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(Signed)

AN APPLICATION AND EVALUATION OF
AN IN-PATIENT BED ASSIGNMENT CONTROL
BOARD AT THE KENNESTONE HOSPITAL
MARIETTA, GEORGIA

A THESIS

Presented to
the Faculty of the Graduate Division
Georgia Institute of Technology

In Partial Fulfillment
of the Requirements for the Degree
Master of Science in Industrial Engineering

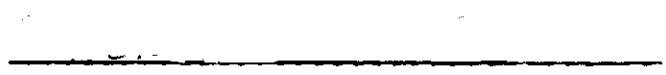
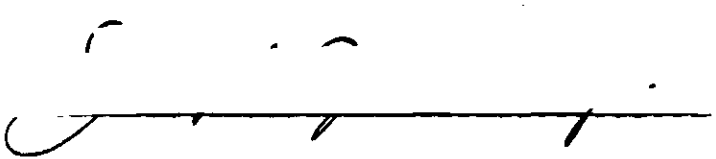
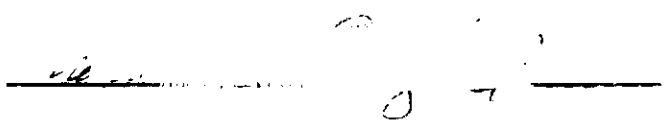
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Approved:

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CHAPTER I

INTRODUCTION

Statement of the problem.—It is proposed to develop, install, operate, and statistically evaluate an effective method of forecasting and scheduling hospital in-patients by the use of an in-patient bed assignment control board similar in design to a Gantt Scheduling Chart. The forecasting and scheduling of the patients will be based upon each patient's attending physician or physicians furnishing the Admission Department with a non-binding estimate of each patient's length of hospitalization and other critical information. It will be determined by statistical methods if the doctor's errors of estimated lengths of stay of each patient are influenced by the age and sex of the patients and if the doctor's estimates are sufficiently accurate to permit successful operation of the control board system of admissions.

Literature survey.—In 1899, the Association of Hospital Superintendents was founded with the purpose of solving the rapidly increasing problems of hospital management, and in 1907, the title was changed to the American Hospital Association. Since its early beginning, the association has made valuable advances in the standardization of hospital equipment and supplies and has furthered the adoption of more

efficient hospital practices (1)¹ with the focus on all effort directed to the care and comfort of the patient (2).

During the past quarter of a century, the American public has witnessed a rapid development in scientific medicine and research (3) and thus have become extremely health and hospital conscious to the extent that the total number of hospital in-patients has more than doubled since 1935 (4) especially in the general type hospitals of the low income states (5).

It was not until World War II that there was a necessity of hospital cooperation in the formation of constructive policies brought forward by the exchange of key personnel and interchange of equipment (6).

In the postwar readjustment era, many hospitals have benefited by the advances of large scale production and operation of factories and utilities (7); therefore, the modern hospital of today has the opportunity to serve its public with a maximum effectiveness by ridding itself of old prejudices (8) and applying the scientific methods of present industry.

Although many recent policies have somewhat alleviated the inter-hospital problem, one intra-hospital problem which has not been sufficiently stressed until recently was the effective assignment of in-patient to space. In most hospitals

¹ Numbers in parenthesis refer to bibliographical references.

of any size, bed assignment is under the jurisdiction of the Admission Office whose goal should be a simplification of admitting practices without the impairment of efficiency in the hospital (9).

John R. McGibony, M.D., in his book, Principles of Hospital Management, suggests that scientific research be promoted in the areas of hospital administration and administrative service, of which admitting practices and procedures are a major part (10).

It is usually the duty of the Admission Office to know what beds are empty, what discharges will be made in the near future, and what reservations for future occupancy have been made (11); thus, the solution of in-patient bed assignments can be classed into two divisions--production forecasting and production scheduling. The production forecasting problem is concerned mainly with the measures of the patients' and doctors' demands and the hospital's capacity to meet this demand. Production scheduling must be approached in a similar manner.

It is common practice in many hospitals to have the Admission Office call the individual stations of the hospital and ask the head floor nurse on duty for information concerning the current availability of beds in her section. This is not only a time consuming method since it distracts the nurse from her regular duties, but also is a waste of the Admission Department's time and often delays the attending physician

or the patient who must wait in the admitting department or on the telephone until information is obtained (12). It was upon this basis that several attempts, some successful, have been made on the in-patient bed assignment problem.

The Menorah Medical Center, Kansas City, Missouri, is currently using a system which is centered about a four-sided revolving card index file. Each card holder of the file represents the type of bed accommodation and the bed and room number. When a card is not in the holder, the room is vacant and an in-patient can be readily assigned; when a card is in the holder, the bed is occupied (13). This system is excellent but it has two limitations; namely, that immediate advance reservations cannot be made since the file only gives the present occupancy and that there is no idea of how long the present bed space will be occupied by the present in-patient.

At Hurley Hospital in Flint, Michigan, a wall-mounted control board, consisting of small pockets with the room number under each pocket, is used. The basic idea is the same as that of the previous system but this plan goes into greater detail—two colors of cards are used to denote the sex of the patient; on the day a patient is to be discharged the card is tipped on its corner to the left, and when a room reservation is requested, a card is inserted and tipped to the right.(14). The control board does provide an immedi-

ate visual aid as to the current availability of bed space, but how long the bed will remain in use is not immediately known; therefore, future assignments cannot be made without the withdrawal of each individual card. Since several cards usually collect in each pocket, confusion may result.

R. R. Langée has devised a centralized bed assignment control board which is currently being used in the Ottawa General Hospital, Ottawa, Canada. His system is designed around an estimate of the length of stay of each individual in-patient and the type of service desired. This information is furnished by the attending physician upon a request for bed space. The control board consists of a wall-mounted panel with the days of the month running horizontally from each bed number. When a request for bed space is received, pegs are inserted in the holes corresponding to the dates of entry and estimated discharge. Another peg is placed three days prior to the estimated date of discharge; this peg is used by the Admission Office as an alert date to check with the head floor nurse of each floor as to the progress of the patient. The floor nurse gives a further estimate. If it is expected that the patient will require hospitalization beyond the estimated date of discharge, the discharge date peg is moved forward, as is the alert peg, for the required number of days, and likewise vice versa for a shortened length of hospitalization. Each additional estimate by the floor nurse furnishes a more accurate discharge

date. It is suggested that pegs of different colors be used for each purpose; that is, entry, discharge, and alert dates. If any changes of bed space are deemed necessary due to premature discharge or death, the head floor nurse immediately notifies the Admission Office so that necessary changes to the bed assignment control board will be readily made. Under this system, assignment or transfer cannot be made without the approval of the Admission Office (15). Since normal patients are not admitted after six P.M. and the room where the bed assignment control board is located is closed at night, a list of available beds and type of service is forwarded to the emergency night admitting location each evening and is returned to the Admitting Office (indicating the admissions and discharges which were made) the next morning (16). Except in the case of extreme hardship, for good and sufficient reasons, patients are not admitted or discharged on Sundays (17). Admission on Sundays, as at night, is restricted to emergency cases (18). This system has the advantages of complete centralization of bed assignments and also produces an exact panoramic view of the overall occupancy of the hospital with the exception of nursery cribs (19). The disadvantages of this system are that the patients cannot be admitted at night or on Sundays, except in emergency; that the repeated contact of the head floor nurse is time consuming; that the peg system will not work for a short stay patient (less than three days); that the

control board is difficult to evaluate unless observed at distances of five feet or under (for the pegs begin to appear as holes at greater distances); and that if more than one peg at a time is moved, considerable confusion could result.

Dr. R. T. Staton, Ph.D., has developed a system of bed assignment which is currently being used at Johns Hopkins Hospital in Baltimore, Maryland (20). It is basically the same as R. R. Langée's except that he uses a strip of tape instead of pegs and a control board similiar to a Gantt Scheduling Chart. This system furnishes a better panoramic view from a considerable distance. Each piece of tape, which is representative of the estimated length of stay, contains the patient's name and other vital information. Johns Hopkins' in-patient population is comprised of varied types of cases from all locations in the world. Although Dr. Staton's work does supply a statistical evaluation of the critical factor, the estimate of the length of stay, it is believed that decision making would be simplified if a further evaluation of the data by age and sex groups and by hospitalization insurance status were available.

Conclusions.—Some of the present systems of bed assignment, when not over-taxed, have proved to be very successful in spite of their many shortcomings. This most likely is a result of the experience of the Admission Office or operating personnel. They recognize the particular systems' deficiencies; therefore, they minimize their effect or compen-

sate for them. Since most of the present day systems are somewhat difficult and confusing to apply, the fact that they have a number of shortcomings increases the need for trained and experienced admitting personnel. In this light, the need for a more accurate and easily applied admitting system becomes even more apparent. Such a system should be constructed on a firm foundation. This foundation will depend upon the hospital administrator, the admitting office personnel, patients, doctors, and nurses. It also seems feasible that operating room time and laboratory time could be integrated into a bed assignment system. It is in view of the above comments and conclusions that an investigation of hospital in-patient bed assignment is directed.

CHAPTER II

SELECTION OF SITE FOR EXPERIMENTATION

Desirable features of the site.—Of the twelve types of hospitals classified by the American Medical Association for 1953, the general type of hospital afforded the largest number of patients of each sex and of different ages (21) whose average length of stay could more likely be accurately estimated and yet would yield a wide variety of data as a basis of proving the versatility and effectiveness of an in-patient bed assignment control board system of admissions for the forecasting and scheduling of in-patients in a specific hospital.

Piedmont Hospital.—Piedmont Hospital in Atlanta, Georgia, was first to be contacted. After several interviews with the Administrator and his discussions with the Board of Directors, it was his opinion that if the experiment were to be carried on at Piedmont, it would be best to commence with the operation at their new site which was scheduled for completion during the latter part of 1956 (Figs. 1, 2, 3, and 4). Since this arrangement would have resulted in considerable delay with the actual experimentation and operation, several other medium size, general type hospitals in and around the Atlanta area were considered as possible sites.

Kennestone Hospital.—Kennestone, a young and progressive general type hospital located in Marietta, Georgia, was contacted (Fig. 5). Several discussions with the Administrator regarding the value and basic operation of a bed assignment control board system of admissions and his subsequent appearances with the Board of Trustees and the Medical Staff resulted in their unanimous approval for experimentation and operation (Fig. 6).

CHAPTER III

DESIGN OF THE SYSTEM

General information.—Kennestone is a medium size general type hospital with a basic in-patient (Fig. 7) bed complement (Fig. 7) of 155 (22), but it does have a maximum theoretical bed capacity (Fig. 7) of 225 when the spacious private rooms are equipped for semi-private use, when four-bed wards are converted to accommodate five, and when physiotherapy and isolation rooms can be used for semi-private rooms or wards.

The basic in-patient population of Kennestone is comprised mainly of local residents of which a majority are covered by Lockheed Aircraft or other types of hospitalization insurance.

The basic bed complement, for all practical purposes, is divided into G-section, or basement, a general type floor for colored patients but sometimes used for white patients when the demand occurs; Medical Section, the first or ground floor level; Pediatrics and Obstetrics, the second floor; and Surgery, the third floor (Fig. 8).

When an overflow of one type of patient results, the patient is placed in any available hospital bed (Fig. 7) on any floor.

A more exact breakdown of the bed complement by room

number and floor is described in Table 1 and in Figure 9.

The Medical Staff of Kennestone is comprised of fifty-eight M. D.'s and D. D. S.'s (23) in all fields of medicine. Their average age represents one of the youngest medical staffs in Georgia. They are very receptive to opinions and new concepts which may aid medical advancement.

The Admission Office is under the supervision of the Bookkeeping Section whose supervisor is directly responsible to the administrator (Fig. 10). It is normally staffed by a chief admission clerk and two assistant clerks during the rush or normal admitting hours and by one clerk during the off-hours. Also located in the Admission Office are the cashier and switchboard operator. The cashier is part of the Bookkeeping Section.

Although the primary function of the Admission Office is the effective admission of in-patients, it performs other duties—the keeping of admission records, the forwarding of records to Bookkeeping upon discharge of a patient, the operation of the switchboard, the receiving of visitors, and the release of information and names of patients to the local newspaper (24).

Preliminary details.—Several visits with the administrator and various members of his staff were required to organize the proposed system of forecasting and scheduling bed space and to arrange for the effective communication of pertinent information to the interested parties.

It was decided, during the course of these discussions, to operate the proposed system on a pilot plant basis which would only involve the Surgical Section (Fig. 11), and that the system would be operated by the experimenter until such a time that it was in smooth operation and the admission office personnel were properly oriented with its unique operation.

The Surgical Section was selected for the pilot plant operation since most of the physicians agreed that a more accurate estimate of the length of stay could be made on surgical cases. This selection allowed a larger population of in-patients with a large age span and assorted types of cases which would furnish the desired information for the successful evaluation of the system for the surgical floor.

Present admitting system.—The present basic admitting system can be divided into four steps for all practical purposes—reservations, admissions, transfers, and discharges.

It should be further emphasized that the following procedure holds true only for in-patients who require surgery and are to be assigned to the surgical floor or for patients not requiring surgery but are to be assigned to the third floor.

The usual reservation procedure is for the doctor or his secretary to call the operating room or the surgical floor and to request a reservation for operating room time and for bed space. Normally, he furnishes the date of sur-

gery, patient's name, diagnosis, and sometimes age, sex, and type of bed space desired. The Surgical Section assigns an operating room time and date, and posts the operation on a schedule sheet. A separate sheet is used for each day of surgery. This information is forwarded to the Admission Office on the morning that the patient is scheduled for admission. Sometimes the above data are received by the Admission Office prior to the admission date by several methods which do not follow a definite pattern—the doctor, the operating room, or by inquiry. When the Admission Office does receive this information in advance, it is posted, in the order received, in a notebook and is used for reference purposes. Usually no notice of cancellation or changes for bed space reach the admitting personnel until the day of scheduled admission or when the in-patient fails to appear for admission.

Each morning the supervisor of nurses for the surgical floor delivers the patient condition report to the Admission Office. At this time, she usually relays to the chief admission clerk, or the senior clerk on duty, the room number and names of patients who are expected to be discharged that day and transfers which have been or will be made. It is only then that admitting personnel can begin to foresee bed space requirements for incoming patients.

