UNCOUPLING THE RADIOLOGY SYSTEM

by

Roslyn Lindheim
Architect, AIA

Support for this work was provided by the United States Public Health Service, Division of Hospitals and Medical Facilities under Grant HM 00299-01-D38.

Center for Planning & Development Research: Institute of Urban & Regional Development
and
Department of Architecture University of California, Berkeley

August, 1967

ACKNOWLEDGEMENTS

A great number of people have given help and advice in the preparation of this study. I would specifically like to thank Allan Blackman, city planner and research specialist, who helped research and formulate the final project. I would also like to thank Franco Bertola, architect, who was responsible for some of the early studies and the illustrative material. Dr. Louis Davis, Dr. Edward Crossman, and Dr. Gordon Robinson helped evaluate the early stages of the project.

The following persons gave of their time and opened up their facilities and statistics for our use, and we are deeply grateful: Dr. Henry Breen; Dr. Klaus Dehlinger; Dr. Alexander Margolis; Dr. Earl Miller; Mrs. A. Temple; Dr. Gershon-Cohen; Dr. William Davis, planning engineer for Kaiser Foundation; and Mr. Rao Y.R., for his Kaiser studies.

TABLE OF CONTENTS

	Page
Acknowledgements	i
List of Tables	iii
List of Figures	v
Introduction	1
Chapter I: The Context of the Problem	9
Chapter II: The Goals of Radiology	29
Chapter III: The Calculation of the Size of Diagnostic X-Ray Departments	38
Chapter IV: A Study of the System of Diagnostic Radiology	64
Chapter V: Uncoupling the System to Provide Spatial Flexibility ...	92
Chapter VI: Study Methods	107
Appendix A	117
Appendix B	127
Appendix C	151
Appendix D	171
Bibliography	181

LIST OF TABLES

Chapter		Page
III	Table III-1: X-Ray Examinations in a University Hospital	42
	Table III-2: Annual X-Ray Examination Rates Per 1,000 Persons of Both Sexes, by Type and by Age of Examinee, Monroe County, N.Y.	43
	Table III-3: Distribution of Number of X-Ray Procedures .	45
	Table III-4: Radiology Department Workload Projections ..	52
	Table III-5: Radiology Department Long Range Planning Study	53
	Table III-6: Radiology Department Out-Patient Visits	54
	Table III-7: Sampling of Existing X-Ray Room Utilization During 5 Day 8 Hour Period	55
	Table III-8: X-Ray Room Requirements	56
IV	Table IV-1: Chart Showing the Average Waiting Time of Each Patient and the Average Time He Spends in the Diagnostic Room	82
	Table IV-2: Activity of Radiologist in a Community Hospital--Typical Day	88
	Table IV-3: Summary of Technician Supervisor's Activities in a Community Hospital	89
	Table IV-4: Technician's Activities	90
Appendix		
A	Table A-1: Utilization: Laboratory and X-Ray Examinations, Nonfederal Short Term General and Special Hospitals, By Size, 1953-1962	120
	Table A-2: Number of Diagnostic X-Ray Visits and Number per 100 Persons per Year, by Race and Area of Body X-Rayed: United States, July 1960-June 1961	121

List of Tables - Cont.

Appendix		Page
A	Table A-3: Seasonal Variations in X-Ray Examination Rates, Expressed in Percent Deviation from Corresponding Mean Annual Rates, Monroe County, N.Y., 1958-59	122
	Table A-4: Utilization of Diagnostic Radiology by In-Patients, Out-Patients and Emergency Patients in a University Hospital by No. of Procedures	123
	Table A-5: Distribution of X-Ray Procedures Between In-Patients, Out-Patients and Emergency in a Community Hospital	124
B	Table B-1: Survey of Means of Transportation	149
	Table B-2: Chart of Procedures and Percentages of Utilization During Various Hours of the Day	150
C	Table C-1: Distribution of Time Spent in Radiology Department--Typical Day	153
	Table C-2: Distribution of Time Spent in Radiology Department--Typical Day	158
	Table C-3: Time Required for X-Ray Examinations in University Hospital	166
	Table C-4: University Hospital Controlled Appointment Plan	167
	Table C-5: Time Required for X-Ray Examinations in a Hospital with a Prepayment Plan	169
	Table C-6: Table Showing Average Time per Procedure in a Hospital with a Prepayment Plan	170
D	Table D-1: Characteristics, Community Hospital	171
	Table D-2: List of Equipment and Supplies, Community Hospital	173
	Table D-3: Community Hospital X-Ray Fee Schedule	180

LIST OF FIGURES

Chapter		Page
I	Figure I-1: Growth of Number of X-Ray Procedures, Community Hospital	13
	Figure I-2: Growth in Number of X-Ray Examination Procedures, University Hospital	14
	Figure I-3: Utilization of Diagnostic X-Ray, University Hospital	15
III	Figure III-1: Simulation of Morning Activity in a Community Hospital Radiology Department	48
IV	Figure IV-1: Multiple Process Diagram	66
	Figure IV-2: Process Sequence Path	67
	Figure IV-3: Process Sequence Path (Incomplete)	68
	Figure IV-4: Basic Activities in Diagnostic Radiology	69
	Figure IV-5: Analysis of Procedures: Radiology Department Procedures in a Community Hospital	72
	Figure IV-6: X-Ray Examination Flow Chart	80
	Figure IV-7: Sequence Diagram of Gastro Intestinal Examination Procedure, Out-Patients	81
	Figure IV-8: Chart Showing the Time Spent by a Patient in the X-Ray Department Expressed as a Percent of the Total Time in the Department	83
V	Figure V-1: El Camino Hospital	94
	Figure V-2: X-Ray Diagnostic Department	96
	Figure V-3: Basic Elements of X-Ray Diagnostic System	100
VI	Figure VI-1: Planned Observation of Activities: Work Sheet	109

List of Figures - Cont.

Appendix		Page
A	Figure A-1: Monthly Variation in Patient Load at a University Hospital	125
	Figure A-2: Number of X-Ray Procedures in Relation to Available Population in a University Hospital	126
B	Figure B-1: Daily Variation of Patient Load and Daily Variation of X-Ray Rooms Utilization, Community Hospital	127
	Figure B-2: Daily Variation of Patient Load, Random Selection, Community Hospital	128
	Figure B-3: Daily Variation of Patient Load, Random Selection, Community Hospital	129
	Figure B-4: Community Hospital Utilization of X-Ray Rooms	130
	Figure B-5: Community Hospital Utilization of X-Ray Rooms	131
	Figure B-6: Utilization of X-Ray Room 270 on a 15 Minute Basis for a 9 Hour Day, Community Hospital ...	132
	Figure B-7: Utilization of X-Ray Room 500 on a 15 Minute Basis for a 9 Hour Day, Community Hospital ...	133
	Figure B-8: Utilization of X-Ray Room 277 on a 15 Minute Basis for a 9 Hour Day, Community Hospital ...	134
	Figure B-9: Patient Arrival Per Hour, Community Hospital	135
	Figure B-10: Patient Arrival Per Hour, Community Hospital	136
	Figure B-11: Patient Arrival Per Hour, Community Hospital	137
	Figure B-12: Patient Arrival Every 15 Minutes, Community Hospital	138
	Figure B-13: Number of People, Community Hospital	139

List of Figures - Cont.

Appendix | | Page

B Figure B-14: Patient Arrival Every 15 Minutes, Community Hospital 140

Figure B-15: Distribution of Patient Load on a Weekly Basis, University Hospital 141

Figure B-16: Distribution of Patient Load on an Hourly Basis, University Hospital 142

Figure B-17: Utilization of X-Ray Room 347 on an Hourly Basis and Utilization of X-Ray Room 349F on an Hourly Basis, University Hospital 143

Figure B-18: Utilization of X-Ray Room 341 on an Hourly Basis and Utilization of X-Ray Room 345 on an Hourly Basis, University Hospital 144

Figure B-19: Utilization of X-Ray Room 373 on an Hourly Basis and Utilization of X-Ray Room 359 on an Hourly Basis, University Hospital 145

Figure B-20: Utilization of X-Ray Room 323 on an Hourly Basis and Utilization of X-Ray Room 327 on an Hourly Basis, University Hospital 146

Figure B-21: Utilization of X-Ray Room 349G on an Hourly Basis and Utilization of X-Ray Room 375 on an Hourly Basis, University Hospital 147

Figure B-22: Distribution of Patient Load on a 15 Minute Basis, University Hospital 148

C Figure C-1: Change in Type of Examinations, Community Hospital 151

Figure C-2: Time of Examinations, Community Hospital ... 152

Figure C-3: Time of Examinations, University Hospital ... 157

Figure C-4: Hospital with a Prepayment Plan Showing Patient Per Procedure and Expressed as a Percentage of the Total Number of Patients 168

D Figure D-1: Community Hospital Radiology Department 172

INTRODUCTION

The following monograph is a study of diagnostic radiology within the hospital setting. It is based on the premise that understanding the problems of hospitals and health in all of their complexity will enable the architects to produce better design solutions, and that this understanding can be achieved by a systematic analysis of a given problem. The study is an example of how the system of radiology was analyzed and spatially uncoupled. It serves as a preview of what must be done to other hospital departments as well as to the hospital as a whole if new design alternatives are to be developed and accepted.

The long-term goal of this study was to develop methods of research and analysis which, given specific objectives, could provide the architect with a sounder basis for arriving at design decisions, in order to produce more effective and efficient plants. To illustrate how these design procedures can be applied to a <u>specific</u> problem, a detailed analysis was made of the internal activity of a key hospital service--radiology. The radiology department was selected for investigation because it presents many of the same design considerations as are encountered in other hospital departments:

1. It renders services essential to the operation of other departments, i.e., surgery, emergency, medicine, orthopedics.

2. It requires relatively large numbers of personnel whose activities are interdependent.

3. It is utilized by patients in all degrees of sickness and health--

ambulant, bed, chronic, emergency, in- and out-patients.

4. It must be in a central priority location and yet maintain flexibility and expansion potential.

5. It requires a major capital outlay in terms of plant and equipment.

6. It is undergoing constant technical change and consequently requires the most flexible design approach possible.

7. Because of special technical problems, almost all current guides for design of X-ray departments have come from the X-ray companies making the equipment used. This may guarantee proper technical functioning but, of necessity, lacks the overall view that should go into design and placement of such a key department in the total hospital picture.

Diagnostic radiology departments in three types of hospitals were selected for study: a university hospital, a hospital and clinic which operates under a large prepayment plan, and a typical community hospital. It was felt that careful study of these different types of institutions would reveal any common denominators in the system of radiology on which generalizations could be drawn concerning its past, present, and future aspects. The university hospital was selected because its research and teaching role would be likely to indicate the future of radiology in terms of more complicated and innovative procedures. The hospital with a clinic and large prepayment plan would indicate some of the problems which occur in the accommodation of inpatients with a substantial number of outpatients using the same hospital facilities. The third hospital was selected as a typical community hospital which would present the current procedures and problems of diagnostic radiology. It was felt that to study three institutions in depth would be more significant than to study many superficially. The results of this study have taken two forms. The first is this monograph which is focused primarily on the specific problems affecting the design of Radiology Departments. A companion volume entitled Notes on Architectural Program Planning for Hospitals deals more theoretically with the factors affecting design decisions and their impact on the physical form of hospitals and health facilities.

Before it is possible to develop any type of physical solution for a design problem it is necessary to identify in a language common to both architect and client the design goals, the criteria by which the design will be judged, the needs and requirements of the building users, and the activities which must be accommodated. The statement of the above is generally referred to as the architectural program. The importance of this document cannot be overestimated as it, in fact, sets the design course and establishes the objectives, scope, constraints, and requirements for a given project.

A design program as originally written and conceived is bound to change during the course of design development. The translation of a program into three dimensional language often exposes new relations as well as limitations due to the requirements of structural systems, site, building codes, and priorities of other functions. The written program should be regarded as a hypothesis to be used as a take off point for further design study and evaluation.

It would seem axiomatic that the first step in architectural program planning is to understand the problem and, based on this understanding, develop the most appropriate program directives as the starting point for design activity. Unfortunately, in actual practice there is rarely sufficient time or money to throughly study a problem before being pressured to find a physical solution.

Substitute devices for problem study have been offered architects in the form of either prototype plans or "list of room" programs. Prototype plans have been prepared by the governmental agencies or, in the case of radiology, by equipment manufacturers. Plans have been developed for fifty, one hundred, two hundred or five hundred bed hospitals which show suggested room arrangements, sizes, and equipment. The list of room program is prepared by the radiologist, technicians, or sometimes administrators, often prior to the time the architect is hired. In either case it is important to recognize that once a room has been defined in terms of function and a size assigned, the architectural solution is frozen.

If this type of program would generate adequate design solutions, there would be nothing wrong with it, but, unfortunately, the scope of service, the technology, and the patient requirements change faster than the concepts embodied in the prototypical plans. Instead of the physical form responding to new functional requirements, we find obsolete design notions hampering the activity of the users. Perhaps the most obvious fault with the concept of a prototype plan is that it is conceived in isolation from the functioning of the rest of the hospital system. Clinic policy affects the functioning of the radiology department, and so does the location and volume of emergency and surgery. Meal time shut downs lower the utilization rates of diagnostic radiology rooms; a radiology department is integrally related to the organization of the rest of the hospital as well as to the medical facilities within the larger geographic community.

Whether we are dealing with an individual facility or a group of facilities, no aspect of the health problem can be treated in isolation. The patient bed, the servicing system, the information system, ambulant care, or as in this study the system of diagnostic radiology must all be looked at as part of the health picture. Today the design of a multipurpose facility, whether spatially contiguous or separated, requires a systems approach.

A Systems Approach

The method used to study diagnostic radiology within the hospital setting has been a systems approach. The word "system" has taken on as many different meanings as there are users of the word. Webster offers several definitions:

> An organic or organized whole; a complex of ideas, principles, etc., forming a coherent whole; an assemblage of objects united by some form of regular interaction or interdependence.
>
> The entire thing; all that is comprehended under some concept, generic term, or abstraction of any sort; a totality, sum or entirety; a complete assemblage or organization of parts or elements.

By a systems approach we mean a state of mind more than any specific amalgam of mathematical, scientific, or technological methods. A system is a set of interrelated needs and activities linked together to accomplish a desired end. To approach the study of any aspect of a health system, the following questions must be asked: "What is the desired end or function of the system; what are the sets of interrelated needs and activities which make up the system; what are the links in the system or the structure of the system; how are they interrelated; how are the parts or the subsystems put together?"

A systems approach implies that before a decision can be reached about one aspect of the system one must encompass an overall view of the problem, because the solution might not lie in the immediate organization but rather in its relationship to the larger whole. Lastly, a systems approach by identification of the various subsystems at work and their interrelationships, helps us develop a method for the preliminary ordering of facts awaiting description, interpretation and analysis, which is useful in understanding a problem. A hospital is a subsystem of the health system of a community; so are a doctor's office, a public health clinic, and a mobile X-ray truck. Each of these in turn has its own subsystems. Surgery, radiology, etc., are subsystems of the hospital, and they in turn have their own sets of subsystems.

The needs of the system and the needs of the respective subsystems have to be identified. It is in response to needs that an organizational system as well as a physical plan are formulated. There are a variety of ways of answering needs: some are organizational, some are environmental, some are technological, some are spatial arrangements. No answers occur in isolation; organizational answers affect spatial solutions; spatial solutions affect personal relationships, efficiency, etc.

Radiology is a subsystem of a larger hospital system, and the decisions reached about its location, organization, and function depend in large part on the projected utilization and relationship of diagnostic radiology to the rest of the hospital.

The conditions of radiology which have to be studied and analyzed as a basis for design decisions are the following:

1. The Context of the Problem: What is the function and organization of radiology today? What is the pattern of use of radiology? How is the use of radiology growing? Is there adequate radiology manpower? How are technological trends, medical trends and new health programs likely to change the practice of radiology?

2. Goals: What are the goals of a particular radiology department? What is its particular role within the larger hospital context? What are its projected research and teaching functions? What will be its responsibility for radiology services in the neighborhood, the city, and the region?

3. Scope and Size: What will be the scope of service and the corresponding size? How many patients will there be? What type of patients? What facilities will be required to meet the needs of these patients? Consideration must be given to the demographic trends taking place in the area the hospital serves which might affect the patient load. Involved in the calculation of patient population is a knowledge of the other available facilities.

4. Activities: What activities will take place in the building and what kinds of facilities do they require? What are the functional processes that must take place to satisfy these activity requirements? What are the relationships of the different functions to each other?

5. Users: Who are the users and what are their needs in each of the activities? What are the social and ethnic backgrounds of the patients and what are their attitudes toward hospitals, doctors, and privacy? What kind of physical environment best suits their needs?

6. Uncoupling the Spatial System: Depending on the nature of the problem and the size of the organization, decisions must be made as to

what elements of the system must be physically located together. What elements can be physically separated but still functionally linked? What technology is available to do the latter?

7. Grouping: How should the components of the system be grouped? Should the system be centralized or decentralized? What are the most effective grouping patterns for patients, for staff, for efficient service, and for economy of operation?

The answers to the above questions can only be found as a result of a team effort. The team must include, in addition to the radiologist and the manufacturers of radiology equipment, other professionals from the fields of sociology, economics, industrial engineering, nursing, administration, and architecture. The patient from every age and income group must also be part of the team. The collective knowledge of all of these participants will be needed in order to acquire the insight and information prerequisite to resolving the design problems posed by the rapidly changing and complex requirements of the radiology department.

Within this context the specific role of the architectural planning programmer is to act as a catalytic agent and probe the radiology organization into self-examination, analysis, and decision making. By doing this the architect can help clarify the problem of the organization so that functional requirements can be most effectively translated into the architectural language of space.

CHAPTER I: THE CONTEXT OF THE PROBLEM

The conditions within which planning takes place have both a _specific context_ as well as a _general context_. By a specific context, we mean factors specific to a particular project, such as a particular budget, a site, a set of government regulations, a particular architect and a particular client, which influence architectural design. But architectural designs are also influenced by more general factors including the history, culture, economy, politics, and technology which form the design images and constraints. Planning for radiology departments takes place in both a specific and a general context. A particular radiology department is located in a specific hospital with a specific set of resources and particular problems. At the same time, all radiology departments must be planned within a general context composed of national patterns of medical care, of changing technology, rising costs, new organizational patterns, new legislation, new demands for medical services and continuing personnel shortages both in radiology and medicine as a whole.

Within almost every public service field--education, health, city building, etc.--there is a constant battle between local planners and administrators and national planners and administrators. The locals criticize the nationals for ignoring variabilities in local cultures, problems, resources and needs. The nationals criticize the locals for ignoring broad trends, for being provincial and ignorant of new developments. Often, both the locals and nationals are correct in their criticisms of each other. The field of radiology is not excepted from this conflict.

Planning for individual radiology facilities must take into consideration the general, the regional, and the national contexts of the problem; national radiology planning, including nationally developed architectural prototype for radiology departments, must consider regional and local variabilities. This chapter presents statistics which show the pattern of use of diagnostic radiology services throughout the United States, the variations in use according to age, sex, and income, and also some discussion of the medical, legal, and technological trends affecting radiology. The information in this chapter is the result of a review of current literature on radiology and medical facility planning as well as interviews with radiologists, public health officials, and hospital administrators. We have tried to indicate

1. Trends in uses of diagnostic radiology;
2. Patterns of X-ray use;
3. Trends in manpower distribution and training;
4. Trends in technology which indicate additional usage and/or substitute technologies; and
5. The implications of new government health programs.

Growth in the use of Radiology

The National Advisory Committee on Radiation recently estimated that total demand for diagnostic X-ray service in the United States is increasing at an annual compound rate in excess of 7.2 per cent.[1] A comparison of the 1964 and 1961 U.S.P.H.S. studies of X-ray usage indicates that the annual number of X-ray visits grew in that period by about 8%.[2] These statistics do not reflect the fact that 25% of a radiologist's time is spent on special procedures examination, yet these examinations account for only 3% of all services rendered. If the increase in demand were calculated on the basis of time requirements for trained radiological personnel, the figures would be even larger.

Appendix A, table 1, reflects unevenness in the rate of growth in different size hospitals. The smaller hospitals had a larger percentage increase in X-ray examinations than the larger. Presumably this was due at least in part to the influence of the Hill-Burton Act which required diagnostic X-ray in new small rural and suburban hospitals.

The growth rates of the hospitals we studied are depicted in figures 1-1, 1-2, and 1-3.

The Pattern of X-Ray Use

X-ray usage varies significantly according to the demographic characteristics of the population and according to the way medical services are organized. Many studies have been made which describe the variation in X-ray usage.[3,4,5] Nationally, in 1964, an estimated 67 million persons made 93 million visits to medical X-ray facilities at which they received 119 million medical X-ray procedures.[6] Regionally, in 1964, the Northeast states had the lowest usage rate--56.8 medical examinations per hundred persons; the Western states had the highest rate--72.7[7] (the population in the West has a considerably higher rate of health insurance coverage than the population in other areas[8]). In all regions, persons living in metropolitan areas have a higher rate of X-ray examinations than do persons in non-metropolitan areas.[9]

In addition to these geographical differences, X-ray usage varies according to the sex, age, race, education, income, and seasons of the year. Some areas of the body are X-rayed more often than other areas. X-rays are given in hospitals, private doctors' offices, mobile units and elsewhere, and each of these places reflects a different use pattern (see Appendix A).

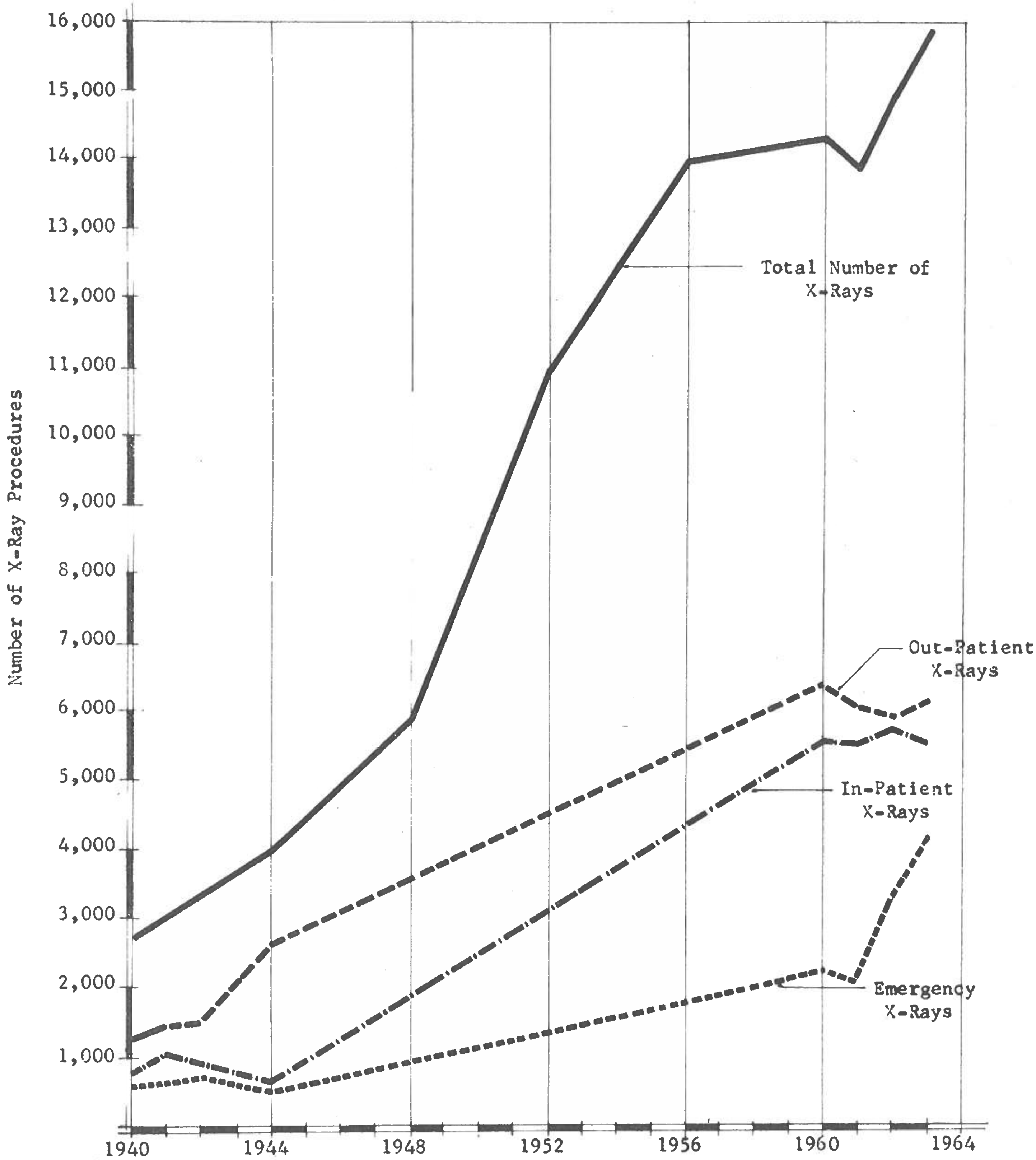
Radiology Manpower

There were 9,087 radiologists in active practice in the United States in 1964.[10] The field of radiology has experienced great growth during the past thirty years. Between 1931, when there were about 1,000 full-time radiologists, and 1962 the number of radiologists increased 6.4 times. In contrast, during the same period, the number of all full-time medical specialists increased 5.2 times and the number of all physicians increased only 1.6 times.[11] There is no sign that the growth in radiologists will abate in the near future. One measure of this is the fact that 63 per cent of radiologists are under age 45, whereas only 58 per cent of all specialists are under age 45. Along with other areas of medical practice, radiology depends to a significant extent on students educated outside the United States. Nine per cent of radiologists received their medical education in Canadian or foreign medical facilities.

Of the radiologists who are not in training programs, 82 per cent are diplomats of the American Board of Radiology.[12] This fact is one measure of the relative quality of radiology practice, since only 42 per cent of all specialists are board diplomats. Another indicator of the high quality of radiology practice is the fact that only 3 per cent of the radiologists are part-time practitioners.[13]

The distribution of radiologists throughout the United States is extremely uneven. The number of radiologists per 100,000 population ranges from a high of 5.1 in California and 5.5 in Connecticut to a low of 1.4 in Mississippi and .4 in Alaska.[14]

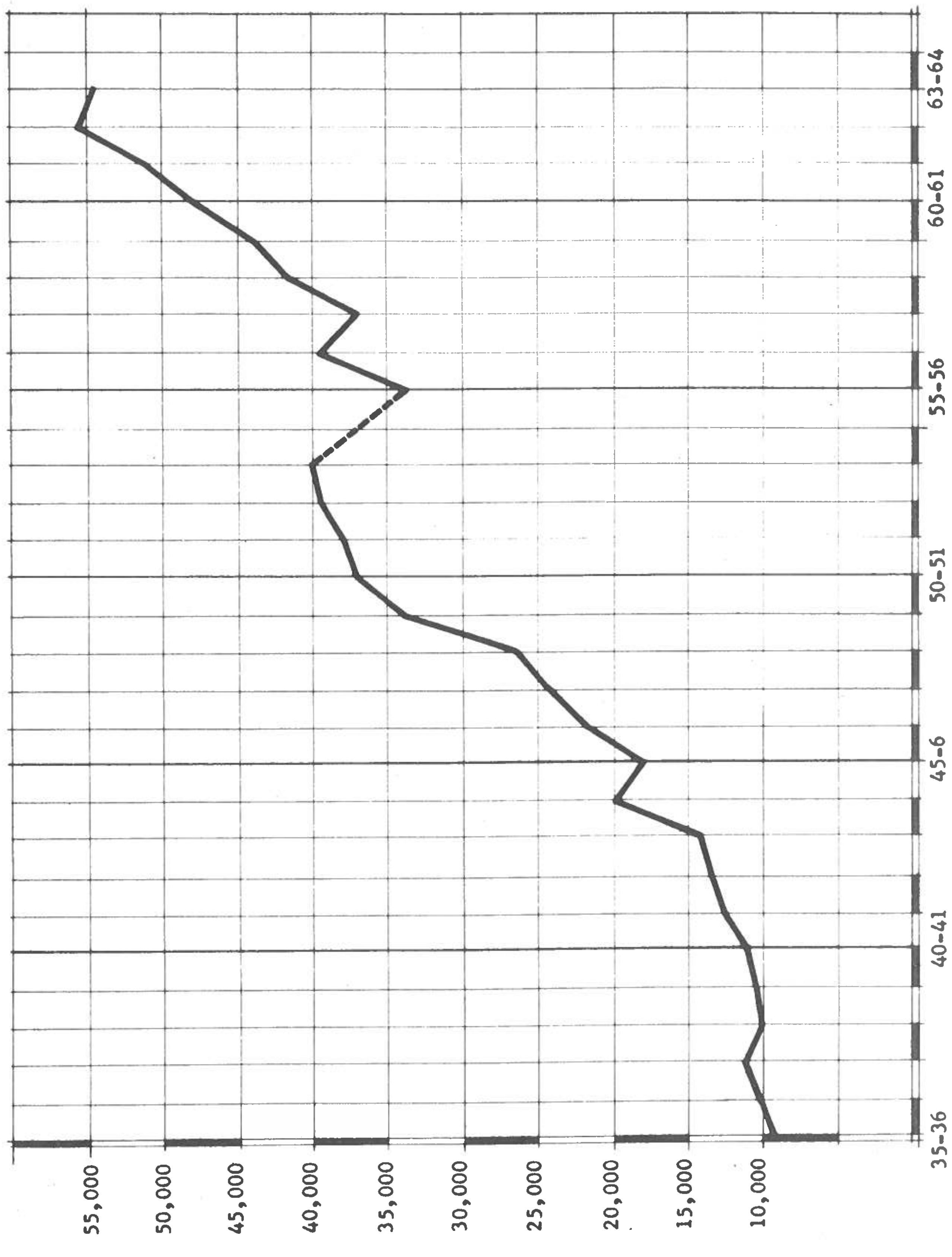
FIGURE I-1



GROWTH OF NUMBER OF X-RAY PROCEDURES

COMMUNITY HOSPITAL

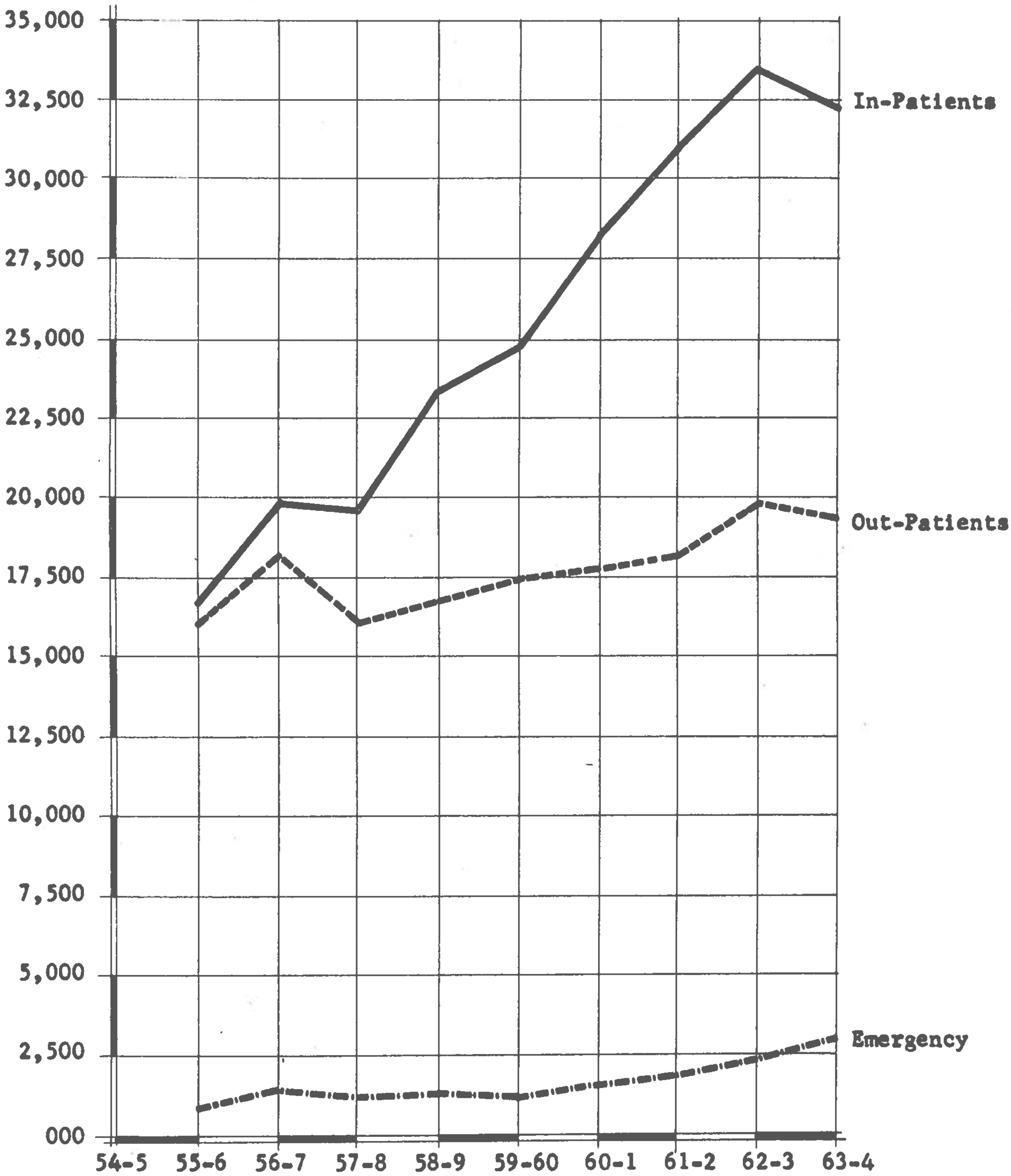
FIGURE I-2



GROWTH IN NUMBER OF X-RAY EXAMINATION PROCEDURES

UNIVERSITY HOSPITAL

FIGURE I-3



UTILIZATION OF DIAGNOSTIC X-RAY BY: **In-Patients**
Out-Patients
Emergency

UNIVERSITY HOSPITAL

The Shortage of Radiologists

Despite the great growth in numbers of radiologists, the demand for radiological services has grown at an even greater rate. The Commission on Education of the American College of Radiology recently estimated that we currently need 20,000 radiologists. The National Advisory Committee on Radiation has made a similar estimate that we need twice as many radiologists as are currently available and that by 1975 we will need three times more than the current supply. The National Advisory Committee recognizes that these "needs" will not be met since to do so would require tripling the number of physicians entering radiological training each year and would require that "over 20% of the medical students graduating each year enter radiological training."[15] The Committee has proposed what it believes is a reasonable manpower goal: "Every effort should be made to increase the annual number of physicians entering the radiological sciences from the current level of 500 to a level of 800 or more..."

In large part because of the Hill-Burton Act, almost all hospitals have diagnostic X-ray equipment, and hospitals are quite evenly distributed among the states and between rural and metropolitan areas. This means that while radiology manpower is highly concentrated, radiology equipment is highly dispersed. The effect of this contrast on the quality of medical practice is difficult to estimate. Certainly, a doctor in a rural area with proper radiology equipment can do a better diagnostic job than he could without such equipment. On the other hand, the diagnostic ability is inferior to that which could be performed by a radiologist certified by the American Board of Radiology. All doctors, regardless of their location, who have access to radiology equipment are confronted with the possibility of using the equipment themselves rather than referring the patient to a radiology specialist. The problem is heightened by the fact that, given their relative short supply, radiology specialists are often not available. Drawing the line between examinations which a specialist should make and those which a non-specialist can make is not easy. Given the distribution of equipment and the lack of trained radiologists, many medical men are encouraged to go beyond their area of competence.

From the perspective of the individual hospital, there are no adequate solutions to the radiology manpower shortage. The individual hospital will attempt to acquire as much radiology equipment as possible and will use this equipment either to attract a specialist or to bolster the skills of the non-specialist. Relatively more adequate solutions to the manpower problem will result from organizing diagnostic radiology into an areawide operation and from the use of technological and transportation devices which have the effect of extending the geographical area served by the specialist. Some of these devices and organizational schemes will be discussed later in the monograph.

The Impact of Medicare and "Medicaid" on Radiology

If planning for radiology departments were dependent just on our understanding of the already existing complex content of radiology services, the planning job would be difficult enough. But new government programs just going into effect and programs promised for the near future are bound to greatly change the practice of radiology and the physical planning of radiology departments.

Though government officials, doctors, hospitals, and the public all expect Title 18 (Medicare) and Title 19 (Medicaid) of the Social Security

Amendments of 1965 to have significant impact on the organization, financing, and distribution of medical services, no one is in any way certain of the nature or intensity of the impact. In part this is because the impact depends on certain unresolved conflicts such as that between hospitals and hospital-based specialists and the effort by the AMA to get doctors to bill patients directly. However, in large part, the uncertainty is the result of the complete inadequacy of federal statistical and forecasting services. While to a considerable degree the impact of the 1965 laws on radiology will depend on their impact on medical practice as a whole, we will try to assess here the unique impact these laws will have on diagnostic X-ray services. In California, 2.5 million people will be eligible for medical assistance in comparison with 1 million before Title 19 was adopted. In New York a family of four with a net annual income of $6,000 has been defined as medically indigent. Herman Somers has estimated that by 1975, 35 million people will be covered by Title 19.[16]

Title 18 should not produce a sharp increase in utilization of medical services by the elderly, but it undoubtedly will produce a utilization growth rate greater even than the impressive rate of growth experienced in recent years under the impetus of private insurance plans. There are several reasons why Medicare should not produce a sharp jump in utilization. According to Wilbur J. Cohen, Undersecretary of the Department of Health, Education, and Welfare, Medicare will finance only "some 40 percent" of an aged person's medical costs.[17] (Earlier private insurance plans were estimated to have covered no more than 35 per cent of medical costs.) Thus partial coverage will prevent the elderly from being profligate in their demands for medical services. In addition, many elderly have been receiving medical care from voluntary insurance programs, local and state governments, charity, and their own private resources. Medicare will simply shift the financial burden of these people to the Federal government. It is in no way certain that states and localities relieved of some of their financial burden will use their savings to expand or improve medical services. New York City expects to receive $60 million to $100 million from Medicare and Medicaid, but the money is earmarked for the city's general fund rather than for hospitals.[18]

Of the 82 million X-ray visits estimated for July 1960-June 1961, only about 10 per cent were by persons age 65 or over.[19] Furthermore, persons age 65 or over, regardless of income, have a total rate of X-ray usage lower than any other adult age group.[20] However, certain specific types of X-ray examinations are given to persons age 65 or older at a greater rate than to other age groups. These include GI series, barium enemas, pyelograms, and abdominal and pelvic X-rays,[21] and it is just these types of X-rays which require the greatest amount of time (for indications of just how long these particular types of X-rays take to administer, see Appendix C; see also the times indicated in a study by the Nuffield Foundation[22]). An intravenous pyelogram, the most time-consuming of these X-rays, can take from one to two hours. Furthermore, even for a simple X-ray procedure, the time it takes to X-ray an elderly person is generally longer than the time needed to X-ray a young person. The elderly person moves slowly and probably requires assistance getting on and off tables.

