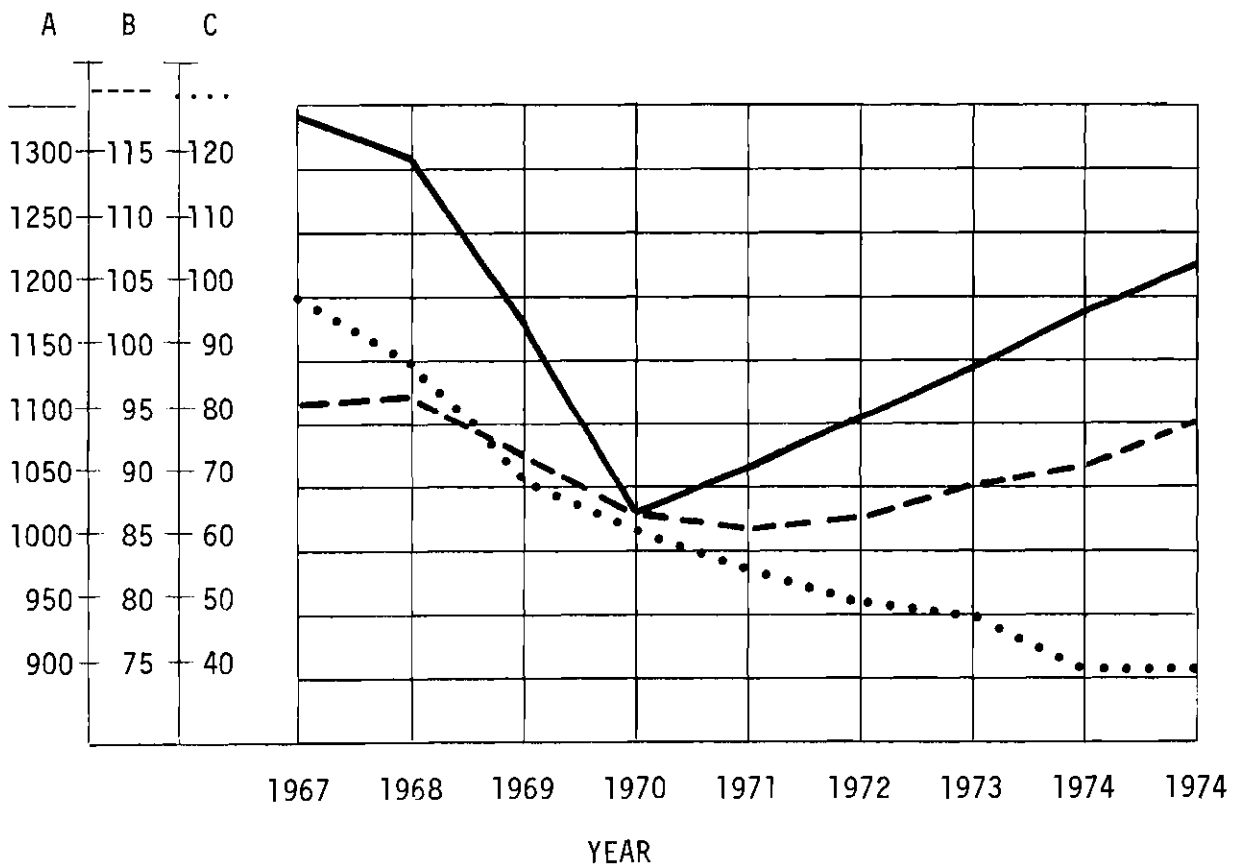


Figure 12
Simulation Six Condensed Results

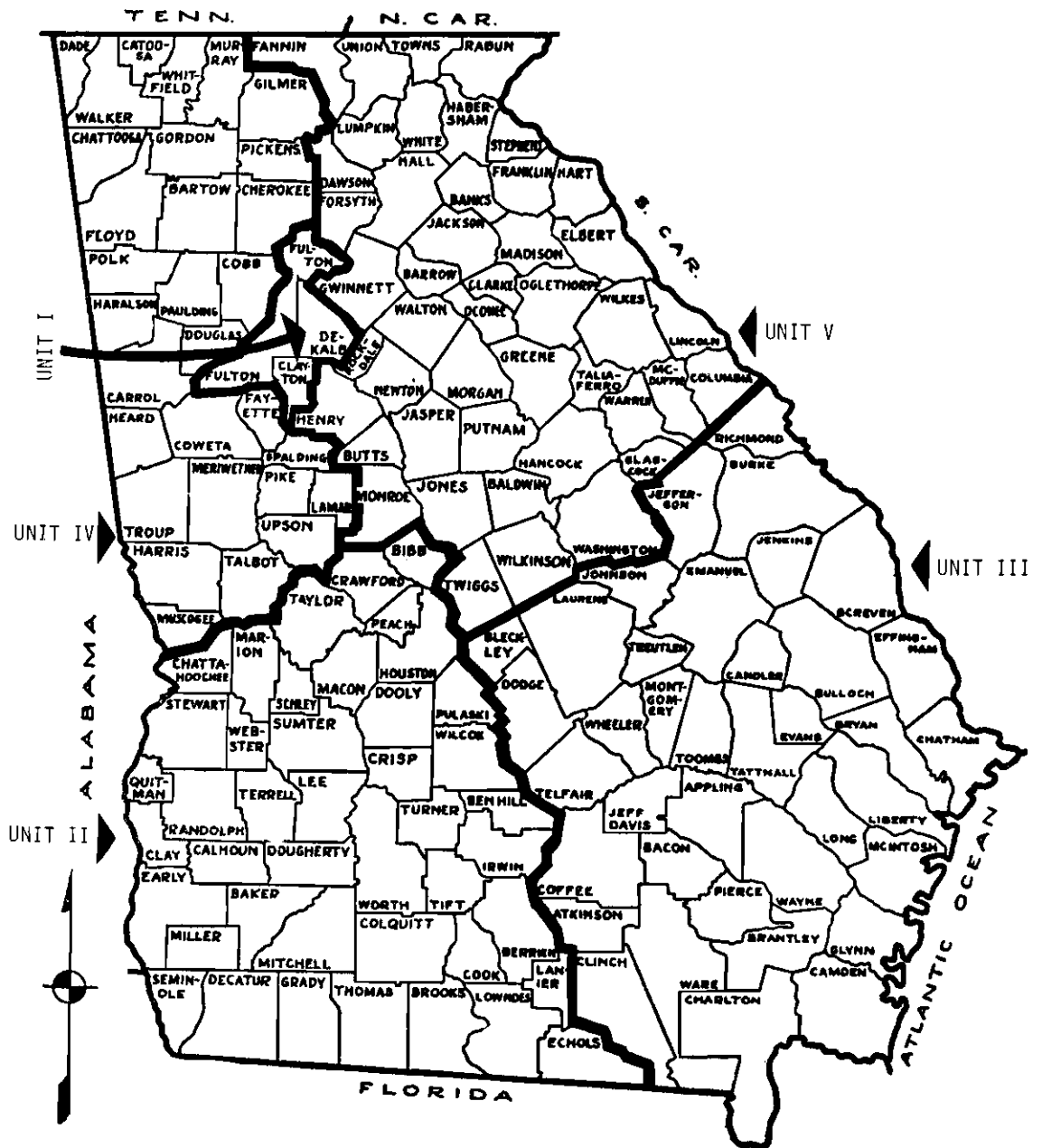