The normal admission of in-patients is supervised by the chief admission clerk, who greets the incoming patient

and any relatives or friends who accompany the in-patient, asks for information concerning the type of accommodations desired, and answers any specific questions the patient or relations may have. She then introduces the patient to an admission clerk and assigns a bed space. The admission clerk prepares the admission forms, contacts an aid to assist the in-patient to the head floor nurse of the assigned section, and forwards the necessary admission records to the bed section. An in-patient card is placed in the in-patient register at this time.

Emergency admissions during the normal admitting hours are handled, as far as practical, the same as a normal admission. When an emergency in-patient must be taken directly to a bed and relatives or friends do not accompany the patient, a clerk will go to the patient when he is able to furnish complete and correct admission information. If this is not possible for some time, a relative or friend will furnish the information which the clerk will use to complete the admission forms. Only basic information such as the patient's name, room number, and nearest relative is required for an emergency admission.

Night admissions, between the hours of ten P. M. and seven A. M., are processed by the night admission clerk in addition to her duties as night cashier and switchboard operator. In the case of emergency night admissions, she records the patient's name and room number. This is forwarded

to the first shift for admitting record completion.

If the type of accommodation desired by the patient is not available, the floors affected are notified and a transfer is completed as soon as possible. When the transfer of patients from bed to bed or from floor to floor is completed, the Admission Office is notified so that it may revise the in-patient register. This is also the case when transfers which were not requested at the time of admission are made.

At the time an in-patient is scheduled for discharge, his chart is sent to the admission clerk and forwarded to the cashier so his bill may be prepared. When the patient reports for checking out, his card is removed from the in-patient register.

It can be readily deduced that the admission clerks are unable to forecast the need for bed space or schedule in-patients until the day of admission, for the rate of admission to the surgical floor is governed, in most cases, by the posting of surgery. Since the Admission Office does not have the authority to control these rates, admissions are unusually heavy during the early part of the week, and discharges are heavy the latter part. As a consequence, on the days of heavy admissions, the first patients to report for admission have a larger choice of accommodations from which to select than the remaining or late reporting patients. It is common, under this system of admissions, for operations

to be cancelled and for patients to be refused admission if they are able to wait until bed space is available. This is very inconvenient, not only for the patient, but to the doctor and the hospital in general.

Proposed admitting system.—The proposed admitting system would consist mainly of the present admitting system, with slight modifications, and the operation of a bed assignment control board for the forecasting and scheduling of in-patients. Major deviations from the present admitting system were minimized to reduce the possibility of loss of cooperation from the Admission Office and other parties associated with the admission procedure.

The only major deviation from the present to the proposed admitting system (other than the eventual operation of the control board which will be described later) was that the attending physician or the surgical floor, upon a request for a reservation, furnish the Admission Office with the following pertinent information on each in-patient who is to be admitted for surgery and is to occupy a bed on the surgical floor and for each patient not requiring surgery but to be assigned to the surgical floor, and that this information should be recorded in the admitting department reservation book for reference purposes:

- (1) Doctor's Name,
- (2) Patient's Name,
- (3) Date to be Admitted,

- (4) Estimated Length of Stay (non-binding),
- (5) Age of the Patient,
- (6) Sex of the Patient,
- (7) Type of Accommodations Desired,
- (8) Diagnosis,
- (9) Date of the Reservation, and
- (10) Is the Patient Covered by Hospitalization Insurance?

During the course of several informal meetings with the administrator and the chief admission clerk, it was stressed that each item of the above information would be a critical factor in determining the complete or partial success or failure of the system.

CHAPTER IV

EQUIPMENT AND OPERATION

Equipment.—The bed assignment control board is fundamentally a Gantt Machine Load Chart (25) with minor alterations.

Many factors, such as the ease of operation, interpretation, modification, reproduction, support, cost of operation and initial construction, color, shape, size, material, rigidity, resistance to wear, location, color contrast, accessibility, viewability, orientation, length of time to be represented, and the continual reuse of the same board were considered in the basic design of the control board for the Surgical Section.

A suitable combination of the above factors resulted in a basic control board which was divided into three sections for ease of handling and viewability; namely, North Surgery, Northwest Surgery, and South Surgery (Fig. 12). This breakdown, although its elements were not of equal size, corresponded to the physical layout of the third floor at Kennestone Hospital (Tab. 1).

Horizontal and vertical lines and lettering of black drafting ink on a grey matte-poster board in combination with Scotch drafting tape (buff color), also with black ink lettering, furnished excellent contrast and visibility factors. After the ruling and lettering were completed, the

surface of the matte-board was sprayed with three light coats of Weber "Fixatif" clear artists' varnish which enhanced the contrast and furnished a surface from which the drafting tape could be continually removed and replaced without noticeable effects to the board. The board was mounted on 3/8 inch, three-ply plywood with Weldwood Contact Cement. This allowed the board to approach the required factors of suitability for wall mounting, lightness, and rigidity.

The expense of the three control boards with the equipment necessary to facilitate its operation did not exceed the cost of one commercially available board which would have required extensive revamping.

The physical layout of the bed assignment control board consisted of separate boards for the three sections of the Surgical Section; each with a set increment of time in days of the month represented along the horizontal axis and room numbers along the vertical axis. Additional pertinent information which was recorded beside the room numbers indicated the type of room and facilities. For instance, room number 322, which is a semi-private room with toilet facilities, was indicated by 322 S.P.T., or room 353, which is a deluxe private room with toilet facilities, was identified by 353 D.P.T., and so on for a four-bed ward, three-bed ward, plain semi-private, and plain private. This information proved to be most valuable when scanning the

board for a desired type of room with certain features. Each room number contained a space or subdivision along the vertical axis for the maximum number of beds that could be placed in the room. Only one month, 31 days, plus a few additional spaces for overruns was represented on each of the three boards. In this manner, patients could be scheduled as far as one month in advance provided that the space did not contain a previous reservation or that it was not occupied at that time.

Since one-half inch drafting tape is to be placed on the control board as the actual time measure, a space of 0.60 inches high was acceptable as sufficient in which to place the strip of tape. Inasmuch as the minimum length of stay for an in-patient would be one hospital day (part of two consecutive days), an inch along the horizontal axis was accepted as the minimum space required to place a strip of tape with the necessary in-patient information--doctor's name, patient's name, age, sex, date of admission, and estimated length of stay. This would require that the control board be a minimum of approximately thirty-five inches along the horizontal.

As only one month of time was the maximum that could be recorded on the control board, no evidence as to the month represented was required. It was accepted that if the date was the fifteenth of a month, all patients posted on the board till the end of the month inclusive represented the

remainder of the present month, while those posted from the first to the fifteenth represented the coming month unless the space was already occupied. Patients who were admitted before the fifteenth and were still in the hospital on the fifteenth could be readily identified by examining the tape for the date of admission.

Operation.—When a private or a semi-private room is being used or is scheduled to be occupied as a private room instead of a semi-private room, a piece of unmarked drafting tape is placed in the second or additional space for the respective period of time that private use will continue. This will eliminate the possibility of a second patient being assigned to the room earmarked for private use. When a private or a semi-private room is to be for semi-private use, the tape is removed. The same procedure is true with regard to the four bed wards which can accommodate five.

Upon a request for bed space, the proper admitting information is recorded in the reservation book. The necessary in-patient information is then recorded on a strip of the drafting tape whose length (an inch for each day of estimated length of stay) is representative of time. This tape is then placed on the control board with respect to the type of accommodation desired and the admitting date.

To eliminate any confusion as to whether a patient is scheduled for admission and has not been admitted or whether the patient has already been admitted, a flag or marker con-

sisting of a strip of yellow tape about one-eighth inch wide is placed on each reservation tape. When the patient is admitted, the flag is removed.

Since the normal dismissing and admitting time for Kennestone Hospital is two P.M., an estimated length of stay of three days would be represented by one-half of an inch of the board space on the day admitted, the next two inches or two days following, and one-half of the next day. Although this actually represents part of four calendar days, it is only three hospital or charged days, since the hospital day at Kennestone is from two P.M. until two P.M.

Doctors are to notify the Admission Office directly and immediately when a reservation is to be altered or cancelled so that appropriate changes can be made to the control board.

When an in-patient expires, the head floor nurse on duty should immediately notify the Admission Office and should be prepared to furnish information as to when the room will be available for occupancy. The clerk on duty should remove the tape bearing the name of the expired patient.

All transfers should be approved by an admission clerk. When the transfer is completed, the tape is simply changed to the proper room number. Patients who request a transfer at the time of admission should have first preference for a vacant bed space except when a transfer is necessitated by

a patient's condition.

Emergency patients are posted to the control board as they are assigned a bed space. The attending physician is still required to furnish the information as for a normal admission.

The reservation tape of an in-patient who does not report for admission as scheduled is removed and the attending physician is notified; a patient who reports for admission but is not assigned to the surgical floor as planned should also have his reservation tape removed.

CHAPTER V

INSTALLATION AND OPERATION OF THE SYSTEM

Initial eight week period.—On March 28, 1956, a notice from the Administrator of Kennestone was forwarded to each member of the Medical and Dental Staff and to the Admission Office. It announced that the bed assignment control board system of admissions would be formally installed on April 2, 1956 (Fig. 11).

The system was inaugurated as scheduled and was operated and guided by the experimenter until June 26, 1956, at which time the responsibility of its operation was transferred to the Admission Office.

Although it was first conceived that the control boards would be wall mounted, the physical layout of the admitting office (Fig. 13) resulted in an insufficient usable wall area which would obscure the boards from the direct view of incoming patients and visitors. As a consequence, the control boards were provisionally stored, after their use, behind one of the admitting clerk's desks.

Since only a short period of time expired between the installation notice and the actual installation, several problems resulted. The boards could not be placed in a usable state until all of the present in-patients had been

dismissed and until the patients whose reservations had been made previous to the date of the notice (Fig. 11) had been admitted and discharged, for there was no estimate of length of stay on which to operate the control boards. A period of time was required for the complete turnover of these patients.

In the meantime, all in-patients who occupied a bed space on the Surgical Section and patients who had reservations without an estimated length of stay were posted to the control boards. Their length of stay was represented by an estimate, on occasion, from the attending physician or more frequently by the opinion of the chief admission clerk. The complete turnover, except for two long term patients, the length of whose stay no one would venture to estimate, was accomplished in about ten days.

The bed assignment control board system of admissions was operated by the experimenter during the evening hours of six to ten P.M. on a six-day week basis and on Sundays when the experimenter was present from two until six or seven P.M. This arrangement did not interfere with the normal admitting procedure but did substantially cover all in-patients who were admitted and discharged on any day. It also provided uninterrupted access to admitting records in order that data, pertinent to the system, could be collected on a daily basis for later evaluation.

Although data collection and evaluation were of primary importance during the initial eight week period,

the control boards were installed and operated entirely separately from the normal admission system. This did not provide the best conditions for the operation of the system but it did allow the experimenter to readily determine and correct any weak points or obstacles before the system was placed in operation on a full time basis.

While the system was still in the early stages of operation, several members of the Medical Staff became extremely interested in its development and operation. During the course of several informal discussions with these doctors, it was discovered that there was a misinterpretation of the term "length of stay". Some had made the error of expounding the term to mean "from the time of surgery until discharge" instead of the correct meaning of "from the time of admission until discharge". This error was corrected during the next regular staff meeting. Collected data which were in error were also revised.

As anticipated for any new system, during the first several weeks incomplete reservation information was received and sometimes recorded by the admission clerks. This condition rapidly improved with the continued operation of the system.

The control board system of admissions was operated on a part-time basis until the latter part of the eighth week. At this time, a preliminary evaluation of the data by visual inspection and frequency histograms (Tabs. 2 and 3,

and Figs. 14 and 15) indicated that the system could be a valuable aid in the forecasting and scheduling of surgical in-patients if, and only if, the system was correctly operated and maximum cooperation was received from the parties involved in its operation.

During the initial eight week period, the attending physicians were so receptive to the system that they also furnished the necessary reservation information data on Pediatric patients although the majority of these patients were not assigned bed space on the surgical floor. These data (Tab. 2) were also included in the preliminary evaluation and further substantiated that the system should successfully work in the Pediatric Section of the second floor. Final four week period.—During the final four week period of experimentation, the location of the control boards was changed in anticipation of a brief training program for the Admission Office and its complete responsibility for operation of the system.

After the preliminary evaluation of the data indicated that the doctor's estimates of length of stay were of an accurate nature and assumed positive skewed distributions, each having like form and appearance, a reminder notice, which briefly review the correct method of requesting reservations, was forwarded to the doctors and other interested personnel (Fig. 16).

Upon the suggestion of the administrator, the control

boards were mounted in the top tray of a hospital cart. This was done in conjunction with the full-time operation of the bed assignment control boards being handled by the Admission Office. Although this arrangement did not provide all of the advantages of wall mounting, it did allow better accessibility to the control boards, which up until this time were concealed behind an admission clerk's desk when not in use and required extensive manual handling during use. The bottom tray of the cart held the supplies necessary to operate the boards—two types of tape and a ruler for measuring and cutting the tape. The expense of the cart was absorbed by the hospital.

The basic principles of the bed assignment control board system of admissions were explained to each member of the Admission Office who would be associated with the proper operation of the system. Instruction was performed on an individual basis so it would not interfere with the normal duties of the personnel.

The training consisted of a review of the proposed admission system, the physical layout of the control boards, the operation of the system, and how the Admission Office, Kennestone Hospital, patients, and doctors could benefit by the system.

Actual cases were posted by the admitting clerks to the control boards under the supervision of the experimenter to assure that the correct procedure was followed in its op-

eration.

It was suggested that the chief admission clerk have jurisdiction over the system during her duty hours, that cases be posted by the clerks during her absence, and that the night clerk execute a thorough check of patients posted to the control boards against the in-patient room register for possible errors and duplications. Any errors or duplications should be corrected by the night clerk and these corrections should be forwarded to the admission clerk who relieves her. These arrangements would permit the system to be operated on a twenty-four hour basis and have corrective checks.