Thus, while Medicare may have only a small impact on routine chest X-rays, it could have a very great impact on the growth of special procedures and the total time demands on radiologists. Similarly, the poor have generally had access to routine chest X-rays, but have had relatively low utilization rates for the more elaborate X-ray procedures. So Medicaid, too, could have considerable impact on the growth of radiology. As we point out below, increases in fees for the lengthier special procedures may mitigate the impact of Medicare and Medicaid.

Shifts from Public to Private Facilities

Since Medicare funds can be spent at any hospital, it is generally expected that some patients will shift from public or charity hospitals to private hospitals which they could not previously afford. If the shift is considerable, certain private X-ray facilities may experience a greater impact from Medicare than the radiology system as a whole.

Shift from In-Patient to Out-Patient Demand

Blue Cross and some other private health insurance plans contributed to the recent growth of hospital utilization because they covered medical services only when given in a hospital. This encouraged doctors to hospitalize patients who might have been treated as out-patients. Both the Medicare and Medicaid laws attempt to correct this situation by covering out-patient services including diagnostic X-rays. Most X-ray facilities, therefore, should experience a shift in their workload from the in-patient department to the out-patient department.

Cost Accounting

Because the total average cost of treating the elderly appears to be lower than the cost of treating other age groups, the Social Security Administration plans to pay hospitals only for the actual cost of treating elderly patients, plus 2 per cent for hospital "growth and development"[23,24] (Blue Cross paid hospitals on the basis of overall average daily costs).

In order to determine these costs, hospitals will have to adopt detailed cost-accounting systems which most of them have not had previously. In the past, most hospitals have used the profit they made from X-ray services to subsidize other services. Under Medicare they will no longer be able to do this, so the fee charged for X-rays should decline. With a decline in fee, doctors may be encouraged to make greater use of radiographic procedures. On the other hand, the fee for special procedures may be increased. Many of these special procedures require very expensive equipment and a great amount of the time of radiologists. The high cost of these procedures may have been hidden in the past by the overall profit of the X-ray department. Under an accurate and precise cost-accounting system, the real cost of special procedures should be demonstrated with the result that the price charged for them may increase. This may discourage their use. (For an example of cost analysis applied to radiology, see the study by Bordonare.[25])

<u>The Payment of Radiologists</u>

At the insistence of the AMA, the Medicare law was written to allow hospital-based specialists (anesthesiologists, pathologists, radiologists, and others) to bill their patients directly. "The 'fee-for-service' option, the AMA believes, would help the hospital specialists, particularly the pathologists, free themselves from dependence on salaries or other financial arrangements with the hospitals."[26] Under the Medicare Law, all physician services can be paid for only under the supplementary plan which pays proportionately less than the basic hospital plan. At least one hospital administrator fears that this separating of the specialist's fee will "result in frequent omission of the radiological consultation with a specialist in radiology..."[27]

Much to the dismay of the AMA,[28] hospitals and the Social Security Administration are trying to defeat the direct billing movement by indirect means. The Social Security Administration has ruled that physicians can bill Medicare patients only for those procedures they personally perform and not for procedures performed entirely by technicians or automatic machinery nominally under the supervision of the specialist.[29] Hospitals in some instances are threatening to fire doctors who insist on direct billing arrangements. It was this threat which caused the 1966 meeting of the AMA to adopt a resolution calling for the boycotting of hospitals that don't allow physicians to bill patients directly.[30] Presumably, if direct billing succeeds, the Federal government and the hospitals will have less control over costs, and there will be an inflation in the fees of hospital-based specialists.

It is not at all clear that direct billing would be bad for medical practice. In New York City, the manpower shortages in another hospital-based specialty, anesthesiology, has led to the development of a unique medical arrangement. Anesthesiologists in New York City have organized themselves into groups which service several hospitals on a contractual basis.[31] The groups hire their own physicians, nurses, technicians and clerical help and bill the patients directly. The anesthesiologists bill patients for procedures they do not personally perform but which were performed by a resident or nurse in the hire of the group. These group arrangements encourage doctors to spread themselves thin, and, though this may lead to inadequate supervision of anesthetic procedures, it should also lead to a more efficient use of anesthesiologists. The anesthesiology groups make extensive use of foreign physicians, nurse anesthetists, technicians, and other paramedical personnel. Despite the medical manpower shortage, the medical profession has generally opposed shifting work to foreign physicians and paramedical personnel. If this type of group arrangement were to lead to greater use of paramedical personnel, it would be a boon to our medical system.

(It should be noted that some of the anesthesiology groups have been charged with providing inadequate supervision, with exploiting foreign physicians with relatively low pay, with making excessive charges for service not rendered, and with making kickbacks to hospitals to obtain exclusive rights to the hospital practice.[32,33]) Except for the need for greater investment in equipment, there is no reason why this independent team approach could not be adopted by radiologists. Were it to lead to a more efficient usage of radiologists, it would be a good arrangement.

Alternatives to X-Ray Diagnosis and Future Technological Advances in Radiology

Technological change, in the field of medical diagnostics is constantly going on. Some new technologies could sharply reduce the need for radiological diagnoses. Others may demand an increase in diagnostic facilities. These new technologies in turn may make possible or even require new physical and organizational arrangements.

Tuberculin Testing

Tuberculin testing is an alternative to chest X-rays for the detection of tuberculosis. The injections have the advantage of indicating the presence of TB bacilli whether or not the bacilli are active. Chest X-rays show only active bacilli. Tuberculin injections do not involve radiation exposure, require no radiation shielding or expensive equipment, and can be administered by a nurse. A disadvantage of tuberculin injections has been the necessity of waiting several days for the tests to develop. Several pilot programs are currently in process which are using tuberculin to routinely test children and high risk groups for tuberculosis.[34] Ultrasonic equipment[35] and Infrared Thermography[36] are two newly developed diagnostic tools which could replace radiology in certain situations but whose future is difficult to judge.

Medical Trends Affecting Radiology

Mass Screening for Breast Cancer

The Health Insurance Plan of Greater New York, HIP, is currently conducting a pilot study of breast cancer screening with the X-ray procedure called mammography.[37] The study involves the screening of 30,000 women in the 40 to 64 age bracket. The women are given three annual screenings. While the study will not be complete for several years, its preliminary findings appear to indicate that mass screening with mammography is an effective tool for early detection of breast cancer.

Using efficient organization and tight scheduling, the HIP study is able to screen women at the rate of 13 patients per three-hour session, or about 14 minutes per screening. The screenings are conducted by specially trained technicians. If this procedure were to be adopted on a nationwide scale, similar to current tuberculosis chest screening programs, the impact on radiology would be impressive. In 1960, there were 24.5 million women in the 40-64 age bracket. If 40 per cent of them (9.8 million) were to receive an annual mammography, 1100 new fully equipped mammography rooms with 1100 new trained technicians working 8 hours a day for 250 days or 1500 rooms and technicians working 6 hours a day for 250 days would be required to handle this workload. The report on the HIP screening program does not indicate how much time it takes for a radiologist to read and report on the film from the mammography; however, if it takes him only 1 minute, 81 radiologists working full time would be required to read 9.8 million films each year. If a reading takes 5 minutes, over 400 radiologists would be required. Widespread adoption of mass screening for breast cancer with mammography would clearly place an enormous additional burden on our radiology system.

Concern Over the Hazards of Radiation

As a side effect, the fight for an atomic test ban treaty resulted in the widespread circulation of information about the hazards of radiation from all sources. Concern over the dangers of radiation has increased sharply with the result that the medical profession is more cautious in its use of radiology. Many physicians who once gave X-ray examinations in their private offices now send the patients to hospitals or clinics where proper shielding is available (in 1951, prior to the test ban fight, 81 per cent of the X-ray installations were located in the private offices of general practitioners and specialists other than radiologists[38]).

With radiation equipment becoming more sophisticated and more expensive, and with the hazards of radiation a continuing problem, we can expect the shifting of X-ray examinations from private offices to hospitals to be a continuing factor in the growth of hospital radiology.

FOOTNOTES: CHAPTER I

1. The National Advisory Committee on Radiation, Report to the Surgeon General on Protecting and Improving Health Through the Radiological Sciences, (Chicago: American College of Radiology, April 1966), p. 21.

2. J. N. Gitlin and P. S. Lawrence, Population Exposure to X-Rays: U.S. 1964, Public Health Service Publication No. 1519, p. 82.

3. William Haddon, Jr. and R. H. Morgan, "Frequency of Medical X-Ray Examinations in Monroe County, New York," Public Health Reports, Vol. 80, (June 1965), pp. 515-525.

4. U.S. National Health Survey, Volume of X-Ray Visits, U.S. July 1960-June 1961, Public Health Service Publication No. 584-B38.

5. Gitlin and Lawrence, op. cit.

6. Ibid, pp. 150, 86, 159.

7. Ibid, p. 158.

8. Ibid, p. 85.

9. Ibid, p. 158.

10. American Medical Association Journal, November 19, 1965.

11. U.S.P.H.S., Health Manpower Source Book: Medical Specialists, Publication No. 263, Sec. 14, (1962), p. 9.

12. Ibid, p. 223.

13. Ibid, p. 222.

14. Ibid, p. 226.

15. National Advisory Committee on Radiation, Report to the Surgeon General on Protecting and Improving Health through the Radiological Sciences, (Chicago: American College of Radiology, April 1966), p. 31.

16. "The Big Sleeper in the Medicare Law," Medical Economics, (January 24, 1966), p. 110.

17. "Personal Finance: Supplementary Plans to Medicare Offered by Insurers are Examined," The New York Times, July 7, 1966.

18. "Serious Troubles Plague City Hospitals as Medicare Approaches," The New York Times, June 27, 1966.

19. U.S. National Health Survey, op. cit., No. 584-B38, p. 16.

20. Ibid.

21. W. Haddon, op. cit.

22. Nuffield Provincial Hospitals Trust, Towards a Clearer View: The Organization of Diagnostic X-Ray Departments, (Oxford University Press, 1962).

23. "Relating Hospital Charges, Costs," Wall Street Journal, May 2, 1966.

24. "Medicare Spurs Vast Revisions in U.S. Hospitals," New York Times, June 13, 1966.

25. Albert J. Bordonare, "The Rational Approach to Charges," Hospital Topics, (January 1963), pp. 54-59.

26. "Doctors vs. the Government: Ruling that Pathologists Can't Bill Medicare Patients Rouses AMA Ire," Wall Street Journal, January 25, 1966.

27. S. J. Tibbits, "Relations between Hospital-Based Specialists and Hospitals," Hospital Forum, (June 1966), pp. 17-18, 27.

28. "AMA Delegates Call for Hospital Boycotts by Some Specialists," (July 1, 1966).

29. A. Bordonare, op. cit.

30. The Wall Street Journal, op. cit., July 1, 1966.

31. "Hospitals Short of Anesthetists," New York Times, May 16, 1966.

32. Ibid.

33. "Kickbacks Laid to Anesthetists," New York Times, May 17, 1966.

34. "Mass Testing for TB is Planned in Schools to Wipe Out Disease," New York Times, January 20, 1965; "TB Attack: Test on Mountaineers in Kentucky may Help End the Disease in U.S.," Wall Street Journal, November 2, 1965; U. M. Anderson and A. Graubau, "Routine Tuberculin Testing in Infants and Young Children," American Journal of the Diseases of Children, Vol. III, (January 1966), pp. 31-34.

35. Wendell G. Scott, et. al., Planning Guide for Radiologic Installations, (2d ed.; Baltimore: Williams and Wilkins Co., 1966).

36. Erich Brueschke, *et.al.*, "Infrared Thermoprofile Analysis in Clinical Medicine," *American Journal of Medical Electronics*, Vol. 4, (April-June 1965), pp. 65-69.

37. Sam Shapiro, *et.al.*, "Evaluation of Periodic Breast Cancer Screening with Mammography," *Journal of the AMA*, Vol. 195, (February 28, 1966), pp. 731-738.

38. S. W. Donaldson, "The Practice of Radiology in the United States: Facts and Figures," *The American Journal of Roentgenology and Radium Therapy*, Vol. 66, (December 1951), pp. 929-946.

CHAPTER II: THE GOALS OF RADIOLOGY

The prime function of diagnostic radiology is to enable a trained radiologist to see parts of the human body hidden from the naked eye, and to utilize this additional information to help diagnose a person's illness. To accomplish this function, it is necessary to bring together persons and machines, medical and technical personnel, past and present information, so that the radiologist can simultaneously utilize the total available information for the purpose of making a diagnosis. Essential to the success of the system is the transmission of the diagnosis to the responsible physician for action within a specified amount of time.

Radiology Related to Larger Health System

The goals of a radiology department must be seen and integrally connected with the goals of the hospital as a whole. Radiology is a subsystem of a larger hospital system. The decisions reached as to the location, organization, and function of diagnostic radiology depend in large part on the project utilization and relationship of diagnostic radiology to the rest of the particular hospital.

Effectiveness of a Radiology Department

The design of a radiology department should be judged by its effectiveness in promoting health and curing illness. These terms are abstract concepts; it is necessary to explore with more precision what is meant by them. An effective radiology department means that quick and accurate diagnosis can be given in an emergency; it means that doctors can obtain the films taken of a patient and the radiologist's report on the films within a reasonable length of time; it means the radiologist can obtain without undue effort previous films taken of a patient and whatever other diagnostic information may seem necessary in order to facilitate a diagnosis; it means that the morale in the department is high among the technicians and clerical staff; it means patients do not have to wait too long to be admitted for an examination and do not wait too long during and after the examination; it means that the relative value of output and cost is comparable to other departments doing similar types of work; it means that growth of the department and technological change can be accommodated without too much disruption. Architecturally it means that the physical facilities allow the above to happen.

The stated goals of the design of a radiology department are usually not very clearly articulated and come to the architect as a mixed-up bundle of ends, means, and constraints which state that the department should be home-like, efficient, flexible, and planned for maximum utilization. Before a physical plan can be developed, however, the architect must determine which goals are possible of accomplishment, which goals have priority, which means are related to real rather than irrelevant goals, which means have substitutes and which constraints can be breached.

Frequently, constraints themselves are goals. The budget that is a financial constraint is also a goal--the goal of spending only so much money. A common constraint for a radiology department will be that fact that it is constructed or reconstructed in an existing building. In such a situation, the amount of space available, the shape of the space, the spacing of columns and bearing walls, and the location of other hospital departments will all severely constrain the design goals of the radiology department. Too often, however, constraints are seen as immutable when in fact they are not. Each apparent constraint should be challenged with questions: Are there benefits to be gained by violating the constraints? Can the costs of violating the constraint be compensated for in other ways? Does the constraint exist only because we are unwilling to make the political or legal fight necessary to eliminate it? The question of efficiency, flexibility and high utilization are raised so often as goals that each will be dealt with at greater length.

Efficiency

Measures of efficiency are not at all clear. In other aspects of hospital design the efficiency has been equated to the reduction of steps for doctors and nursing staff. Minimizing the walking distance of radiologist and technician if it raises his productivity is certainly a valid measure of efficiency. There are additional ways to measure the efficiency of a department which include the length of time a patient must wait before being seen, the time required for the radiologist to obtain a film for reference, and the length of time before a film is taken and a diagnosis made. Other measures of efficiency include the number of examinations which can be made by technician and radiologist, the cost of operation of the department versus the income, and the rate of utilization of the different machines. To arrive at a standard of measurement implies the existence of normal level of work between different radiology departments. Comparing the work output of two separate radiology departments in two different hospitals is extremely difficult and so, setting standards for keeping records and comparing work loads and output requires fantastic amounts of interpolation and interpretation. The problems of measuring work output is discussed under the chapter on size.

Too often a high case load is considered a measure of efficiency when in fact too high a case load may work to the detriment of a department.

A radiology department which sees to it that technicians and radiologists are busy every moment may turn out to be inferior to a department where there is some free time for personnel to read current literature and exchange information over coffee. One radiologist complained that too much of his time was spent in informal conversation with doctors. As he thought about it, it occurred to him that he owed the very success of his department to this informal exchange and the satisfaction of the doctors because of it.

Utilization

The maximum utilization of facilities is often considered a goal for the design and operation of a radiology department. There is terrific variation in the utilization of a diagnostic radiology department.

Our studies indicate that not only is there a monthly variation in the utilization of X-ray, which reflects the pattern of utilization of the hospital as a whole, but weekly variation, daily variation, and hourly variation as well. Nobody gets sick in December if he can help it because of the holidays, or in July and August because of vacations, and absolutely nobody on Thanksgiving. The morning is the busiest period in all of the institutions studied. This is true whether the appointments are scheduled or non-scheduled. Some of the reasons for this are that

1. For certain types of procedures it is necessary to have the film taken on an empty stomach.

2. Other activities of the hospital, such as meal time, cleaning, rounds, and so on, make it necessary for the nursing units to be left only at certain times.

3. Outpatient clinic is often held in the morning and a rise in utilization occurs right after the clinic.

4. Even when outpatients are scheduled, personnel prefer an active morning and a slower afternoon.

It would seem possible to do several things to equalize the patient load:

1. To schedule all but emergency patients.

2. If service is rendered to clinic patients on demand rather than by appointment, it would seem helpful in a case such as that of the hospital studied which operates under a large prepayment plan and which has separate facilities for in- and out-patients, to turn over the entire facility for outpatient use when the clinics are in session, thus increasing capacity.

There seems to be more lip service to the concept of maximum utilization of machinery than serious attempts to achieve a maximum utilization. In all the hospitals studied, the utilization of the X-ray rooms was under 50% based on an average 8-hour work day. If scheduling for evening hours were considered, the percentage of utilization would be even less. There was considerable variation in the use of individual rooms (see Appendix B).

Basically, the lack of uniform distribution of room utilization was due to the fact that the machines in each room had special functional capabilities. If the equipment was uniform in each of the diagnostic rooms the utilization of them would be equalized. In small departments particularly each room, to be efficient, must serve a multiplicity of functions. In larger departments the volume of complicated special procedures justifies the retention of single purpose functions.

Given the money and manpower shortages confronting most radiology departments, efficiency and high utilization rates are generally considered desirable goals. In some cases providing reserve machines for emergency purposes may cause a low utilization figure but may be the best way of achieving the goal of always having equipment available for emergency purposes.

Growth, Expansion and Flexibility

Provisions to accommodate growth and expansion as well as to provide flexibility to accommodate technological change are stated as high priority goals within the Radiology department. The accelerated tempo of change in methods and techniques make hospital decision-makers reluctant to commit themselves to one particular form of organization of services and one particular set of facilities because of fear that radical changes in machinery, techniques and procedures will make them functionally obsolete within a short period of time. This is especially true with respect to the radiology department because of its history of rapid growth and continual change in equipment used and procedures undertaken. To date, change has been accommodated in the following manner. Generally, adaptations are made within the confines of a traditional radiological suite. Thus, as a new procedure develops it is accommodated within the suite by shifting walls, moving plumbing, and so on. When the number of new procedures gathers momentum and minor changes are no longer sufficient, a total department may have to be reorganized. Room is sometimes made for this reorganization by subspecialties becoming entities in their own right and moving to another part of the building. For example, X-ray therapy in most hospitals was originally a part of diagnostic radiology, but the combined pressures of the need for more diagnostic radiology rooms and the increase in the use of therapy has required the development of entire new therapy departments. Of course, when new functions or new demands for space are of such a nature to make impossible the reorganization of the existing structure, then it is sometimes sounder economically to start from scratch and rebuild the department rather than pay the price of makeshift accommodations.

Spatial flexibility is not difficult to achieve technologically, it is just costly. Movable partitions are standard items of the construction industry--even movable partitions with lead lining. It is more difficult to integrate partition changes with changes in the mechanical, electrical and plumbing systems.

One approach to flexibility is to design the radiology department for a relatively short life span--and plan on its replacement. Additional approaches are discussed in Chapter V, "Uncoupling the System."

Priorities

Each specialty and subspecialty of medicine generally attempts to obtain ideal or maximal conditions for itself without due regard to the impact of its own personal needs on the total system. Our resources of manpower, equipment and buildings are limited. As private insurance coverage and government programs of medical care have grown, the number of people demanding medical service has grown faster than our medical resources. Medicare and Medicaid will continue to add to this disparity. One way to deal with this problem is to be more rational in our planning of health services and to establish priorities.

Every hospital must decide which type of radiographic procedure it plans to offer. A radiology department can concentrate on complicated special procedures, which use expensive equipment, which are time-consuming for the radiologists, and which serve relatively rare diseases; or it can concentrate on routine procedures which serve widespread health problems; or it can choose some balance between special and routine procedures. The choice among these alternatives should be part of the health strategy of the area. Unfortunately, the choice is more often left to the individual decisions of the radiologist rather than based on an assessment of the area's total health needs.

Within the context of the total hospital system, the radiology department must establish priorities among its many competing and conflicting goals. A given hospital may decide that it would rather spend money on other types of equipment than on reserve emergency X-ray machines or a group of hospitals could agree to share specialized facilities rather than each provide their own. Only by the establishment of priorities can a beginning be made to maximize the use of our total radiological resources.

The goals of a radiology department are determined to a significant extent by the geographical scope of its services. The national radiology programs of the Public Health Service have different goals than the radiology departments of individual hospitals. If an architect were asked to design a model hospital's radiology plant and the architect's client were the U.S.P.H.S., he would concentrate on the most general nation-wide characteristics and problems of the radiology system. In contrast, if an architect's client is a metropolitan health planning agency which has asked him to design a regional radiology system, he needs to understand the national characteristics of radiology but he must focus on the unique characteristics of his region and the unique goals of the regional agency. Generally, the architect's client is an individual hospital. For such a client, the architect needs to understand the national and regional trends, but he also must recognize that they may have only limited influence on the requirements of the individual client hospital. Usually, a hospital is in a region with other radiographic facilities, and the architect must know the specialized procedures performed in the other hospitals--the regional emergency program, the referral patterns, etc. The regional picture is very important for making specific individual hospital decisions concerning goals and scope of service.

CHAPTER III: THE CALCULATION OF THE SIZE OF DIAGNOSTIC X-RAY DEPARTMENTS

Before it is possible to reach any decisions about the organization of either plan or plant of the radiology department it is necessary to determine scope and type of service that the particular hospital radiology department will undertake. Decisions on the scope and type of service determine the size of the department. Unfortunately, decisions about institutional size are frequently made without a clear conception of the manifold implication of size on every aspect of design. The size of a department affects subsequent decisions about whether to centralize or decentralize the facilities, the method of operation, and the organization of resources.

Ideally, the scope of service of a given hospital's radiology department should be determined on a regional basis based on the needs for service in the area. If the number of facilities are determined on a regional basis, they can then be systematically allocated among the various health suppliers for maximum benefit to the community as a whole. In practice, although lip service has been paid to regional planning, the calculation of required facilities has been left up to each institution. The determination of need for radiological services goes far beyond the scope of this monograph. The concept of need is an extremely complex one. What is conceived of as a need in one set of circumstances may be impossible to accomplish in another. We have shown in Chapter 1 that existing patterns of use of diagnostic radiology vary depending on the economic and social character of the population served, the medical policy of the hospital, and the method of payment for diagnostic services.

Decisions on scope of service will vary depending on the type of hospital and its role in the community, the extent of regional planning, the preference of the particular department head and the organizational structure. An institution whose aim is to provide diagnostic services for an entire community will require a different facility from one which is to be devoted entirely to bed patients. A large teaching hospital and research institution will perform many more time-consuming and complicated procedures than will a community hospital. What is being done in a teaching hospital may indicate what will become routine in the community hospital five or ten years hence.

To calculate the size of a radiology department it is necessary to answer the following questions:

1. What will be the estimated volume of work to be done in the facility under design?

2. Over what period of time are the demands for service to be realized before the department becomes too small to handle the volume?

3. What facilities will be necessary in terms of machines, personnel, etc., to handle this volume of work, based on decisions as to the number of hours in operation, the amount of utilization desired for each machine, the acceptable length of waiting time for patient and technician, to mention a few of the most important variables.

<u>Measurement of Service Rendered or Work Done</u>

The work load of an X-ray department is not determined by the number of patients it serves, nor by the number of procedures it performs, nor by the number of films taken. Work can only be measured in terms of the hours of room time, radiologists' time, technicians' time, and machine time used over a given period. There are currently well over 40 different kinds of X-ray examinations. They are taken of different parts of the body and require different lengths of time to perform as well as different types of equipment and personnel skills. For example, a chest X-ray may take seven and one-half minutes of room time and be taken by a technician, whereas a mylogram may require an hour and a half of time and require the work of the radiologist. It is obvious that in terms of value of work a given number of chest X-rays cannot be equated with an equal number of mylograms.

Various attempts have been made to develop a method of equating one type of examination with another in order to compare and project relative work loads based on different policy decisions. The most commonly proposed method is called the unit-system. The essence of this system is the assignment of different unit values to the various types of X-ray procedures. The unit values assigned are based primarily on the average time spent in the X-ray room for a given radiological procedure. Thus, a chest X-ray which takes seven and one-half minutes to perform has approximately one-twelfth the value of a mylogram which takes approximately ninety minutes. If each unit is equated to seven and one-half minutes of time the value of the chest examination is one unit and the value of the mylogram is twelve units. By this method it is possible to compare the work of a radiology department which performs a large amount of chest work with a department which performs many more special procedures. The charge placed on the cost of the different X-ray procedures reflects, to a degree, the differences in time value. It also reflects the number of films taken; the time required of the radiologist vs. the technician; and, perhaps, a little of "what the traffic will bear."

The unit system is by no means an accurate assessment of the work done as the time required for different procedures varies depending on the age of the patient, his ability to move, etc. It can take twice as long to perform the same examination on an infirm person as on an agile one. Table III-1, indicates the time required to take the various examinations in a university hospital in order of frequency of examinations. Appendix C has additional statistics illustrating the variation in time of examination for different diagnostic procedures. Before the size of a radiology department can be determined, the department must estimate who its patients will be and what types of examinations they will require.

Projecting the Frequency with Which Different Types of Examinations will be Required

Every planner is involved with the projection of the future. The basis for future guesstimates as to the nature of the diagnostic X-ray procedures that will be required in different types of institutions is based on two factors: (1) the experience of the past; (2) current research and its probability of being used in the future.

The prediction of frequency of type of examination likely to occur must be based on a careful analysis of the particular community and its characteristics to be offered (Table III-2 indicates the distribution of different types of examinations in Monroe County, New York. Table III-1 also shows the distribution of different types of examinations at the university hospital. Additional statistics on the frequency of different types of X-rays are to be found in Appendix C).

The four most numerous types of examinations in the university hospital (chest, extremities, spine and pelvis, and fluoroscopy) constitute 67.1 per cent of the examinations given, but take only 39.0 per cent of the department's time.

TABLE III-1

X-RAY EXAMINATIONS IN A UNIVERSITY HOSPITAL

In order of time spent on examinations

	% of Time	% of Exams	Relative Time of Examinations
I.V. Pyelogram	18.4	4.46	4.1
Chest	15.4	31.1	.495
Extremities	9.4	13.3	.70
Spine and Pelvis	8.72	11.7	.74
Skull	5.98	5.17	1.13
Fluoro	5.48	11.04	.49
Encephalogram	4.31	.78	5.5
Gastrointestinal Tract	4.25	6.86	.62
Cerebral Angiogram	3.91	.54	7.2
Myelogram	3.82	.60	6.3
Chemopallidectomy	2.73	.18	15.2
Barium Enema	2.37	4.40	.54
Abdomen	1.79	3.33	.54
Gall Bladder	1.74	1.98	.87
Tomograms	1.66	.54	3.1
X-ray Movies	1.60	.20	8.0
Small Bowel	1.52	.87	1.74
Angio Cardiogram	1.37	.19	7.3
Operative Cholangiogram	1.05	.11	10.4
Miscellaneous	<1.0		

In order of frequency of examinations

	% of exams	% of hours	relative time for examination
Chest	31.1	15.4	.495
Extremities	13.3	9.4	.70
Spine and Pelvis	11.7	8.7	.74
Fluoroscopy	11.0	5.48	.49
Gastrointestinal Tract	6.9	4.25	.62
Skull	5.17	5.98	1.13
I.V. Pyelogram	4.46	18.4	4.1
Barium Enema	4.40	2.37	.54
Abdomen	3.33	1.79	.54
Gall Bladder	1.98	1.74	.87
Sinuses	1.46	.96	.65
Small Bowel	.87	1.52	1.74
Encephalogram	.78	4.31	5.5
Myelogram	.60	3.82	6.3
Tomograms	.54	1.66	3.1
Cerebral Angiograms	.54	3.91	7.2
Pneumocolon	.39	.35	.90
Pelvimetry	.30	.39	1.3
Miscellaneous	<.30		

TABLE III-2

Annual X-ray examination rates per 1,000 persons of both sexes, by type and by age of examinee, Monroe County, N.Y.

Age (years)	Head	Sinuses	Neck	Chest [1]	Photo-fluoro-gram	Tho-racic spine	G.I. series	Gall blad-der	Bari-um enema	Pyelo-gram	Abdo-men
0-4	14.8	0.29	1.68	57.3	0.35	0.32	2.2	0.45	2.1	4.2	4.6
<1	18.2	[3] .23	1.22	125.6	------	[3] .23	7.3	1.5	6.2	4.0	9.5
1	19.4	[3] .23	[3] .69	60.1	------	[3] .46	2.2	[3] .2	1.2	2.8	3.7
2	13.1	[3] .23	1.75	34.0	[3] .23	[3] .46	.8	[3] .2	1.3	4.4	3.9
3	10.6	.78	4.52	33.7	.78	[3] .23	[3] .7	------	1.0	3.0	4.3
4	12.6	------	[3] .23	32.4	.78	[3] .23	------	[3] .23	[3] .7	6.7	1.7
5-9	11.7	.62	.47	23.0	9.08	1.07	2.0	[3] .16	1.7	3.9	2.6
10-14	9.6	.88	1.20	22.1	9.00	3.46	2.5	.31	1.2	3.5	4.2
15-19	16.5	1.49	7.38	57.3	21.63	3.62	5.3	1.54	3.9	5.0	4.6
20-24	18.3	2.43	13.06	112.3	31.19	4.41	13.8	4.64	6.9	7.4	9.6
25-29	15.2	4.04	12.20	119.5	30.95	3.92	18.7	9.66	9.4	9.2	10.3
30-34	11.2	4.80	17.56	107.7	34.33	8.73	21.2	11.13	11.5	9.9	11.5
35-39	9.0	2.81	15.84	126.7	33.02	4.33	25.4	15.15	14.2	9.3	11.6
40-44	13.4	4.33	20.86	133.8	35.05	5.96	29.5	16.26	15.3	13.0	15.0
45-49	12.9	3.52	17.89	160.4	32.92	6.85	33.2	18.22	19.3	14.2	12.2
50-54	12.0	3.23	23.43	180.2	36.73	4.94	41.8	20.82	29.0	13.2	14.5
55-59	14.1	4.37	14.99	171.3	35.75	5.91	44.3	22.45	31.7	16.0	22.7
60-64	16.3	2.49	15.84	183.1	33.30	6.77	46.9	20.37	34.0	15.7	22.8
65-69	9.9	2.79	7.44	166.7	30.48	7.82	45.0	20.20	36.8	17.2	23.6
70-74	12.1	2.20	6.82	160.3	23.37	5.55	41.8	21.83	36.8	14.7	28.1
75-79	15.0	2.19	5.81	139.8	20.29	5.56	45.7	14.23	37.0	18.4	30.1
80-84	14.1	[3] .49	4.54	167.0	17.82	3.08	41.6	12.63	35.6	15.2	31.4
85 and over	10.8	[3] .83	3.60	198.4	10.25	5.26	29.9	5.54	21.3	10.8	41.0
Average	13.1	2.42	10.54	106.8	23.6	4.40	21.4	10.2	14.3	9.5	11.9

[1] Exclusive of photofluorograms.

[2] Includes only fluoroscopy without associated radiography. Radiographic examinations which included fluoroscopy are tabulated in the preceding categories.

[3] Rates based on less than 10 examinations.

NOTE: 93 cardiac catheterizations, 6 angiocardiograms, and 62 cinefluorographic examinations performed in the four 4-week primary sampling periods have been omitted in the calculation of the rates in this table.

Age (years)	Lumbar spine	Pelvis	Shoul-der, arm	Elbow, fore-arm, wrist, hand	Thigh, knee	Leg, ankle, foot	Bones, general-ized	Fluoroscopy			Exam-ination type unspeci-fied
								Chest [2]	Abdo-men [2]	Type unspeci-fied [2]	
0-4	0.9	16.0	7.1	13.9	5.8	9.6	1.65	5.5	[3] 0.05	0.35	0.95
<1	2.0	46.5	6.7	10.9	6.7	13.2	2.52	10.5	------	1.30	2.22
1	1.8	17.8	4.3	12.2	4.8	7.7	2.75	4.0	------	[3] .23	1.07
2	[3] .2	4.7	14.8	11.0	6.0	9.1	.91	2.0	[3] .23	------	[3] .69
3	[3] .5	5.1	4.5	15.3	7.9	7.6	1.79	7.9	------	------	[3] .23
4	------	5.6	5.3	20.5	3.7	10.4	[3] .23	3.3	------	[3] .23	[3] .55
5-9	1.0	8.3	4.5	24.7	7.8	8.9	.62	3.0	------	.17	.55
10-14	2.2	7.0	4.7	40.7	12.2	21.0	.83	1.7	------	.51	.45
15-19	14.6	7.2	9.7	38.7	13.6	34.1	[3] .08	4.0	------	.69	.32
20-24	20.4	11.0	6.8	40.7	15.8	29.9	[3] .19	6.1	------	[3] .29	.52
25-29	16.8	10.6	11.5	39.2	15.9	20.7	.40	16.4	------	[3] .17	.92
30-34	26.2	12.1	9.8	34.0	11.8	35.6	[3] .15	14.3	------	[3] .23	.77
35-39	30.8	15.6	11.4	38.7	15.8	26.9	.71	18.5	------	.64	.95
40-44	32.7	14.6	20.0	41.2	19.4	29.9	2.07	38.1	[3] .07	1.13	1.50
45-49	29.9	18.8	21.5	40.0	19.2	41.9	2.11	28.4	------	2.27	.70
50-54	30.4	15.5	23.4	48.0	21.6	41.9	3.01	34.2	------	1.43	1.40
55-59	24.5	24.8	22.9	47.3	22.1	37.5	3.47	32.6	[3] .10	2.37	1.03
60-64	32.8	23.6	18.8	41.7	22.5	36.7	4.80	25.8	------	1.70	1.21
65-69	21.4	23.3	14.5	31.3	14.2	28.5	4.64	26.0	.73	2.75	1.07
70-74	17.4	29.0	18.6	30.2	17.2	18.9	3.57	21.3	------	2.47	.55
75-79	15.6	39.7	17.8	24.9	19.4	15.6	3.79	13.6	------	2.02	1.43
80-84	12.5	59.0	15.7	27.7	13.8	24.1	5.34	18.3	------	[3] .49	1.62
85 and over	14.7	116.9	20.0	16.9	23.3	10.3	4.43	28.8	------	[3] 1.11	[3] 1.11
Average	17.8	16.1	12.6	34.8	14.7	25.9	1.70	16.3	0.04	0.97	0.86

The National Advisory Committee on Radiation has estimated that while only 3 per cent of all examinations undertaken are special procedures, this 3 per cent absorbs about 25 per cent of the time of radiologists. Before the size of a radiology department can be determined, the physician must establish policies on the number and type of special procedures he wants to administer.

Projection of Future Needs

In the determination of the size of a radiology department a decision must be reached as to the planning time period. The size of a radiology department will obviously vary depending on whether it is built to handle current work loads, work loads for a projected five-year period or for work loads projected ten years hence.

The Number and Type of X-ray Procedure and the Population Served

In the past the size of diagnostic radiology department of a hospital was based on the number of beds in the hospital. Both the United States Public Health Service as well as the Radiology Equipment manufacturers specified the number of X-ray rooms required for hospitals of different sizes.[1] Today the diagnostic radiology departments are being used increasingly by emergency and outpatients. This increase of use by outpatients is likely to accelerate as Medicare and other insurance companies pay more for diagnostic X-ray services for ambulant patients. The percentage distribution of services to the Emergency, inpatient, and outpatient departments can vary considerably from hospital to hospital. Table III-3 indicates the distribution of in-, out-, and emergency patients in two of the hospitals studied.

TABLE III-3

DISTRIBUTION OF NUMBER OF X-RAY PROCEDURES

Community Hospital 1963	No.	%	University and Teaching Hospital 1963-64	No.	%
In-patient	5,586	35.6	In-patient	229,610	65.0
Out-patient	6,116	38.8	Out-patient	159,490	27.9
Emergency	4,043	25.6	Emergency	15,376	7.1
Total	15,745	100	Total	404,476	100

In an English study of six different types of hospitals the percentage of radiology referrals from the "wards" (in-patients) varied from 6.9 per cent to 40.1 per cent, the percentage of radiology referrals from the out-patient departments varied from 39.0 per cent to 50.2 per cent, and the percentage of radiology referrals from "casualty" (emergency) varied from 9.1 per cent to 39.8 per cent.[2]

The demands of the Emergency department on Radiology differ significantly from the demands of the in-patient and out-patient departments. Whereas in-patients and out-patients can be scheduled, postponed, and delayed, emergency patients cannot be scheduled and frequently require immediate service. Because of these differences, one author has made the following recommendation:

> In allocating space, equipment, and personnel for Emergency Radiology, planning must be on the basis of maximum anticipated patient loads. To use average loads as a basis for planning emergency areas results, by definition, in less than 'average' care at least half of the time . . . In real emergencies, there is no adequate justification for avoidable delays or less than ideal care . . . In a large general hospital with an active emergency service . . . /by/ integration with the remainder of the department some economy can be effected by utilizing/emergency/rooms for the examination of other patients when the emergency load is light. The primary planning, however, must be for emergencies, and, since

> emergencies cannot be scheduled as can other examinations, some economic inefficiency must be accepted if optimal medical efficiency is to be obtained.[3]

Many hospitals would find that compliance with this recommendation would be costly, inefficient, and even unnecessary. Though emergency workloads will be always to some extent uncontrollable, they are to a considerable extent predictable.[4] Accident loads, especially from motor vehicle accidents, follow a general pattern. Motor vehicle accidents have a peak during the day at the evening rush hours and during the week they peak on the weekend. The evenings and the weekends are times when there is the least use of the radiology department by in-patients and out-patients. Therefore, many hospitals can reasonably expect to handle their peak emergency loads with X-ray facilities normally used by other departments.