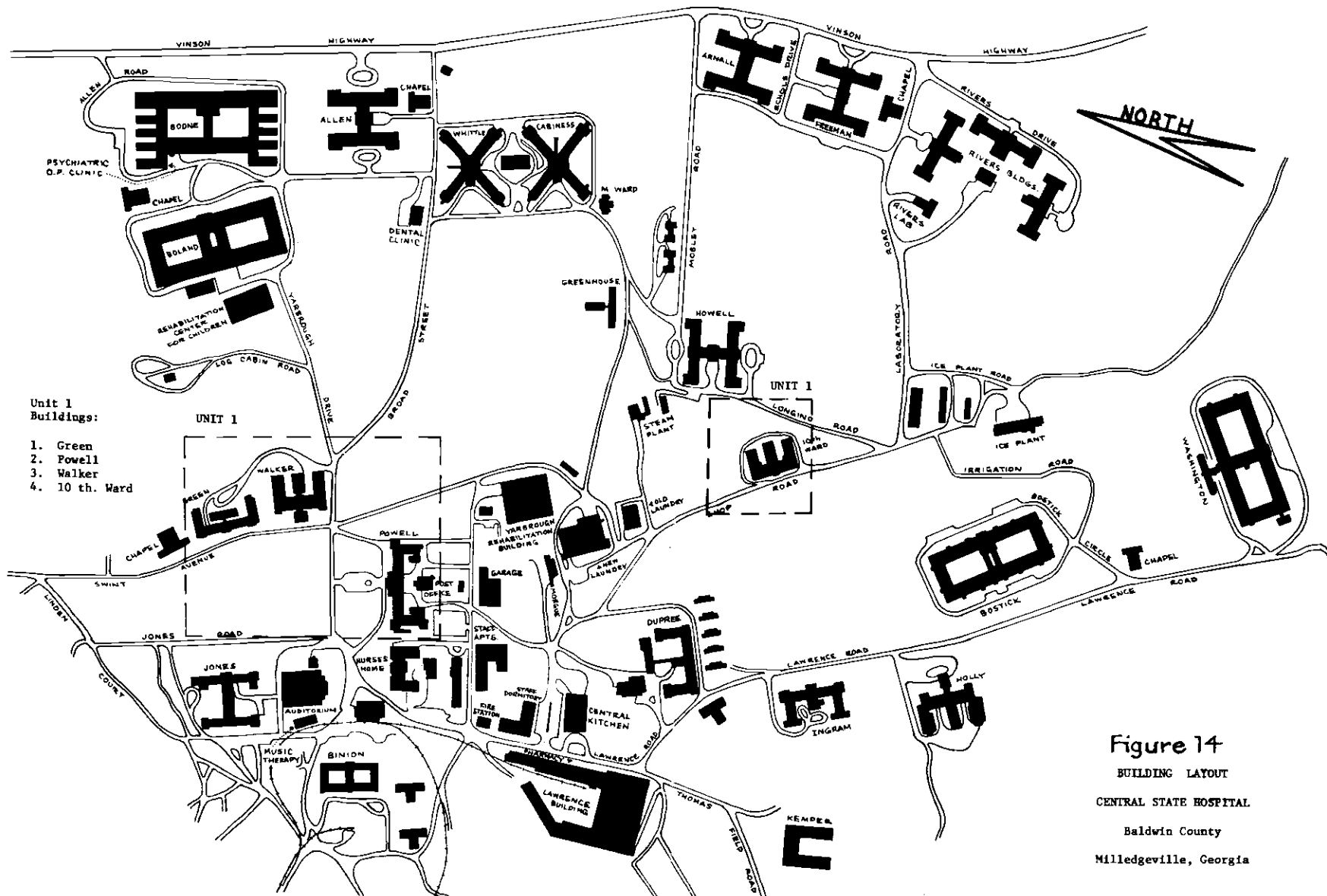


Figure 13

Unit Area Geographical Districts



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