Some difficulty was encountered shortly after the training periods when one of the admitting clerks resigned. An experienced admission clerk was not available and this resulted in a definite loss to the system's operation since the new clerk first had to be trained for the normal admitting clerk's duties. This change in personnel resulted in the system being operated only as time allowed, for the burden of admissions was unequally distributed among the experienced clerks. A brief instructional period was given to the new admission clerk several days prior to the transfer of the system's operation to the Admission Office. This delay in training allowed the new clerk ample time to become familiarized with the admitting procedure before an explanation of the control board system was given her.

It was repeatedly stressed during the training program that if the system was to yield maximum benefits, reservations, admittances, transfers, and discharges must be posted to the control boards as soon as they occur or are received, since any deviation would not furnish an exact panoramic view of the current and projected bed space occupancy and requirements.

After the training period, the experimenter and the chief admission clerk continued to supervise the operation of the system for several weeks during which time additional data were collected.

On June 26, 1956, the transfer of complete responsibility for the operation of the bed assignment control board system of admissions was made to the Admission Department. Data collection was also terminated at this time and a final evaluation of the data was prepared.

Collection of the data.—Data were collected on every reservation which required bed space in the Surgical Section and for every surgical in-patient and pediatric in-patient, even if they were not to be assigned bed space in the Surgical Section. Several of the attending physicians furnished data on Medical in-patients and this was also recorded; insufficient quantity resulted in its not being used in the final evaluation.

Data were recorded on three by five inch white index cards in a standard manner (Fig. 17). This permitted rapid

interpretation for later evaluation. The cards were filed in one of three major categories—reservations, admittances, or discharges—or in one of two inactive categories—cancellations or did not show.

Each evening, the first operation which the experimenter performed was to record on an index card the patient's name, section to which he was assigned, age, sex, doctor's name, date to be admitted, the type of accommodations desired if available when admitted, and the estimated length of stay. This information was available in the admitting department reservation book if complete information was received and recorded. These cards were then filed in the card index box in chronological order with respect to admitting date, rather than the date the reservation was made, under the reservation section for further use.

As patients were admitted, their reservation card was pulled from the card box and further information was recorded, namely, the room number to which assigned, the patient's hospital medical record number, and whether the patient was covered by hospitalization insurance. The patient's hospital medical record number was an excellent method of securing additional data after the patient had been discharged. Each card was checked for errors before it was filed in the admittances section of the card index box in alphabetical order by the patient's last name for easy reference upon discharge.

When the patient had been discharged, his card was removed; the date of discharge was recorded as well as the error of the estimated length of stay. It was then filed under discharges and remained there until needed for the evaluation of the data. If a patient expired, information was recorded as if a normal discharge had resulted; therefore, an expired patient appeared as having an error in the length of stay if the patient expired on other than the estimated day of discharge.

The collection of data by the standardized card system (Fig. 17) furnished a readily interpretable and accessible permanent record and provided a rapid check against the control boards and admission records. If a patient did not show, his card would remain in the reservations file until the end of the day he was scheduled for admission and would be pulled and marked "no show". If a patient was assigned to a floor other than the Surgical Section, the remaining reservation card would be an indication that the tape should be removed and discarded.

Patients who did not report for admission on the correct day had their reservation card pulled and the card was marked "no show" and filed under the inactive or "no show" section.

If a cancellation or a change in a reservation was received by the Admission Office, the card was pulled and marked "cancellation" in the case of a cancellation and

filed. The tape on the control board was also removed and discarded. If a change in the admission date was requested, the card was removed and corrected and placed in the reservation section. The tape on the control board was also corrected.

Emergency admissions were handled in the same manner as a normal admission, except that the data were posted to the data cards as they became available and the card was marked "emergency".

CHAPTER VI

FINAL EVALUATION OF THE DATA

Data evaluation.—To make a breakdown of the data according to age, a decision was made to employ the age and sex groups of the number of males and number of females 14 years of age and under (excluding new-born), the number of males and females 15 through 44 years of age, the number of males and females 45 through 64 years of age, and the number of males and females 65 years of age and over (26). This breakdown was accepted as best for a statistical evaluation, although Kennestone considers the age group of zero to twelve years of age as Pediatrics. There always seemed to be some doubt as to where to place a child of around twelve, on the Surgical or Pediatric Floor. The final decision usually rested on the size of the patient and on the bed facilities available more than on age.

By using the above age and sex groups, the findings of the statistical evaluation could be readily correlated with American Medical Association data.

The means and variances of the estimated and actual length of stay of each age and sex group were statistically evaluated. Since the collected data, Pediatric and Surgical, indicated that 96.3 per cent of the in-patients were covered

by the liberal Lockheed Aircraft hospitalization policy or by other hospitalization coverage, it was assumed that the variance of the sampled population would not be influenced by the patient's insurance status. The exact procedure is exemplified by the sample calculations and by frequency histograms (Figs. 18, 19, 20, and 21).

Sample calculations.—The mean value of the estimated length of stay in days (\bar{X}_e) and of the actual length of stay in days (\bar{X}_a) was determined by using the statistic

$$\bar{X} = \frac{\sum_{i=1}^k f_i X_i}{N} \quad (27)$$

where \bar{X} is the mean value,

f_i is the frequency of an observation,

i is the individual observation,

X_i is the value of the individual observation,

and N is the sample size or total number of observations,

and the variance of the estimated length of stay in days (s_e^2) and the actual length of stay in days (s_a^2) was determined by the statistic

$$s^2 = \frac{\sum f_1 X_1^2 - \frac{(\sum f_1 X_1)^2}{N}}{N - 1} \quad (28)$$

The same statistics were used for the evaluation of all data (Tabs. 4, 5, 6, and 7) for each age and sex group to determine the variance and the mean (Tab. 8).

To illustrate the exact uses of the above statistics, the mean and the variance of the data for the estimated length of stay (male) from Table 4 is computed.

From the estimated length of stay (male) of Table 4:

Days	Frequency		
X_1	f_1	$f_1 X_1$	$f_1 X_1^2$
11	1	11	121
10	0	0	0
9	0	0	0
8	4	32	256
7	0	0	0
6	6	36	216
5	3	15	75
4	6	24	96
3	72	216	648
2	6	12	24
Totals	98	346	1436

$$N = \sum f_1 = 98$$

$$\bar{X}_e = \frac{\sum f_1 X_1}{N} = \frac{346}{98} = 3.53 \text{ days}$$

and

$$\begin{aligned} s_e^2 &= \frac{\sum f_1 X_1^2 - \frac{(\sum f_1 X_1)^2}{N}}{N - 1} \\ &= \frac{1436 - (346)^2 / 98}{97} \\ &= \frac{214}{97} = 2.21 \end{aligned}$$

The same procedure as above is repeated for the actual length of stay (male) from the data of Table 4 and yields a mean value (\bar{X}_a) of 3.33 days and a variance (s_a^2) of 1.50 days. These results are represented in table form by:

	Actual Length of Stay	Estimated Length of Stay
\bar{X}	3.33	3.53
s^2	1.50	2.21

for N = 98 patients

It is next desired to determine if there is a signifi-

cant difference between the variance of the doctor's estimates (the estimated length of stay) and the actual length of stay.

From the null hypothesis, $H_0: \sigma^2 \text{ estimated} = \sigma^2 \text{ actual}$; at the five per cent level of significance and the F-Test (29) where s_e^2 is the variance of the estimated length of stay and where s_a^2 is the variance of the actual length of stay we have:

$$F = \frac{s_e^2}{s_a^2} \quad (30)$$

and the hypothesis will be rejected if

$$F > F_{1-\frac{1}{2}\alpha} (98-1, 98-1) \text{ or if}$$

$$F < F_{\frac{1}{2}\alpha} (98-1, 98-1)$$

where

$$F_{0.975} = + 1.52$$

$$F = \frac{2.21}{1.50} = + 1.47$$

$$F_{0.025} = 1/F_{0.975} = + 0.66$$

hence, $+0.66 < +1.47 < +1.52$, and there is no justification, at the five per cent level of significance, in rejecting the hypothesis.

Further, it is desired to determine if the two populations have the same mean when it is known that $\sigma_e^2 = \sigma_a^2 = \sigma^2$, but when the actual value of σ^2 is not known.

$H_0: \mu_e = \mu_a$, at the five per cent level of significance.

We shall use $t = \frac{\bar{X}_e - \bar{X}_a}{s_p \sqrt{(1/N_e) + (1/N_a)}}$ (31)

$$\text{where } s_p^2 = \frac{\sum X_{e1}^2 - \frac{(\sum X_{e1})^2}{N_e} + \sum X_{a1}^2 - \frac{(\sum X_{a1})^2}{N_a}}{N_e + N_a - 2} \quad \text{and,}$$

where $\sum X_{e1}^2$ = sum of the squares in the first sample,

$\sum X_{a1}^2$ = sum of the squares in the second sample,

$\sum X_{e1}$ = sum of observations in first sample, and

$\sum X_{a1}$ = sum of observations in second sample.

The rejection region is $t > t_{1-\frac{1}{2}\alpha}(N_e + N_a - 2)$ and

$$t < t_{\frac{1}{2}\alpha}(N_e + N_a - 2)$$

$$t = \frac{+0.20}{1.36 \sqrt{0.0204}} = +1.033 \text{ and } t_{0.025} = -1.98$$

$$t_{0.975} = +1.98$$

Hence, $-1.98 < +1.033 < +1.98$, and there is not sufficient justification at the five per cent level of significance to reject the hypothesis, but since the distributions are skewed the significance level may lie between four and seven per cent (32).

Results.—Similiar calculations were performed on all age and sex groups with the following results:

Age Group	Sex	$H_0: \sigma_e^2 = \sigma_a^2$		$H_0: \mu_e = \mu_a$	
		Accept	Reject	Accept	Reject
0-14	M	x		x	
0-14	F		x	x	
15-44	M	x		x	
15-44	F	x		x	
45-64	M		x	x	
45-64	F		x	x	
65 plus	M	x		x	
65 plus	F	x		x	

The means and the variances of the errors of estimates for the 0-14 year age groups and the 15 year and over age groups (Tabs. 9 and 10, and Figs. 22 and 23) were statistically evaluated to futher exemplify and supplement the means and

variances of the estimated and actual lengths of stay of each age and sex group.

A statistical evaluation of these data revealed the following:

Age Group (M and F) (Years)	Mean (\bar{X}) (Days)	Standard Deviation (s) (Days)	Range within which 95.46 per cent of the errors fell (Days)
0-14	- 0.197	1.57	- 3.337 and + 2.943
15 plus	+ 0.608	3.18	- 5.752 and + 6.968

CHAPTER VII

CONCLUSIONS

Conclusions.—The statistical evaluation of the mean of the estimated lengths of stay against the mean of the actual lengths of stay for each age and sex group indicated that the doctors' estimates were a true representation of the actual lengths of stay.

The variance, a measure of dispersion, of the estimated and actual lengths of stay for each age and sex group was likewise tested. In all but three cases, namely, the 0-14 female, the 45-64 male, and the 45-64 female classifications, the variances of the estimated lengths of stay were characteristic of the actual lengths of stay.

The results of the collected data indicate that the doctors' estimates of lengths of stay were of a satisfactory nature to be used as an actual length of stay when forecasting and scheduling in-patients to the Surgical and Pediatrics Sections of Kennestone. The variances of the 0-14 female, the 45-64 male, and the 45-64 female classifications exemplified that the doctors' estimates enveloped a wider span than the spread of the other divisions and that these estimates could not be regarded, on the whole, as accurate as the other classifications.

The evaluation of the errors of estimates also indicated that the errors of over-estimating approximately balanced the errors of under-estimating with 95.46 per cent of the errors for the 0-14 year age group falling within -3.337 and $+2.943$ days and with 95.46 per cent of the errors for the 15 year and over age group falling within -5.752 and $+6.968$ days (33 and 34). With this being true, the estimates could have been successfully incorporated into the operation of the in-patient bed assignment control boards at Kennestone Hospital. It is here that the differences in the variances would have been useful in determining which of several patients in different age and sex groups would most likely over or under-stay their estimated length of stay.

The sex symbol, which appeared on each strip of scheduling tape posted to the control board, eliminated the possibility of the mixing of sexes in the same room and the age, which was likewise recorded on the tape, could be used to schedule patients of similar ages in a room.

CHAPTER VIII

RECOMMENDATIONS

Recommendations.—Although the bed assignment control board system was not operated in direct relation to the the normal admitting system during the experimentation period, the results of the collected data and experience with the operation of the control boards indicated that if the system were to be placed in direct operation as part of the proposed admitting system for the Surgical Section, if the control boards were operated correctly, if the future level of accuracy in estimating would not decrease, and if the error of the human element was considered as negative, the system would reduce the probability of surgical cancellations and would permit, with the exception of emergency cases, control of the occupancy level in the Surgical Section.

With due regard to the past data, it is recommended that the control board system be expanded to include the Pediatrics Section.

If future data would indicate that the doctors' estimates were a true representation of actual lengths of stay for G-Section, Obstetrics, and Medical Section, it is further suggested that control boards be placed in operation for these divisions.

Once the entire occupancy level of Kennestone is controlled, this level could be a valuable aid in the forecasting and scheduling of surgical time, laboratory work, housekeeping, X-rays, nursing, central supply, maintenance, and dietary requirements.

It is also believed that if Kennestone were to undergo a considerable expansion (Fig. 24), the control board system of forecasting and scheduling in-patients would be the only logical solution for the effective admission of in-patients.

It should be further exemplified that this system of in-patient bed assignment was specifically designed for Kennestone Hospital and that extreme caution should be exercised if an attempt is made to install and to operate this system in another hospital without a thorough investigation of its in-patient population and operating conditions.