The calculations for estimating projected workloads for diagnostic X-ray facilities must, therefore, take into consideration the variety of types of users of the diagnostic X-ray department, because the number of procedures per patient as well as the type of procedures to be prepared varies with the condition of the patient, whether bed, outpatient, or emergency, as well as with the illness of the patient.

Peak Loads and Waiting Time

A key factor in deciding the number of facilities to provide is the decision on acceptable standards of waiting time for patients. If there is no limit to waiting time, facilities can keep on going until everybody is served and the job accomplished. Unfortunately, X-ray departments seem to be characterized by endless patient-waiting. This has been particularly evident in cases where hospitals and large OPD clinics send patients directly to X-ray from the clinics. The X-ray departments are not geared to handle these peak loads and, consequently, patients have to wait. Figure III-1 shows the waiting time on a typical morning in a community hospital. Based on our observations, Appendix C shows waiting times in both the teaching hospital and the community hospital.

Several alternatives can be used to solve the problem of peak loads and corresponding long waiting periods.

1. To increase the capacity of the radiology department.

2. To reschedule the clinics to minimize the peak loads in X-ray.

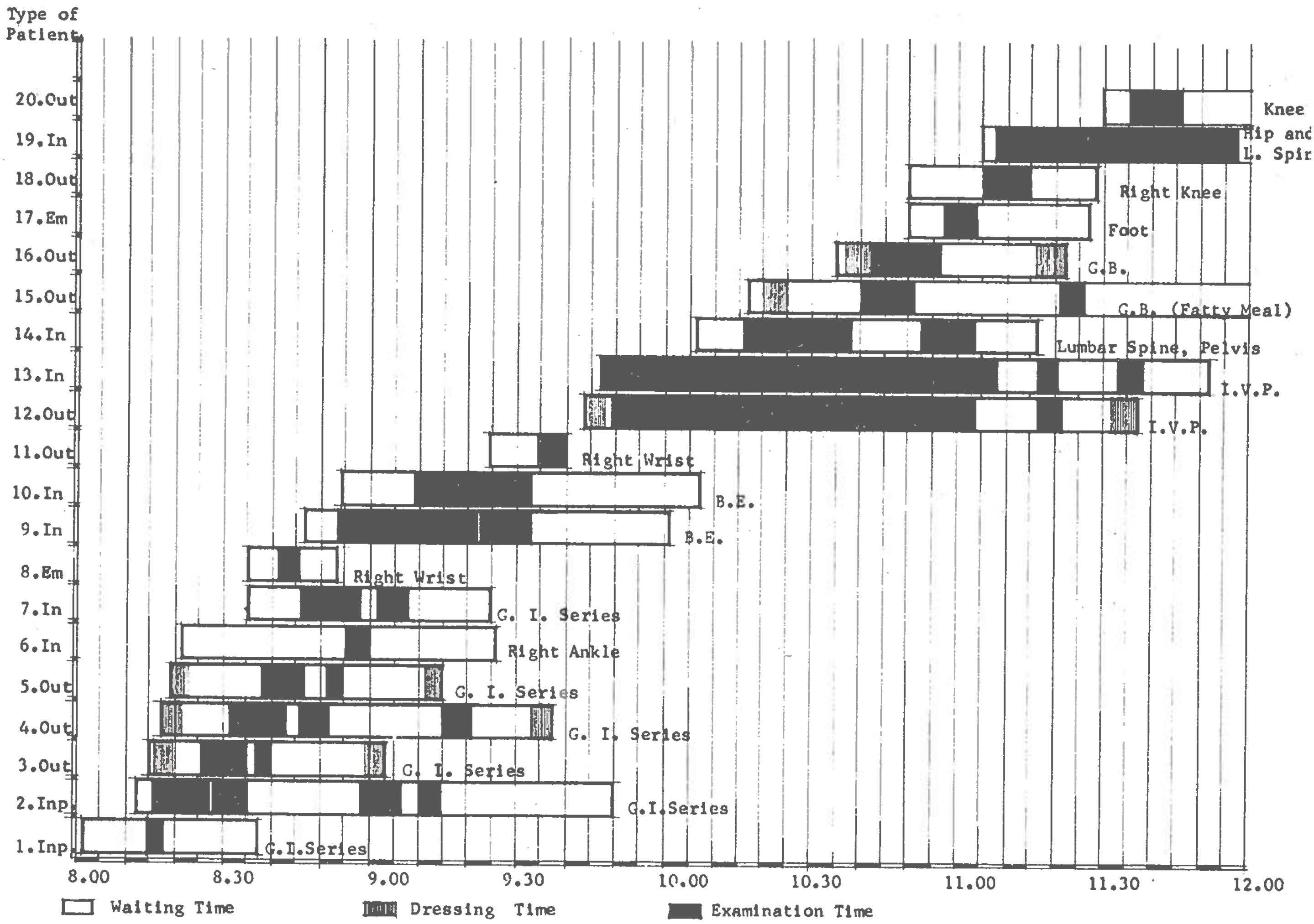
3. To schedule patients so that they are better distributed throughout the day.

4. To increase the hours of operation.

X-ray use tends to peak in the morning, in the beginning of the week, and during certain months of the year depending on the region. Emergencies peak at night. X-ray facilities built to handle the load on a Monday morning in December, in a region where December is the peak month, will be idle a good many hours of the year. To the extent that these peaks result from lack of organization in the medical services system, they can be lowered. However, to a considerable extent the peaks represent patterns of disease and patterns of practice on the part of physicians and patients which will be difficult to change. For certain types of procedures it is necessary to have the films taken on an empty stomach. Other activities of hospital such as meal time, cleaning, rounds, etc., make certain times desirable for leaving the nursing units. Therefore, even in the most efficient system, the radiology planner will probably still be confronted with some peak loads (see Appendix B for variations in utilization of X-ray rooms).

One of the characteristics of an efficient department is its ability to minimize the patient waiting time and still maintain a full work flow

FIGURE III-1



SIMULATION OF MORNING ACTIVITY IN A
COMMUNITY HOSPITAL RADIOLOGY DEPARTMENT

for technician and radiologist. Historically, hospitals have been less concerned with patient waiting for clinic patients than for privately referred patients. With the advent of Medicare this outlook might well change.

<u>Hours of Operation</u>

Another decision that must be made before the size of a radiology department can be determined concerns the hours of operation of the department. How early in the morning, how late in the evening, and how many hours of the weekend will the department be open? Obviously a given number of radiology rooms can handle a larger load if open longer hours. Before the decision about hours can be made, the hospital must know what hours technicians, nurses, and radiologists are willing to work. Many patients would prefer evening hours because they do not interfere with the work day, or in the case of housewives, husbands can baby sit while the wife goes through the required procedures.

<u>Size and Equipment</u>

The selection of equipment and its location effect the size of a diagnostic radiology department. While radiology equipment is expensive, radiology manpower remains the major expense of an X-ray department. If equipment is of a general sort, staff time is consumed in adjusting the equipment for special purposes. If the equipment is specialized, the staff can work more quickly. Curt E. Westman has described the advantages of the use of specialized equipment:

> The stream of routine examinations is very great and is increasing every year. This increase is best catered for by use of special examination tables for certain types of examination.
>
> (a) The continually increasing number of spine examinations, for instance, demands a special spine examination

table, with a sliding top under a tube with simple suspension from the ceiling.

(b) Chest work of all types is best served by special equipment for thoracic investigations.

(c) The investigation of free intra-abdominal air or free plural fluid demands the use of horizontal beams made easier by the use of special equipment for such purposes. Such special apparatus cuts down the work of the staff, and thus increases the capacity of the department. It is sufficient to mention the outstanding example of this, i.e., the skull table.[5]

In order for a hospital to afford such specialized equipment it must have sufficient volume to make it economically feasible.

Methods for Calculating Number of X-Ray Rooms

Several methods have been developed to calculate the number of X-ray rooms required. The first example is taken from a Bay Area hospital with a bed count of 358 beds. The hospital was expecting to expand its bed count to 615 beds and its out-patient services and wanted to plan for a radiology department to accommodate the required load based on a ten-year use projection.

A 45 per cent growth in population was projected based on the statistics of the local planning department. It was estimated that there would be 150 admissions annually, not counting mental patients, per 1,000 population. This statistic was a rough judgment by the hospital administration. The outpatient X-ray load was estimated by projecting the recent growth rate in the outpatient department. An estimate was made of the growth ratio of X-ray examinations to inpatient admissions. This estimate was based on a rough prediction made by the chief radiologist. The projections for the X-ray work load were broken down into fluoroscopy, chest X-ray, general examinations, and special procedures, and time estimates were made for each type of examination. It was also decided, based on previous experience, that 75 per cent of the load occurred between 9:00 a.m. and

4:00 p.m. An 85 per cent utilization figure for each room was desired. Given these parameters we find that the number of X-ray rooms needed for each type of examination could be calculated by the following formula:

$$\frac{\text{(percentage of peak load) (maximum number of procedures x the time required for these procedures)}}{\text{amount of time each X-ray room or unit is to function daily}}$$

Thus, if the projected peak number of fluoroscopic examinations were 40 per day, 75 per cent, or 30, would take place from 8:00 a.m. to 4:00 p.m. The average time for fluoroscopic examinations is thirty-five minutes; thus, the computed examination time per day for fluoroscopic examinations would be 23.3 hours. If the room is figured as being available for eight hours, it would require 2.9 or 3 rooms to handle the load (the calculations which were used in projecting the size of this radiology department are presented in Tables III-4 to III-8).

In like manner, if the maximum number of chest examinations projected to fifty, then 75 per cent of fifty would be thirty-four to be handled in the eight-hour day. The average time for this examination is ten minutes, and 34 x 10 is 5.7 hours of time required per day; thus, one room would be adequate. Calculations for other general examinations and special procedures are made in a similar manner.

This system just described is very crude. An individual hospital can make studies of the disease pattern and demographic characteristics and trends among its patients with considerably more sophistication. Even with greater sophistication there are obvious areas based on judgment of the future, and these are subject to considerable error. For the given purpose the crude estimates may work out satisfactorily, particularly if the benefit of doubt is always on the side of more facilities. Planning

TABLE III-4

RADIOLOGY DEPARTMENT WORKLOAD PROJECTIONS

	1965	1975	Percent Increase
I. In-patient Service (Exclude Mental Health):			
A. Patient Care Projections:			
Admissions	12,360	19,700	60
Patient Beds	346	567	64
B. Radiology Department Workload:			
Fluoroscopic Examinations	2,900	5,500	90
Radiographic Examinations:			
Chest Examinations	4,000	7,600	90
General Examinations	5,300	10,050	90
Special Studies & Procedures	600	1,150	91
Total	12,806	24,300	90
II. Out-patient Service (Radiology Dep't only)			
A. Out-patient Visits	7,500	13,500	80
B. Fluoroscopic Examinations	400	750	88
Radiographic Examinations:			
Chest Examinations	1,200	2,150	80
General Examinations	8,800	15,850	80
Special Studies & Procedures	200	350	75
Total	10,600	19,100	80
III. Total Radiology Department Workload:			
Fluoroscopic Examinations	3,300	6,250	89
Radiographic Examinations:			
Chest Examinations	5,200	9,750	88
General Examinations	14,100	25,900	84
Special Studies & Procedures	800	1,500	88
Total	23,400	43,400	85

TABLE III-5

RADIOLOGY DEPARTMENT LONG RANGE PLANNING STUDY

	1965	1975	Percent Increase
I. Long Range Patient Care Projections			
In-patient Service:			
Admissions	12,600	21,060	67
Patient Days	91,500	162,000	77
Patient Beds	358	615	72
Out-patient Service:			
X-ray Out-patient Visits	7,500	12,000	60
II. Radiology Department Workload Projections:			
In-patient Service:			
Fluoroscopic Examinations	2,900	5,500	90
Radiographic Examinations	9,900	18,800	90
	12,800	24,300	
Out-patient Service:			
Fluoroscopic Examinations	400	750	88
Radiographic Examinations	10,200	18,350	80
	10,600	19,100	80
III. X-ray Room Requirements:			
General Purpose Rooms	4	8	100
Special Procedure Rooms	1	2	100

IV. Assumptions:

1. Radiology Department in-patient workload projections are based on the Anticipated admissions except Mental Health patients.
2. Radiology Department out-patient workload projections are based on the experienced growth rate of out-patients examined during 1959-64.
3. The 8 AM to 4 PM workload represents 80% to 100% of the total daily workload as tabulated below:

Fluoroscopic Examinations	100%
Chest Examinations	90%
General Radiographic Examinations	80%
Special Studies and Procedures	100%

4. With the exception of the special procedure rooms, other X-ray rooms will be cross-utilized to provide flexibility and to reduce capital investments.
5. The projected expansion of medical and surgical beds will be cross-utilized whenever possible.
6. The opening of the new X-ray rooms will be gradual depending upon the demand. This approach will minimize operating cost.

TABLE III-6

RADIOLOGY DEPARTMENT OUT-PATIENT VISITS

YEAR	NUMBER OF VISITS	PERCENT
1959	5,383	100
1960	4,660	86
1961	6,002	93
1962	5,958	110
1963	6,709	125
1964	7,381	137

TABLE III-7

SAMPLING OF EXISTING X-RAY ROOM UTILIZATION
DURING 5 DAY 8 HOUR PERIOD

	Room 1	Room 2	Room 3	Room 4	Room 5	Total
I. Patients Examined:						
Total (5 days)	155	48	39	31	23	297
Range/Day	26-37	7-13	5-10	3-11	3-8	52-69
Average/Day	31	10	8	6	5	59
II. Examinations Performed:						
Fluoroscopic:						
Total (5 Days)	0	28	29	0	0	57
Range/Day	0	3-9	3-8	0	0	7-16
Average/Day	0	6	6	0	0	11
Chest: Total (5 Days)	82	1	0	4	0	87
Range/Day	12-20	0-1	0	1-2	0	14-21
Average/Day	16	*	0	1	0	17
General: Total (5 Days)	92	19	10	25	18	164
Range/Day	10-25	1-7	1-3	3-9	1-7	27-43
Average/Day	18	4	2	5	4	33
Special: Total (5 Days)	3	0	0	2	5	10
Range/Day	0-2	0	0	0-1	0-2	2-2
Average/Day	1	0	0	*	1	2
III. Total Productive Time (Minutes)						
Fluoroscopic:						
Total (5 Days)	0	971	645	0	0	1616
Range/Day	0	97-233	84-174	0-4	0	263-379
Average/Day	0	194	128	1	0	323
Chest: Total (5 Days)	466	11	0	50	0	443
Range/Day	42-111	0-11	0	0-15	0	57-126
Average/Day	76	2	0	10	0	88
General: Total (5 Days)	751	358	147	764	746	2852
Range/Day	129-181	25-127	5-99	83-243	15-400	410-770
General/Day	150	72	30	152	149	570
Special: Total (5 Days)	220	0	0	160	490	870
Range/Day	0-145	0	0	0-85	0-235	110-235
Average/Day	44	0	0	32	98	174
Total Time Utilized: (Minutes)						
Examinations	1,437	1,340	792	976	1,236	5,781
Room Preparation**	885	240	195	155	115	1,590
Total	2,322	1,580	987	1,131	1,351	7,371
Average Hours/Day Shift	7.7	5.3	3.3	3.8	4.5	4.9
Utilization Factor	97%	66%	41%	47%	56%	61%

Notes: * Insignificant
** 5 minutes in between examinations

TABLE III-8

X-RAY ROOM REQUIREMENTS

I. Sampling of Workload Distribution (Based on January, 1965):

1. Number of Examinations:

	In-Patient	Out-Patient	Total
Fluoroscopic Examinations	337	35	372
Chest Examinations	464	100	564
General Examinations	620	734	1,354
Special Studies & Procedures	73	15	88
	1,494	884	2,378

2. Daily Workload Range (Week Days)

Fluoroscopic Examinations	5-23
Chest Examinations	11-26
General Examinations	25-74
Special Studies & Procedures	0-7

Notes: (1) Rechecks are counted as regular examinations.
(2) Number of Examinations covers 24-hour period.
(3) New Year's day workload is excluded from the sampling of daily workload range due to extremely small volume.

II. Projected Daily Workload Distribution:

1. Fluoroscopic Examinations	10-40
2. Chest Examinations	20-50
3. General Examinations	45-135
4. Special Studies & Procedures	0-15

III. Projected Room Requirements:

1. Assumptions:
   a. Approximately 80-100% of total examinations in a 24-hour period will be performed between 8 AM to 4 PM = 7 hr. day.
   b. The room requirements are based on 85% of peak workload.

2. Computed Examination Time:

		Hours		
a. Fluoroscopic Examinations:	40 x 35 min.	23.3	$\frac{23.3}{8} = 2.9$	= 3 rms.
b. Chest Examinations:	34 x 10 min.	5.7	$\frac{5.7}{8} =$	1 rm.
c. General Examinations:	92 x 22 min.	33.7	$\frac{33.7}{8} = 4.2$	= 4 rms.
d. Special Studies & Procedures;	10 x 92 min.	15.3	$\frac{15.3}{8} = 1.9$	= 2 rms.
Total Time		78.0		10 rms.

Note: Computed time includes 5 minutes in between examinations.

for a department to handle 75 per cent of a peak load at one time gives considerable latitude for expansion of use at other than peak hours.

Determination of the Number of X-ray Rooms by E. Todd Wheeler[6]

Another way of calculating X-ray rooms is to determine the number of X-rays required by different types of patients. Wheeler uses the following factors for the number of X-rays required for different types of in-patients.

1. Medical patients may average 1.5 determinations per patient admission, which generates

$$\frac{1.5 \text{ x } 80\% \text{ occupancy}}{8 \text{ days' average stay}} = 0.15 \text{ determination per bed per day}$$

2. Surgical patients may average 3.0 determinations per patient admission, including specialities, giving

$$\frac{3.0 \text{ x } 85\% \text{ occupancy}}{5 \text{ days' average stay}} = 0.5 \text{ determination per bed per day}$$

3. Maternity patients may average 0.4 determination per patient, giving

$$\frac{0.4 \text{ x } 70\% \text{ average occupancy}}{6 \text{ days' average stay}} = 0.05 \text{ determination per bed per day}$$

4. Pediatric patients (mostly surgery) average 2.5 determinations per patient, giving

$$\frac{2.5 \text{ x } 60\% \text{ occupancy}}{5 \text{ days' average stay}} = 0.30 \text{ determination per bed per day}$$

5. Mental and other long-term patients are negligible, perhaps 0.1 determination per patient admission, giving

$$\frac{0.1 \text{ x } 95\% \text{ occupancy}}{20 \text{ days' average stay}} = 0.005 \text{ determination per bed per day}$$

These factors are then multiplied by the number of beds assigned to each type of patient. The resulting products are the number of determinations per day required by the different types of in-patients. For a 500-bed hospital the results would be:

Type	Factor	No. of beds	No. of determinations per day
Medical	0.15	152	23
Surgical	0.5	168	84
Maternity	0.05	70	3.5
Pediatrics	0.30	70	21
Psychiatric	0.005	40	0.5
		500	132

Since different types of X-rays require different examination times, Wheeler next divides the estimated number of determinations per day into three categories. Based on empirical factors, Wheeler estimates that 50 per cent of the total determinations will be general radiographs, 30 per cent will be GI's, and 20 per cent will be other types and special procedures. For a 500-bed hospital, the breakdown would be as follows:

Unit	% of Total	Determinations per day
General radiographic	50	66
GI	30	40
Other special	20	26
	100	132

For out-patients, Wheeler uses the following factors:

Type	Determinations per Out-patient Admitted
Medical	0.3
Surgical	1.0
Maternity	1.0
Pediatrics	0.3
Long Term	0.1

These factors are then multiplied by the number of new out-patients per day in each category to determine the total determinations per day. For a hospital with 100 new out-patients per day, the results would be:

Type	Percent	New patients per day	X-ray determinations per patient	Total determinations per day
Medical	35	35	0.3	10
Surgical	25	25	1.0	25
Maternity	20	20	1.0	20
Pediatric	15	15	0.3	4.5
Long term	5	5	0.1	0.5
		100		60

Using the same percentage distribution as was used for in-patients, the total out-patient determinations are also divided into three different types of X-rays:

Unit	Per cent of total	Determinations
General radiographic	50	30
GI	30	18
Other special	20	12
	100	60

Combining the daily loads for bed and ambulant patients gives:

Unit	Bed patients	Ambulant patients	Total
General radiographic	66	30	96
GI	40	18	58
Other special	26	12	38
	132	60	192

Based on general experience, Wheeler estimates that a general radiographic unit can handle twenty-one determinations per day, that a GI unit can handle ten determinations per day, and that other units can handle about twenty determinations per day, though this figure varies considerably; for really complex special procedures many radiologists figure two examinations per day. The number of determinations per day, estimated above, is then divided by these capacity figures to determine the number of X-ray units required. For our sample hospital, the results are:

Unit	Load per day	Capacity	Theoretical number	Actual program
General radiographic	96	21	4.6	5
(GI) combination	58	10	5.8	6
Other special	38	20	1.9	1
				12

Wheeler does not provide two special units because he feels some of the special work can be done on the standard machines.

Any given hospital may have factors considerably different from those suggested by Wheeler. This can be adjusted by using Wheeler's formulas while substituting factors based on the experience of the individual hospital.

Wheeler's method of calculation does not provide for peak loads, and it assumes in the capacity factors utilization rates which may not be appropriate for all hospitals. Wheeler says: "Because most radiographic work can be scheduled at will, it is possible to use average figures rather than to figure peak load requirements. Not many patients must be X-rayed immediately as an emergency."[7] Our own studies and the Nuffield Trust studies have indicated that peak loads are a serious problem.

The Nuffield Trust Method for Calculating the Number of X-ray Rooms Needed[8]

As part of its intensive study of diagnostic X-ray departments in

English hospitals, the Nuffield Trust developed a formula for calculating the number of X-ray rooms needed. It reads as follows:

> It is suggested, therefore, that the following steps should be taken:
> (a) The number and types of all investigations carried out over a period of at least three weeks (excluding Saturdays and emergency service periods)[1] should be recorded and summarized.
> (b) Using the average time per investigation given in the table in Appendix A, the total "room-occupancy" time should be calculated in minutes for the whole period. From this an average "room-occupancy" time per day should be calculated, assuming a 5-day week.
> (c) Assuming that a usage of 70%[2] can be achieved with good organization, each room should provide for 336 minutes of work per day (8 hours x 60 x 70/100). The number of rooms required can be calculated by dividing the average "room occupancy time" per day ((b) above) by 336.
> (d) The resulting number of X-ray rooms should be checked by comparing this provision with the demands of a busy (but reasonably typical) working day.
>
> Complete weeks should be taken rather than days selected at random. For organizational purposes the pattern of demand over the week and on the same days in different weeks is important and should be studied.[9]

The Appendix A to which it refers contains average examination time for almost 100 different types of examinations. Therefore, the formula is quite sensitive to different types of workloads. The formula as developed attempts to tell the hospital administrator the number of X-ray rooms he ought to have and how to improve organization of the existing workload. It does not provide for projecting the workload into the future. In addition the formula makes no provisions for peak loads. The 70 per cent utilization rate in activity is twice the rate found in the hospitals the Nuffield Trust studied. The Nuffield report focuses on improving the efficiency and utilization of X-ray departments, and it assumes that its proposals for increased efficiency and utilization will be successfully put into effect.

We question the validity of basing room calculations on the <u>expectation</u>, rather than the actuality, of increased efficiency unless it can be demonstrated in regular practice that the higher utilization rates can be achieved. Some of these patterns of X-ray use, such as accident patterns, and the habits of doctors and patients are outside the control of the X-ray department, and may prevent the desired utilization pattern making their projected utilization rate unrealistic.

<u>Summary</u>

To calculate the number of diagnostic radiology rooms required for a given institution it is necessary to determine:

1. The nature of the population to be served;

2. The number of inpatients, outpatients, and surgery patients who will use the facility immediately as well as in the future;

3. The types of examinations each group of patients is likely to require;

4. The length of time required for these examinations;

5. The expected utilization roles for each room;

6. The hours the radiology department will be open.

Using these statistics, it is possible to determine the number of facilities required. Given the scope of service, it is possible to project various methods for organizing the departments.

FOOTNOTES: CHAPTER III

1. United States Public Health Service, Division of Hospital Facilities, _Elements of the General Hospital_, (Washington: 1950); W. R. Taylor, "Diagnostic X-Ray Suites for the General Hospital," _Architectural Record_, (October 1959), pp. 217-224; Picker X-Ray Corporation, _Handbook for Hospital X-Ray Department Planning_, (White Plains, New York).

2. Nuffield Provincial Hospitals Trust, _Towards a Clearer View: The Organization of Diagnostic X-Ray Departments_, (Oxford University Press, 1962), Table 16.

3. John D. Reeves, "Progressive Patient Care in Radiology," _Radiology_, Vol. 73, (November 1959), p. 780.

4. Nuffield Provincial Hospitals Trust, _op. cit._, Chapter 5.

5. Curt E. Westman, "Planning New Diagnostic Departments," _British Journal of Radiology_, Vol. 35, (April 1962), pp. 265-268.

6. E. Todd Wheeler, _Hospital Design and Function_, (New York: McGraw Hill Co., 1964).

7. _Ibid_, p. 164.

8. Nuffield Provincial Hospital Trust, _op. cit._

9. _Ibid_, paragraph 308.

CHAPTER IV: A STUDY OF THE SYSTEM OF DIAGNOSTIC RADIOLOGY

Every activity of man has unique functions and characteristics which require their own set of technological and spatial solutions. The architect must understand the technical requirements of the various activities and operational processes and the requirements of the people involved. In order to provide the best spatial relationships for the radiology department we utilized some of the techniques developed by industrial engineers in studying various industrial processes and developed some of our own methods as well.[1] One of our first objectives was to obtain an overview of the system in operation and to see what were the activities taking place, what was happening simultaneously within the system, and how the activities were interrelated. The internal spatial arrangement of the various elements of a radiology department has a significant bearing on the ability of the department to achieve its overall medical and operational objectives. In order to obtain an accurate and concise description of the present activity patterns in radiology, we went into the actual work situations of the three radiology departments studied and observed what went on. We attempted to look separately at the various processes in operation: the patient process, the flow of the patient through the system; the material process, the flow of the X-ray film through the system; the medical process which included the technicians, nurses and radiologists; the administrative and office process which included the scheduling of appointments, billing, etc.

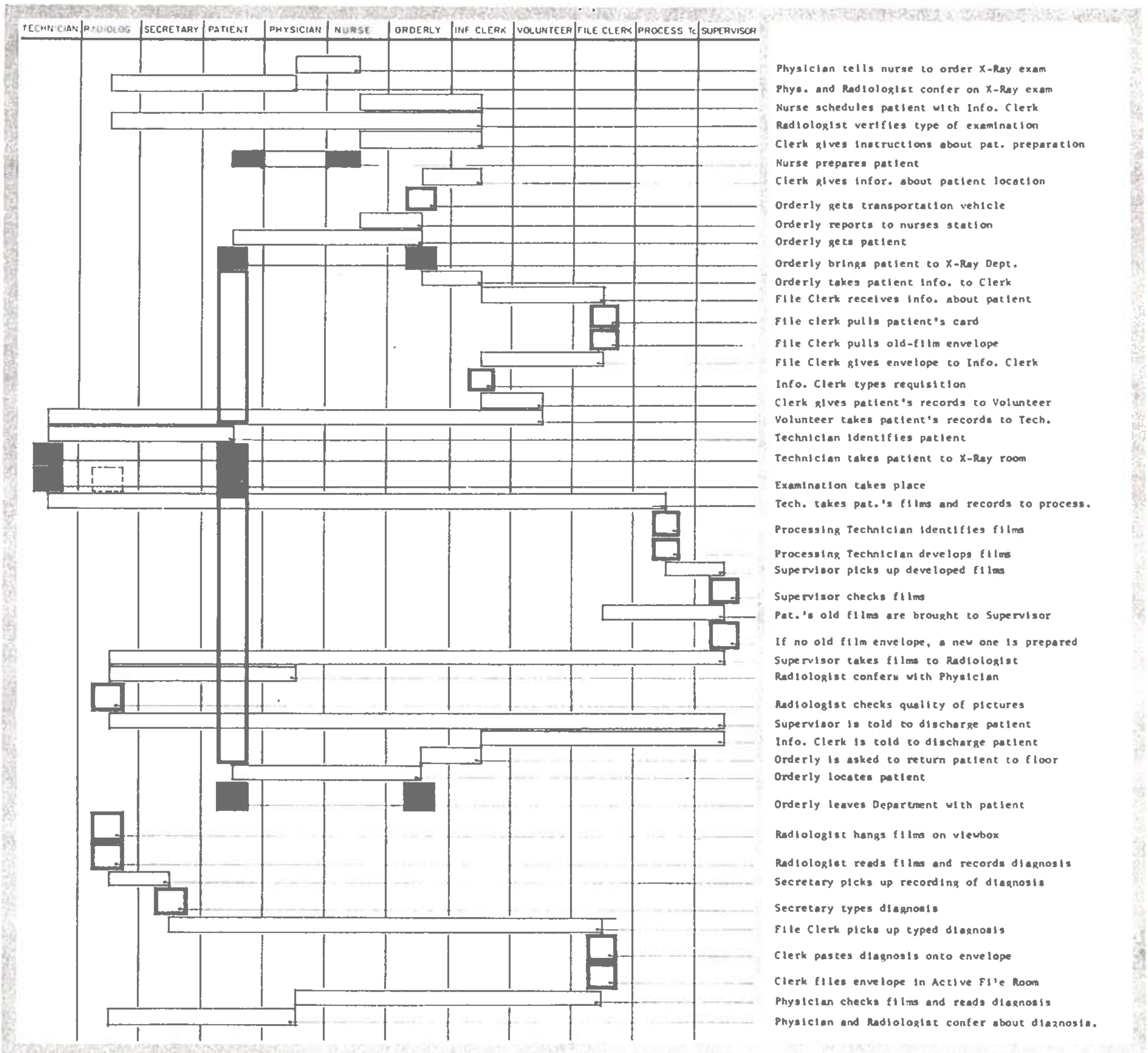
We developed various methods to help us understand the functioning of the system. One method we called "a multiple process analysis" which showed the various people in the system, the activities they performed, and when they physically met in the system. See Figure IV-1. This chart differentiated the activities which required direct personal contact, i.e., the patient and orderly, the patient and technician, the patient and radiologist, from those which could be accomplished without face-to-face personal contact. The chart also shows what is happening while the patient is waiting in the X-ray department.

The Users of the System and Their Requirements

The primary users of the system of diagnostic radiology are the patients, the radiologist, the technicians, the other doctors associated with the hospital, and the clerical staff. Each of these users have their own sets of physical requirements necessary for maximum comfort and efficiency. Sometimes what is desirable for one user is in conflict with the well-being of another user. For example: in many cases the patient wants privacy, the staff wants the maximum ease of supervision; the undressed patient needs greater warmth, the staff feels overheated. The resolution of conflicting needs can only be made when the conflicts are clearly outlined and priorities established. The basic activities we called the "constants of the system"; the others, the "variables".

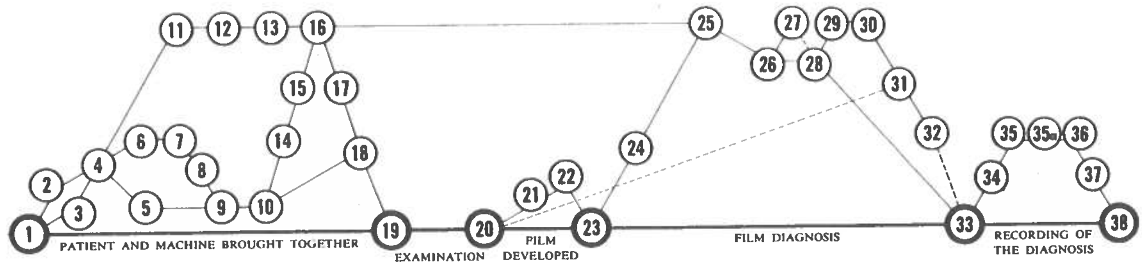
To further identify the constants of the system and clearly expose and differentiate the essential requirements from the less essential we drew a pseudo-critical path diagram. This is in many ways similar to the method of "link analysis" developed by industrial engineers. Figures IV-2 and IV-3 compare the activities in two radiology departments. The "constants" of the system are the same in each Radiology department. The patient and the machine are brought together, the examination is conducted, the films are developed, the films are diagnosed and the film and diag-

FIGURE IV-1



MULTIPLE PROCESS DIAGRAM

FIGURE IV-2

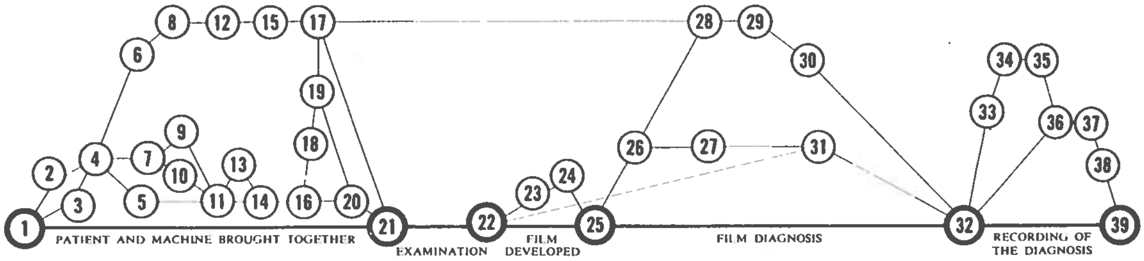


HOSPITAL A

1	Physician has completed patient's exam.
1- 2	Physician tells nurse to order X-ray examination.
1- 3	Physician calls radiologist to check on X-ray exam.
2- 4	Nurse makes appointment with Radiology's information clerk.
3- 4	Radiologist verifies type of examination with information desk.
4- 5	Appointment desk notifies the nurse concerning patient's preparation.
5- 9	Nurse prepares patient.
4- 6	Appointment desk calls orderly.
6- 7	Orderly picks up transportation vehicle.
7- 8	Orderly reports to nurses station to obtain patient information.
8- 9	Orderly gets patient.
9-10	Orderly brings patient to radiology.
10-18	Patient waits.
10-14	Orderly brings patient information to the information desk.
4-11	Information clerk gives patient information to file clerk.
11-12	File clerk pulls patient's card.
12-13	File clerk pulls envelope containing patient's past films.
13-16	File clerk gives envelope to information desk.
14-15	Information clerk types requisition.
15-16	Information clerk calls volunteer.
16-17	Volunteer gets patient's information and takes it to technician.
17-18	Technician goes to patient.
18-19	Technician brings patient to machine.
19-20	Examination takes place.
20-21	Technician takes films to processing room.
21-22	Film is identified with patient's name.
22-23	Film is developed.
23-24	Film is inspected by the supervisor.
24-25	The new films are put into the envelope.
16-25	Old films are brought by the file clerk to dry room where they are joined with the new.
25-26	New and old films are brought to the radiologist by the supervisor.
26-27	Radiologist calls physician.
26-28	Radiologist inspects films.
28-29	Radiologist tells supervisor to discharge patient.
29-30	Supervisor tells information desk to discharge patient.
20-31	Patient waits.
30-31	Information tells orderly to return patient to the wards.
31-32	Orderly leaves the department with patient.
28-33	Radiologist records the diagnosis.
33-34	Secretary picks up the recording of the diagnosis.
34-35a	File clerk brings envelope to file room.
35a-36	A copy of the diagnosis is pasted to the envelope by the file clerk.
36-37	File clerk files envelope in file room.
37-38	Physician checks the films and reads diagnosis.

PROCESS SEQUENCE PATH

FIGURE IV-3
(Incomplete)



HOSPITAL B

1 Physician has completed patient's exam.
1- 2 Physician tells nurse to order X-ray examination.
1- 3 Physician calls radiologist to check on X-ray exam.
2- 4 Nurse makes appointment with Central Appointment Facility by sending requisition.
3- 4 Radiologist verifies type of examination with CAF.
4- 5 CAF communicates confirmation to nurse.
4- 6 CAF sends patient information to master file.
4- 7 CAF sends requisition to in-patient information facility.
5-11 Nurse prepares patient.
7-10 In-patient supervisor checks requisition and plans schedule for patient.
10-11 In-patient information facility contacts nurses' station concerning availability of patient.
7- 9 In-patient information facility sends orderly to pick up patient.
9-11 Orderly reports to nurses' station.
11-13 Orderly picks up transportation vehicle.
13-14 Orderly locates patient.
6- 8 Master file clerk pulls patient's card.
8-12 Master file clerk gives information to file orderly.
12-15 Orderly pulls patient's old films and diagnostic materials.
15-17 Orderly takes films to assembly desk.
17-21 Clerk takes films to technician in charge of fluoroscopy rooms.
14-16 In-patient orderly brings patient to X-ray.
16-18 In-patient orderly brings patient's records to information desk.
18-19 Technician picks up patient's records.
19-20 Technician identifies patient.
16-20 Patient is waiting.
20-21 Technician brings patient to X-ray room.
21-22 Examination takes place.
22-23 Technician identifies the film.
23-24 Technician brings films to processing room.
24-25 Films are developed.
25-26 Technician inspects films.
26-28 Clerk brings films to assembly table.
28-29 New and old films are put together (if there are no old films, a new envelope is prepared).
29-30 New and old films are brought to reading rooms.
26-27 Technician tells in-patient information to discharge the patient.
27-31 Information desk asks orderly to return patient to floor.
30-32 Radiologist records diagnosis.
31-32 Orderly and patient leave the X-ray department.
32-33 Typist picks up recording of diagnosis.
33-34 Typist types diagnosis.
34-35 Clerk takes diagnosis to assembly desk.
35-36 Radiologist checks and signs typed diagnosis.
32-36 Clerk takes envelopes containing films to assembly desk.
36-37 Clerk pastes diagnosis to envelope.
37-38 Envelope is filed in active file room.
38-39 Clerk gives envelope to referring physician

PROCESS SEQUENCE PATH

nosis are sent to the proper medical specialist and recorded. These activities are represented by the heavy horizontal line. The paths connecting these activities can and do vary depending on the type of hospital and its other physical relationships. The variations in process are shown by the lighter lines connecting the main constants of the system.

The numerous activities which take place in a diagnostic radiology department can be grouped under the following main categories:

1. The activities necessary to get the patient and the X-ray machine together.

2. The activities required for the X-ray examination.

3. The activities involved in retaining the X-ray or fluoroscopic image.

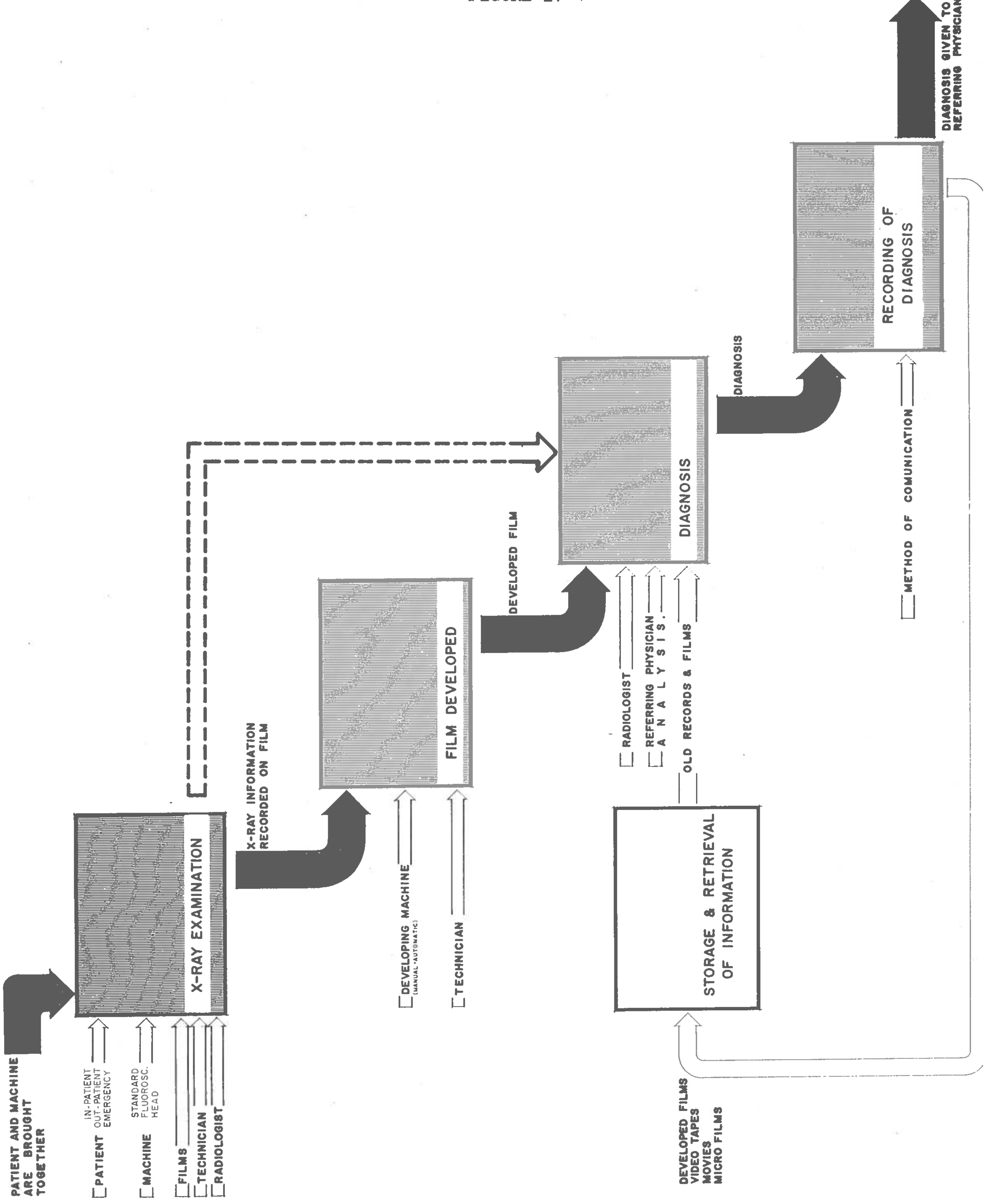
4. The diagnosis.

5. The transmission of the diagnosis to the proper medical authority.

6. The storage and retrieval of the information obtained.

In greatly oversimplified form, these activities are the series of steps constant to all radiology departments. The methods used to accomplish these activities vary from place to place. For example, one radiology department may use the hospital's central escort service to transport patients; in another department the escort service may be part of the radiology department. One hospital may schedule all patients; another may handle them on a first come first served basis. One hospital may have two technicians work with every patient; another may have only one. One hospital may use a pneumatic tube to transmit orders for X-ray examinations; another will use a telephone. But regardless of variations in methods used, the basic activities are the same in all diagnostic radiology departments (Figure IV-4 illustrates these six sets of activities diagrammatically).

FIGURE IV-4


PATIENT AND MACHINE ARE BROUGHT TOGETHER
PATIENT
IN-PATIENT
OUT-PATIENT
EMERGENCY
MACHINE
STANDARD
FLUOROSC.
HEAD
FILMS
TECHNICIAN
RADIOLOGIST
X-RAY EXAMINATION
X-RAY INFORMATION RECORDED ON FILM
FILM DEVELOPED
DEVELOPING MACHINE
(MANUAL-AUTOMATIC)
TECHNICIAN
DEVELOPED FILM
DIAGNOSIS
RADIOLOGIST
REFERRING PHYSICIAN
A N A L Y S I S.
OLD RECORDS & FILMS
STORAGE & RETRIEVAL OF INFORMATION
DEVELOPED FILMS
VIDEO TAPES
MOVIES
MICRO FILMS
DIAGNOSIS
RECORDING OF DIAGNOSIS
METHOD OF COMUNICATION
DIAGNOSIS GIVEN TO REFERRING PHYSICIAN

We tracked the activities of both inpatients, outpatients, and emergency patients through various procedures in the three hospitals studied. Figure IV-5 verbally describes the procedures for inpatients, emergency patients, and outpatients in the community hospital studied.

Figure IV-6 is a flow chart developed by the American College of Radiology which differentiates the steps visible to the patient from the steps invisible to the patient. Figures IV-1, IV-2, IV-3, and IV-4 show various ways of looking at the steps in the radiological process. Figure IV-7 shows the procedures in the university hospital required in a gastro-intestinal examination for an outpatient.

Patients

As we examined the system further we were able to verify that in all departments observed, a patient spends a great deal of time waiting. This waiting occurred previous to the examination, in the waiting room before a patient was seen by anybody, in the dressing room after a patient was told to undress but was waiting to be called into the examination room, and after the examination while waiting for the film to be processed in order to determine if the film was adequate or if another film was required. Table IV-1 and Figure IV-8 show how a typical patient spends his time in the hospital with a prepayment plan. Figure III-1 shows the time distribution in a typical morning in the community hospital.

The large amount of time spent in the department not actually in the examination room makes it imperative that facilities are designed to accommodate the various patient needs prior to, during, and after examination.

Patients cannot be grouped as one unit. A clear distinction must be made between facilities for inpatients and outpatients--or, rather than

FIGURE IV-5

Analysis of Procedures: Radiology Department Procedures in a Community Hospital

1) IN-PATIENTS
   a) Private patients
   b) Clinic patients

2) OUT-PATIENTS
   a) Private patients
   b) Clinic patients
   c) Emergency patients

Procedure, In-Patients (a) and (b)

1) The nurse on the nursing floor sends a requisition (see, Form RT-X) to the X-ray information desk.
2) The clerk at the information desk of the radiology department schedules the patient in the day book.
3) At the appropriate time, the clerk at the information desk asks the orderly to go for the patient.
4) The orderly notes the data needed to find the patient in his book (floor, room number, etc.).
5) The orderly reports the patient's name, room number, and the time of the requisition of the patient in the X-ray booth at the nurses' station. He gets the patient's medical records from the nurse and a wheelchair or guerney (depending on the condition of the patient) to transport the patient.
6) The orderly dresses the patient in a green coat to identify the patient as an in-patient.
7) The orderly brings the patient to the X-ray department. He leaves the hall adjacent to the diagnostic rooms and takes the medical records to the information desk.
8) The clerk at the information desk types a form (see Form 1-64) and records the arrival of the patient

on the day sheet (patient's name and type of examination).

9) The first page of Form 1-64 is used as patient's card to be kept in the department file if the patient has not had any previous X-ray examinations. If the patient has had previous examinations in the department, the first page of Form 1-64 is then used by the file clerk to find the old films of the patient.

10) If the patient is going to have a fluoroscopy examination the file clerk finds the patient's old films and places them on the information. If the patient is going to have a routine examination, the old films are placed in the dry room where they will join the new ones.

11) The "traffic supervisor," the person who checks the activities in the department, asks the volunteer in charge to bring the patient's papers and the patient's old films to the waiting hall. The volunteer leaves the papers in the appropriate boxes which are located along the walls of the in-patient's waiting hall.

12) The technician picks up the papers and takes the patient into the X-ray room.

13) The examination takes place.

14) The technician notes the number and size of the films taken on page 3 of Form 1-64. He then takes the patient out of the room and back into the waiting hall.

15) The technician takes the films and the patient's papers to the processing room. A light system inside the processing room helps the technician to find the "delivery box" in which the films have been placed. A sound system gives notice of the delivery in case the technician is not in the processing room.

16) The technician in the processing room identifies the films by the use of page 2 of Form 1-64. The films are then placed in the X-OMAT machine which delivers them directly to the dry room. The patient's papers and old films are delivered to the same room by another "delivery box" also provided with a sound system to signal their arrival.

17) The technical supervisor examines the technical quality of the films; if he thinks they are sufficiently adequate he takes the new films along with any old films and the patient's papers to the radiologist's office.

18) The radiologist checks the films and the requisition. If the charges are correct, and the films are acceptable in terms of quality, he says that the patient may be allowed to leave. The supervisor then goes to the information desk where he places a note on the patient's medical record which indicates that the X-ray examination has been completed.

18a) In case the films must be retaken, the technical supervisor finds the technician who performed the procedure and instructs him on the requirements for the next set of pictures, pointing out the inadequacies of the first set.

19) If the patient is discharged, the orderly picks up the patient's medical records and the patient and returns both to the originating room. The orderly notes the time of the return of the patient on the X-ray book.

20) After the radiologist has superficially checked the films in order to enable the patient to leave the department, he proceeds to make the diagnosis. He records the diagnosis on a dictaphone.

21) The file clerk picks up the films and takes tham to the file room. There he labels the envelopes in which the films are to be placed with a colored adhesive tape. For every day of the week there is a different color. By using this device, the clerk can keep the envelopes in the active file room for exactly one week.

22) The secretary goes to the radiologist's room and picks up the records on which the radiologist has previously recorded the diagnosis. She brings the records to her office and types the diagnosis on pages 6, 7, 8, 9, and 10 of Form 1-64. The first copy, page 6, goes to the originating floor; the

second copy, page 7, is pasted on the envelope containing the films; the third copy is sent to the medical file or to the originating doctor; the last two copies are sent to the other doctors who are involved.

23) The physician in charge of the patient goes to the file room where he can see the films and compare them with his original diagnosis. Many times, the originating physician will ask the secretary to repeat the results of the examination over the telephone if the radiologist isn't there.

Procedure, Emergency Patients:

1) The Emergency Station calls the radiology department announcing the arrival of an emergency patient.

2) An orderly in the emergency section brings the patient to the X-ray in-patient waiting hall. The orderly leaves the patient's papers (see Form 206) and the requisition (see Form RT-X) on the information desk.

3) The clerk of the information desk types Form 1-64. In case the requisition Form Rt-X has been sent to the X-ray department, she destroys pages 2 and 3 and leaves only page 1 of the requisition. If there is no requisition, no other paper is needed; Form 1-64 is sufficient for all the procedures in the X-ray department.

4) This step is analogous to step 9 of Procedure 1.
5) " " " " " " 10 " " 1.
6) " " " " " " 11 " " 1.
7) " " " " " " 12 " " 1.
8) " " " " " " 13 " " 1.
9) " " " " " " 14 " " 1.
10) " " " " " " 15 " " 1.
11) " " " " " " 16 " " 1.
12) " " " " " " 17 " " 1.
13) " " " " " " 18 " " 1.
14) The orderly of the X-ray department picks up the patient's papers (Form 206 and the business office's copy of Form 1-64), the patient and takes both back to the emergency department.
15) This step is similar to step 20 of Procedure 1.
16) " " " " " " 21 " " 1.
17) " " " " " " 22 " " 1.

<u>Procedure 3, Clinic Out-Patients</u>:

1) The clinic sends the requisition Form RT-X to the X-ray department.
2) The clerk at the information desk schedules the patient in the day book.
3) The patient arrives at the information desk. The clerk types Form 1-64 and gives page 5 to the patient (Patient's copy); the clerk then records the patient's arrival.

4) The patient goes to the business office and pays the examination fees.

5) The patient goes to the waiting room. The clerk records the arrival on the day sheet.

6) This step is similar to step 9 of Procedure 1.

7) " " " " " " 10 " " 2.

8) The traffic supervisor that checks the activities of the department, asks the volunteer to bring the patient to one of the dressing rooms. The volunteer picks up the patient's papers and brings the patient to the dressing room where he asks him to undress. The volunteer gives the patient a white coat and asks him to put it on. The papers are left in the appropriate box.

9) This step is similar to step 12 of Procedure 1.

10) " " " " " " 13 " " 1.

11) " " " " " " 14 " " 1.

12) " " " " " " 15 " " 1.

13) " " " " " " 16 " " 1.

14) " " " " " " 17 " " 1.

15) The radiologist checks the films and the requisition. If the charges are correct and the films acceptable, the supervisor goes to the information desk where he communicates the favorable result of the examination to the volunteer.

16) The volunteer goes to the dressing room and asks the patient to dress himself.

14) The patient dresses and goes to the information desk. There the clerk in charge gives him the patient's copy of Form 1-64.

15) The patient goes to the adjacent business office and pays the examination fee. The patient then leaves the department.

16) This step is similar to step 20 of Procedure 1.

17) " " " " " " 21 " " 1.

18) " " " " " " 22 " " 1.

FIGURE IV-6

X-RAY EXAMINATION FLOW CHART*

A - Steps Visible to Patient

Patient in

M.D. request for examination

Appointment and instructions for preparation

Registration and assignment of examination number

Patient to dressing room undress 5 min.

Requisition studies by radiologist and/or technologist and film marker set up

X-ray room radiography 10 min.

or

Fluoroscopic room fluoroscopy and radiography 10 min.

Patient to waiting or dressing room 10 min.

Film to dark room processing 10 min.

Processed films reviewed by technologist and/or radiologist

Additional views or retakes according to need 10 min.

Secretary's desk for instructions, billing arrangements, etc. 5 min.

Patient out

B - Steps Invisible to Patient

Films dried, trimmed, sorted, labeled and enveloped 10 min.

Films studied by radiologist and, if indicated, previous films obtained studied and correlated 5/30 min.

Diagnostic report dictated

Reports typed checked and signed

Reports assembled and delivered to chart or mailed to referring M.D. 30 min. up

Films frequently reviewed by radiologist in consultation with referring M.D. No limit

Consultation with associates in difficult or unusual cases No limit

Supplementary report dictated, typed and sent to referring M.D.

Selected films set aside for teaching, conference or research or for slides

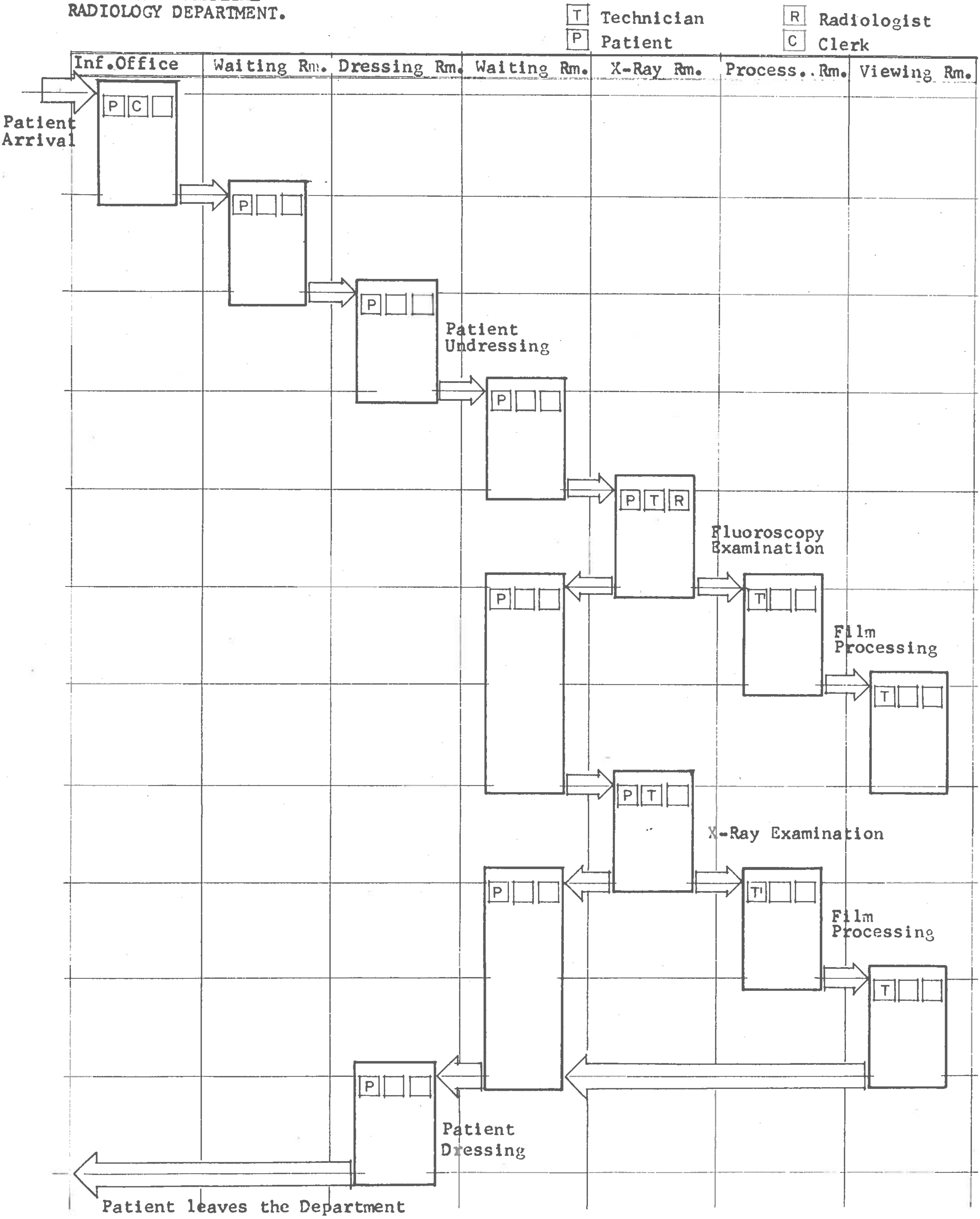
New types of film, fluoroscopic and radiographic equipment tested

Selected films brought to weekly staff meeting for opinions

*Times are approximate averages

FIGURE IV-7

UNIVERSITY HOSPITAL
RADIOLOGY DEPARTMENT.



SEQUENCE DIAGRAM OF GASTRO INTESTINAL EXAMINATION PROCEDURE. OUT-PATIENTS.

TABLE IV-1

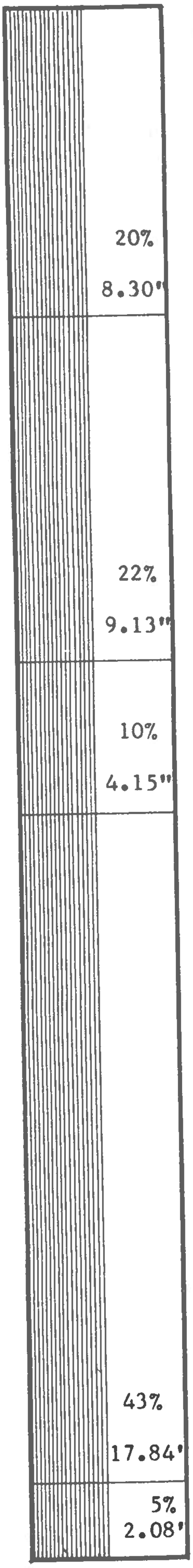
CHART SHOWING THE AVERAGE WAITING TIME OF EACH PATIENT AND THE AVERAGE TIME HE SPENDS IN THE DIAGNOSTIC ROOM

Procedure	Average Time Spent In Registration, Waiting Room and Dressing Room:	Average Time Spent In Diagnostic Room:	Average Time Spent in Diagnostic Room Expressed as a Per Cent of the Total Time:
Laminogram	32.37 Minutes	26.0 Minutes	44.6%
Barium Enema	" "	15.7 "	32.6%
Gastro Intes.	" "	10.6 "	24.8%
Gall Bladder	" "	10.3 "	24.2%
Spine	" "	9.9 "	23.5%
Skull	" "	8.7 "	21.2%
I.V.P.	" "	8.3 "	20.4%
Hips	" "	6.8 "	17.4%
Hand	" "	5.3 "	14.2%
Elbow	" "	4.7 "	12.7%
Toe	" "	4.6 "	12.5%
Pelvis	" "	3.5 "	9.8%
Chest	" "	2.0 "	5.8%

Note: Minifilm is excluded.

FIGURE IV-8

CHART SHOWING THE TIME SPENT BY A PATIENT IN THE X-RAY DEPARTMENT EXPRESSED AS A PERCENT OF THE TOTAL TIME IN THE DEPARTMENT. Prepayment Hospital



20% of the total time patient waits for the finished film.

22% of the total time patient in Diagnostic room.

10% of the total time patient in Dressing room.

Note. Excluding minifilm, a patient spends 41.5 minutes in the X-Ray Department.

43% of the total time patient in Waiting room before being called into Diagnostic room.

5% of the total time patientspends on Registration classify in that manner--between horizontal patients and vertical patients. In each of these groups additional care must be taken to accommodate the needs of the very young and the very old. Let us look at some of the separate facilities required by the various types of patients.

Horizontal patients--horizontal patients are often quite ill and may come to radiology in a state where they require constant supervision. In many cases what is required is a waiting area for guerney patients which is almost like an intensive care center. They need provisions to be bed panned and privacy for this function. They need very careful handling, the means to call for help, constant supervision, and special training and facilities to be placed on and off the X-ray tables.

Vertical patients--the vertical or ambulant patient has his own set of needs. He generally is apprehensive about what the radiologist is going to find, and in all the personal interviews the ambulant patient found contact with a horizontal patient or an emergency patient very disturbing. Ambulant patients do not want to wait with horizontal patients or be exposed to their problems. It is particularly difficult for children to be exposed to someone who is very ill.

The Elderly patient--many of the ambulant patients who come to the hospital to use the diagnostic radiology facilities are elderly people and statistically the numbers are increasing. They have separate problems which are not generally recognized by the design of our departments. Elderly people have difficulty getting up and down and in and out of chairs. For some unknown reason all the waiting rooms had low, soft, easy chairs which were extremely difficult to sit down in, and once down it was almost impossible for an older person to get up unaided.

Many older people had difficulty dressing and undressing. The dressing rooms were generally too small. They need to be large enough to permit two people and/or a wheel chair to get in them. Old people have trouble bending to tie and untie shoelaces. Provisions should be made for a step to put their feet on so they can do this more easily. Waiting in a dressing room is a very dismal experience. Essential facilities with which to call for help are not generally provided. In cases where patients had the option of waiting in separate male and female waiting rooms in semi-undressed states, the supervision and the overall sense of being watched over was better. Provisions must be made for bathroom facilities while waiting undressed.

Once in the examination room, the difficulty encountered by an old person in trying to get on the table makes one wonder at the state of the art of equipment design. Many technicians say the same examination for an old person takes double the usual time. If a barium enema is to be given, the results are often over the floor before the patient can make it to the toilet. At least, provisions for clean up should be adjacent.

Children--children vary from babies to teenagers. Babies need special devices for holding them still. Most children are afraid of the machines, and the strangeness of the place. Probably it is the personal relationships which affect the children more than the physical location, except that the sight of the obviously ill person is frightening. Exposing children to emergency cases or very ill people often has a terribly traumatic effect and should be avoided.

Whereas the foregoing are special considerations, there are some criteria that apply to all age groups:

1. Dressing room areas should be large enough to be comfortable.

2. There should be clear instructions on how to put on a gown.

3. A place must be provided to lock up clothes; people are anxious about their possessions.

4. Waiting in an undressed state is cold; additional heat should be provided in dressing areas.

5. People feel isolated waiting, and should be able to call or see other people.

6. No provision is generally made for people to go to a bathroom easily while undressed.

7. Though seemingly insignificant in themselves, these small details can, taken as a whole, add up to the difference between patient ease or lack of it.

The Radiologist

The radiologist is in charge of the department. He should be located near the emergency and surgery departments. Since he is primarily involved with emergency, fluoroscopy, and special procedure cases, this should be planned for. The radiologist also needs adequate and comfortable space to view and review films, and facilities to accommodate previous films and newly-taken films simultaneously for comparative purposes. The problem of the subjective reading of films is a serious one and every effort must be made to minimize influences that interfere with objective readings.[2] Special lighting should be maintained so the radiologist does not have to make adjustments after fluoroscopy. Probably one of the important new requirements will be the development of apparatus that will allow him to see other information about the patient simultaneously. A successful test of the idea is being done by Dr. Miller[3] at the University of California, where he simultaneously sees the image of an X-ray film and other information showing children with speech difficulties. The radiologist needs easily reached dictation machines. If teaching is part of his duties, additional facilities obviously are required. A great deal of the radiologist's time is spent consulting with other doctors, and the pattern for such consultations must be worked out so the radiologist has privacy when necessary, and in such a way that doctors do not walk through the radiology department. Table IV-2 shows how the time in a typical day is spent by the radiologist.

The Technician

The technician is responsible for most of the film-taking. He must study the request of what is to be done, get the patient on the table, see that the correct films are available, adjust the machine, read the films for adequacy, consult with the radiologist, and clean up the room after each examination. The jobs are numerous and involve patient handling and technical skill. A work corridor distinct from the patient corridor is generally very convenient for technicians. Regarding their personal requirements, they need a place to hang clothes, change if they wish, lock up their possessions, have a coffee break, and have a place to read and study if desired. They need adequate clean up facilities, and convenient storage areas for film supply. Table IV-3 and IV-4 show a typical day of a technician supervisor and a technician.

We have tried in this chapter to describe the process which takes place in diagnostic radiology. In the next chapter we shall review the plan organization of different radiology departments, how it came into being, and its effectiveness in meeting the user requirements of the patient, the technician, and the radiologist.

TABLE IV-2

Activity of Radiologist in a Community Hospital--typical day.

Time	Telephone Conversation	X-Ray Theraphy	Checking Films Contact with Personnel	Fluoroscopy Examinations	Reading Films and Recording Diagnosis	Hanging Films	Conversation with Physician	Rest Periods	Others
8 - 9			2	34			10		14
9 - 10	7		13	11	6	5	6	4	8
10 - 11	17	6	9		5	2	4	7	10
1 - 2	12		9		4		11		24
2 - 3	14	4	4		10		2		26
3 - 4	6		5		12		16		21
4 - 5	21	2	9	6	7		1	14	
TOTALS	77	12	51	51	44		50	25	103

TABLE IV-3

SUMMARY OF TECHNICIAN SUPERVISOR'S ACTIVITIES IN A COMMUNITY HOSPITAL

Hours	Actual Work in Viewing Room	Helping Technicians	Talking with Radiologist	To Information Desk	Idle Time	Breakfast and Lunch	Miscellaneous
8:00-9:00	18 min.	2 min.	6 min.	6 min	24 min.	4 min.	-
9:00-10:00	16	-	30	-	8	-	6
10:00-11:00	2	-	24	2	6	26	-
11:00-12:00	6	38	-	-	-	-	16
12:00-1:00	2	12	18	-	-	20	8
1:00-2:00	2	-	6	-	5	46	-
2:00-3:00	-	-	10	-	-	-	50
3:00-4:00	-	-	5	-	-	-	54
4:00-5:00	4	-	4	-	-	-	48
TOTALS over a 9 Hour day	50	52	104	8	50	96	182

	Actual Work in Viewing Room	Helping Technician	Talking with Radiologist	To Information Desk	Idle and Personal Time	Miscellaneous
TOTALS over an 8 hr. day	50 min.	52 min.	104 min.	8 min.	86 min.	182 min.
Percentages	10.42%	10.89%	21.78%	1.66%	17.39%	37.96%

TABLE IV-4

Hospital with a prepayment plan

Technician's Activities:	Average Time Taken:
1. Get the requisition form from the box to the desk.	8 Seconds
2. Make up the marker.	45 "
3. Call the patient.	14 "
4. Adjusting the controls and filming only one film. (Note: No. of films taken varies widely from procedure to procedure.)	13 "
5. Positioning the patients.	Varies from procedure to procedure. ( )*
6. Dismiss the patient.	15 "
7. Take the film to the Dark Room (only in rooms #3 and #4) and forms to the X-OMAT Room and bring back the required film.	40 "
8. Take only the requisition form to the X-OMAT Room and come back to the Diagnostic Room. (Make: only in Rooms #1 and #2.)	16 "

*This figure is obtained by subtracting the sum of activities 1, 2, 3, 4, 6, 7, & 8 from the average time taken from each procedure.

FOOTNOTES: CHAPTER IV

1. Examples of work engineering studies are: Ernest J. McCormick, Human Factors Engineering,(New York: McGraw-Hill Co., 1964); James M. Moore, Plant Layout and Design, (New York: The Macmillan Co., 1962); and Gerald Nadler, Work Design, (Homewood, Illinois: R.D. Irwin, Inc., 1963).

2. Jacob Yerushalmy, "Recent Developments in Applications of Statistics to Tuberculosis Control Programs," Proceedings of the International Statistical Conferences, Vol. III, (1947), pp. 576-592; J. Yerushalmy, "Problems in Radiological Interpretation," California Medicine, Vol. 70, (January 1949), pp. 1-5; J. Yerushalmy, "The Reliability of Chest Roentgenography and Its Clinical Implications," Diseases of the Chest, Vol. 24, (August 1953), pp. 133-148; J. Yerushalmy, "Reliability of Chest Radiography in the Diagnosis of Pulmonary Lesions," American Journal of Surgery, Vol. 89, (January 1955), pp. 231-240.

3. Dr. Earl Miller, University of California Medical School, San Francisco, personal communication.

CHAPTER V: UNCOUPLING THE SYSTEM TO PROVIDE SPATIAL FLEXIBILITY

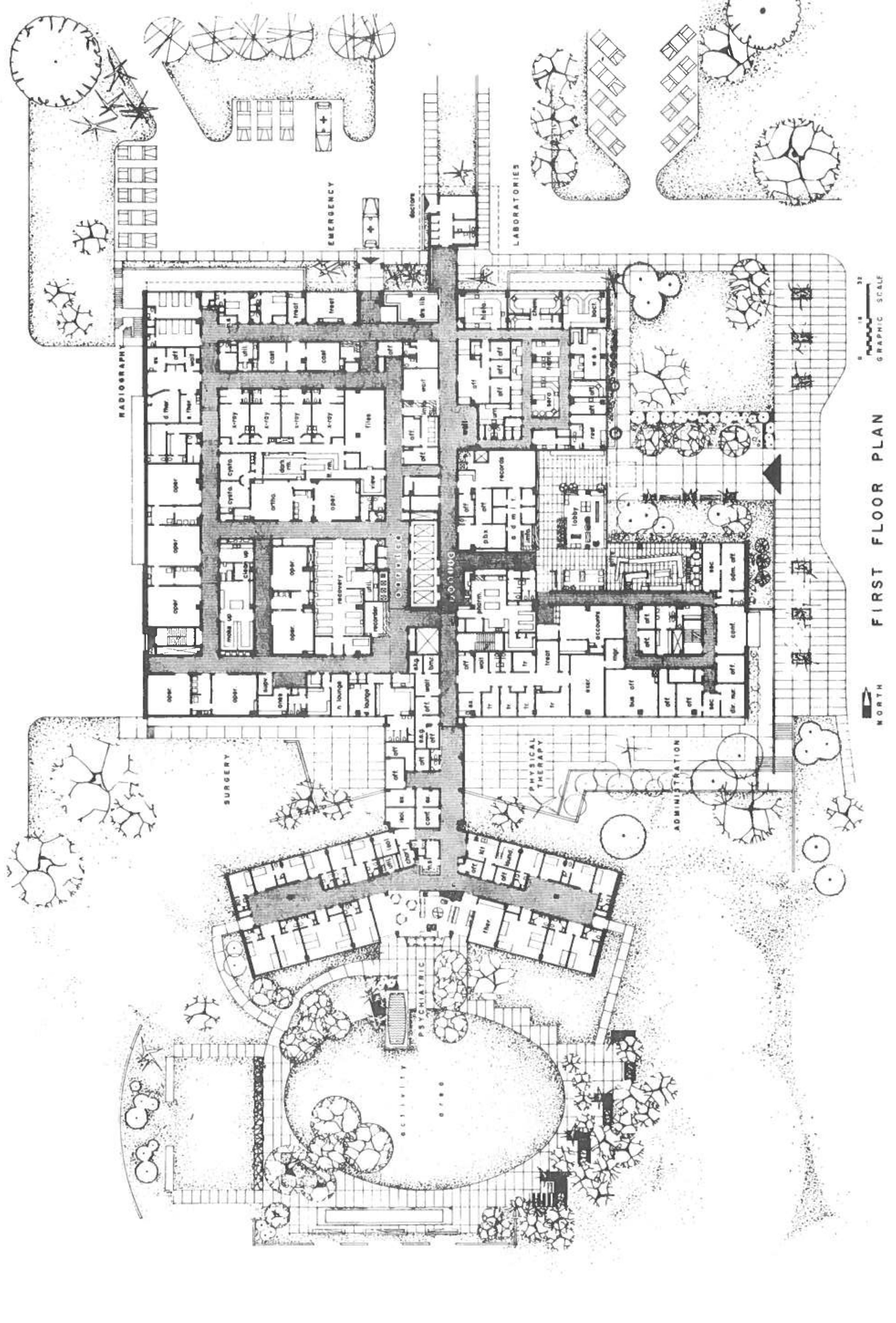
Over a period of years designers and Radiologists have developed principles of spatial organization which have strongly influenced the architectural design of these facilities. These concepts have been adjusted to accommodate new technological developments. It is important to constantly re-examine these concepts because, unless continually re-evaluated, habits of spatial organization become etched into the minds of both architect and client. Habits by definition lag behind new technology. We must overcome the tyranny of habit or our designs will become functionally obsolete even as they are being built. The purpose of this chapter is to first look at the reasons for the prevalent notions of what makes a "good" diagnostic radiology spatial configuration; then to examine the system of radiology and see what influences, technological, social, organizational or economic are making possible new design alternatives, what factors are forcing us to consider new design solutions; then to see how the system can be uncoupled. Based on new design problems and new design opportunities we can then determine what is the most effective direction for the design of radiology departments.

Existing Rules for the Design of Diagnostic Radiology Departments

Radiology departments have emerged from the basement to a new, respected first floor location. The unprecendented growth of the radiology department, and its constant use as a key diagnostic tool for both inpatients and outpatients makes its location within the hospital and its organizational structure extremely important for the overall hospital function.

Because it is used by both inpatients and outpatients, the ideal location was considered to be the first floor where outpatients could use this department without having to tax the vertical transportation system of the rest of the hospital. We have already shown how the outpatient in many hospital situations accounts for as much as 60 per cent of the utilization of the diagnostic radiology facilities. The emergency department was also customarily located at ground level and this location for radiology afforded the additional advantage of being close to emergency. For these reasons the radiology departments, whenever physically possible, were located on the ground floor adjacent to emergency and surgery and accessible to both inpatients and outpatients.

We have previously documented the yearly increase in the use of diagnostic radiology. There are also new technological developments which allow for new forms of medical diagnosis and which will further increase the use of diagnostic radiology. To accommodate this growth, another "rule" for the design of the radiology department was to locate it so that one end would be open for horizontal expansion. In addition many architects located so-called software such as lockers and storage next to the radiology department to allow for expansion into these easily removable and replaceable areas. An excellent example of how these rules were put into operation is illustrated by the El Camino Hospital Radiology Department in El Camino, California. Figure V-1 is a plan of this department and shows the location of X-ray next to surgery and emergency. It is open ended on the west side so it can expand. It also embodies another rule which has governed radiology planning for many years, which is to locate the radiographic rooms around a central processing unit consisting of a light room and a dark room which in turn leads into a viewing room and file room.



EL CAMINO HOSPITAL
mountain view · california

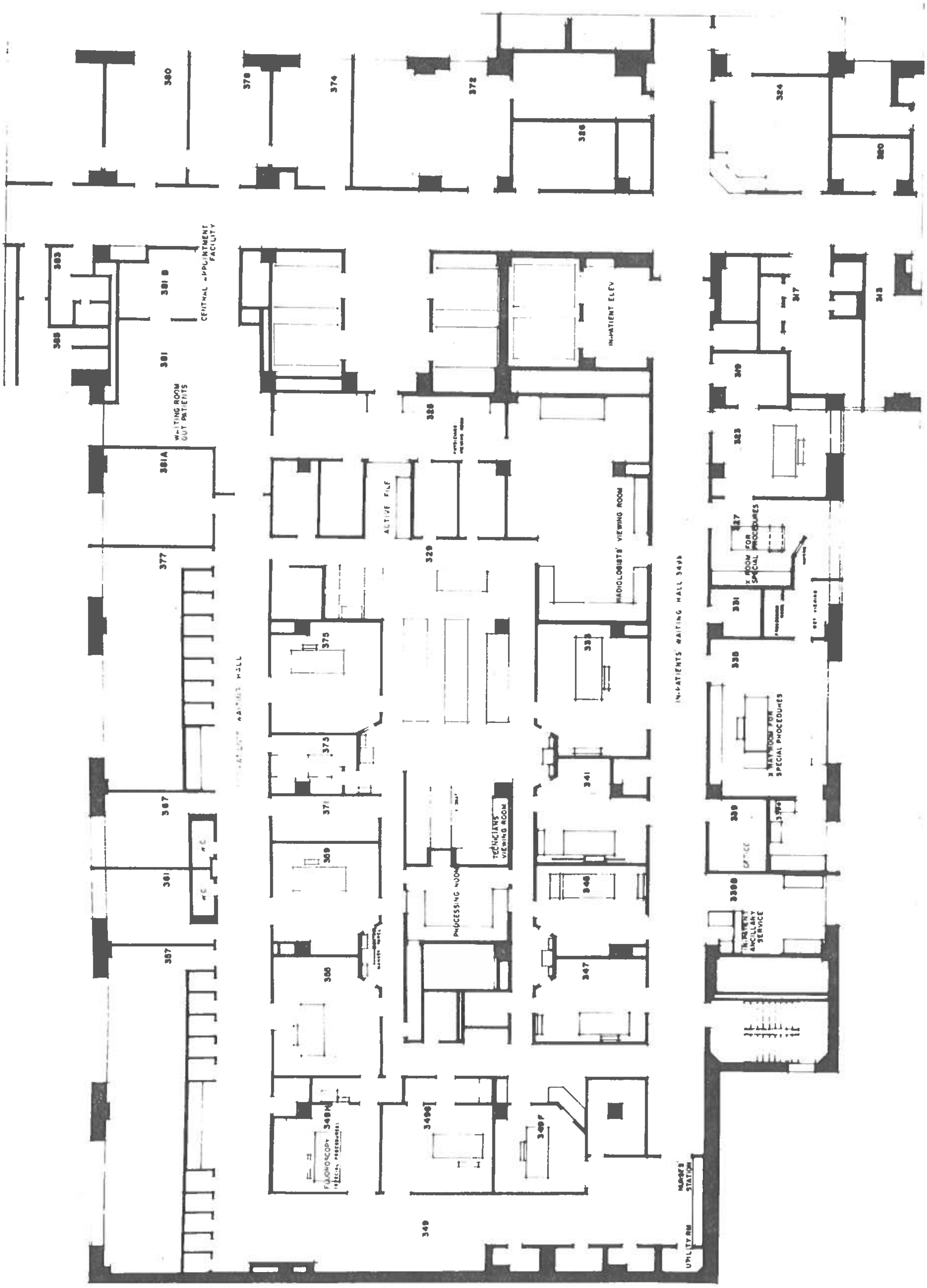
Figure V-2 is a plan of the Diagnostic Radiology Department at Moffitt Hospital, University of California Medical Center, San Francisco. When it was built it represented an extremely forward looking plan. The diagnostic rooms surround a central processing unit which in turn leads directly into a file room and viewing rooms. A separate work corridor for technicians is differentiated from the public corridor for patients. Inpatients and outpatients have separate waiting facilities as well as separate corridors. The fluoroscopy rooms can be used by both inpatients and outpatients.