APPENDIX

Table 1. Numerical Listing of Bed Space by Type of Service-Kennestone Hospital

MEDICAL

Room No.	Type
138	Private
139	Private
140	Ward
146	Semi-Private
147	Semi-Private
148	Ward
149	Semi-Private
150	Deluxe Private
151	Deluxe Private

N.W. MEDICAL

171	Semi-Private
172	Semi-Private
174	Semi-Private
175	Semi-Private
176	Private ... Toilet
179	Private ... Toilet
180	Private ... Toilet
183	Private ... Toilet
184	Private ... Toilet
187	Private ... Toilet

PEDIATRICS

234	Physiotherapy
236	Physiotherapy
237	Semi-Private
240	Semi-Private
243	Semi-Private
244	Semi-Private
245	Ward
246	Semi-Private
247	Deluxe Private ... Toilet
251	Deluxe Private ... Toilet

N.W. SECOND

218	Ward
220	Semi-Private
221	Isolation
225	Isolation
226	Semi-Private
227	Private ... Toilet
230	Semi-Private
231	Private ... Toilet
232	Private ... Toilet

O.B. FLOOR

257	Semi-Private
258	Semi-Private
259	Private
260	Deluxe Private
261	Semi-Private
262	Semi-Private
263	Semi-Private
264	Deluxe Private ... Toilet
267	Semi-Private
269	Ward
270	Ward
271	Semi-Private
272	Semi-Private

NURSERY

Cribs not listed

N.W. SURGERY

318	Ward
320	Private
321	Private
322	Semi-Private ... Toilet
325	Private ... Toilet
326	Private ... Toilet
329	Semi-Private ... Toilet
330	Semi-Private ... Toilet
333	Private ... Toilet

NORTH SURGERY

335	Private
336	Private
337	Private
338	Semi-Private
341	Semi-Private

344	Semi-Private
345	Semi-Private
346	Ward (4 bed)
348	Private
349	Deluxe Private
353	Deluxe Private

SOUTH SURGERY

359	Semi-Private
360	Semi-Private
361	Private
362	Private
363	Private
364	Private
365	Private
366	Deluxe Private
369	Ward (3 bed)
371	Ward (4 bed)
372	Ward (4 bed)
373	Private
374	Private

G-SECTION

G-18	Semi-Private
G-27	Ward
G-29	Ward
G-36	Deluxe Private
G-37	Deluxe Private
G-39	Deluxe Private
G-41	Deluxe Private
G-44	Semi-Private
G-45	Semi-Private
G-48	Semi-Private

Table 2. Distribution of the Number of Patients for Estimated and Actual Lengths of Stay of the 0-14 Year Age Group-Male and Female (first eight weeks data)

Length of Stay (in days)	Estimated Stay (in number of patients) M and F	Actual Stay (in number of patients) M and F
27	0	0
26	0	0
25	0	0
24	0	0
23	0	0
22	0	0
21	0	0
20	0	0
19	0	0
18	0	0
17	0	0
16	0	0
15	0	0
14	0	0
13	0	0
12	0	0
11	0	0
10	0	0
9	0	1
8	2	1
7	1	3
6	3	0
5	2	2
4	8	8
3	96	93
2	13	16
1	0	1
0	0	0
Totals	<hr/> 125	<hr/> 125

Table 3. Distribution of the Number of Patients for Estimated and Actual Lengths of Stay of the 15 Year and Over Age Group-Male and Female (first eight weeks data)

Length of Stay (in days)	Estimated Stay (in number of patients) M and F	Actual Stay (in number of patients) M and F
27	0	0
26	0	1
25	0	0
24	0	1
23	0	0
22	0	1
21	0	0
20	0	0
19	0	1
18	0	2
17	0	0
16	1	0
15	3	2
14	3	1
13	1	4
12	0	4
11	5	5
10	9	7
9	6	12
8	23	26
7	16	18
6	16	13
5	23	19
4	40	28
3	61	78
2	32	13
1	1	4
0	0	0
Totals	240	240

Table 4. Distribution of the Number of Patients for Estimated and Actual Lengths of Stay of the 0-14 Year Age Group- Male and Female (first three months data)

Length of Stay (in days)	Estimated Stay (in number of patients by sex)		Actual Stay (in number of patients by sex)	
	M	F	M	F
27	0	0	0	0
26	0	0	0	0
25	0	0	0	0
24	0	0	0	0
23	0	0	0	0
22	0	0	0	0
21	0	1	0	0
20	0	0	0	0
19	0	0	0	0
18	0	0	0	0
17	0	0	0	0
16	0	0	0	0
15	0	0	0	0
14	0	0	0	0
13	0	0	0	0
12	0	0	0	0
11	1	0	1	0
10	0	0	0	0
9	0	0	0	0
8	4	0	0	1
7	0	1	3	0
6	6	0	2	0
5	3	1	2	3
4	6	6	9	3
3	72	67	75	63
2	6	9	5	15
1	0	0	1	0
0	0	0	0	0
Totals	98	85	98	85

Table 5. Distribution of the Number of Patients for Estimated and Actual Lengths of Stay of the 15-44 Year Age Group-Male and Female (first three months data)

Length of Stay (in days)	Estimated Stay (in number of patients by sex) M and F		Actual Stay (in number of patients by sex) M and F	
27	0	0	0	0
26	0	0	0	0
25	0	0	0	0
24	0	0	0	0
23	0	0	0	0
22	0	0	0	0
21	0	0	0	0
20	0	1	0	0
19	0	0	0	0
18	0	0	0	1
17	0	0	0	0
16	1	0	0	0
15	1	1	0	1
14	1	2	0	1
13	0	0	0	2
12	0	0	3	2
11	2	1	2	4
10	0	6	2	3
9	1	1	6	6
8	5	17	8	15
7	8	6	5	13
6	8	8	4	9
5	8	17	10	11
4	11	32	9	23
3	21	51	24	59
2	12	17	5	10
1	0	1	1	0
0	0	0	0	1
Totals	79	161	79	161

Table 6. Distribution of the Number of Patients for Estimated and Actual Lengths of Stay of the 45-64 Year Age Group-Male and Female (first three months data)

Length of Stay (in days)	Estimated Stay (in number of patients by sex)		Actual Stay (in number of patients by sex)	
	M	F	M	F
27	0	0	0	0
26	0	0	0	1
25	0	0	0	0
24	0	0	0	1
23	0	0	0	0
22	0	0	1	1
21	0	0	0	0
20	0	0	0	0
19	0	0	0	0
18	0	0	1	0
17	0	0	0	0
16	1	0	0	0
15	0	1	0	0
14	0	0	0	0
13	0	1	1	3
12	0	0	0	1
11	1	4	0	0
10	0	4	0	3
9	4	1	5	1
8	3	4	7	3
7	2	4	3	2
6	6	2	2	3
5	3	3	1	5
4	5	7	4	5
3	7	11	6	15
2	4	5	3	3
1	0	0	2	0
0	0	0	0	0
Totals	36	47	36	47

Table 7. Distribution of the Number of Patients for Estimated and Actual Lengths of Stay of the 65 Year and Over Age Group-Male and Female (first three months data)

Length of Stay (in days)	Estimated Stay (in number of patients by sex)		Actual Stay (in number of patients by sex)	
	M	F	M	F
27	0	0	0	0
26	0	0	0	0
25	0	0	0	0
24	0	0	0	0
23	0	0	0	0
22	0	0	0	0
21	0	0	0	0
20	0	0	0	0
19	0	0	1	0
18	0	0	0	0
17	0	0	0	0
16	0	0	0	0
15	0	0	0	1
14	0	0	0	0
13	0	0	0	1
12	0	0	0	1
11	0	2	1	1
10	2	1	0	2
9	0	1	0	0
8	1	1	0	0
7	0	1	1	1
6	0	0	0	0
5	1	0	1	0
4	0	2	1	1
3	1	0	1	0
2	1	0	0	0
1	0	0	0	0
0	0	0	0	0
Totals	6	8	6	8

Table 8. Means and Variances by Age and Sex Groups for Estimated and Actual Lengths of Stay (first three months data)

Age	Sex	Estimated Mean (days)	Actual Mean (days)	Estimated Variance	Actual Variance
0-14	M	3.53	3.33	2.21	1.50
0-14	F	3.25	2.99	4.23	0.65
15-44	M	4.95	5.37	8.69	7.90
15-44	F	4.78	5.18	2.82	9.10
45-64	M	5.58	6.50	9.17	19.57
45-64	F	5.94	6.69	11.58	30.83
64 plus	M	6.34	8.18	12.27	36.17
65 plus	F	8.00	10.03	8.00	11.94

Table 9. Errors of Estimates for the 0-14 Year Age Group-Male and Female (first three months data)

Error of Estimate* (days)	Number of Patients
18	0
17	0
16	0
15	0
14	0
13	0
12	0
11	0
10	0
9	0
8	0
7	0
6	0
5	1
4	1
3	1
2	1
1	18
0	127
-1	22
-2	7
-3	2
-4	0
-5	2
-6	0
-7	0
-8	0
-9	0
-10	0
-11	0
-12	0
-13	0
-14	0
-15	0
-16	1
-17	0
-18	0
Total	183

* + represents over the estimate, and - represents under the estimate

Table 10. Errors of Estimates for the 15 Year and Over Age Group-Male and Female (first three months data)

Error of Estimate* (days)	Number of Patients
18	1
17	1
16	1
15	0
14	1
13	0
12	0
11	1
10	1
9	1
8	1
7	3
6	5
5	7
4	11
3	23
2	33
1	48
0	108
-1	51
-2	19
-3	6
-4	4
-5	2
-6	2
-7	2
-8	2
-9	0
-10	0
-11	1
-12	1
-13	1
-14	0
-15	0
-16	0
-17	0
-18	0
Total	337

* + represents over the estimate, and - represents under the estimate

811 Stovall Boulevard, N. E.
Atlanta 5, Georgia
December 6, 1955

Mr. George R. Burt, Administrator
Piedmont Hospital
551 Capitol Avenue, S. W.
Atlanta, Georgia

Dear Mr. Burt:

As you suggested during the course of our conversation on November 28, 1955, I have prepared an outline of a hospital bed assignment system which I have selected as the topic of my Master of Science thesis at the Georgia Institute of Technology, and would appreciate your presenting this proposal to the Board of Directors for their consideration.

Although at first the application of Industrial Engineering principals to hospital operations may seem remote, our field, at times, is referred to as "human engineering", and is particularly adaptable to studies of this type. As I told you, a system similar to the one I have outlined has operated successfully at Johns Hopkins for several years; increases bed occupancy of limited bed space with subsequent reduction of bed overhead has been realized through the innovation of new bed assignment procedures. It occurred to me that an adaptation of the system used at Johns Hopkins possibly would prove advantageous to Piedmont Hospital, both now and in the future. My Faculty Advisor, Dr. R. T. Staton, and I would welcome the opportunity to discuss the plan in detail with you and the Board of Directors.

If the decision of the Board is favorable, I would prefer to initiate operation of the plan in your present plant. In this way, procedures could be established before you move to your new location, subject, of course, to approval of the system in actual operation.

I enjoyed talking with you last week, and would like to thank you for the helpful suggestions you made regarding

Figure 1. Proposal Submitted to Piedmont Hospital

-2-

presentation of my plan to the Board of Directors.

Sincerely,

Seymour C. Anderson, Jr.

SCA

Enclosures:
Proposed System of Bed Assignment

PROPOSED SYSTEM OF BED ASSIGNMENT

The purpose of the proposed system would be to increase overall bed occupancy and to provide for the centralized assignment of bed space (both emergency and projected), utilizing a Bed Assignment Board in the Admitting Office. This board would be maintained on a daily basis from each patient's attending physician's non-binding estimate of every patient's length of hospitalization; the estimate would be given at the time bed space is reserved.

I. Requirements for successful installation and operation

- (1) Cooperation of each staff physician in furnishing the Admitting Office with the following information at the time reservation of bed space is requested:
 - (a) Patient's name, age, and sex.
 - (b) Diagnosis.
 - (c) Proposed date of hospitalization.
 - (d) Type of accommodation desired by the patient and the physicians preference of room location.
 - (e) A non-binding estimate of length of hospital stay.
- (2) Cooperation and assistance of the Hospital Administrator in formulating organizational details.
- (3) Cooperation of Admitting Office staff in incorporating the proposed system into the existing bed assignment procedures.

II. What is to be gained?

- (1) Complete centralization of bed assignment for all services (Medicine, Surgery, O.B.-Gyn., etc.).
- (2) Increased total bed occupancy - thus, more patients could be admitted without curtailing hospitalization of current house patients or lowering the present high standards of professional care.
- (3) A comprehensive panoramic view of the overall current

-2-

and projected bed occupancy, using a self-explanatory Bed Assignment Board - thus:

- (a) The availability of the type of bed space requested by a patient in areas specified by the attending physician would be more easily determined.
- (b) If the type of accommodation requested by the physician would not be available on the specified date, the Bed Assignment Board would simplify explaining to the physician why certain space would not be available and what alternative could be offered.
- (c) Confirmation of bed assignment would be given well in advance (possibly one month).
- (d) Advance assignment of bed space would give the patient an opportunity to complete personal arrangements for hospitalization, and would enable the hospital staff to schedule surgery, therapy, laboratory work, etc.,

III. Expense involved.

The cost of supplies necessary to institute the proposed plan would be at my expense; my personal labor would be considered a part of thesis work at the Georgia Institute of Technology.

IV. Time requirement.

Installation and test operation would not exceed a period of four consecutive months.

SCA

The Piedmont Hospital

INCORPORATED

Atlanta, Georgia

December 12, 1955

Mr. Seymour C. Anderson, Jr.
611 Stovall Blvd. N. E.
Atlanta, Georgia

Dear Mr. Anderson:

We wish to advise that your recent letter with the outline of the study you have in mind will be brought to the attention of the Trustees at the next meeting.

Your interest is deeply appreciated.

With kindest regards, we are

Sincerely yours,

~~PIEDMONT HOSPITAL~~

~~George R. Burt~~
Administrator

GRB.W

Figure 2. Letter Acknowledging Receipt of Proposal from
Piedmont Hospital

The Piedmont Hospital

INCORPORATED

Atlanta, Georgia

January 17, 1956

Mr. Seymour C. Anderson, Jr.
811 Stovall Blvd. N. E.
Atlanta, Georgia

Dear Mr. Anderson:

Your recent letter and outline of the hospital bed assignment system which you have as the topic for your Master of Science thesis at Georgia Institute of Technology was presented to our Board of Directors and it was decided that it would not be advisable for us to consider such a study before we get into the new hospital.