Despite the fact that their plans were originally effective, many radiology departments are suffering from growing pains, inadequate space, increased demands and overburdened organizational methods. The radiology department at Moffitt Hospital was designed to handle a certain capacity and this capacity has been exceeded by both patients and personnel required for processing, storage, filing, reading, teaching, etc. The size explosion has negated the original validity of the plan.

Uncoupling the Radiology System

How can we begin to come to grips with solving the increases in demand; the limitations of space and the rising numbers of ambulant patients who require the use of the facilities, as well as the increase in use of new techniques for diagnosis which require complex apparatus and teams of medical personnel? Our approach was to examine the radiology department from a systems point of view and examine the system in such a way as to determine which components of the system needed to be spatially adjacent in order to function and which components of the system could be functionally linked but physically separated. Based on our analysis of the functioning

FIGURE V-2



X-RAY DIAGNOSTIC DEPARTMENT_
UNIVERSITY HOSPITAL

of the system described in the last chapter, we isolated the subsets of the system which required spatial proximity as a necessary condition to function from those subsets which did not need this spatial contiguity. We found the following:

1. The patient, the machine, and someone both to help the patient and run the machine (the technician) must come together. There is no way yet of taking a picture with the patient in one location and the machine in another; there has to be direct contact. The machines can be operated remotely, but someone still must help the patient on and off the machine.

2. The film and the film-processing must come into contact. If a film is to be developed, there is no technique of developing it remotely. There are numerous alternate ways of developing film (Polaroid, manually, automatically), but contact must still be made between the film and the developing agent.

3. The radiologist, in order to make a diagnosis, needs the X-ray image of the patient as well as previous images and other pertinent information. He can get this image in a number of ways, but whichever way, the image is essential.

These then become the sets which require spatial proximity. Each of these sets has a series of secondary needs which demand spatial solutions. Thus, when a patient, a machine, and a technician are brought together, the patient needs toilet facilities, a place to dress and undress (if the patient is an outpatient), and so on. The machine requires a room with a lead lining (or the scatter of X-rays will become damaging), control booths to protect the technician, and space for the machine requirements (transformers, generators, tube stands). The film and the film-processing, unit require their own sets of spaces depending on the method of processing, and the radiologist in turn will have his own space requirements for viewing the image. If these are the only needs which have to be satisfied by spatial proximity, then by implication, the other subsystems necessary to functionally satisfy the requirements of radiology do not demand spatial proximity to one another.

Links and Linkages

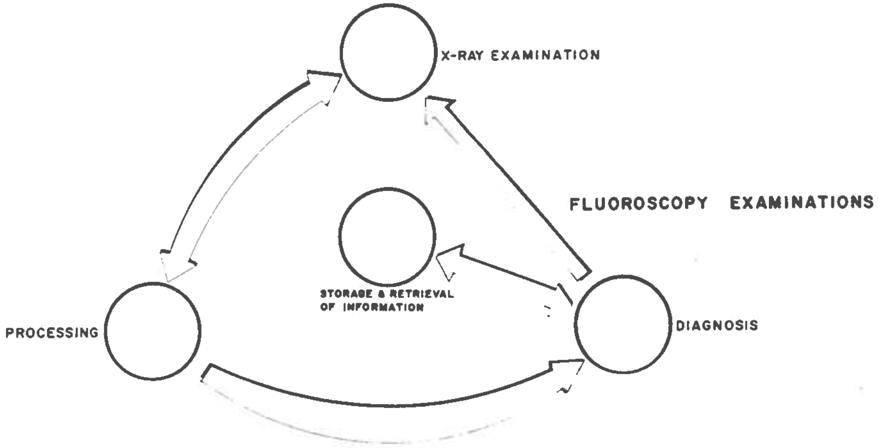
The various forms of links and linkages used to connect different activities are closely related to technological developments. It is now common practice to have verbal messages transmitted over intercom and telephone or written messages transmitted by teletype or pneumatic tube. Dumbwaiters, conveyors, and elevators are commonly used to transport material objects of varying sizes. All of these ways of communicating messages and materials have modified the requirements for physical proximity between activities.

An examination of the technical requirements necessary to link together the activities of radiology shows that the processing of film does not require a location next to the diagnostic rooms. What is required is a method of transporting the exposed film to the processing room. In some cases locating it directly adjacent to the diagnostic rooms will be the best solution. But it is also possible under certain circumstances that the processing may be on one floor and the diagnostic machines on another, and the connection between the two may be by means of dumbwaiter or other vertical conveyance. The filing system certainly does not have to have physical proximity to the diagnostic rooms or the radiologist. All that is important is that a method be developed whereby the image of the old films are delivered at the required place at the proper time.

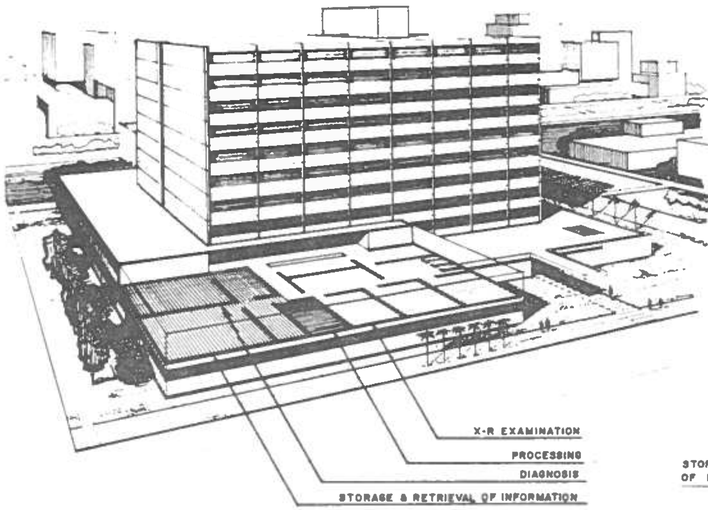
It is not an essential part of the system to locate the radiologist in close proximity to either the diagnostic rooms or the processing unit. The image of the developed film or the fluoroscopic image could be transmitted over closed-circuit television to a radiologist located in another part of the building or even in another building. Already image intensifiers and television are integral parts of fluoroscopy rooms. The video taping of fluoroscopic images is a real technical possibility. Since there is no film to develop, instant playback is possible. The potential for transmitting picture images through space gives increasing freedom for radiological spatial organization. Telognosis and television of radiographs allow the radiologist to be far removed from the patient and the picture-taking machine. A technician, nurse, or general practitioner in a remote area can take the picture, transmit it to a distant radiologist, and receive back a diagnosis very quickly.[1,2,3,4]

Not all of the technical aspects of the radiology system change simultaneously. The major technological advance which affected the practice of diagnostic radiology occurred a decade ago when automatic processing was introduced. In this period, the X-ray machine itself remained relatively unchanged. Today the reduction in cost of automatic processing units allows for several of them to be located in one hospital. Some hospitals have automatic processing units in emergency and surgery as well as in Radiology. The Kaiser hospital in Santa Clara County has one processing unit for each two diagnostic rooms (see Figure V-3). The uncoupling of the various subsystems allows for the introduction of new developments as they occur without constantly having to revise the total physical arrangement of the department. Thus, the introduction of videotape as a method of storing information may eliminate the need for

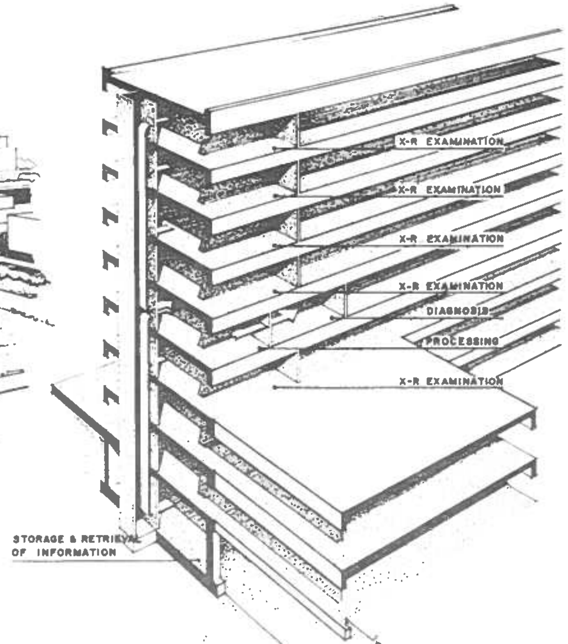
FIGURE V-3



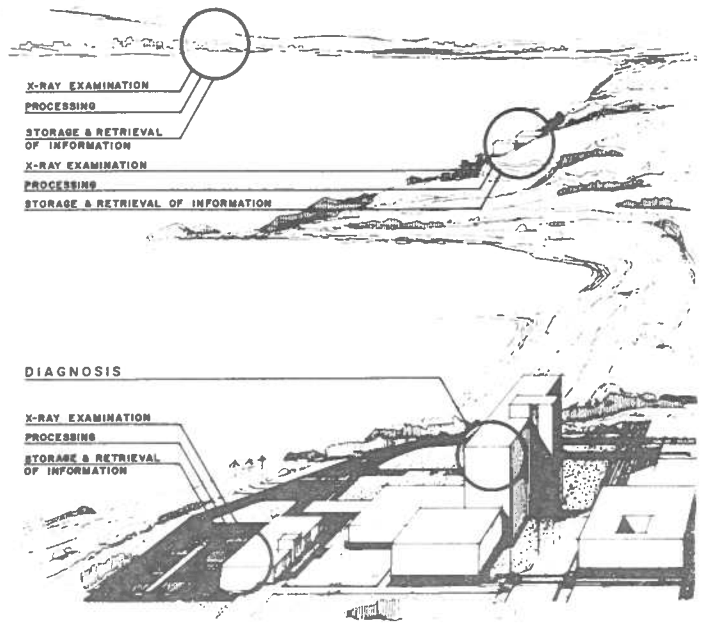
BASIC ELEMENTS OF X-RAY DIAGNOSTIC SYSTEM



TYPICAL DIAGNOSTIC X-RAY DEPARTMENT
ELEMENTS HAVE A CLOSE SPATIAL CONNECTION.



UNCOUPLING OF BASIC ELEMENTS AND RECOUPLING WITH NEW COMMUNICATION LINKS ALLOWS FOR MORE FLEXIBLE DESIGN.



CHANGES IN THE TECHNOLOGY OF COMMUNICATION MAKE FEASIBLE A NEW CONCEPTION OF ORGANIZATION OF THE BASIC ELEMENTS OF DIAGNOSTIC X-RAY.

a developing machine altogether as well as change the central storage and retrieval of information subsystem. These changes brought about by videotape will not, however, change the spatial requirements of the patient-machine-technician subset.

Much of the new technology is used in very time-consuming special procedures and thus exacerbates the manpower shortage. Further uncoupling could occur when computer analysis of X-rays will permit less trained people to make accurate diagnoses.[5,6]

There are many functional problems in hospital design which could be solved if there were a more flexible approach to the organization of space. The concept of uncoupling the system of radiology in no way implies that a centralized radiology department is necessarily wrong or a decentralized radiology department is necessarily right. It would depend on the department's size and relationship to other aspects of the hospital and community. A system for a hundred-bed hospital will be quite a different one from that necessary for a five-hundred-bed hospital, which in turn will be different from the requirements for a thousand-bed hospital. The uncoupling of the system will allow for many types of alternate possibilities including decentralized arrangements which might better satisfy the needs of a large organization. For example, the greater the volume of patients, the more the department can be specialized and the easier it is to divide the department and to locate different parts of it in different parts of the hospital. A hospital with a large enough volume of patients can have separate radiology departments for in-patients and out-patients. A hospital with a high volume of surgery can locate specialized radiology rooms in the surgery department. For example, a solution to the Moffitt

Hospital radiology growth problem could be to subdivide into outpatient, inpatient, and special procedures departments with only one of these in the present location illustrated by Figure V-2.

Special radiology procedures which require expensive equipment can be effectively utilized only in a hospital large enough to make efficient use of the equipment. In a small radiology department each room and machine must serve a multiplicity of functions. The larger the department, the greater the possibility of providing specialized rooms and machines as the increase of volume tends to justify their single purpose accommodation.

Uncoupling the system provides alternatives for expansion of facilities as well as the possibility of locating a portion of the radiology department in a centralized location. There is always a struggle to place key facilities in centralized and strategically located ground floor areas. Those very departments which should logically be in the central locations are also those which require the most opportunity for expansion. By uncoupling the spatial system considerable freedom is gained for alternate spatial configurations. It is also possible to develop a mobile system as part of a hospital X-ray department. Mobile X-ray trucks can use the hospital as a base station and circulate to different nursing homes, schools, or areas of the city where population groups would most benefit by having this equipment directly available. These mobile units could be so designed that they could "literally" couple into each of the facilities they will serve and then transmit the images to the Radiologist in a central location. Such a form is comparable to the Dulles Airport where mobile lounges "couple" into the airplane and then "uncouple" transport patients to the airport proper.

Mobility in bringing the X-ray to the patient can also be achieved within the hospital as the technological potential of the portable X-ray increases.[2] It is not beyond the realm of feasibility to conceive of an X-ray in the elevator, thus reducing the problems of vertical patient transportation.

Conclusion

Studies of diagnostic radiology generally conclude their analysis with a plan illustrating ideal space arrangements.[7,8,9,10,11] Before it is possible to design an "ideal" plan there has to be agreement about criteria by both architect and client. Based on this agreement it is then possible to evaluate alternate solutions for a particular building with its specific organization and specific constraints. The criteria for planning is sometimes referred to as a building program. It is at best a starting hypothesis to use as a basis for design development. As the design solution progresses the conditions of a particular project often make ideal solutions "impossible" and there is need to then modify the initial program.

As a result of this study of diagnostic Radiology the following premises might currently be useful to architects and radiologists as a starting point for their design development.

1. More and more ambulant patients will be using diagnostic radiology both within and without the hospital setting.

2. Inpatient procedures will become increasingly more complex and involve new types of equipment and teams of trained personnel. More procedures will be performed on each patient.

3. The shortage of radiologists will continue and there will be greater need to make the most efficient use of their time and capabilities.

4. The radiologist sees patients in fluoroscopy and in special procedures but does not actually come in contact with the patient in most routine diagnoses.

5. Technology for the transmission of the X-ray image by closed circuit T.V., telephone, and computer will be perfected so that the X-ray image can be transported over remote distances.

6. The storage and retrieval of X-ray images will undergo a complete transformation from the present relatively archaic hand filing and retrieval systems to a modern system of data processing and retrieval. It is conceivable to project the idea of a central system for a geographic area in a city which serves clinics, doctors, and hospitals.

7. X-ray machinery will continue to develop and change, hence, constant revision of existing facilities will be required.

8. Accidents and emergencies will be on the increase and X-ray equipment must be available for this service both in the emergency room and in the ambulance.

9. Processing of X-ray film will become less expensive and consequently each diagnostic room will probably be able to afford its own automatic processing unit thus making the location of the X-ray room independent of the processing department.

10. Diagnostic mobile units containing X-ray equipment will be developed to literally "couple" into pre-designed receptacles located in nursing homes, schools, rural health centers, and areas of the city which would be more effectively served by bringing the equipment to the user rather

then the user to the equipment. The organizational and spatial implications of these ten premises point to a diagnostic radiology department made up of a series of sub-departments. These sub-departments fall under the following categories: (a) inpatient (b) outpatient (c) emergency (d) special procedures (e) surgery (f) mobile units.

Many factors reinforce the validity of the concept of sub-departments within the department of Radiology. Among them are:

1. The variation in the times required for different examinations.

2. The differences in personnel and equipment required for the different categories of diagnostic work.

3. The different needs of inpatients and outpatients in terms of attention, furniture and facilities.

4. The fear that outpatients have when they see the very ill or the genuine emergency case.

5. The different requirements for proximity of location: inpatient facilities should be close to bed areas, outpatient facilities should be close to clinics and offices, special procedures should be close to the facilities of the anesthetist and certain surgical personnel.

We now have the technological possibility of satisfying the functional relationships required between the various parts of the radiology system without having them necessarily physically contiguous. Uncoupling has demonstrated this. Now, therefore, we can satisfy other user requirements of patient comfort, growth, and specialization without the constraint of a unitary spatial configuration.

FOOTNOTES: CHAPTER V

1. M. S. Blumberg, "Electronics Can Expand X-Ray Capability," *Modern Hospital*, (November 1965), p. 14.

2. Wendell G. Scott, *et. al.*, *Planning Guide for Radiologic Installations*, (2d ed., Baltimore: Williams and Wilkins Co., 1966), Chs. 10, 21, and 23.

3. J. Gershon-Cohen, "Contrast Enhancement with Television Technics: Gallbladder Lesions," *Radiology*, Vol. 70, (March 1958), pp. 390-391.

4. Majic S. Potsaid, *et. al.*, "Computer Analysis of Radiographs," *Medical Science*, (March 1966), pp. 35-42.

5. Mary Jo Unkelbach, "The Challenge of Portable Radiography," *Hospital Progress*, pp. 40, 44, 48, 50.

6. Wendell G. Scott, *op. cit.*, Ch. 11.

7. Nuffield Provincial Hospitals Trust, *Towards a Clearer View: The Organization of Diagnostic X-Ray Departments*, (Oxford University Press, 1962), p. 126.

8. Picker X-Ray Corporation, *Handbook for Hospital X-Ray Department Planning*, (White Plains, New York).

9. W. R. Taylor, "Diagnostic X-Ray Suites for the General Hospital," *Architectural Record*, (October 1959), pp. 217-224.

10. Curt E. Westman, "Planning New Diagnostic Departments," *British Journal of Radiology*, Vol. 35, (April 1962), pp. 265-268.

11. United States Public Health Service, Division of Hospital Facilities, *Elements of the General Hospital*, (Washington: 1950).

CHAPTER VI: STUDY METHODS

It became apparent as this study of diagnostic radiology developed that we were dealing with many questions which had general concern for architects and students of architecture. Questions such as how to study an existing organization (how to observe and record all the facets of this organization which might have relevance for design decisions), how to identify the problems (how to study the processes), how to free oneself from preconceptions as to how the spaces should be arranged, and how to approach the problem analytically (how to evaluate the opinions of a client, be he a radiologist, a hospital administrator, or a school superintendent), how to isolate prejudices from genuine and valid ideas.

Problem Limits

This research project was originally concerned with the development of appropriate methodology for the study of operations of the diagnostic radiology department and the implications of the methods of study for other aspects of architectural design. The first year of the study was devoted to the collection of empirical data. This data was derived from an intensive case study of two hospitals and additional information was obtained through reports made in two other hospitals.

The project left many interesting and important aspects of diagnostic radiology unstudied. We did not investigate the design or the effectiveness of radiology equipment and its architectural implications. Nor did we study the costs of alternate design arrangements although we periodically attempted this type of cost benefit analysis with meager results.

Our strategy went through many reversals. Whereas the first part of the analysis was devoted to the identification of the problems of radiology and we approached the identification of the problems from a systems point of view, we contradicted ourselves by concentrating on the inner workings of the system rather than on the interconnections between radiology and the other elements both within and without the system.

The central focus was on how to identify the problems, how to study the work process. We had projected the development of a mathematical model but decided against attempting it at the present time as we had inadequate input information.

In any field it is certainly true that research has to start with some knowledge about the subject and the identification of the problems to be studied. Without this there would be no place to begin, but one of the strange idiosyncracies of the American research institutions is that in order for them to give you money to do research, you are required to present your project in such a way that it would seem as if the research were already done. What you are going to do, where you are going to do it, and, worse yet, what you are going to find and what significance it is going to have--all have to be incorporated in the original request. In the case of this project we had previous experience in hospital design and actually designed several radiology departments. Theoretically we were the "experts". What became appallingly apparent was that, despite this theoretical knowledge, the amount of actual specific information as to process, procedure, and identification of the problems was inadequate. There was an overall knowledge of how a hospital worked as a system and an equally overall

FIGURE VI-1

______ SUB-SYSTEM HOSPITAL______ SHEET No.______

TYPE OF ACTIVITY	ANALYSIS	OBJECTIVES	TIME LAPSE	REQUIREMENTS		
				INFORMATION	PHYSICAL	ENVIRONMENTAL
1 ______ ______ who does what to whom method of operation machine, tool where when						
2 ______ ______ who does what to whom method of operation machine, tool where when						
3 ______ ______ who does what to whom method of operation machine, tool where when						
4 ______ ______ who does what to whom method of operation machine, tool where when						

knowledge that radiology was a key diagnostic tool in this system. There was an overall identification of the problems but not enough information to apply creative thinking or analysis to the same.

Our observations took on several forms:

1. general observation--where the purpose was to become acquainted with the overall workings of the organization to identify problem areas for further study.

2. planned observation--where the purpose was to obtain specific data. This type involved a knowledge of how the organization operated as well as the specific functions you wished to observe. It was necessary to plan ahead both in terms of what you wanted to observe, how you were going to collect it, where you would place people, what they would do, how they would or wouldn't get in the way.

We made several mistakes in our approach to observations. Whereas we knew that it was first necessary to get a bird's-eye view of the situation, we were so eager to be "scientific" and collect data, that we started collecting long before we were ready; and while much of the information we first collected is interesting, it is really not fundamentally important for our architectural purposes. In addition, we made the mistake of spending too much time in one institution before going to another. Becoming too involved in an analysis of the way one institution works can lead to forgetting that its way is not the only way. We therefore recommend that preliminary investigations take place in several institutions before any actual data are collected.

For the collection of detailed information, every minute spent in preparation more than pays off. The first problem is determining exactly what information you are trying to get, then it is necessary to prepare forms in order to simplify the actual process of notation. This is extremely important because there is no simple correspondence between the occurrence of an event and the recording of it by an observer. Three processes are involved, namely, registration, interpretation, and recording, and all involve continuing evaluations by the observer. The detailed observations made were concerned with two types of data-collecting: (1) information which involved value judgments, and (2) information which was quantitative. A real obsession, and one which was difficult for the persons participating in this project to lose, was preoccupation with quantifying objects while neglecting to look at all aspects of the situation. It was therefore necessary actually to structure this type of observation. A form was developed which required the observer to record who, what, where, when, how, and why. Then on a blank page each person had to record what he thought could be done in another way, to identify some of the problems, and so forth.

To obtain an accurate sample of all the activity that was simultaneously going on in the respective departments involved keeping track of specific individuals and following them. We had to identify the patients who came in, how long they waited before being called, how long they took to undress, what type of examination they had and how long it took, how long they waited after the examination, and how long it took to dress and leave. In the beginning we would have been totally lost if volunteers, technicians, and nurses had not given us the different names and helped us make sure we knew what was happening. Even for something as apparently simple as recording the activities of the different personnel over an eight-hour day, preliminary preparation must be made. The first attempt on the part of one of the research assistants to tail the radiologist resulted in a three-hour time-gap. The hiatus turned out to be due to the fact that he had not recorded the radiologist's time spent in talking to us. It rather pointed up the fact that despite all our efforts to remain in the background and record operations as they actually were, we were still observing an organization which was different because we were observing it. Toward the end of our investigation the combination of the adequate forms developed and the strategic locating of different persons made the timing and information-gathering quite expert.

Interviews were conducted and all categories of personnel working within the organizations were studied, as were persons from other institutions. It became obvious that a technician knew more about some aspects of radiology than the radiologist and vice versa and that the receptionist and file clerk were aware, in some cases, of problems that the radiologist did not know existed. The radiologist, for example, was concerned with the attitude of the referring doctor to a delay in getting the results of the examination. He was concerned with the facilities for fluoroscopy and with communication from his spot to all others (not the reverse). He was concerned with a vague concept of efficiency and inefficiency. The technicians, on the other hand, were concerned with cleanup, with problems of getting patients on and off tables, with the parts of the machinery which allowed them to set dials and focus easily, and with morale. The receptionist worried about patients' waiting.

Everybody talked about some aspect of patient comfort. The familiar refrain was that it should be homelike; patients should not wait so long.

But it was very difficult to obtain concrete suggestions for patient comfort. It should be noted that all radiologists said it was necessary to see the patient before each examination, yet in most cases the pressures were such that the radiologist only saw patients while doing fluoroscopy and special procedures. It became apparent that the more each individual felt was known about his specific problem, the more he felt free to talk about it. It became evident that one was not dealing with a single entity called radiology but many different "radiologies," depending on the eyes of the viewer. In many cases the staff and patient needs are contradictory: the patient wants privacy, the staff wants maximum supervision; the patient needs greater warmth, the staff feels overheated.

The great problem about interviews is how to isolate fact from opinion. If one gets the same answer to the same question from many different types of persons, it probably has validity. It takes a good deal of preparatory thinking to formulate the question so that the bias of the person being interviewed does not interfere with his judgment. Under the onslaught of so many opinions and so much information, we were forced to find our way. In an effort to study all aspects of the organization we found it necessary periodically to synthesize the information gathered in the form of graphic models in order to grasp the significance of the information, as well as to determine what was missing. We made models of the following activities:

<u>Sequence of events</u>

Written description of procedures.

Block diagram of process.

Block diagram showing typical sequence of a patient examination.

Link diagram showing successive steps required before another step is made.

Spatial arrangement

Floor plans.

Critical evaluation of floor plans.

Floor plans showing pattern of circulation of each person using the department.

Movement of persons

Simulation of patient's activity in a typical morning.

Simulation of a patient's day.

Graphs showing patient arrival time.

Chart showing movement of a radiologist over an 8-hour day.

Chart showing workload of a technician during a typical day.

Examinations

Charts and graphs showing types of examinations.

Charts and tables showing length of examination time.

Utilization

Graphs showing periods when the radiology department was empty.

Room by room utilization.

Graphs and charts illustrating growth of the radiology department.

The constant interchange necessary in order to collect data and describe the situation in model form forced us to analyze the problem. The stages of data collection, analysis, and synthesis did not occur in tidy, time-labeled packages of analysis, program determination, synthesis, and so on. In fact, it became very difficult to distinguish one phase from another. It was evident we were beginning to analyze our data at each stage of collection, and in the process of analysis we got new ideas which were the basis of a synthesis and of an occasional discovery of loopholes in the information we had gathered. The collection of information, unfortunately, cannot be made to require a specific number of days or weeks. What one observes depends on how much one knows and what one is looking for. This changes as one's understanding of the problem develops. What a person sees at one state of observation is quite different from what he sees at another. On the basis of our work we would recommend the following method of study of an organization:

1. Spend a few days in as many institutions as possible which are performing similar functions; try to understand the overall procedures and become acquainted with the personnel.
2. Find the table of organization and literally tail each type of person in the organization to become acquainted with the specific jobs they do and the problems they encounter.
3. Trace each activity and ask the question, who, what, where, when, and how, and, most important, could it be done in another way?
4. List everything in the department in terms of physical objects in order to determine what use things are put to.
5. Interview as many persons as possible from various vantage points in the organization, and thus find the image of the place in the minds of the various personnel.
6. Check the methods by which the department keeps statistics about itself. So often, significant factors of growth and change can be projected by the very statistics the department has, although sometimes much manipulation is necessary in order to ferret out what you want.
7. Determine by what standards the department evaluates its own output.

8. Diagram the information flow.

9. Develop a picture of how the total process works sequentially and simultaneously I would like to underline this because it somehow was so extraordinarily difficult to do. Everything so far showed fragments of information. To get an overall picture it was necessary to see everything which happened, simultaneously.

10. Verify observations statistically--what people do, the time they spend doing it, and so on.

The architect observer is anything but a dispassionate eye behind the tree or machine. He is perhaps closest to the anthropologist in a foreign culture who is also a human being among fellow human beings, and responds to people and activities with likes and dislikes. To increase our objectivity it is necessary to recognize that we have two means of ascertaining people's needs. One, verbal--to listen to what people say. The other, to observe what they do. I am sympathetic to the behaviorist approach because it allows us to describe facts which can be observed and correlate this with what we hear. But it is important to remember that every statement we record is anything but objective rather the result of a theory which unconsciously declares that some facts are relevant and some are not.

APPENDIX A

APPENDIX A

The Pattern of X-Ray Use

Education and Income. Usage of X-rays increases with increasing education.[1] More interesting is the fact that education and income interact so that persons with both low income and low education have a much lower rate of usage than do persons with low income and high education. This phenomenon is most pronounced for the 15-29 age group and may be the result of the fact that colleges and universities provide their temporarily poor students with a high level of free medical care.[2]

Area of Body X-Rayed. In 1964, 50.6% of all radiographic examinations were of the chest; 24.7% were of the abdomen; 17.0% were of the extremities; and 7.1% were of the head and neck.[3] The volume of X-ray examinations for different areas of the body varies significantly according to age, sex,[4] race,[5] region,[6] and place of X-ray.[7]

Place of X-Ray. 58% of all X-ray examinations take place in hospitals; 20% take place in private physicians' offices; the remainder are in mobile units, private group practices, and health agencies.[8] The different places which administer X-rays tend to have significantly different types of patients[9] and tend to concentrate on different areas of the body.[10] There are also strong regional differences. In the South, close to half of all chest X-rays are given in places other than hospitals or doctors' offices, whereas for the country as a whole the corresponding figure is only 38.4%. The New England States have the highest percentage and the Pacific States the lowest percentage of X-rays taking place in hospitals.[11]

Seasonal Variations. There is great seasonal variation in the usage of X-rays. This was revealed both in a study of Rochester, New York,[12] and in our own survey (see Table A-3 and Figure A-1). Some of this seasonal variation is characteristic of all medical practice and some of it is attributable to phenomena closely tied to radiology such as fall football injuries among teenage males, winter accidents, skiing accidents, etc. Depending on climate and accident patterns, the seasonal variation probably is different for the different regions of the United States.

Sex and Age. In general, males have a higher examination rate than do females (65.6 versus 58.3), however, for males under age 15, the rate is considerably higher than for females under 15 (31.2 versus 20.4) and females 65 and over have a higher rate than their male counterparts (87.6 versus 67.2[13]). X-ray usage increases with age.[14]

Race. Nonwhites, especially nonwhite women, have a chest X-ray rate which is much higher than whites; however, they have a much lower X-ray rate for other areas of the body (see Table A-2). Nonwhites also receive a higher proportion of their X-rays in hospitals and mobile units and a much lower proportion than whites in physicians' offices.[15]

FOOTNOTES: APPENDIX A

1. J. N. Gitlin and P. S. Lawrence, Population Exposure to X-Rays: U.S. 1964, U.S. Public Health Service Publication No. 1519, Table 17.

2. U.S. National Health Survey, Volume of X-Ray Visits, United States, July 1960-June 1961, U.S. Public Health Service Publication No. 584-B38, Table 6.

3. U.S.P.H.S. Publication No. 1519, Figure 21.

4. Ibid, Table 24.

5. U.S.P.H.S. Publication No. 584-B38, Table C.

6. Ibid, Table 3.

7. Ibid, Tables 9 and 10.

8. U.S.P.H.S. Publication No. 1519, Table 22.

9. U.S.P.H.S. Publication No. 584-B38, Tables 9 and 10.

10. Ibid, Table 8.

11. Ibid, Table 9.

12. W. Haddon, Jr. and R. H. Morgan, "Frequency of Medical X-Ray Examinations in Monroe County, New York," Public Health Reports, Vol. 80, (June 1965), pp. 515-525.

13. U.S.P.H.S. Publication No. 1519, Table 19.

14. Ibid.

15. Ibid, Table 6.

TABLE A-1

UTILIZATION: LABORATORY AND X-RAY EXAMINATIONS, NONFEDERAL SHORT-TERM GENERAL AND SPECIAL HOSPITALS, BY SIZE, 1953-1962

		Size of Hospital (Number of Beds)							
		50	100	200	300	400	500	600	700
X-ray examinations	1953	2,000	5,500	12,775	16,000	20,000	26,000	32,000	38,000
	1962	3,500	9,500	22,250	26,000	30,000	34,500	44,000	52,000
Per cent change		75.0	72.7	74.2	62.5	50.0	32.7	37.5	36.8

Note: The table shows the average number of examinations in an average hospital of a given size.

Source: U. S. Public Health Service Publication No. 930-C-7.

TABLE A-2

Number of diagnostic X-ray visits and number per 100 persons per year, by race and area of body x-rayed: United States, July 1960-June 1961

Area of body	Race		
	All races	White	Nonwhite
	Number of X-ray visits in thousands		
All X-ray visits[1]	82,288	72,725	9,564
Chest	50,588	42,933	7,654
Lower abdomen	10,418	9,857	561
Upper abdomen	9,724	8,981	743
Extremities	13,215	12,294	921
Head and neck	5,102	4,669	433
Skin[2]	(*)	(*)	(*)
	Number per 100 persons per year		
All X-ray visits	46.2	46.2	46.6
Chest	28.4	27.3	37.3
Lower abdomen	5.9	6.3	2.7
Upper abdomen	5.5	5.7	3.6
Extremities	7.4	7.8	4.5
Head and neck	2.9	3.0	2.1
Skin[2]	(*)	(*)	(*)

[1] The sum of visits by area of body x-rayed may be greater than the total number of visits, since during one visit more than one area of body may be x-rayed.

[2] Includes unknown areas of the body

Source: P.H.S. Publication No. 584-B-38.

TABLE A-3

Seasonal variations in X-ray examination rates, expressed in percent deviation from corresponding mean annual rates, Monroe County, N.Y., 1958–59

Examination	Fall	Winter	Spring	Summer
Head:				
Males	−6	6	−1	1
Females	−1	−2	1	2
Both sexes	−4	3	1	0
Sinuses:				
Males	9	15	9	−33
Females	25	25	−9	−41
Both sexes	17	19	1	−37
Neck:				
Males	−3	6	2	−6
Females	−14	−9	23	1
Both sexes	−8	−1	12	−3
Chest:				
Males	−1	1	11	−11
Females	−4	9	9	−14
Both sexes	−2	4	10	−12
Photofluorograms:				
Males	−25	−20	18	26
Females	−18	−26	23	20
Both sexes	−21	−23	21	23
Thoracic spine:				
Males	−25	15	4	5
Females	6	2	−6	−1
Both sexes	−9	8	−1	2
G.I. series:				
Males	−14	7	24	−17
Females	−11	16	13	−19
Both sexes	−13	11	19	−18
Gall bladder:				
Males	−2	17	−1	−15
Females	−4	7	8	−11
Both sexes	−3	11	5	−12
Barium enema:				
Males	14	−2	13	−25
Females	13	3	−5	−11
Both sexes	13	1	3	−17
Pyelogram:				
Males	6	−2	−15	11
Females	1	−2	4	−3
Both sexes	3	−2	−5	4

Examination	Fall	Winter	Spring	Summer
Abdomen:				
Males	−3	3	−2	2
Females	−6	−6	7	5
Both sexes	−4	−2	3	3
Lumbar spine:				
Males	−7	6	3	−2
Females	−3	9	−3	−3
Both sexes	−5	7	0	−2
Pelvis:				
Males	−14	8	14	−8
Females	−6	28	−8	−14
Both sexes	−10	19	2	−11
Shoulder and arm:				
Males	−4	8	−10	6
Females	−9	19	0	−10
Both sexes	−6	13	−6	−1
Elbow, forearm, wrist, and hand:				
Males	1	−8	−1	8
Females	−14	31	−4	−13
Both sexes	−5	7	−2	0
Thigh and knee:				
Males	−3	10	3	−9
Females	3	−3	−6	7
Both sexes	−1	4	−1	−3
Leg, ankle, and foot:				
Males	−12	7	−5	10
Females	−7	12	−11	6
Both sexes	−10	10	−7	8
Bones, generalized:				
Males	−7	5	−21	23
Females	4	−14	16	−6
Both sexes	0	−7	3	4
Fluoroscopy of chest:				
Males	−1	−3	−7	11
Females	10	−23	16	−2
Both sexes	3	−11	2	6

NOTE: Differences from zero in the line totals are due to rounding.

Source: W. Haddon, Jr. and R. H. Morgan, "Frequency of Medical X-Ray Examinations in Monroe County, New York," Public Health Reports, Vol. 80, June 1965, pp. 515-525.

TABLE A-4

UTILIZATION OF DIAGNOSTIC RADIOLOGY BY IN-PATIENTS, OUT-PATIENTS AND EMERGENCY PATIENTS

IN A UNIVERSITY HOSPITAL BY NO. OF PROCEDURES

Year	55-56	56-57	57-58	58-59	59-60	60-61	61-62	62-63	63-64	TOTAL
In-Patients	16,697	19,982	19,677	23,454	24,716	28,266	31,007	33,456	32,355	229,610
Out-Patients	16,126	18,243	16,061	16,759	17,342	17,630	18,155	19,869	19,305	159,490
Emergency	721	1,470	1,414	1,445	1,344	1,706	1,935	2,345	2,996	15,376
TOTAL	33,544	39,695	37,152	41,658	43,402	47,602	51,097	55,670	54,656	404,476

UTILIZATION OF DIAGNOSTIC X-RAY

Percent of Total of Type of Patient

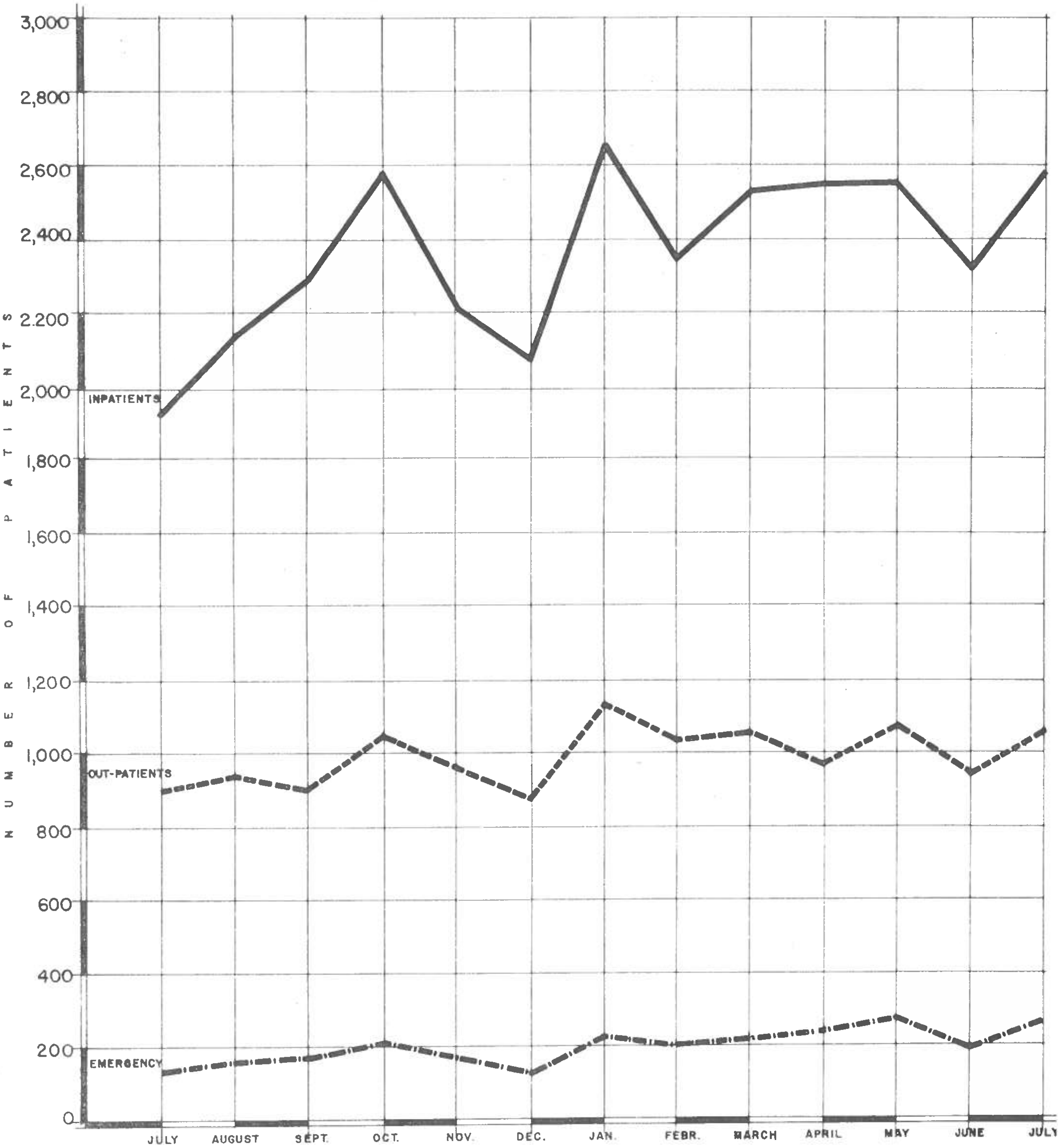
In-Patients	49.7%	50.3%	53.0%	56.3%	56.8%	59,4%	65.8%	66.5%	65.0%
Out-Patients	48.1%	46.0%	43.2%	40.3%	40.1%	37.0%	29.3%	28.0%	27.9%
Emergency	2.2%	3.7%	3.8%	3.4%	3.1%	3.6%	4.9%	5.5%	7.1%

TABLE A-5

DISTRIBUTION OF X-RAY PROCEDURES BETWEEN IN-PATIENTS, OUT-PATIENTS AND EMERGENCY

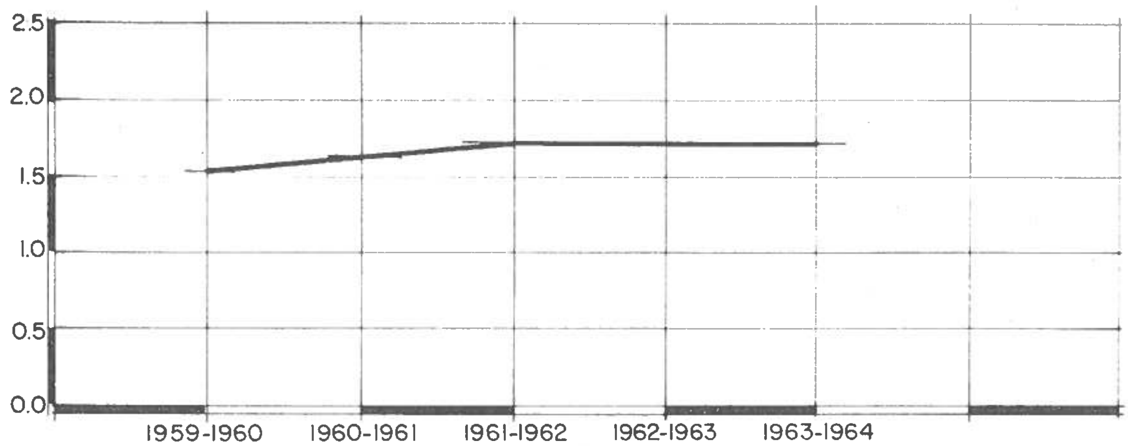
IN A COMMUNITY HOSPITAL. TOTAL NUMBER OF X-RAYS FOR THE YEARS 1962 & 1963

	1962					1963			
Month	In-Patient	Out-Patient	Emerg.	Total	Month	In-Patient	Out-Patient	Emerg.	Total
Jan	562	480	286	1328	Jan	473	550	273	1296
Feb	437	449	245	1131	Feb	480	460	238	1178
Mar	485	539	281	1305	Mar	540	613	374	1527
Apr	518	551	277	1346	Apr	495	569	296	1360
May	593	528	260	1381	May	419	554	371	1344
June	456	474	267	1197	June	458	469	359	1286
July	455	477	247	1179	July	389	474	323	1186
Aug	463	551	237	1251	Aug	430	495	393	1318
Sept	433	435	276	1144	Sept	424	452	304	1180
Oct	463	551	234	1248	Oct	561	599	392	1552
Nov	509	536	320	1365	Nov	490	459	366	1315
Dec	408	410	285	1103	Dec	427	422	354	1203
TOTAL	5782	5981	3215	14,978		5586	6116	4043	15,745
% OF TOTAL	38.5%	40.0%	21.5%	100%		35.6%	38.8%	25.6%	100%

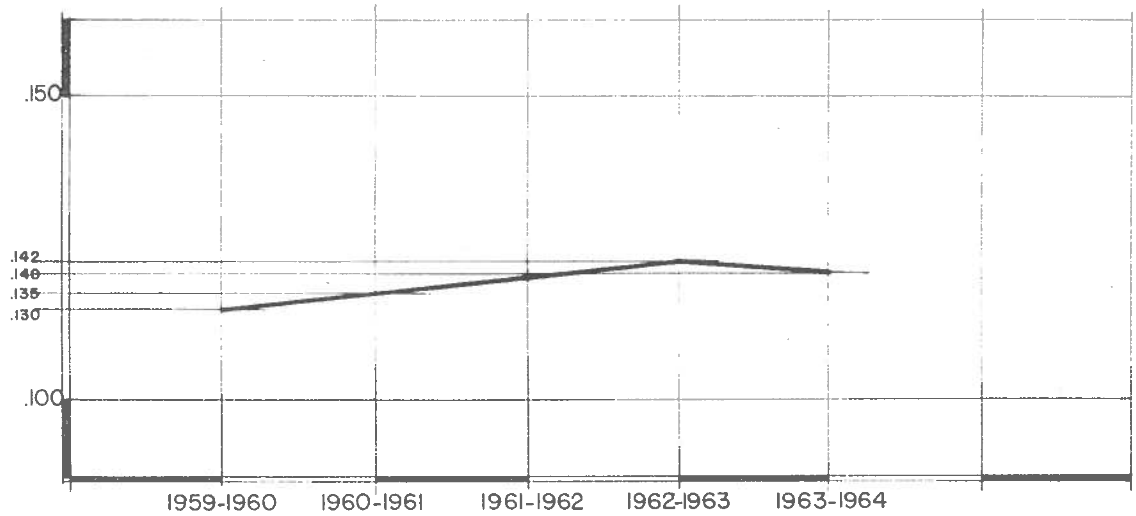


MONTHLY VARIATION IN PATIENT LOAD
AT A UNIVERSITY HOSPITAL

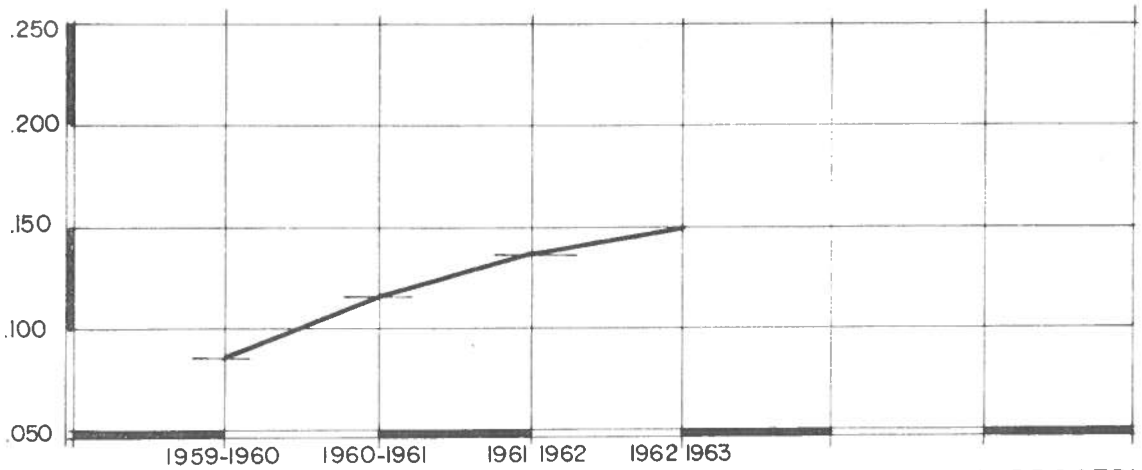
FIGURE A-2



NUMBER OF X RAY PROCEDURES PER IN PATIENT



NUMBER OF X RAY PROCEDURES PER CLINIC VISIT

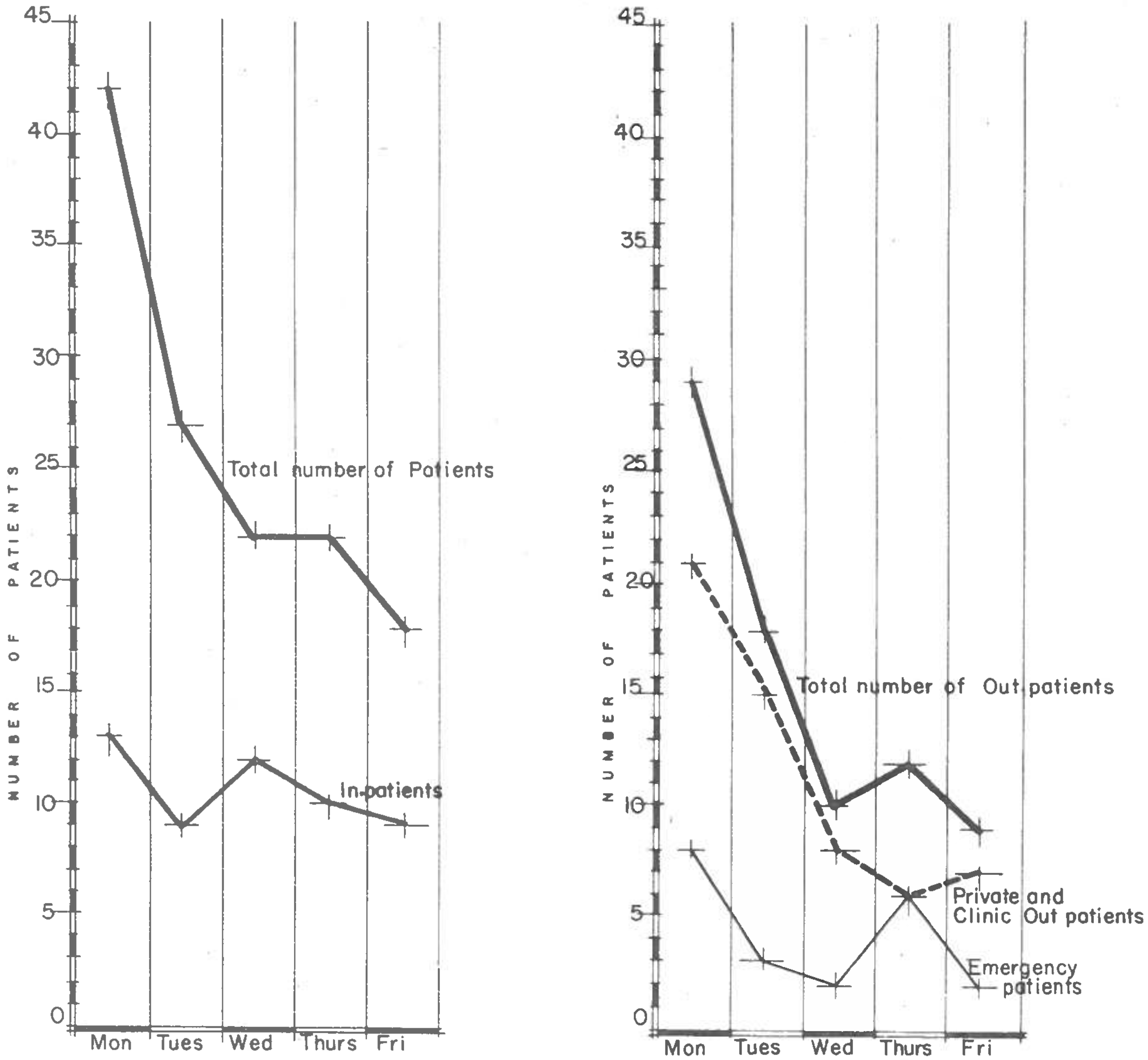


NUMBER OF X RAY PROCEDURES PER EMERGENCY VISIT.

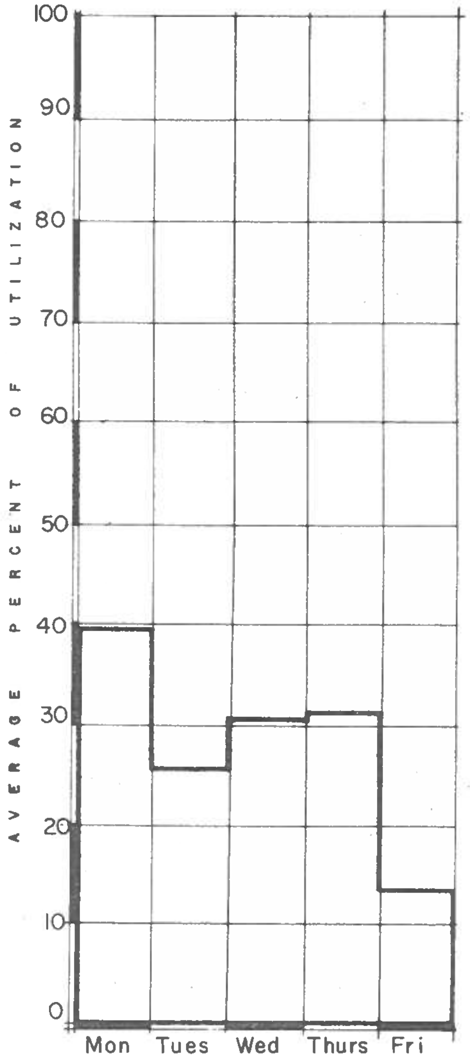
NUMBER OF X-RAY PROCEDURES IN RELATION TO AVAILABLE POPULATION IN A UNIVERSITY HOSPITAL

APPENDIX B

FIGURE B-1

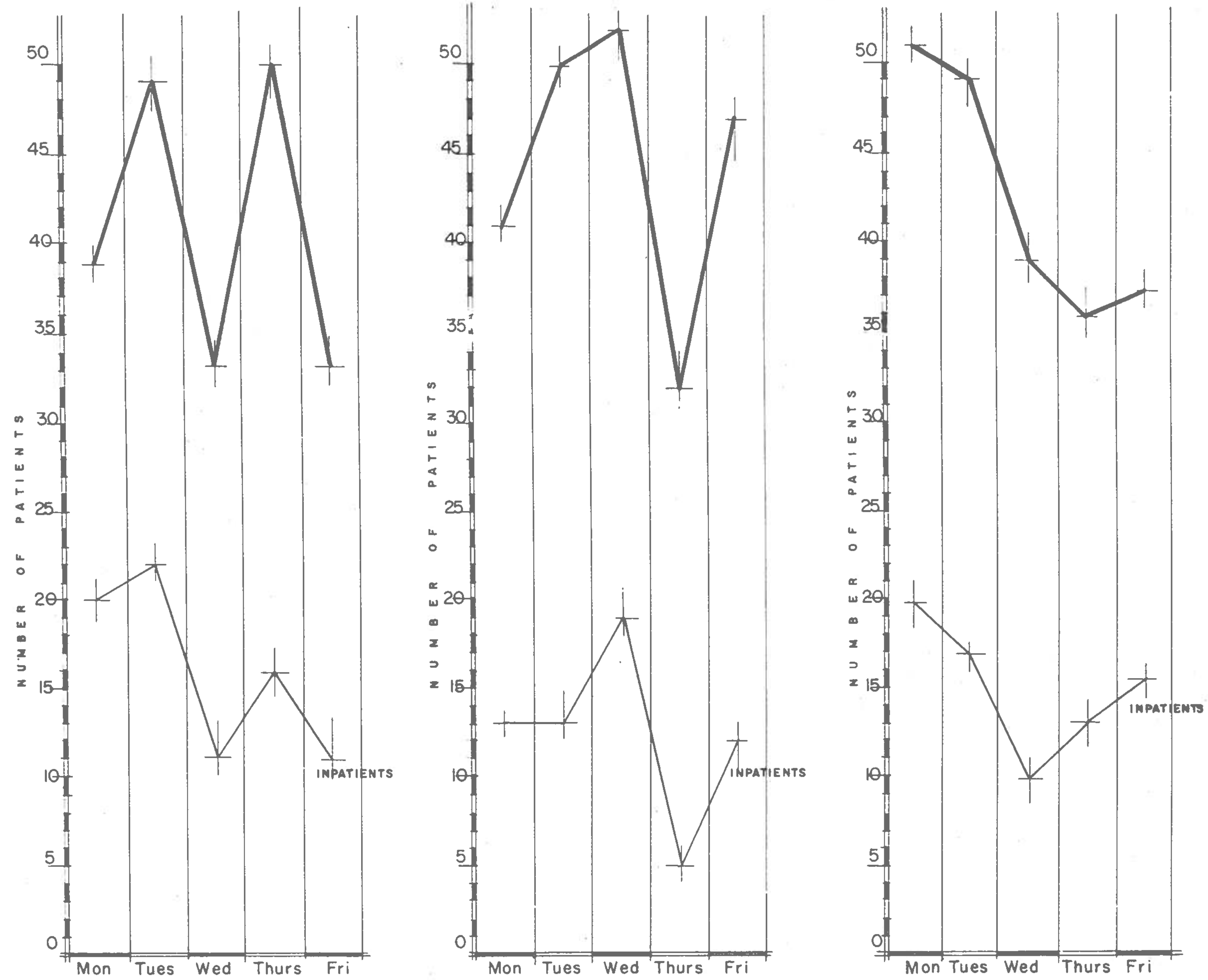


DAILY VARIATION OF PATIENT LOAD
Community Hospital



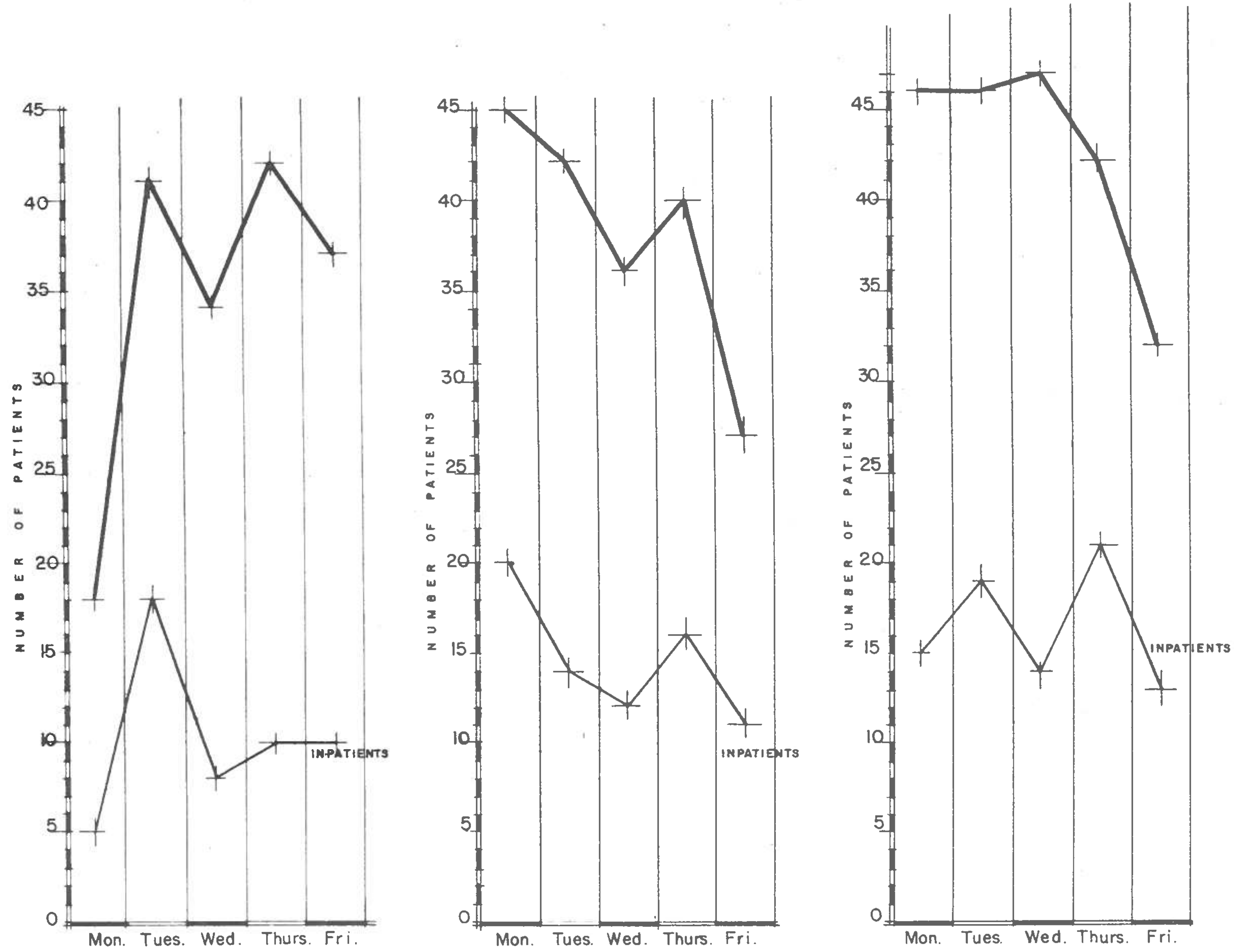
DAILY VARIATION OF X-RAY ROOMS UTILIZATION

FIGURE B-2



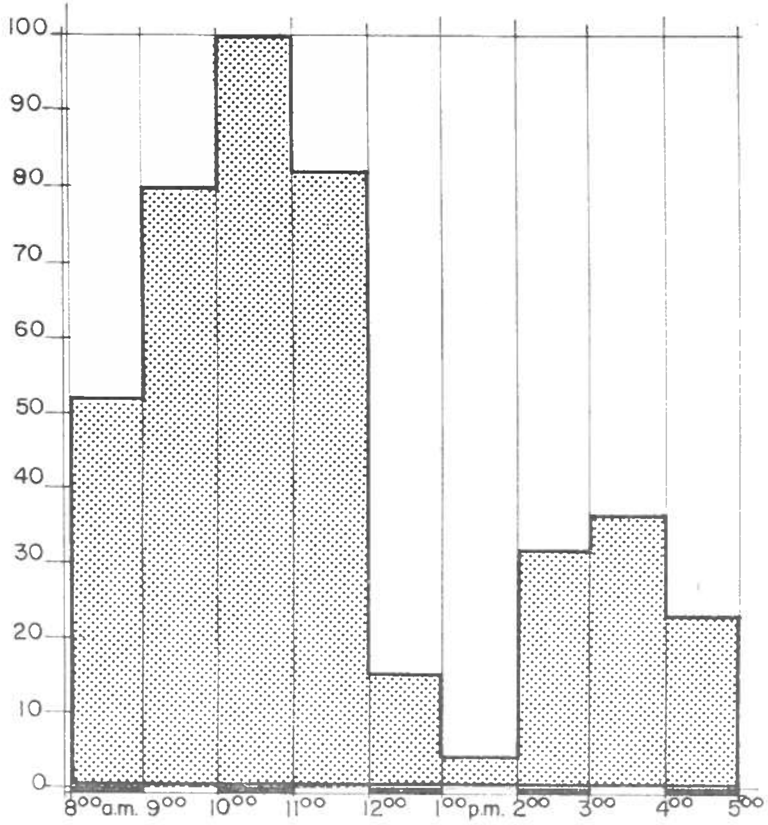
DAILY VARIATION OF PATIENT LOAD Random selection
Community Hospital

FIGURE B-3

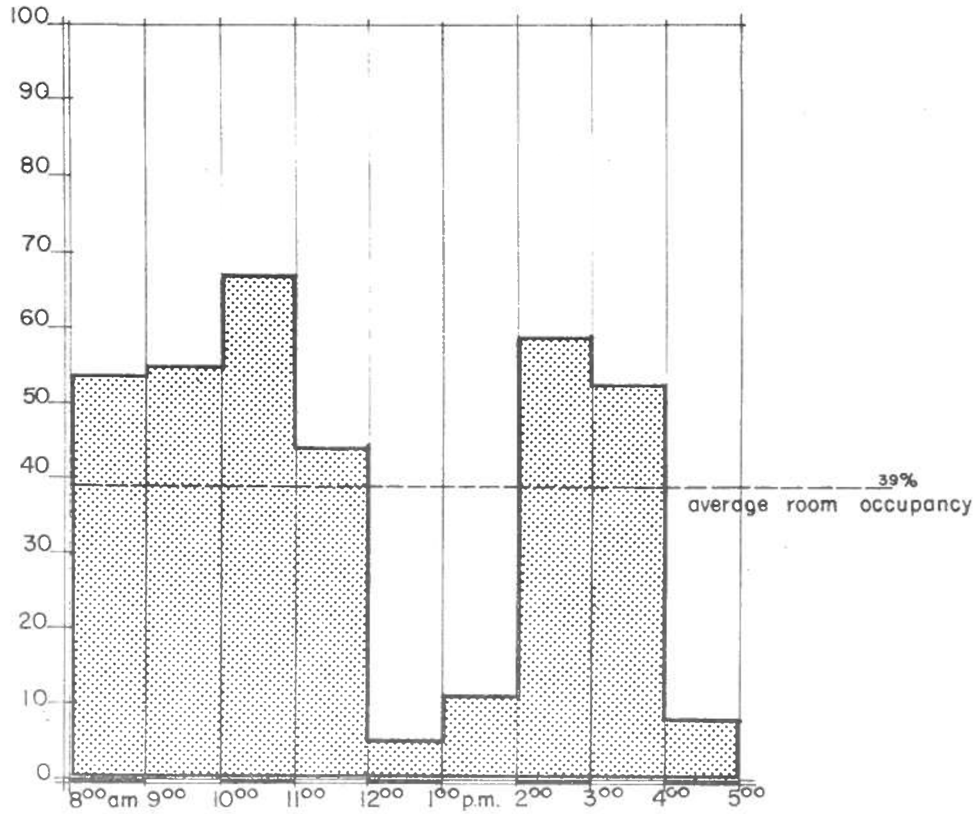


DAILY VARIATION OF PATIENT LOAD Random selection
Community Hospital

FIGURE B-4



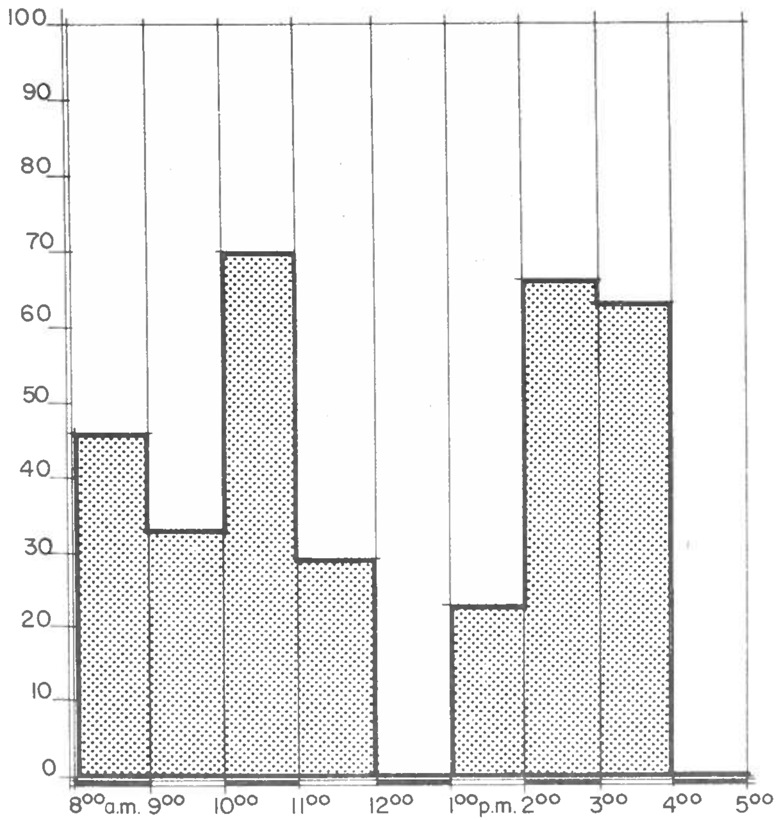
UTILIZATION OF X-RAY ROOM 500 ON AN HOURLY BASIS



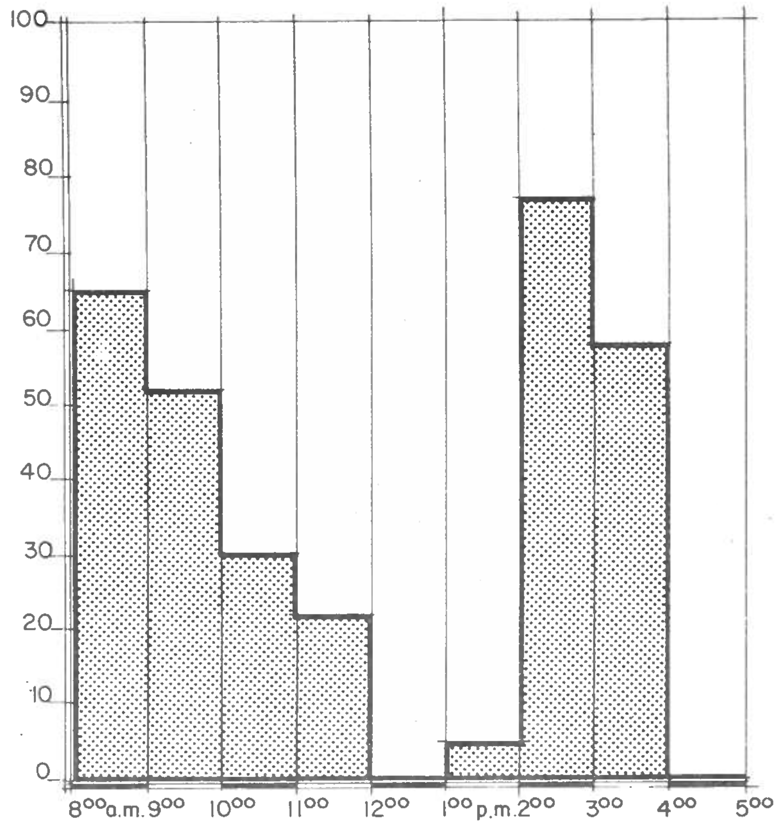
UTILIZATION OF X-RAY ROOMS ON AN HOURLY BASIS

COMMUNITY HOSPITAL UTILIZATION OF X-RAY ROOMS

FIGURE B-5



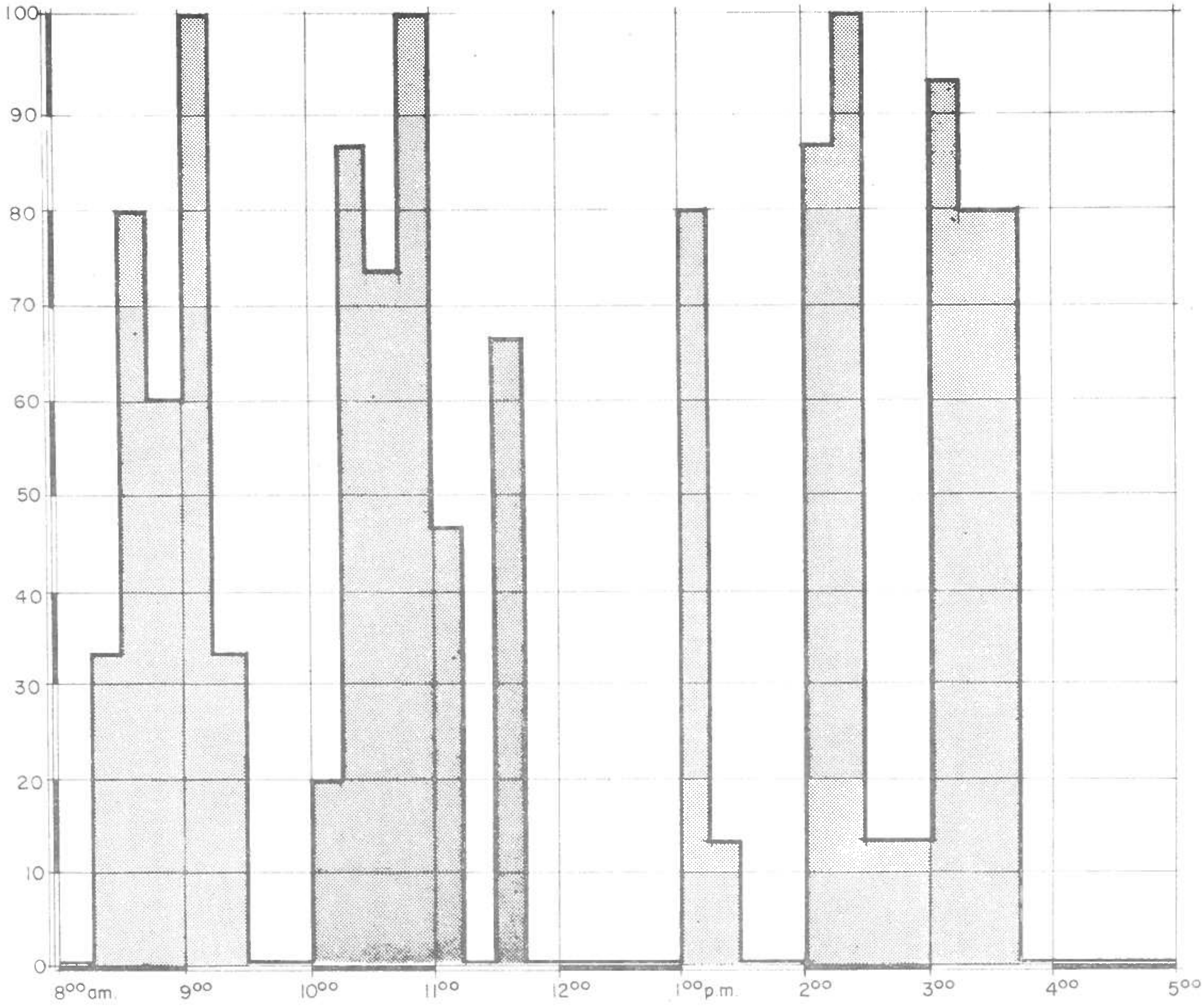
UTILIZATION OF X-RAY ROOM 270 ON AN HOURLY BASIS