If you feel that you would be interested in doing the study later we will be glad to consider the question further at that time.

Thanking you for your offer and consideration, we are

Sincerely yours,

PIEDMONT HOSPITAL

George R. Burt
Administrator

GRB.W

Figure 3. Letter of Refusal from Piedmont Hospital

811 Stovall Boulevard, N. E.
Atlanta 5, Georgia
January 28, 1956

Mr. George R. Burt, Administrator
Piedmont Hospital Incorporated
Capitol Avenue and Crew Street at Crumley
Atlanta, Georgia


Dear Mr. Burt:

I wish to thank you for your recent letter regarding my proposal of a hospital bed assignment system, and also for your and the Board of Directors sincere cooperation.

Although, at first thought, the new Piedmont Hospital was considered to be the logical place for the project, I have been confronted by a critical time element and therefore do not believe that I will be able to investigate the possibility of doing the study at a later date.

Again your and the Board of Directors consideration was deeply appreciated.

Sincerely yours,


Seymour C. Anderson, Jr.

SCA

Figure 4. Letter of Appreciation to Piedmont Hospital

811 Stovall Boulevard, N. E.
Atlanta 5, Georgia
February 5, 1956

Mr. Millard L. Wear, Administrator
Kennestone Hospital
Marietta, Georgia

Dear Mr. Wear:

As you suggested during the course of our conversation on February 3, 1956, I have prepared an outline of a hospital bed assignment system which I have selected as the topic of my Master of Science thesis at the Georgia Institute of Technology, and would appreciate your presenting this proposal to the Board of Directors for their consideration.

Although at first thought, the application of Industrial Engineering principles to hospital operations might seem remote, our field at times is referred to as "human engineering", and is particularly adaptable to studies of this type. As I told you, a system similar to the one I have outlined has operated successfully at Johns Hopkins for several years; increased bed occupancy of limited bed space with subsequent reduction of bed overhead has been realized through the innovation of new bed assignment procedures. It occurred to me that an adaptation of the system used at Johns Hopkins possibly would prove advantageous to Kennestone Hospital, both now and in the future. My Faculty Advisor, Dr. R. T. Staton, and I would welcome the opportunity to discuss the plan in detail with you and the Board of Directors.

I enjoyed talking with you last week, and would like to thank you for the helpful suggestions you made regarding

-2-

the presentation of my proposal to the Board of Directors of Kennestone.

Sincerely,

Seymour C. Anderson, Jr.

SCA

Enclosure:
Proposed System of Bed Assignment

PROPOSED SYSTEM OF BED ASSIGNMENT

The purpose of the proposed system of bed assignment would be to increase overall bed occupancy and to provide for the centralized assignment of bed space (both emergency and projected), utilizing a Bed Assignment Board in the Admitting Office. This board would be maintained on a daily basis from the attending physician's non-binding estimate of every patient's length of hospitalization; the estimate would be given at the time bed space is reserved.

I. Requirements for successful installation and operation

- (1) Cooperation of each staff physician in furnishing the Admitting Office with the following information at the time reservation of bed space is requested:
 - (a) Patient's name, age, and sex.
 - (b) Diagnosis.
 - (c) Proposed date of hospitalization.
 - (d) Type of accommodation desired by the patient and the physician's preference of room location.
 - (e) A non-binding estimate of length of hospital stay.
- (2) Cooperation and assistance of the Hospital Administrator in formulating organizational details.
- (3) Cooperation of Admitting Office staff in incorporating the proposed system into the existing bed assignment procedure.

II. What is to be gained?

- (1) Complete centralization of bed assignment for all services (Medicine, Surgery, O.B.-Gyn., etc.).
- (2) Increased total bed occupancy - thus, more patients could be admitted without curtailing hospitalization of current house patients or lowering the present high standards of professional care.
- (3) A comprehensive panoramic view of the overall current

-2-

and projected bed occupancy, using a self-explanatory Bed Assignment Board - thus:

- (a) The availability of the type of bed space requested by a patient in areas specified by the attending physician would be more easily determined.
- (b) If the type of accommodation requested by the physician would not be available on the specified date, the Bed Assignment Board would simplify explaining to the physician why certain space would not be available and what alternatives could be offered.
- (c) Confirmation of bed assignment could be given well in advance (possibly one month).
- (d) Advance assignment of bed space would give the patient an opportunity to complete personal arrangements for hospitalization, and would enable the hospital staff to schedule surgery, therapy, laboratory work, etc.,

III. Expense involved.

The cost of supplies necessary to institute the proposed plan would be at my expense; my personal labor would be considered a part of thesis work at the Georgia Institute of Technology.

IV. Time requirement.

Installation and test operations would not exceed a period of four consecutive months.

V. Beginning date.

As soon as approval of the Board is received.

SCA

**THE CITY OF MARIETTA HOSPITAL AUTHORITY
KENNESTONE HOSPITAL
MARIETTA, GEORGIA**

71

February 21, 1956

Mr. Seymour C. Anderson, Jr.
811 Stovall Boulevard, N. E.
Atlanta 5, Georgia

Dear Mr. Anderson:

The Kennestone Hospital Board of Trustees, the Medical Staff, and myself heartily approve the project, which you have outlined in a proposed system of bed assignment for Kennestone Hospital.

As soon as it is convenient to you, I will be happy to sit down with you and work out the administrative details so that you can get started on this project.

Sincerely yours,

Millard L. Wear
Administrator

MLW/lb

Figure 6. Letter of Acceptance from Kennestone Hospital

HOSPITAL BED-is one which is installed for regular 24-hour use by in-patients during their period of hospitalization.

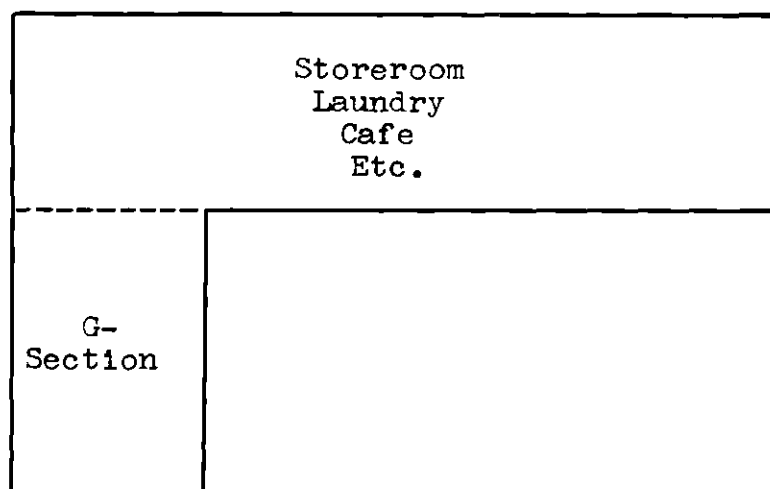
- (a) Adult Beds-those of standard length and shape for use by adults and older children.
- (b) Cribs-those equipped with sides or guards and are for the use of young children.
- (c) Bassinets-for the regular use of infants other than new-born infants.
- (d) New-Born Infant Bassinet-one installed in the hospital for regular 24-hour use by a new-born infant and is not considered to be a hospital bed; however, bassinets used by infants other than new-born infants are included in the bed complement. New-born infant bassinets do not include incubators used for the treatment of new-born infants, but such infants should be reported as occupying bassinets during their period of treatment.

BED COMPLEMENT-of a hospital is the number of hospital beds (exclusive of bassinets for new-born infants) normally set up and available for use by in-patients. This figure is used in calculating bed occupancy. In the ideal hospital, bed capacity and bed complement should be the same.

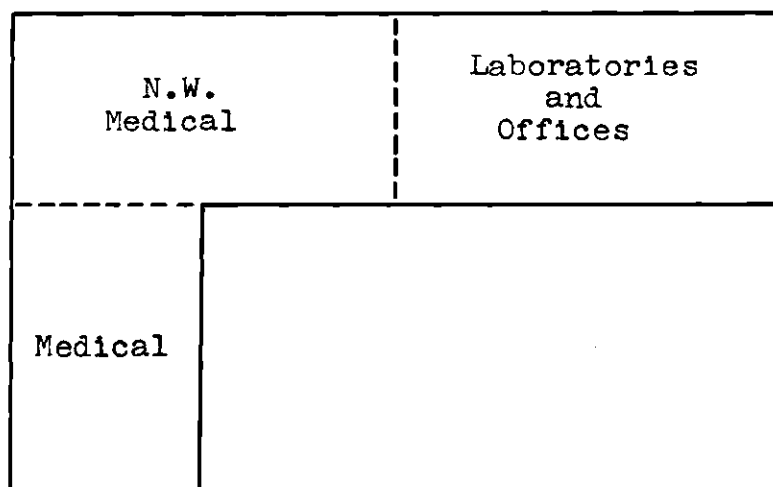
BED CAPACITY-is a statistical term used in relation to area requirements. It is theoretically the largest number of hospital beds, exclusive of new-born infant bassinets, which could be established in the hospital at any given time, based upon space intended for such use, whether or not beds are installed.

IN-PATIENT-is a patient who is lodged, fed, and treated in a hospital or infirmary.

Figure 7. Definitions

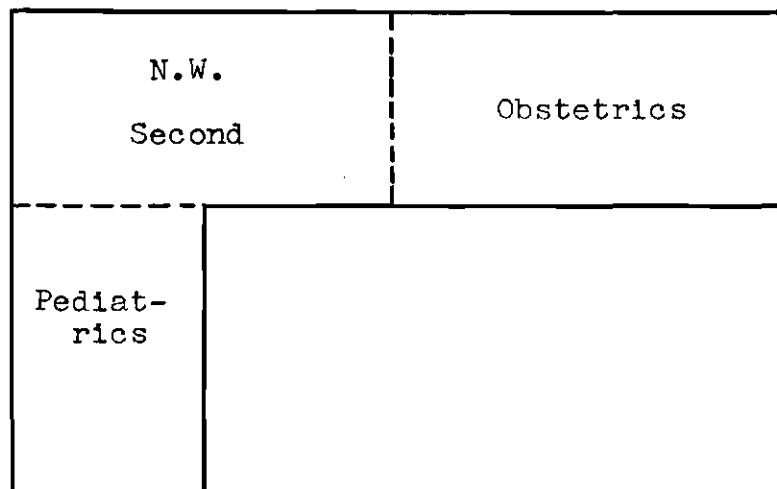


Basement Plan

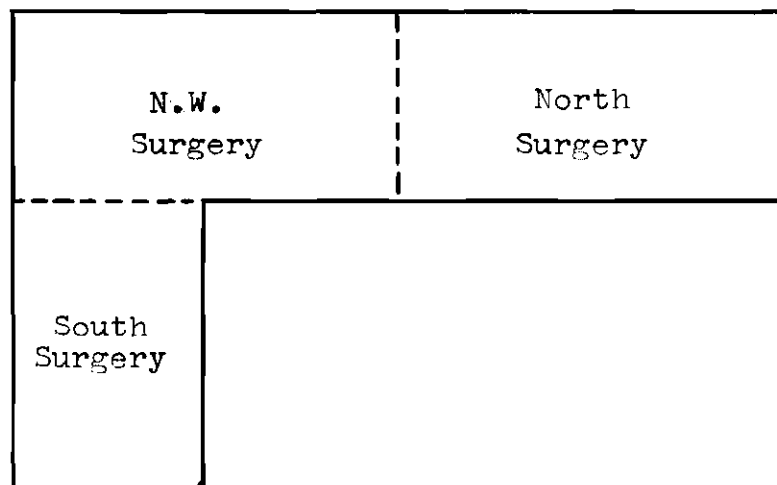


First Floor Plan

Figure 8. Physical Layout by Type of Service - Kennestone Hospital



Second Floor



Third Floor

COPY

All rates and fees are based on the actual cost of operation and are subject to change in proportionate ratios to changes in the cost of operation.

(1)	De Luxe Private Rooms G-30, G-36, G-37, 150, 151, 247, 251, 264, 349, 353, and 366	\$ 14.50
(2)	Isolation - Private room with shower 221, 225	14.50
(3)	Private Room with Hi Low Bed and Toilet 176, 179, 180, 183, and 184	13.00
(4)	Private Room with Toilet 187, 227, 231, 232, 325, 326, and 333	12.50
(5)	Psychiatric Room 234	12.00
(6)	Private Rooms 138, 139, 236, 257, 258, 259, 260, 261, 320, 321, 335, 336, 337, 348, 361, 362, 363, 364, 365, 373, 374	11.00
(7)	Semi-Private Room with Toilet G-44, G-45, G-48, 230, 330, 322, and 329 ...	10.00
(8)	Semi-Private Rooms G-18, 146, 147, 149, 171, 172, 174, 175, 220, 226, 237, 243, 244, 246, 262, 263, 271, 272, 338, 344, 345, 359, and 360	9.00
(9)	Solarium (3 bed ward) 369	8.00
(10)	Wards G-27, G-29, 140, 148, 218, 245, 269, 270, 318, 371, and 372	7.50

This charge includes nursing care, meals, and special diets, certain routine drugs, ordinary surgical dressings,

Figure 9. Day Rate and Fee Schedule - Kennestone Hospital
Marietta, Georgia

(Day Rate and Fee Schedule) -2-

and administrative expenses. The charge varies with the type of accommodation utilized.

NOTE: Those who are unable to pay their entire hospital bill will be by all means assigned to ward beds unless the condition of the patient would require a private room.