UTILIZATION OF X-RAY ROOM 277 ON AN HOURLY BASIS

COMMUNITY HOSPITAL UTILIZATION OF X-RAY ROOMS

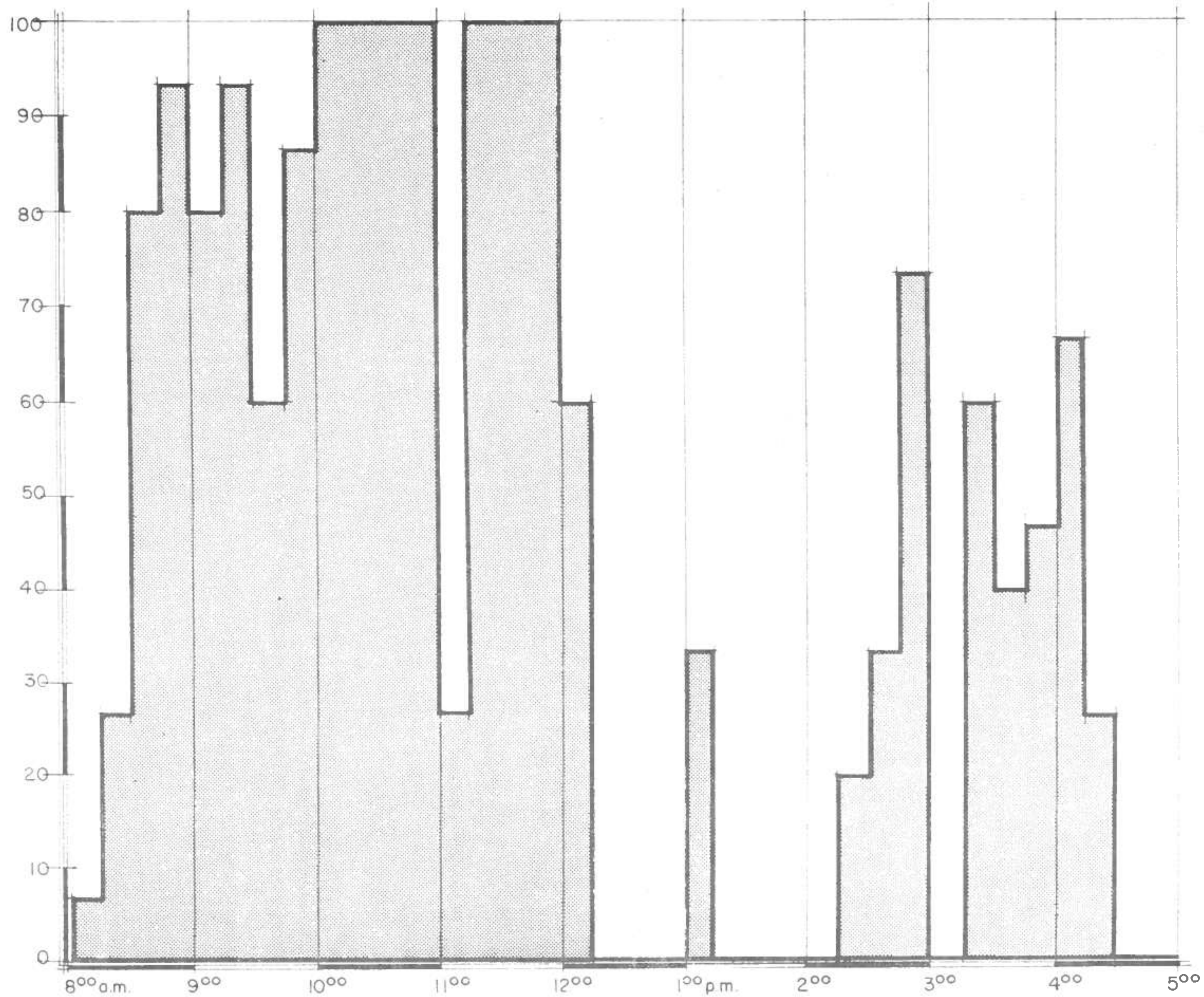
FIGURE B-6



UTILIZATION OF X-RAY ROOM 270 ON A 15 MINUTE BASIS FOR A 9 HOUR DAY

COMMUNITY HOSPITAL

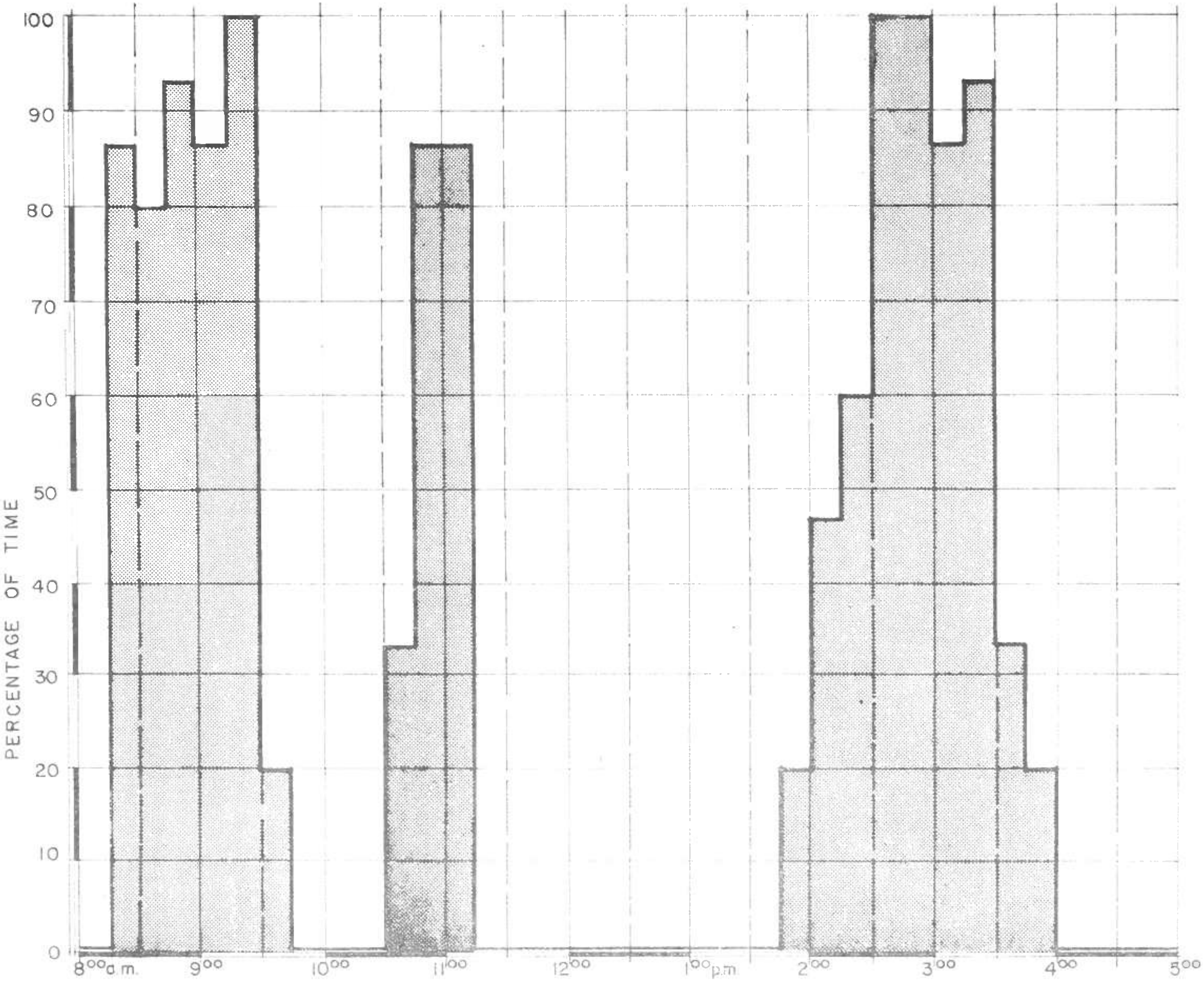
FIGURE B-7



UTILIZATION OF X-RAY ROOM 500 ON A 15 MINUTE BASIS FOR A 9 HOUR DAY.

COMMUNITY HOSPITAL

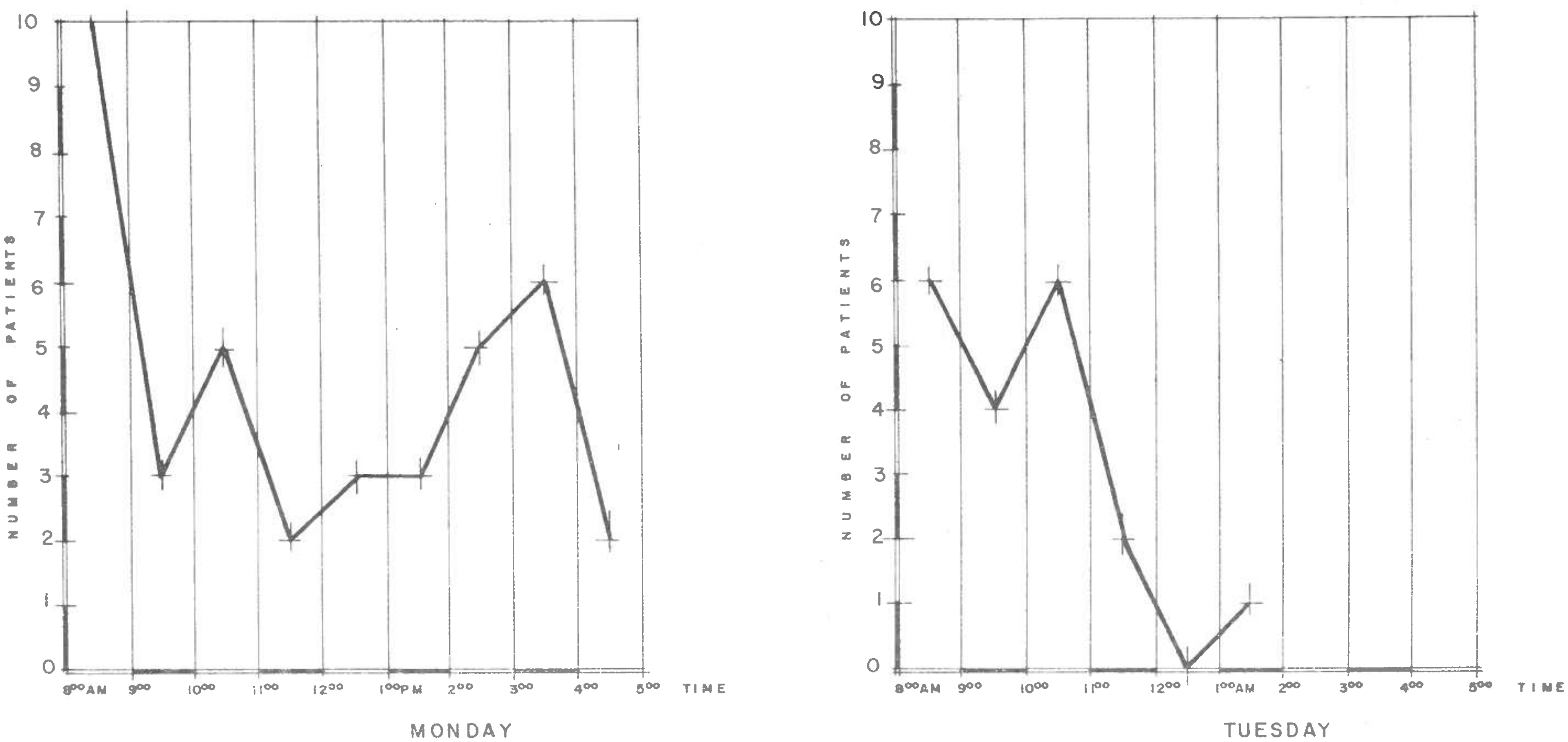
FIGURE B-8



UTILIZATION OF X-RAY ROOM 277 ON A 15 MINUTE BASIS FOR A 9 HOUR DAY.

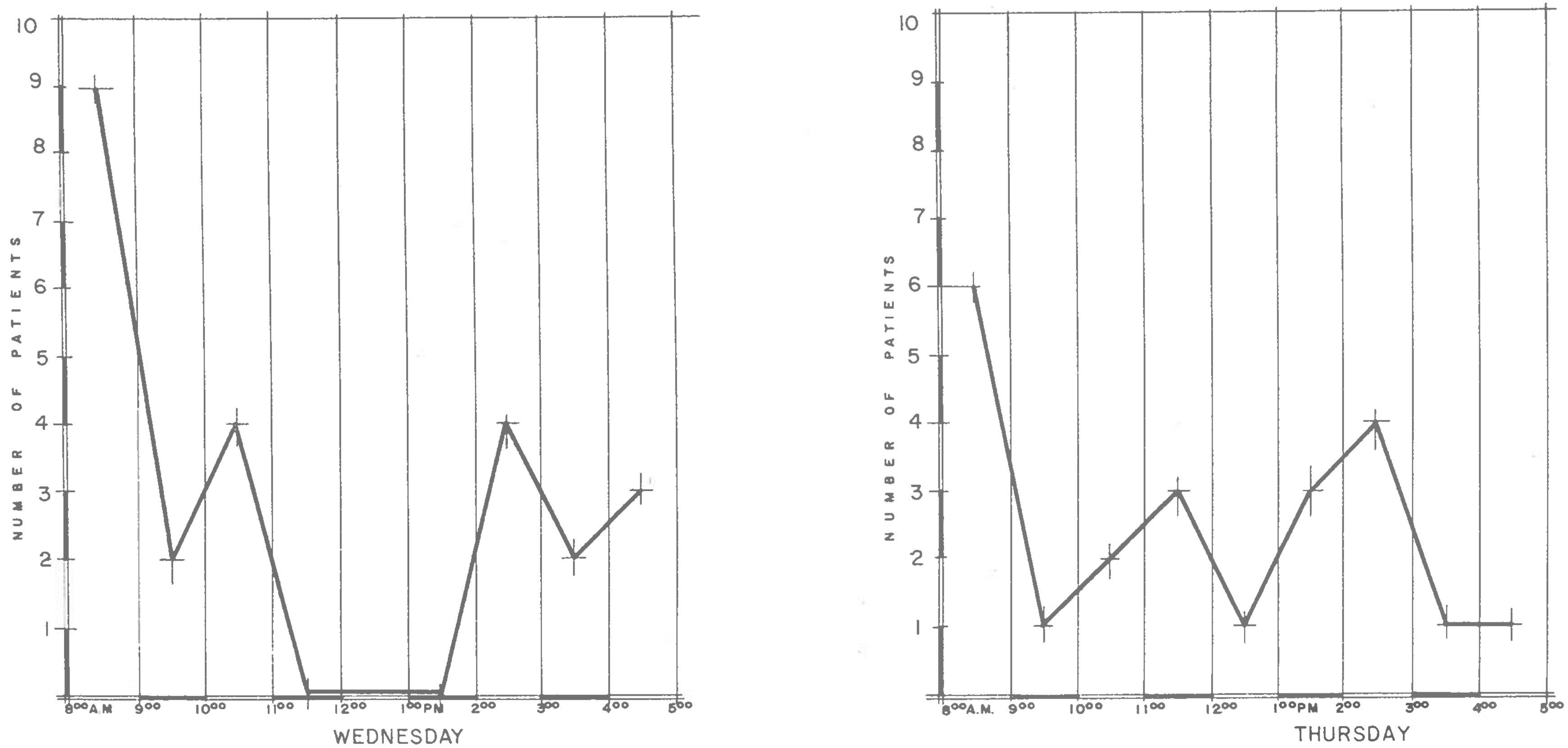
COMMUNITY HOSPITAL

FIGURE B-9



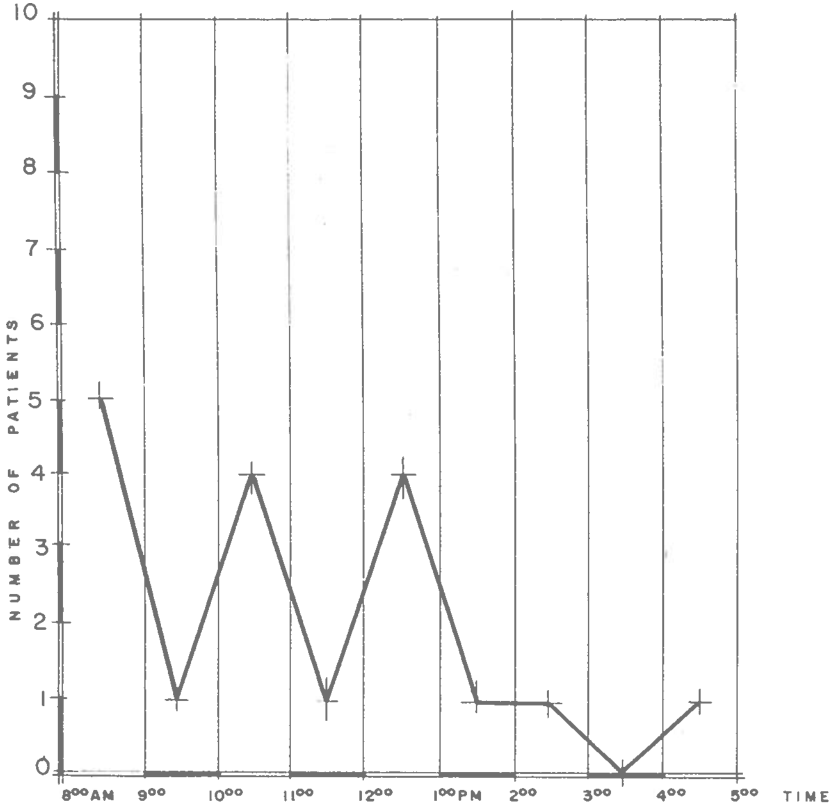
PATIENT ARRIVAL PER HOUR COMMUNITY HOSPITAL