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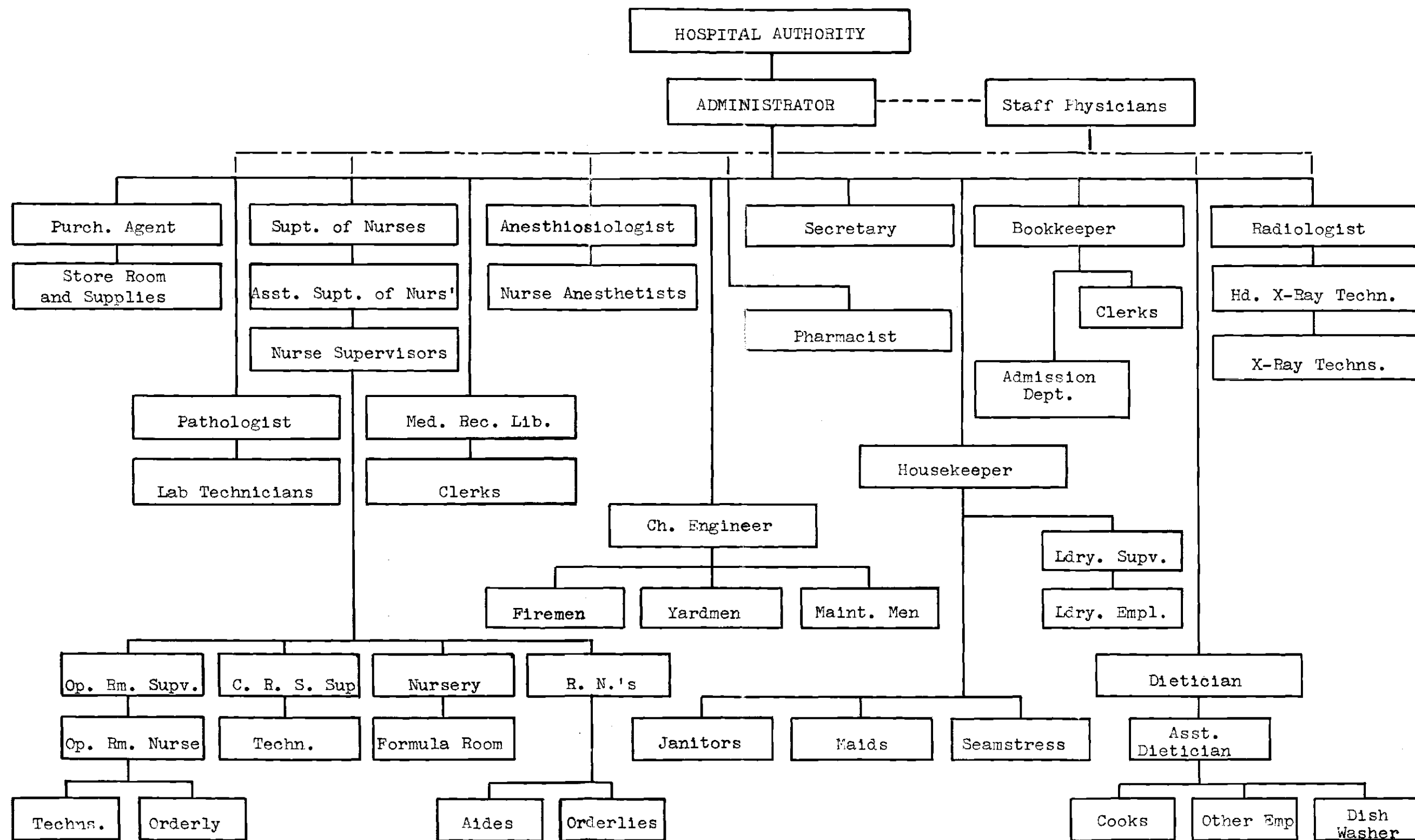


Figure 10

Typical Hospital Organizational Chart

KENNESTONE HOSPITAL

78

MARIETTA, GEORGIA

March 28, 1956

Dear Doctor:

You will recall our discussion about a new procedure to be started in the Admission Department, whereby in addition to other information, the attending physician would be required to give a non-binding estimate of the length of stay of the patient.

We, tentatively, plan to put this into effect at least for the Surgical Department, and later for all other departments, on the 2nd of April.

I want you to have this notice so that when our Admission Department asks for this information, you will be prepared to give it to them.

I appreciate your cooperation in helping us out on this project and believe it will be to your advantage.

Sincerely yours,

Millard L. Wear
Administrator

MLW/lb

Copy: Each member of the Medical & Dental Staff

cc: Mrs. Fears, Chief Admission Clerk

Figure 11. Announcement of the System by the Administrator

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
359 SP																															
360 SP																															
361 P																															
362 P																															
363 P																															
364 P																															
365 P																															
366 DP																															
369 W																															
371 W																															
372 W																															
373 P																															
374 P																															

Figure 12. Physical Layout of a Typical Control Board

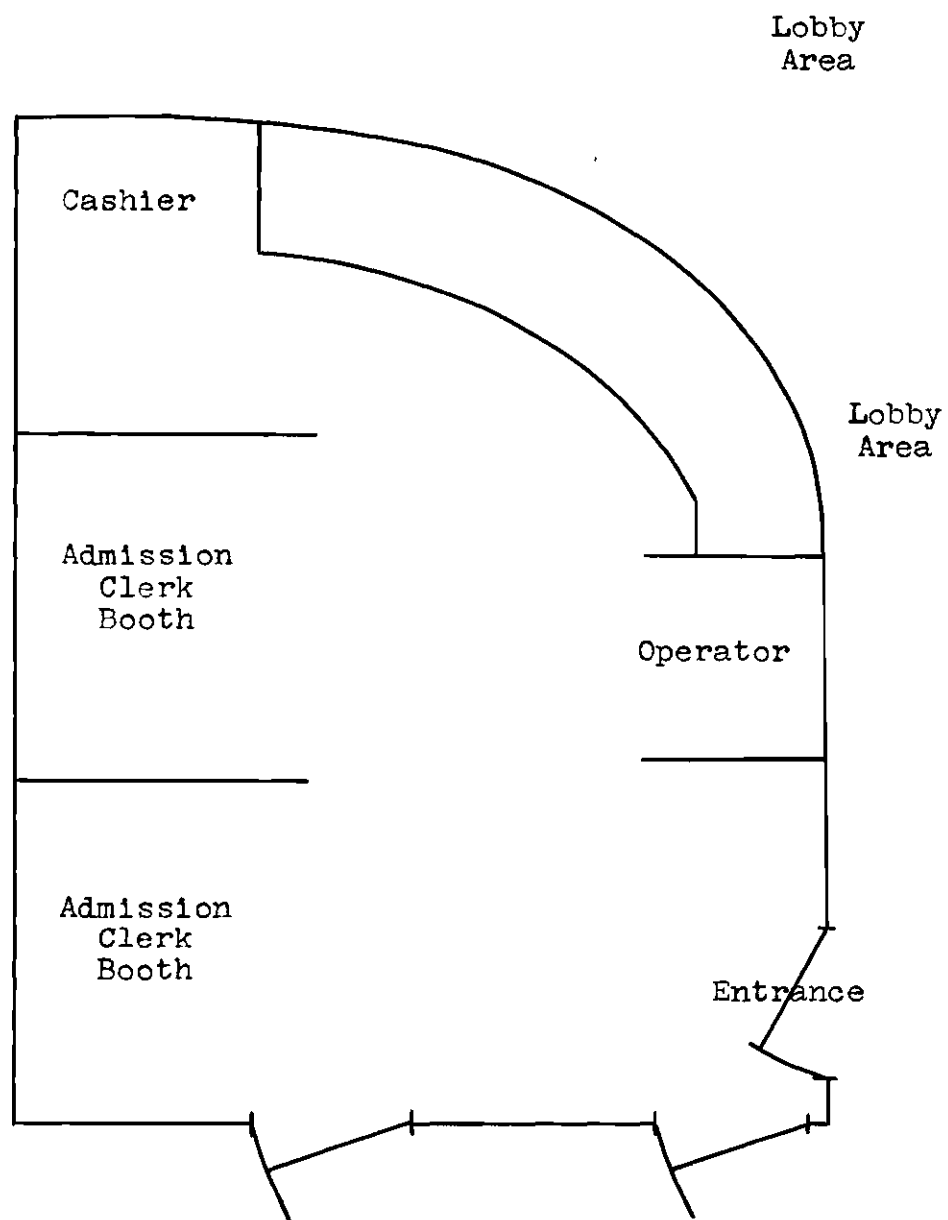


Figure 13. Physical Layout of the Admission Office

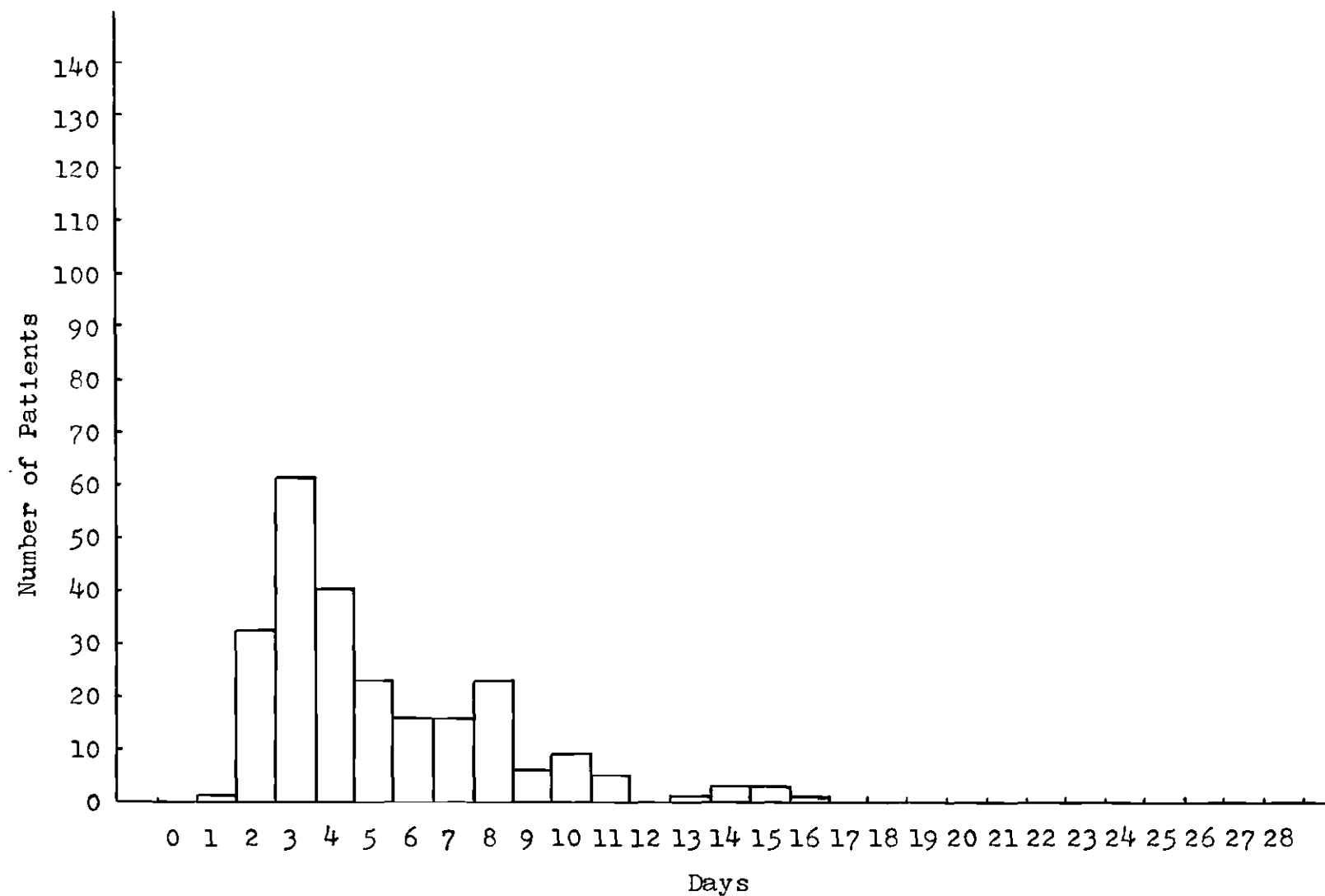


Figure 14. Frequency Histogram of the Estimated Length of Stay for the 15 Year and Over Age Group - Male and Female (first eight weeks data)

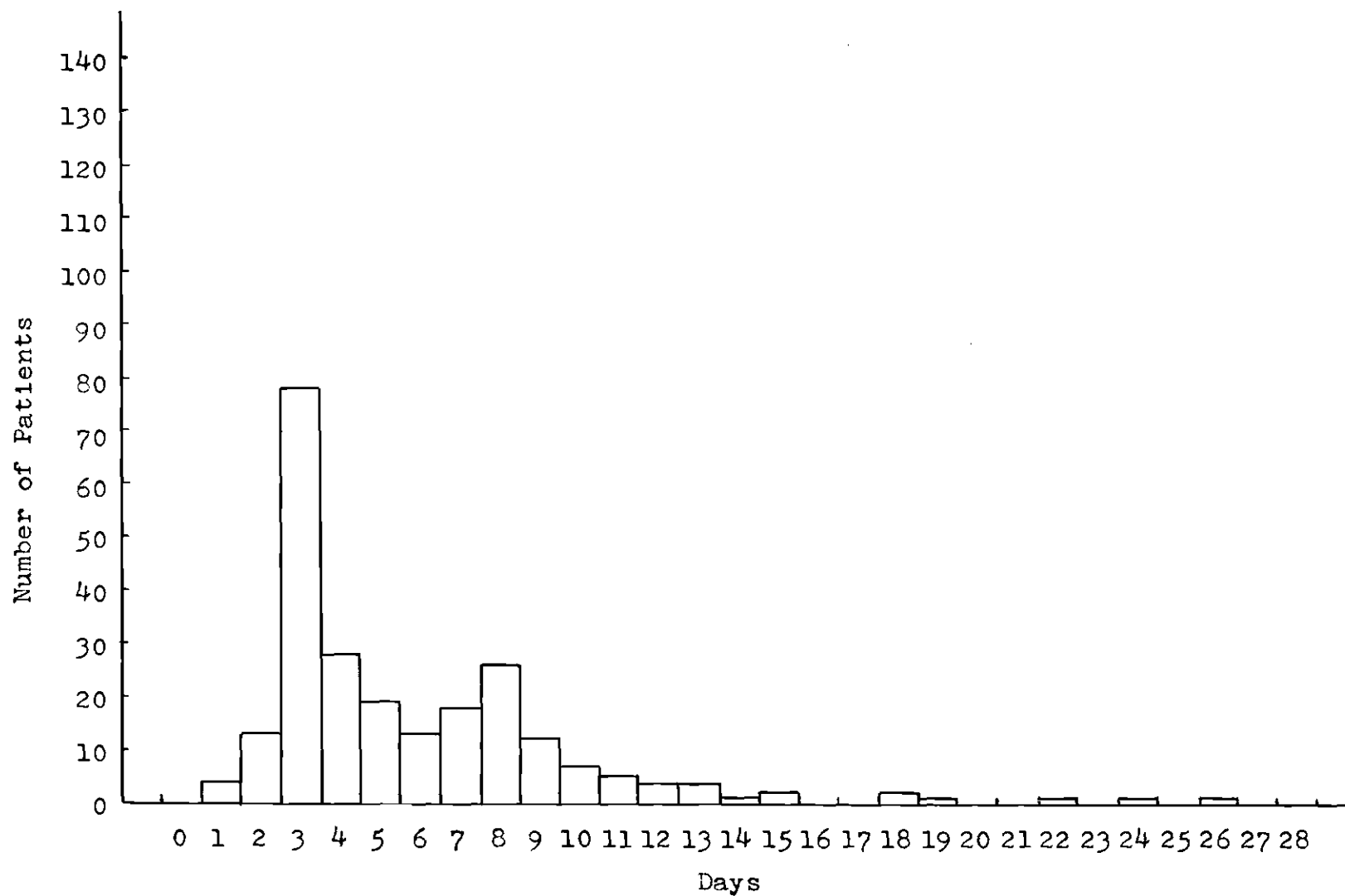


Figure 15. Frequency Histogram of the Actual Length of Stay for the 15 Year and Over Age Group - Male and Female (first eight weeks data)

KENNESTONE HOSPITAL**MARIETTA, GORGIA**

June 16, 1956

MEMORANDUM:

TO: EACH MEMBER OF THE MEDICAL STAFF
MRS. FEARS, DIRECTOR OF ADMISSIONS
MRS. DUDLEY, OPERATING ROOM SUPV.

FROM: MILLARD L. WEAR
ADMINISTRATOR

In the future when an operation is posted for the operating room, it will be necessary for the doctor, who is posting the operation or his secretary to call the admission department and arrange for room reservation. In the past it has been the custom for the doctor in some cases to post the operation and assume that a room would be available; this has caused us to have to cancel operations in a number of cases. We believe that if at the same time the operation is posted, the admissions department is contacted we can work this thing a lot more efficiently.

Sincerely yours,

Millard L. Wear
Administrator

MLW/lb

Figure 16. Reminder Memorandum by the Administrator

1*					
2		3	4	5	6
7		8			
9		10			
11					
12					
13					

*

1. Hospital number,
2. Patient's name and initials,
3. Type of patient: S for Surgical, M for Medical, P for Pediatrics, and OB for Obstetrics,
4. Is the patient covered by hospitalization insurance,
5. Age of the patient,
6. Sex of the patient,
7. Doctor's name,
8. Type of bed space desired, if available,
9. Date of admission,
10. Room to which assigned,
11. Estimated length of stay in days,
12. Date of discharge, and
13. Error of estimate; - for under and + for over.

Figure 17. Standardized Layout of the Data Collection Card

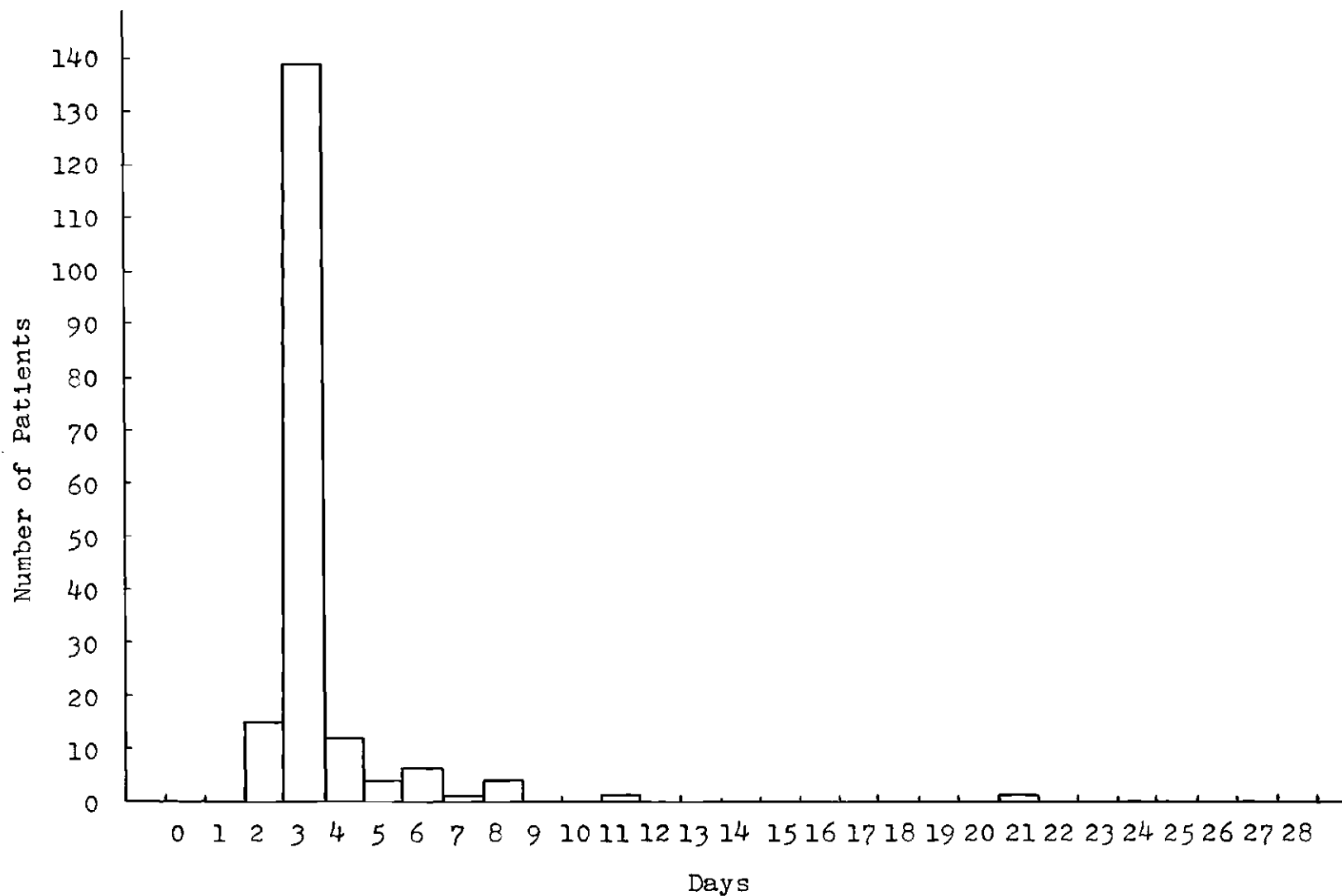


Figure 18. Frequency Histogram of the Estimated Length of Stay for the 0-14 Year Age Group - Male and Female (first three months data)

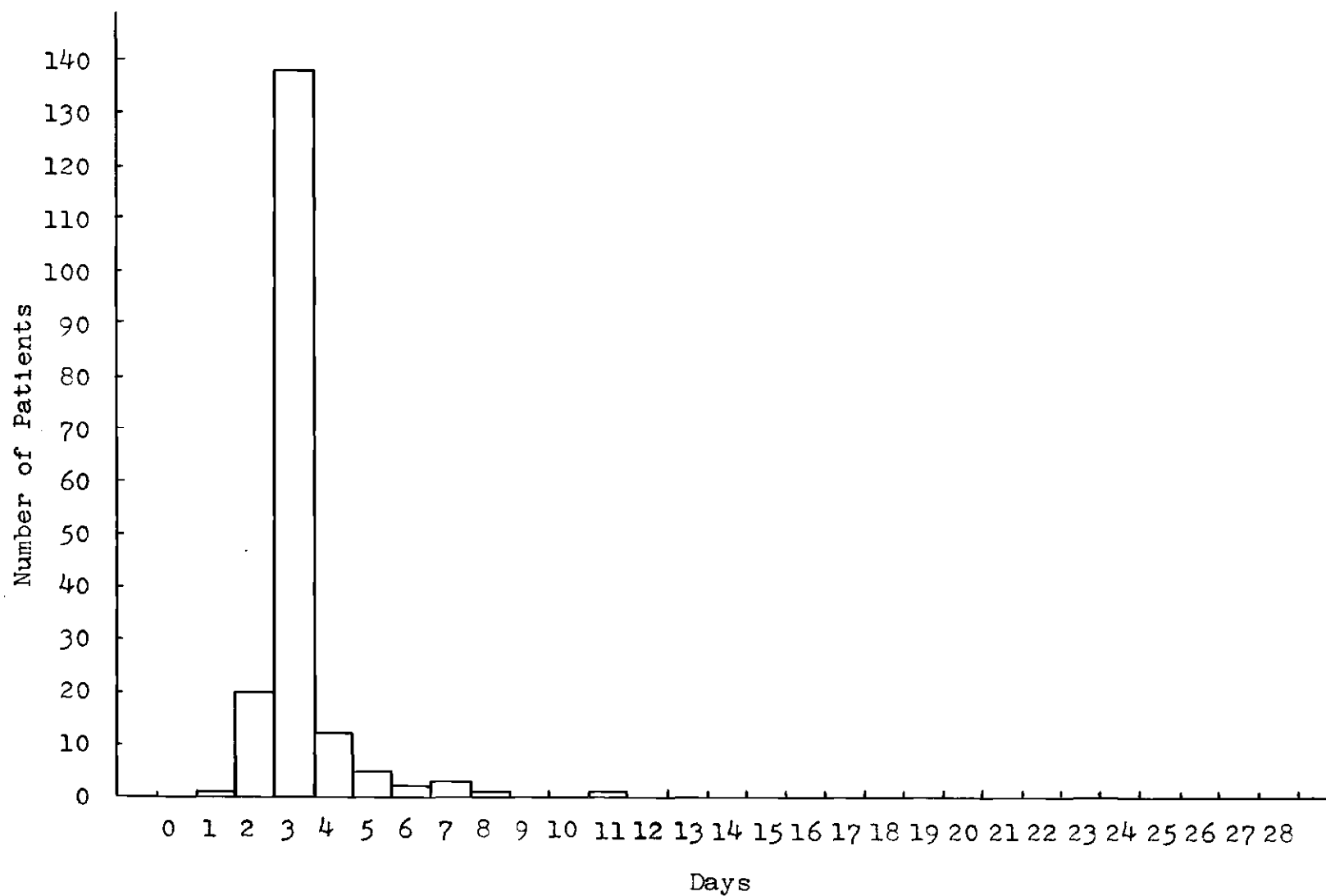


Figure 19. Frequency Histogram of the Actual Length of Stay for the 0-14 Year Age Group - Male and Female (first three months data)

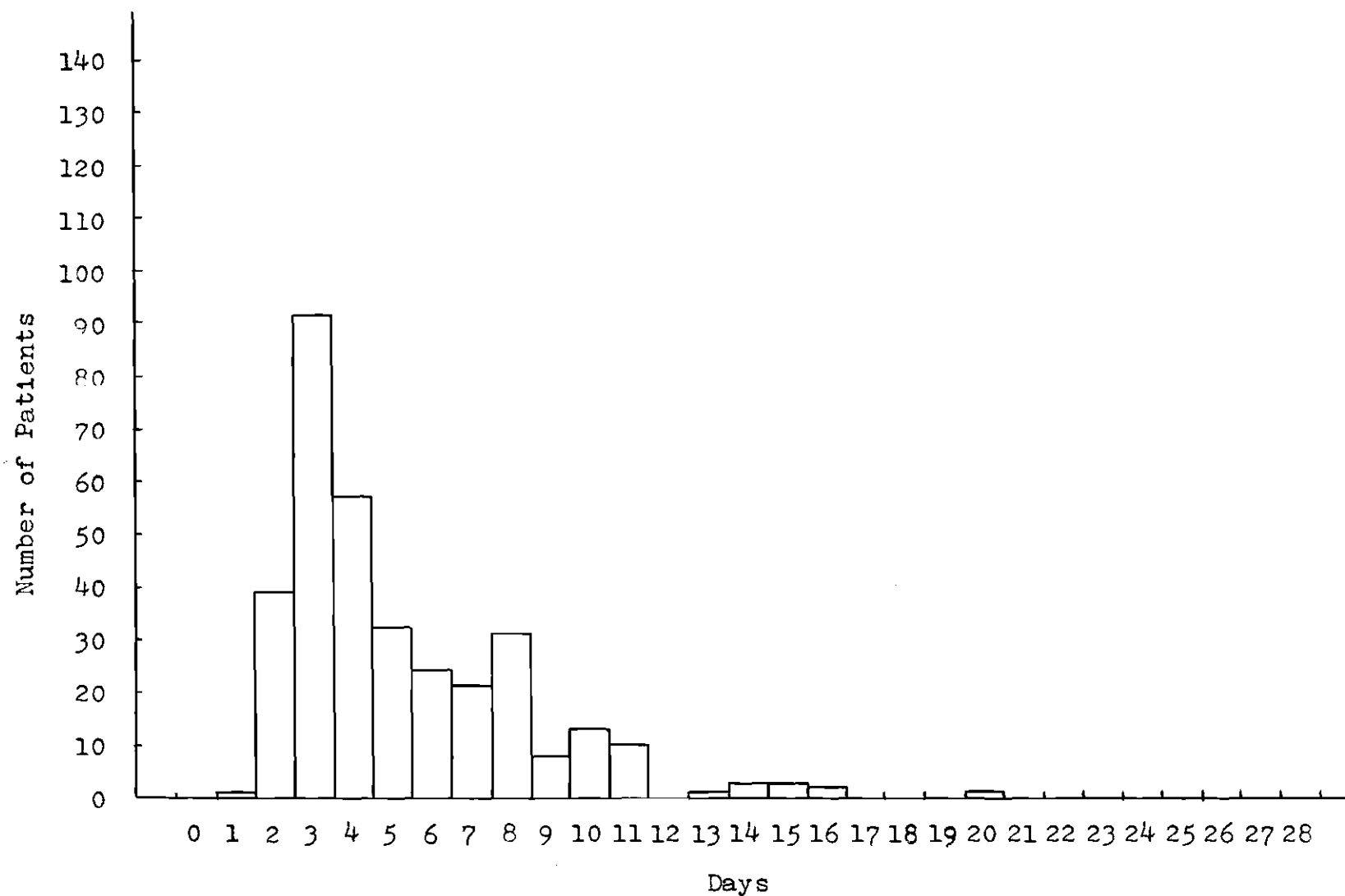


Figure 20. Frequency Histogram of the Estimated Length of Stay for the 15 Year and Over Age Group - Male and Female (first three months data)

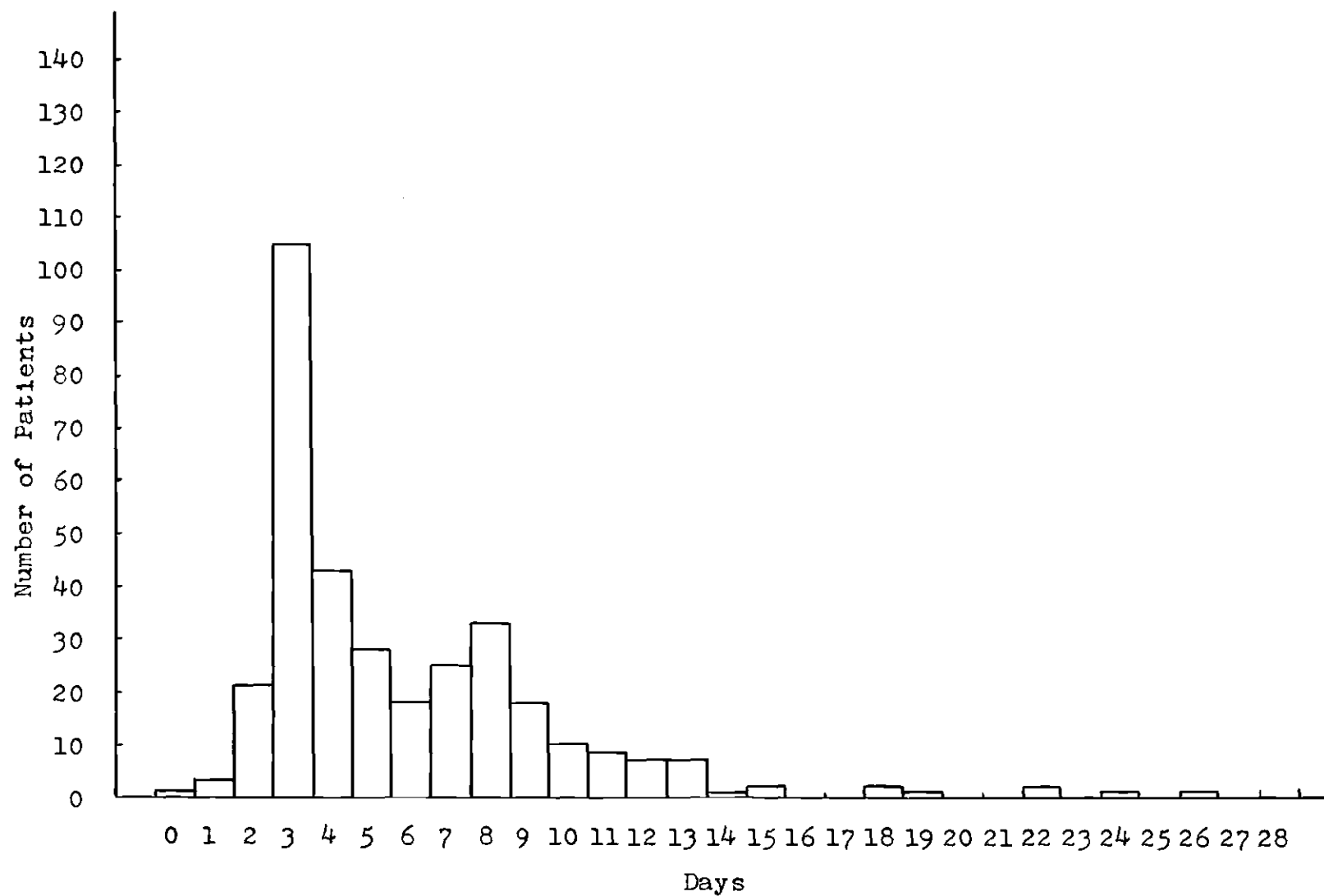


Figure 21. Frequency Histogram of the Actual Length of Stay for the 15 Year and Over Age Group - Male and Female (first three months data)

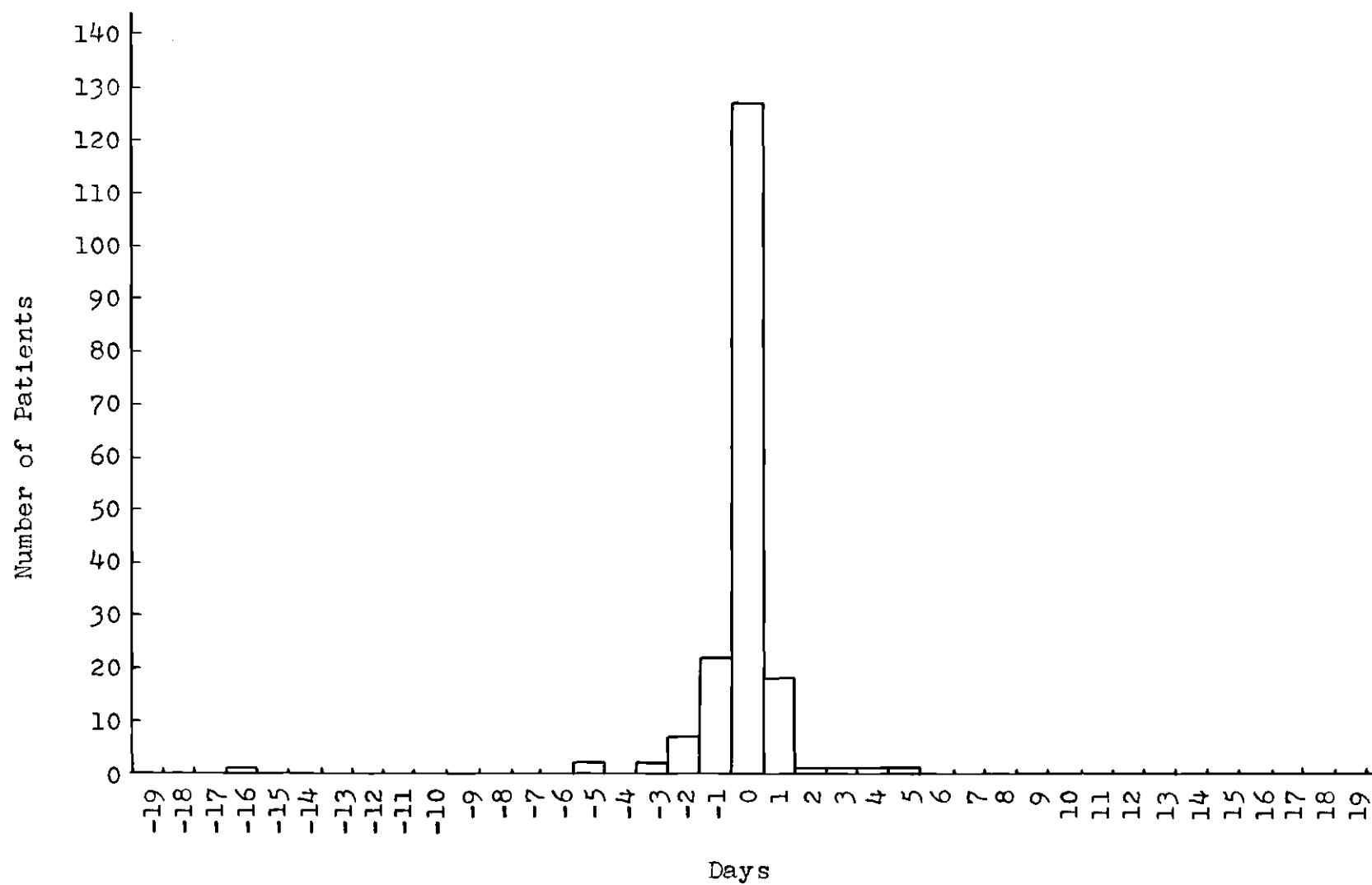


Figure 22. Frequency Histogram of the Errors of Estimates for the 0-14 Year Age Group - Male and Female (first three months data)

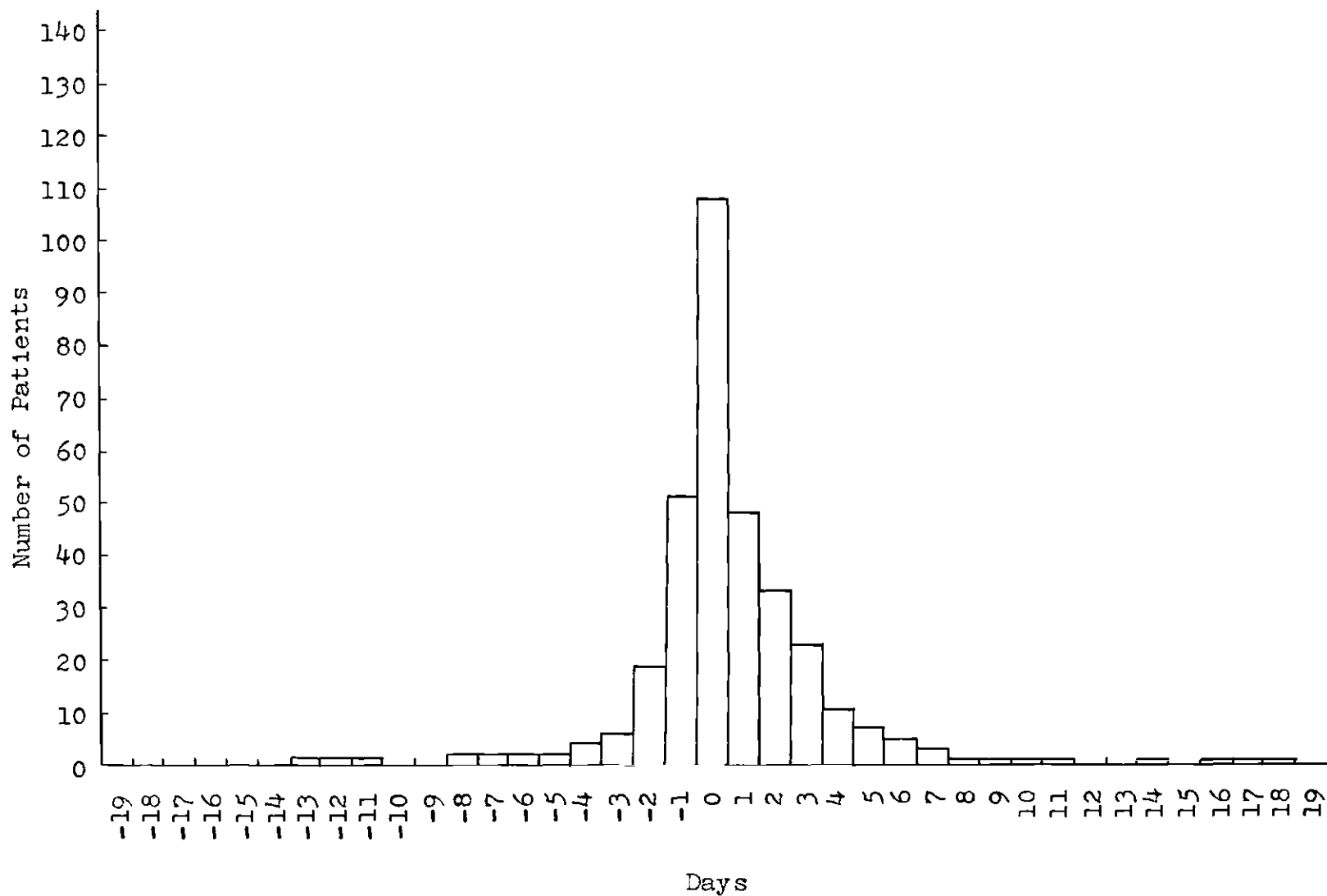


Figure 23. Frequency Histogram of the Errors of Estimates for the 15 Year and Over Age Group - Male and Female (first three months data)

10 **The Atlanta Journal** THURSDAY, APRIL 5, 1956

Kennestone to Get 100-Bed Addition

**Project Likely to Start by January;
Hill-Burton Act Cost Put at 1.7 Millions**

By MARILYN PENNINGTON

Marietta's Kennestone Hospital will almost double its present size with the addition of a 100-bed wing. Administrator Millard L. Wear said construction on the project should start by December or January.

As soon as that project is finished, Mr. Wear said, the hospital will need yet another 100-bed addition. The hospital now has 155 beds.

The addition is expected to cost \$1,700,000. Under the Hill-Burton Act, money will be provided by city, state and Federal Governments.

Members of the hospital staff and governing board have met with architects, and details of the new wing are being worked out now.

The hospital administrator said

the new beds will be distributed among the various departments—surgical, medical, pediatrics, obstetrics — on the basis of past needs.

• • •

IN ADDITION to bed space, Mr. Wear said, laboratory space and facilities will be increased to include an X-ray department. A permanent chest X-ray section to check every patient for tuberculosis and a radiolotope room may be added, Mr. Wear said.

Other improvements would include possible air conditioning of the entire hospital, a larger emergency room, more nursery space and additional elevators.

Kennestone Hospital, opened in 1950, has been enlarged already from its original 100 beds to 155.

Figure 24. Proposed Expansion Program of Kennestone Hospital

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- (32) Cochran, W. G., "Some Consequences When the Assumptions for the Analysis of Variance Are Not Satisfied", Biometrics Section of the American Statistical Association, 3, No. 1 (Mar. 1947), p. 24.
- (33) Grant, Eugene L., Statistical Quality Control, New York: McGraw-Hill Book Company, Inc., 2nd ed., 1952, p. 60.
- (34) Cochran, op.cit., p. 24.