FIGURE B-10

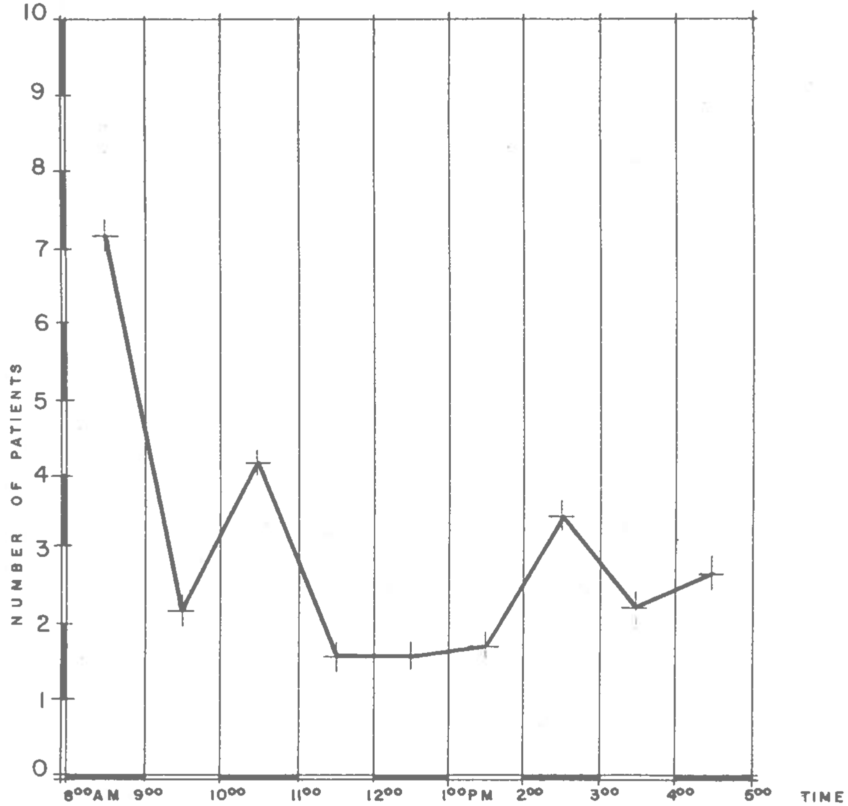


PATIENT ARRIVAL PER HOUR COMMUNITY HOSPITAL

FIGURE B-11



FRIDAY

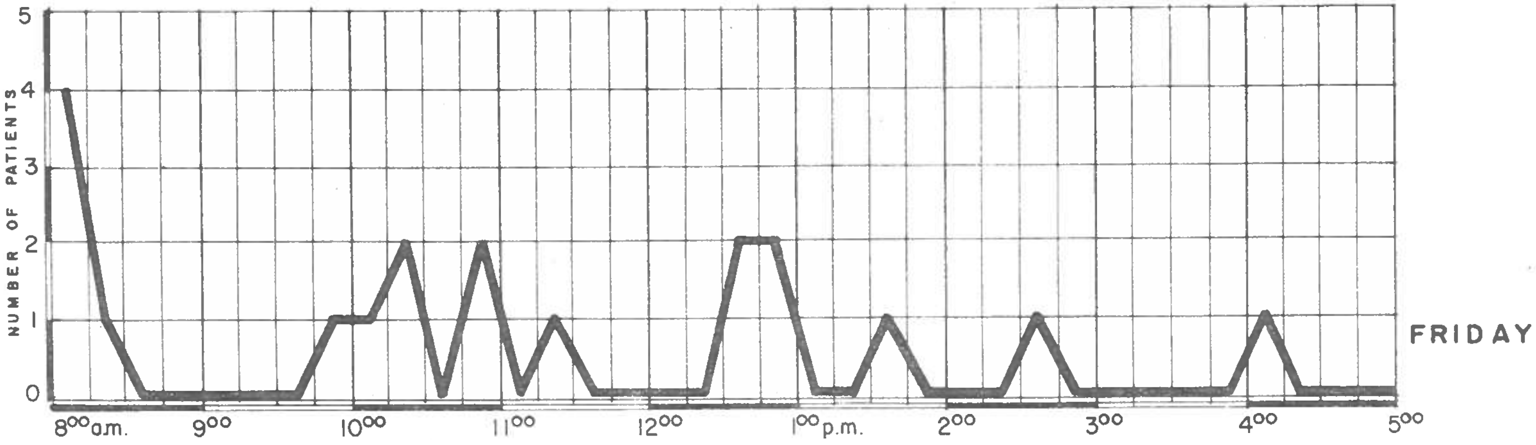


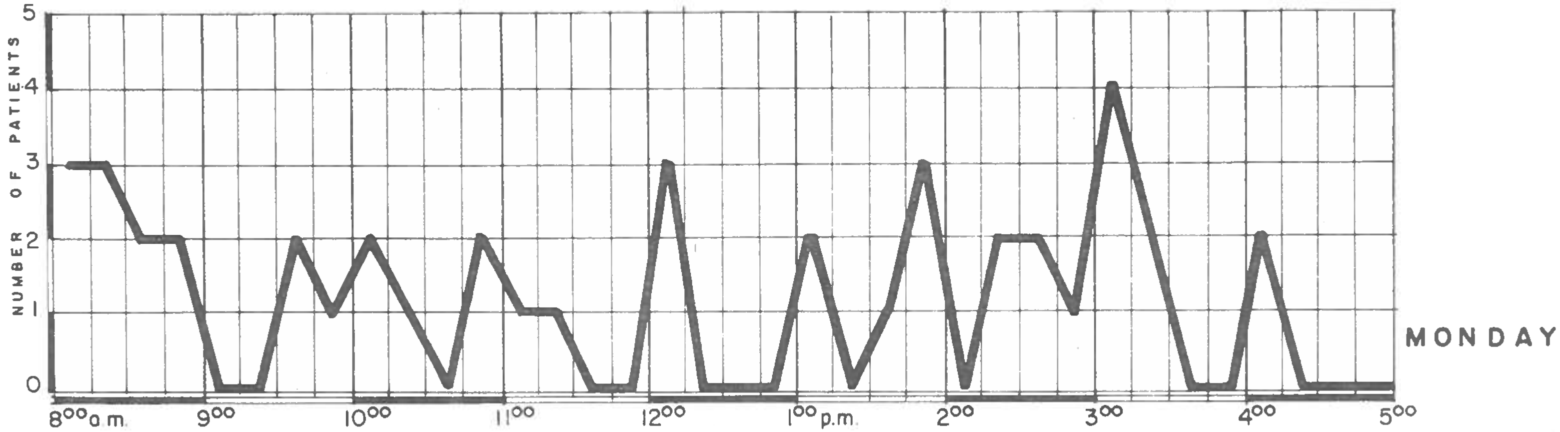
DAILY AVERAGE

PATIENT ARRIVAL PER HOUR

COMMUNITY HOSPITAL

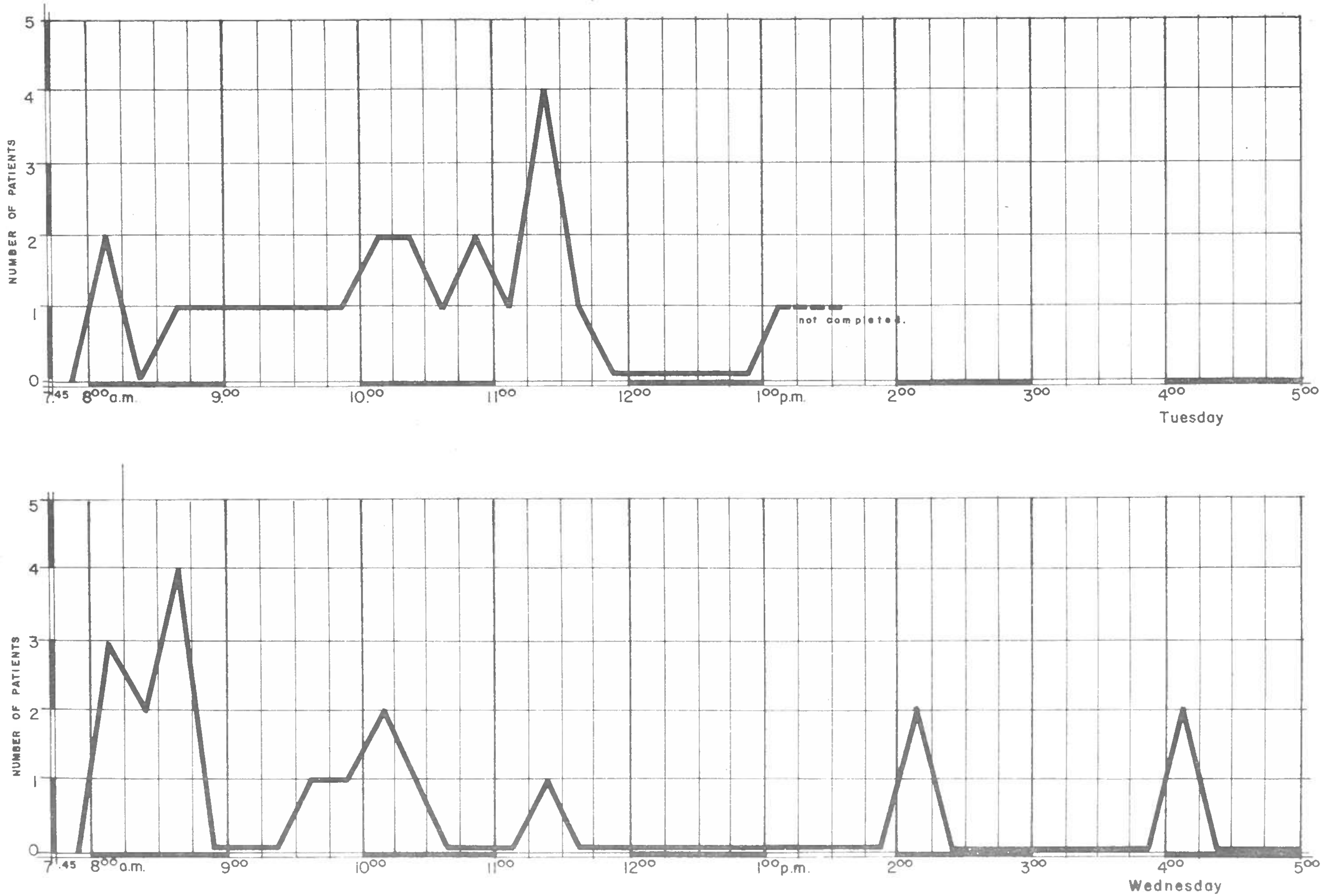
FIGURE B-12





PATIENT ARRIVAL EVERY 15 MINUTES COMMUNITY HOSPITAL

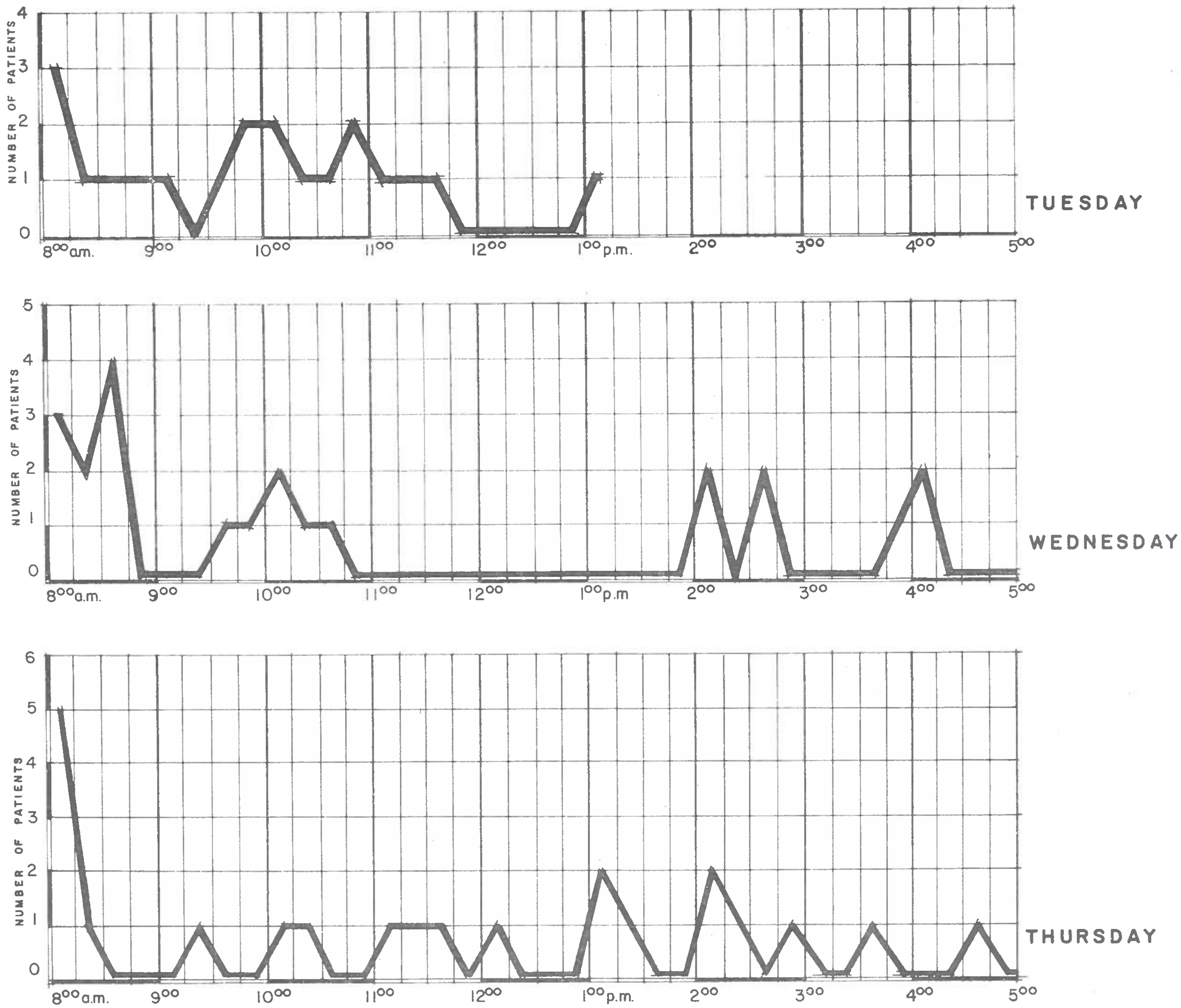
FIGURE B-13



NUMBER OF PEOPLE

COMMUNITY HOSPITAL

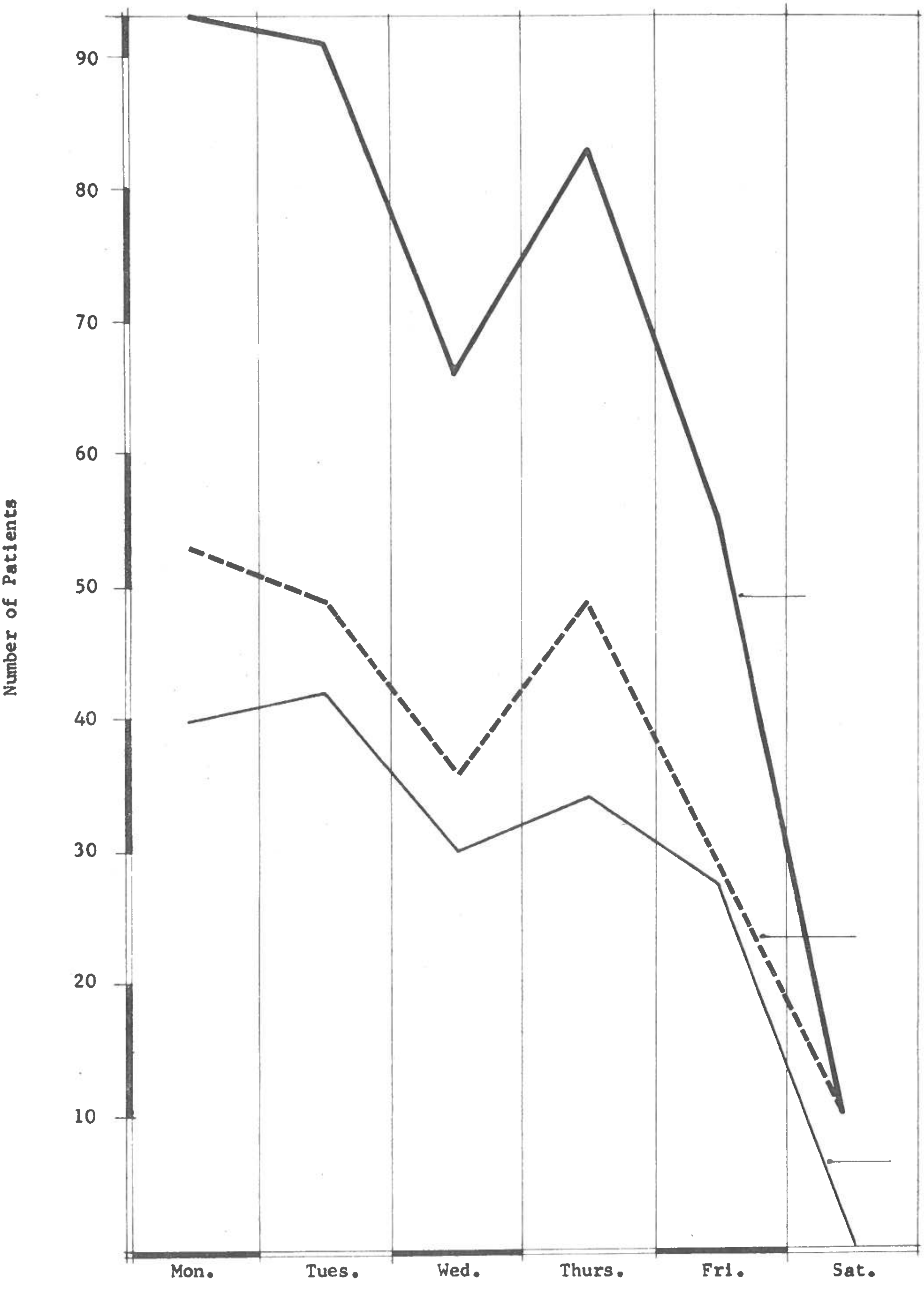
FIGURE B-14



PATIENT ARRIVAL EVERY 15 MINUTES

COMMUNITY HOSPITAL

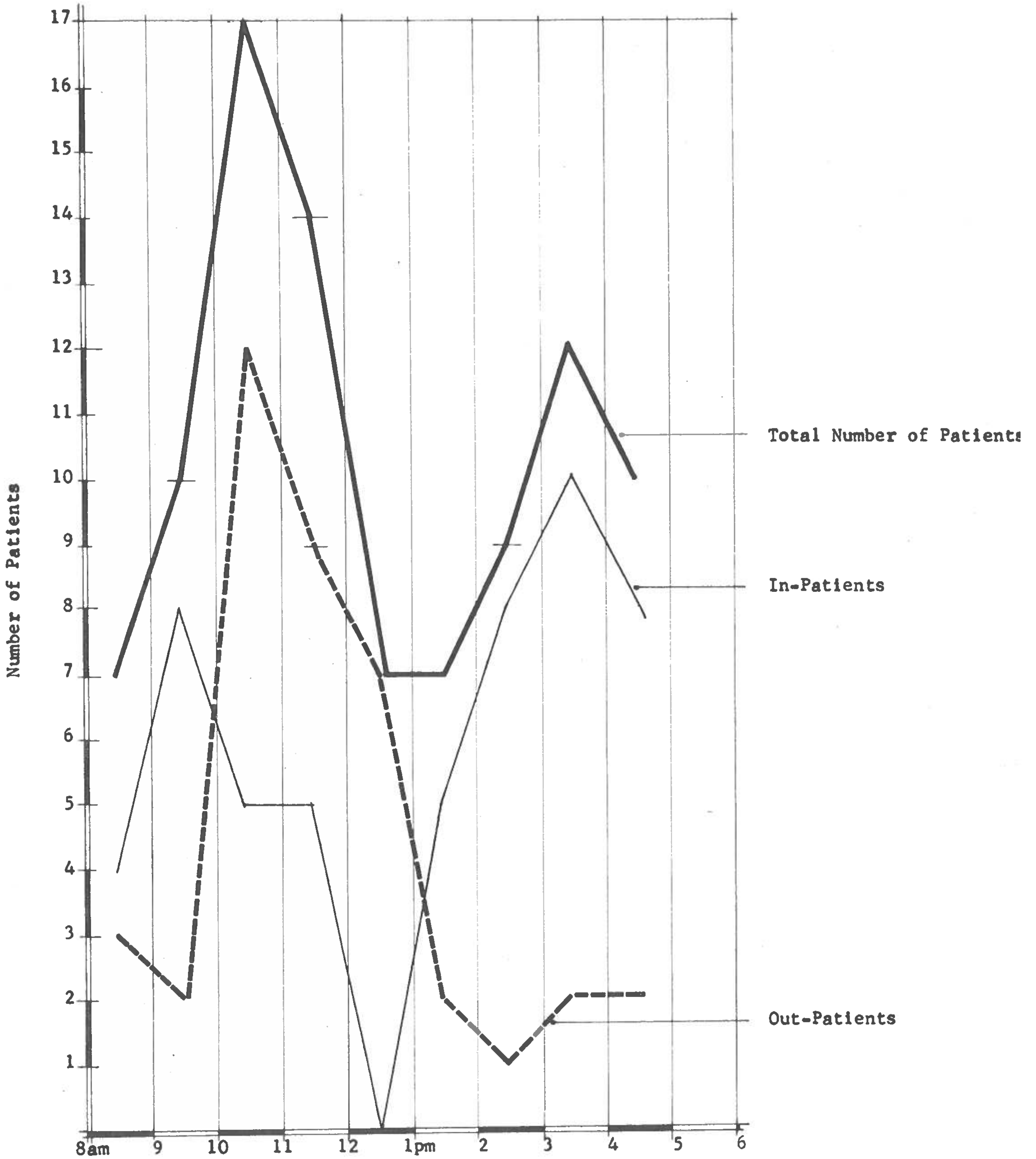
FIGURE B-15



DISTRIBUTION OF PATIENT LOAD ON A WEEKLY BASIS

UNIVERSITY HOSPITAL

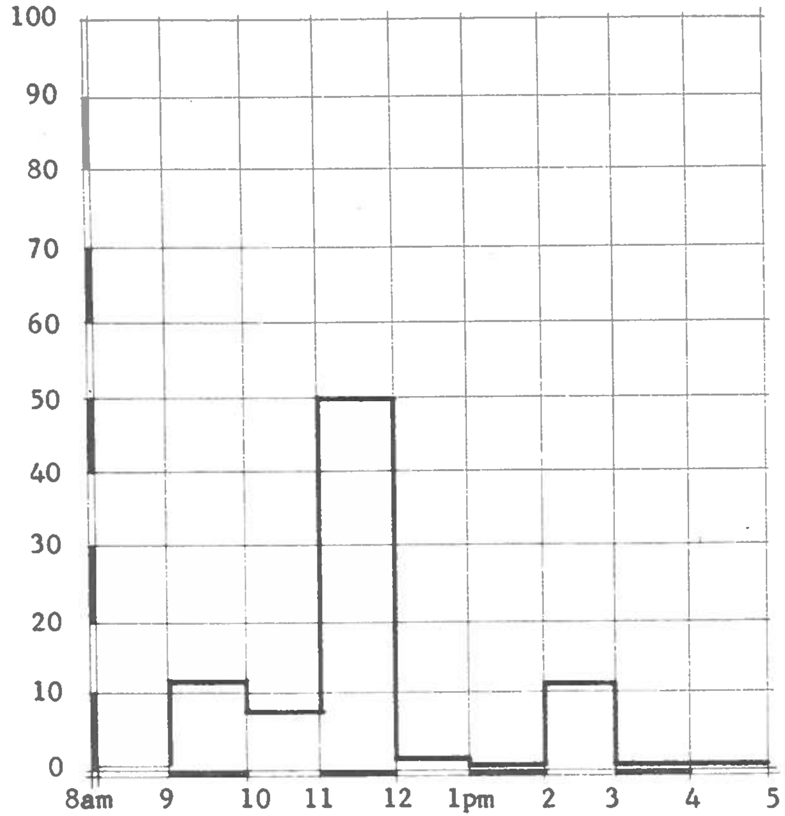
FIGURE B-16



DISTRIBUTION OF PATIENT LOAD ON AN HOURLY BASIS

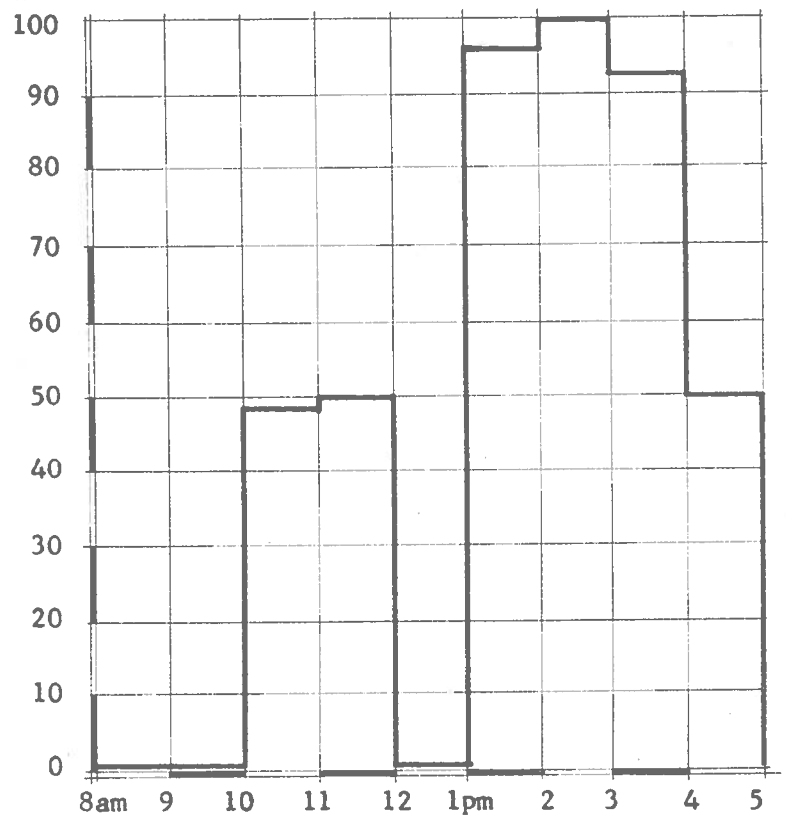
Monday UNIVERSITY HOSPITAL

FIGURE B-17



UTILIZATION OF X-RAY ROOM 347 ON

AN HOURLY BASIS

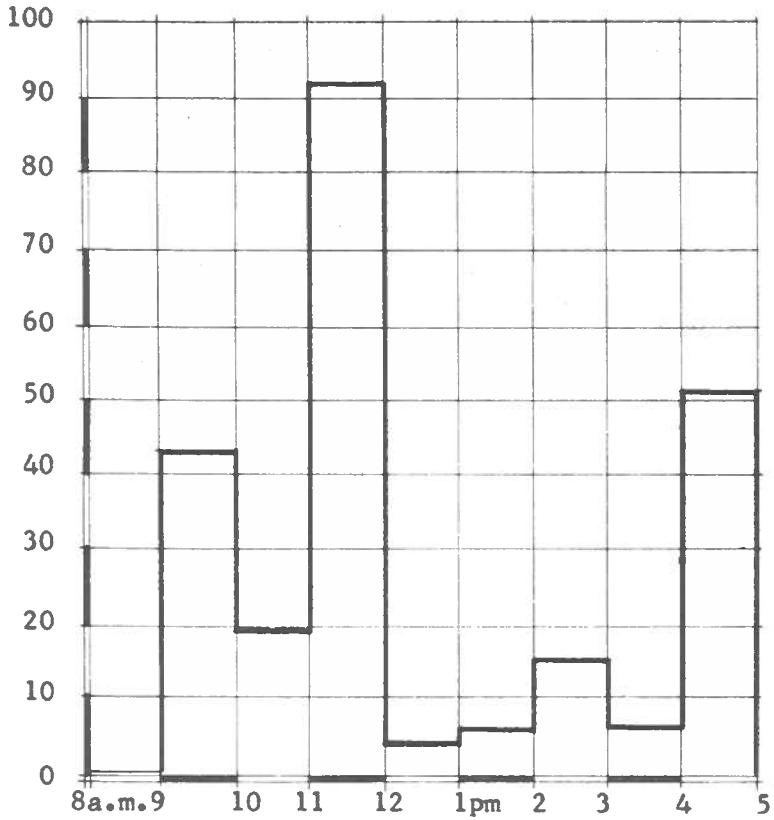


UTILIZATION OF X-RAY ROOM 349F ON

AN HOURLY BASIS

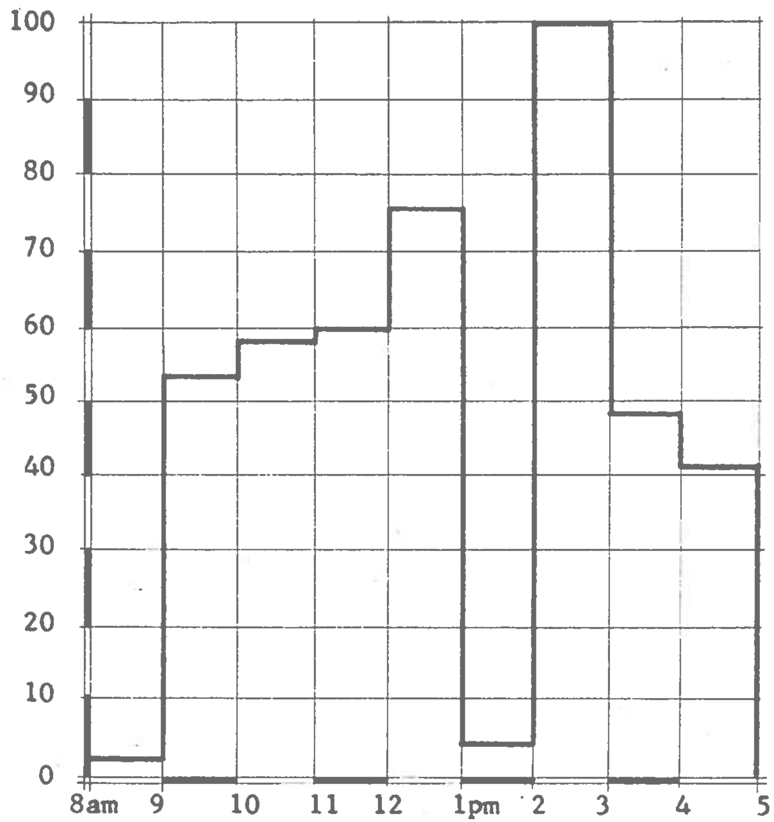
UNIVERSITY HOSPITAL

FIGURE B-18



UTLIZATION OF X-RAY ROOM 341 ON

AN HOURLY BASIS

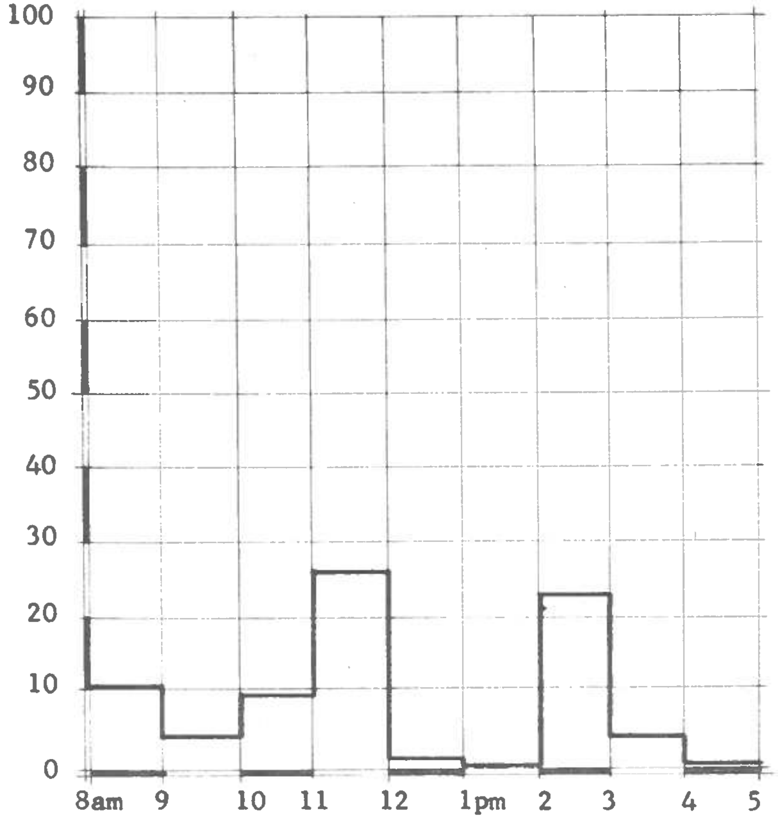


UTILIZATION OF X-RAY ROOM 345 ON

AN HOURLY BASIS

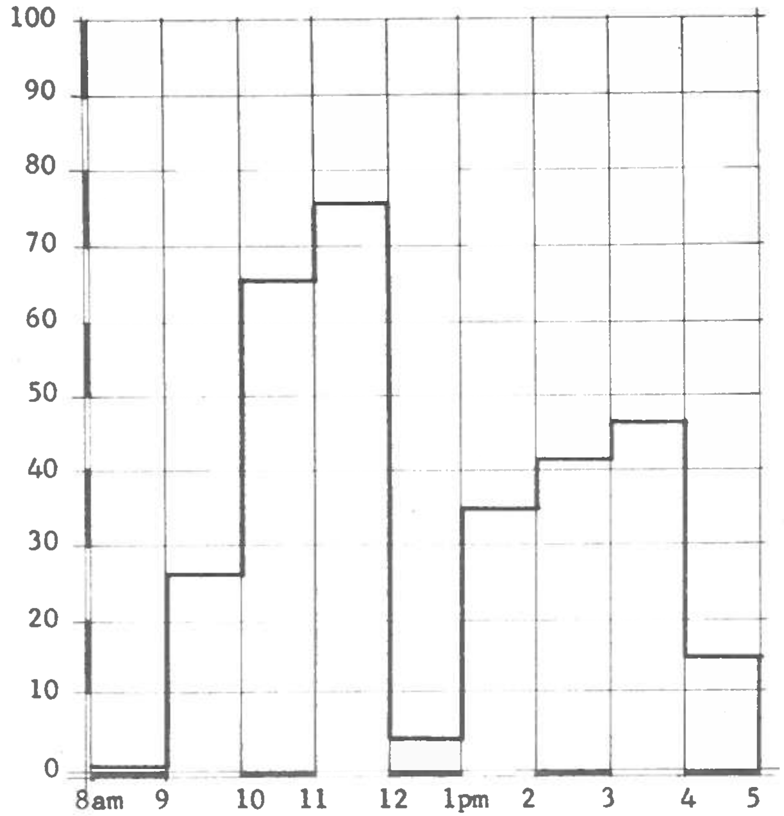
UNIVERSITY HOSPITAL

FIGURE B-19



UTILIZATION OF X-RAY ROOM 373 ON

AN HOURLY BASIS

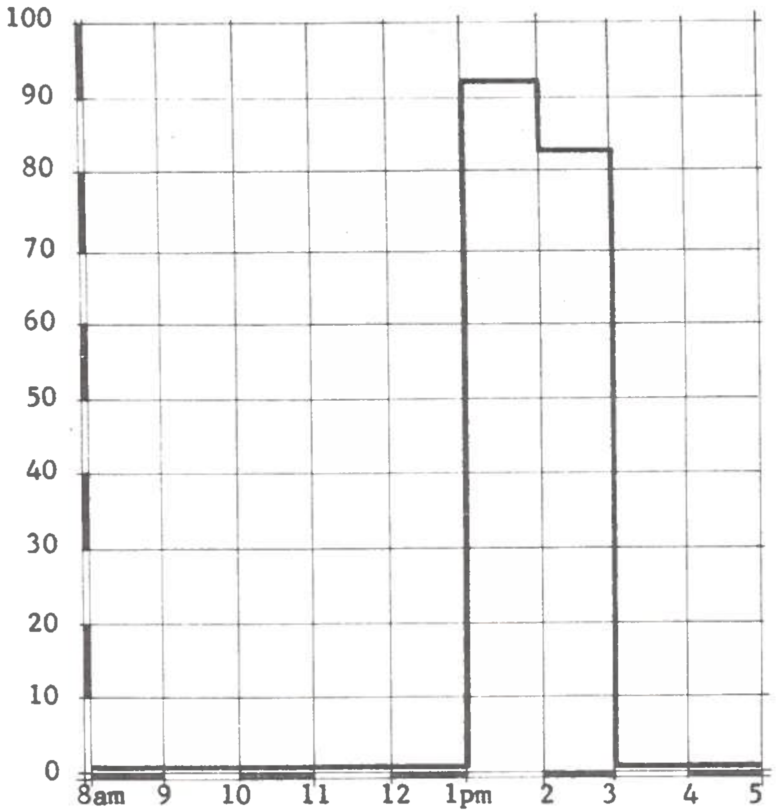


UTILIZATION OF X-RAY ROOM 359 ON

AN HOURLY BASIS

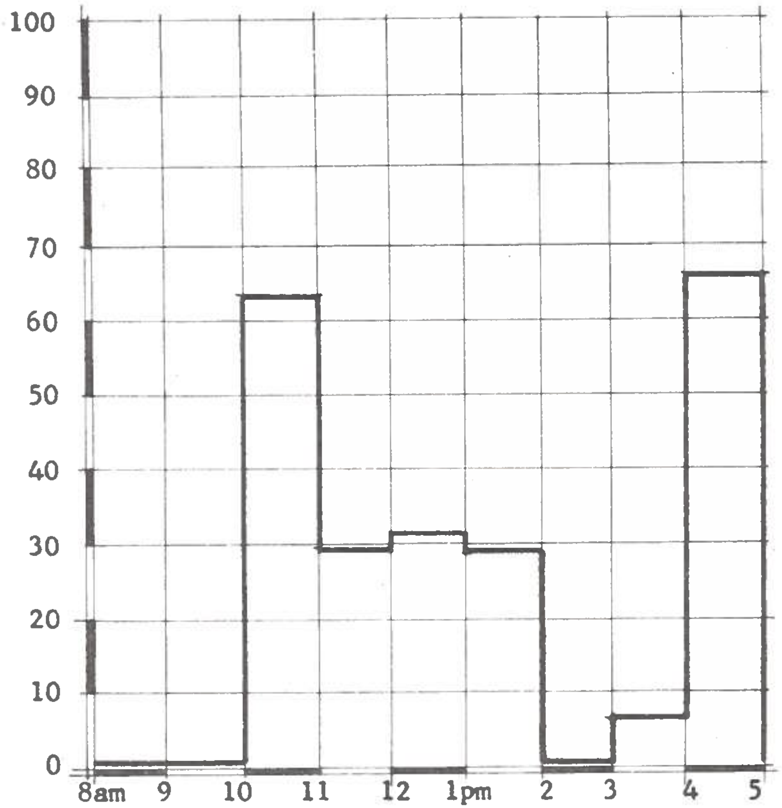
UNIVERSITY HOSPITAL

FIGURE B-20



UTILIZATION OF X-RAY ROOM 323 ON

AN HOURLY BASIS

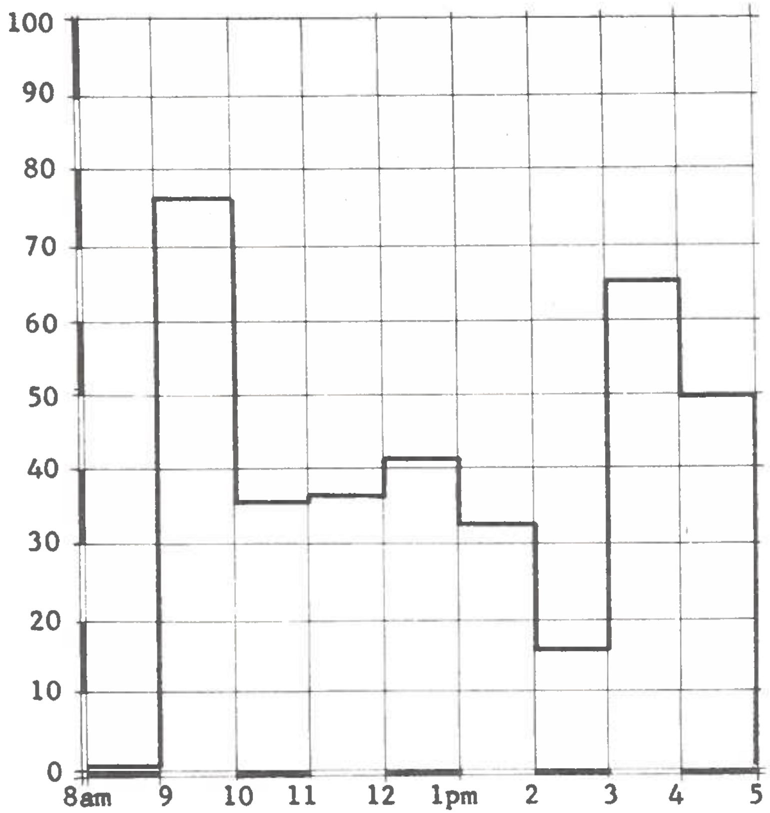


UTILIZATION OF X-RAY ROOM 327 ON

AN HOURLY BASIS

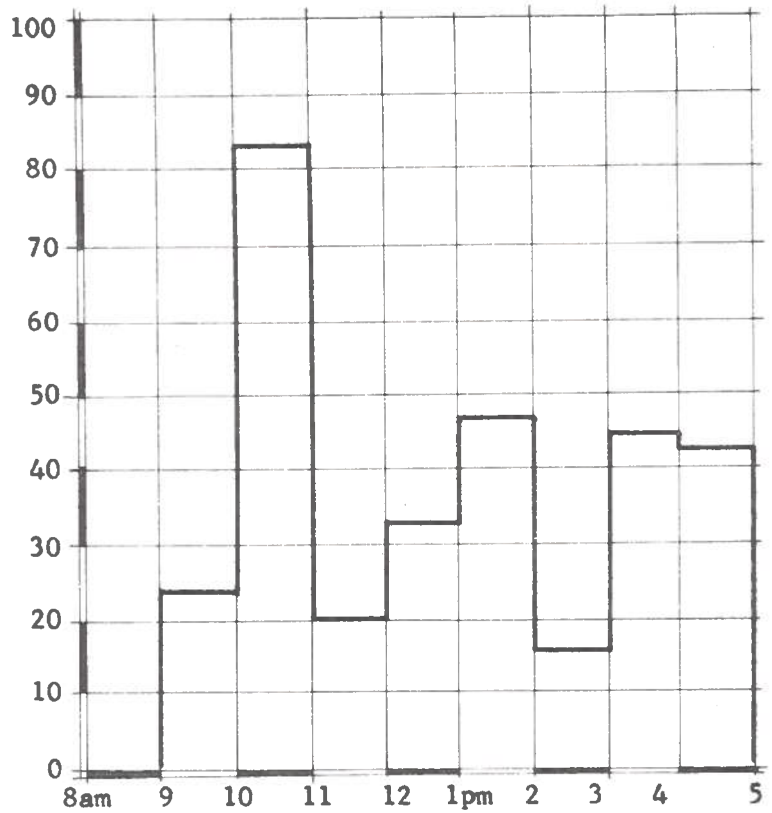
UNIVERSITY HOSPITAL

FIGURE B-21



UTILIZATION OF X-RAY ROOM 349G ON

AN HOURLY BASIS

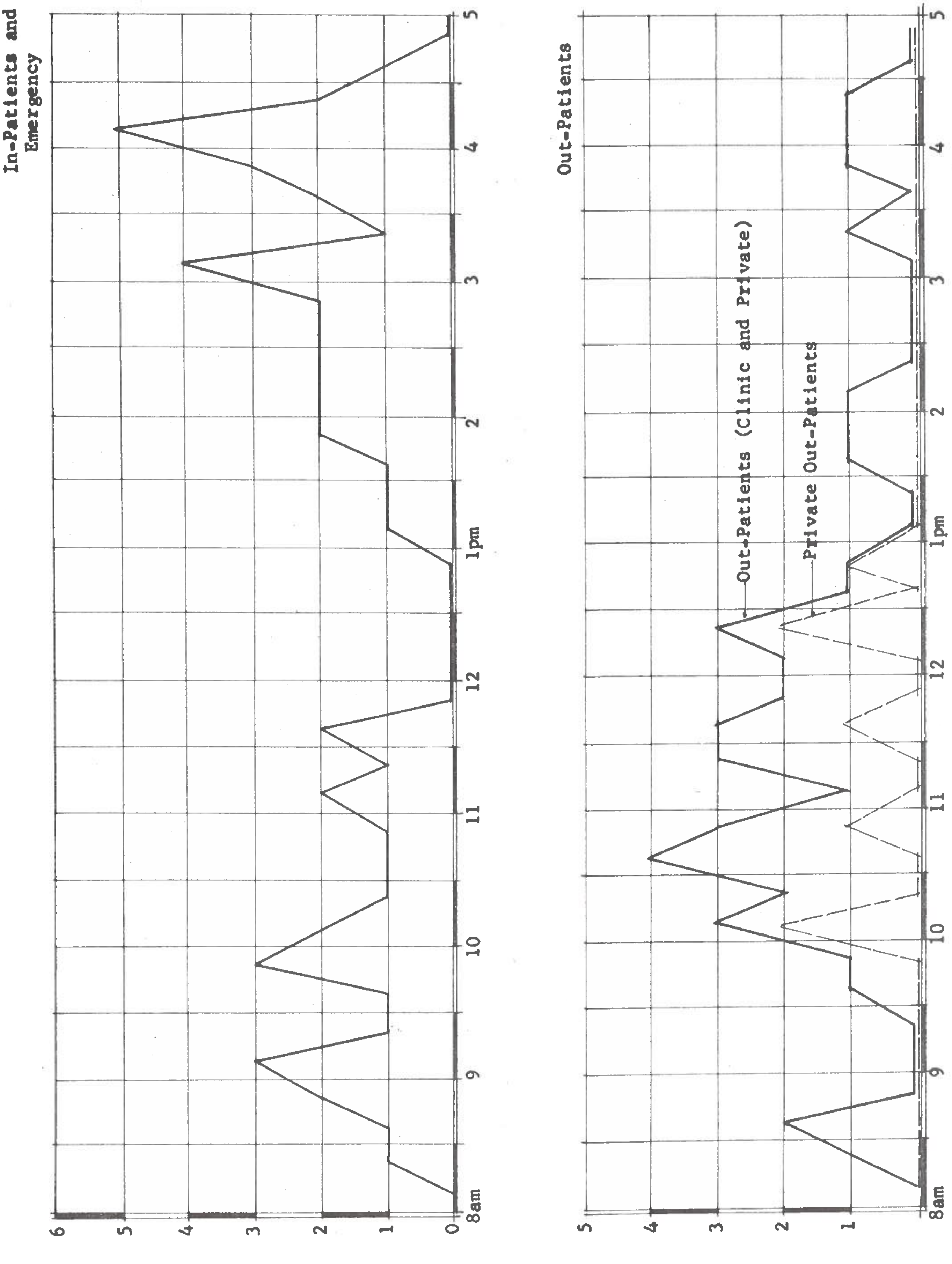


UTILIZATION OF X-RAY ROOM 375 ON

AN HOURLY BASIS

UNIVERSITY HOSPITAL

FIGURE B-22



DISTRIBUTION OF PATIENT LOAD ON A 15 MINUTE BASIS
UNIVERSITY HOSPITAL
Monday

TABLE B-1

SURVEY OF MEANS OF TRANSPORTATION

In-Patient Department UNIVERSITY HOSPITAL

	Stretcher	Bed	Crib	Wheelchair	Carried	Ambulatory	Undetermined
Monday	16	0	1	20	1	5	7
Tuesday	12	1	6	17	0	2	12
Wednesday	7	0	0	22	0	2	6
Thursday	12	0	1	18	0	4	13
Friday	3	0	0	6	0	0	18
Saturday	1	1	0	9	0	0	1
TOTALS	51	2	8	92	1	13	57
Percentage of Total	22.78%	.892%	3.58%	41.0%	.446%	5.80%	25.42%

TABLE B-2

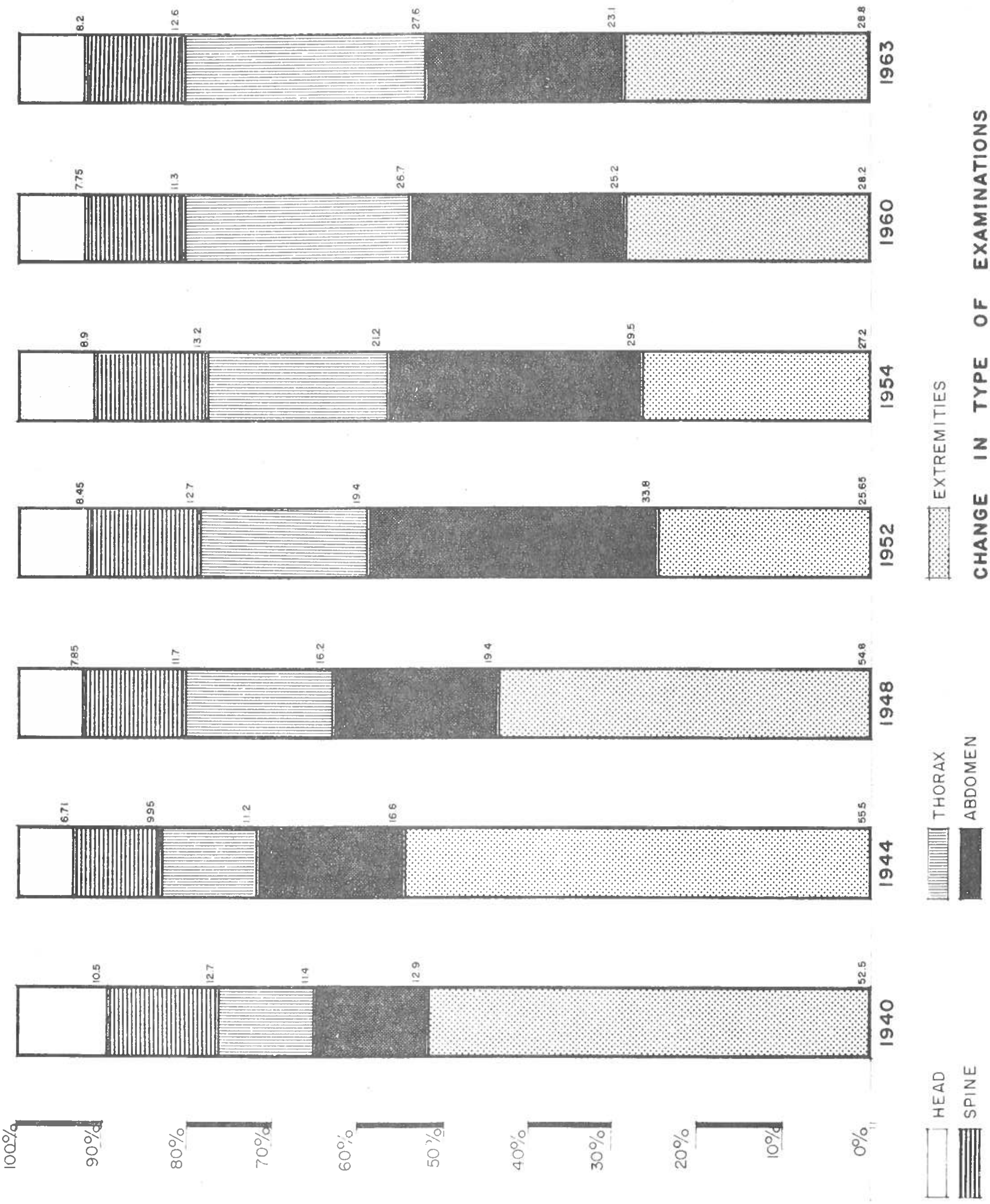
CHART OF PROCEDURES AND PERCENTAGES OF UTILIZATION
DURING VARIOUS HOURS OF THE DAY

Hospital with a
Prepayment Plan

HOURS OF THE DAY		ROOM NO. 1		ROOM NO. 2		ROOM NO. 3		ROOM NO. 4		TOTAL	
FROM	TO	PROCEDURES IN A DAY	% OF TIME UTILIZED	PROCEDURES IN A DAY	% OF TIME UTILIZED	PROCEDURES IN A DAY	% OF TIME UTILIZED	PROCEDURES IN A DAY	% OF TIME UTILIZED	PROCEDURES IN A DAY	% OF TIME UTILIZED
7 A.M.	8 A.M.	3	63.3%	1	50.0%	0	0	1	50.0%	5	40.8%
8 A.M.	9 A.M.	5	78.2%	3	80.0%	6	78.2%	3	75.0%	17	77.9%
9 A.M.	10 A.M.	13	83.3%	3	100.0%	3	83.3%	2	78.3%	21	86.2%
10 A.M.	11 A.M.	11	68.3%	4	70.0%	5	56.7%	4	96.7%	24	72.9%
11 A.M.	12 Noon	13	78.3%	2	100.0%	3	100.0%	10	60.0%	28	84.6%
12 Noon	1 P.M.	13	66.7%	1	40.0%	4	50.0%	4	25.0%	22	45.4%
1 P.M.	2 P.M.	3	41.7%	2	53.3%	1	25.0%	3	68.3%	9	47.1%
2 P.M.	3 P.M.	3	68.3%	2	80.0%	0	0	3	43.3%	8	47.9%
3 P.M.	4 P.M.	6	70.0%	2	63.3%	4	50.0%	5	90.0%	17	68.3%
4 P.M.	5 P.M.	2	16.7%	0	0	4	28.3%	6	51.7%	12	24.2%
5 P.M.	6 P.M.	7	28.3%	0	0	2	20.0%	9	50.0%	18	24.6%
6 P.M.	7 P.M.	24	73.0%	0	0	1	50.0%	4	50.0%	29	43.2%
7 P.M.	8 P.M.	19	43.3%	0	0	3	75.0%	6	55.0%	28	48.3%
8 P.M.	9 P.M.	20	50.0%	0	0	2	20.0%	3	26.7%	25	24.2%
9 P.M.	10 P.M.	3	43.3%	0	0	0	0	0	0	3	10.8%
10 P.M.	11 P.M.	4	73.3%	0	0	0	0	0	0	4	18.3%
11 P.M.	12 mid-night	1	40.0%	0	0	1	23.3%	0	0	2	10.0%
GRAND TOTAL		150	58.9%	20	39.8%	39	40.1%	63	49.5%	272	47.1%

APPENDIX C

FIGURE C-1



CHANGE IN TYPE OF EXAMINATIONS
COMMUNITY HOSPITAL
HEAD
SPINE
THORAX
ABDOMEN
EXTREMITIES
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1940
10.5
12.7
11.4
12.9
52.5
1944
6.71
9.95
11.2
16.6
55.5
1948
7.85
11.7
16.2
19.4
54.8
1952
8.45
12.7
19.4
33.8
25.65
1954
8.9
13.2
21.2
29.5
27.2
1960
7.75
11.3
26.7
25.2
28.2
1963
8.2
12.6
27.6
23.1
28.8

FIGURE C-2

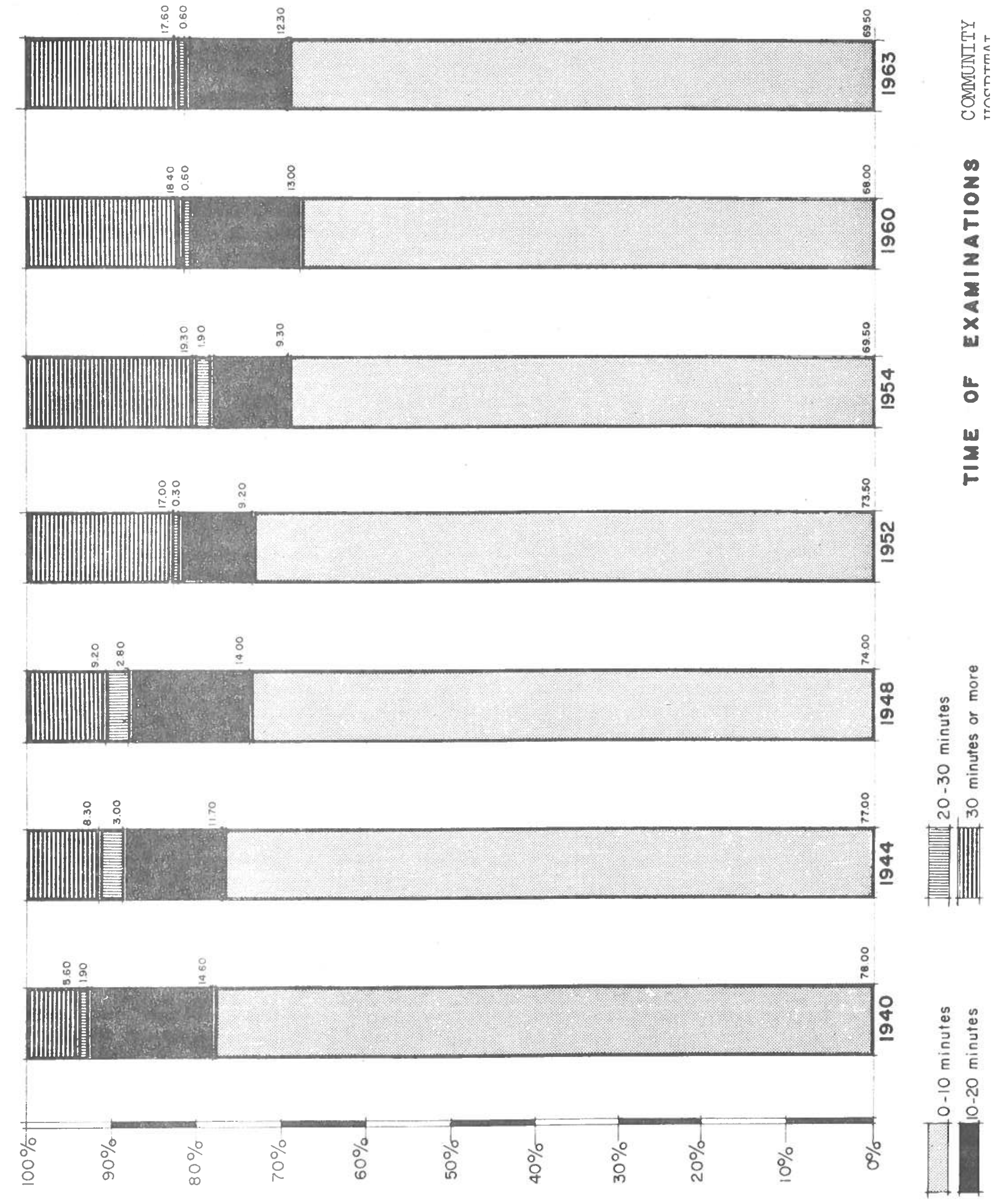

TIME OF EXAMINATIONS
COMMUNITY HOSPITAL
0-10 minutes
10-20 minutes
20-30 minutes
30 minutes or more
1940
78.00
14.60
1.90
5.60
1944
77.00
11.70
3.00
8.30
1948
74.00
14.00
2.80
9.20
1952
73.50
9.20
0.30
17.00
1954
69.50
9.30
1.90
19.30
1960
68.00
13.00
0.60
18.40
1963
69.50
12.30
0.60
17.60
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%

TABLE C-1

COMMUNITY HOSPITAL

DISTRIBUTION OF TIME SPENT IN RADIOLOGY DEPARTMENT - Typical Day*

		EXAMINATION TIME			WAITING TIME					DRESSING TIME		TOTAL
Out Patient	Type of Examination	Exam Time	Room Used	Total Exam Time	before Undress.	after Undress.	between Exams	after last Exam	Total time	Undress. time	Dress time	Total Time In Radiology
1.	G. I. SERIES	10 3	270 500	13	3	3	2	19	27	5	4	49
2.	G. I. SERIES	12 5 6	277 500 500	23	4	4	3 24	12	47	6	4	80
3.	G. I. SERIES	9 3	270 500	12	2	14	4	17	37	2	3	54
4.	RIGHT WRIST	6	500	6	0	-	0	0	0	-	-	6
5.	I.V.P.	10 4	500 500	14	0	1	17	11	29	5	5	53
6.	GALL BLADDER	15	270	15	2	1	-	19	22	4	6	47
7.	GALL BLADDER - P.C.	11 6	277	17	22		111	16	149			166
8.	RIGHT KNEE	10	277	10	15	-	-	14	29	-	-	39
9.	CHEST											41
10.	CHEST	4	500	4	2	0	-	24	26	4	4	38
11.	H.M.H. CHEST	1	500	1	0	0	-	0	0	2	2	5
12.	LEFT KNEE	11	270	11	5	-	-	36	41	-	-	52
13.	HAND	5	500	5	4	-	-	0	4	-	-	9

SHEET 2

COMMUNITY HOSPITAL

		EXAMINATION TIME			WAITING TIME					DRESSING TIME		TOTAL
Out Patient	Type Examination	Exam Time	Room Used	Total Exam Time	before Undress.	after Undress.	between Exams	after last Exam	Total time	Undress. time	Dress time	Total Time In Radiology
14.	LEFT THUMB	8	500	8	17	-	-	22	39	-	-	47
15.	CHEST LUMBO-SAC. SPINE	30 16	270 270	46	9	0	26	36	71	5	3	125
16.	CHEST	5	500	5	4	-	-	21	25	-	-	30
17.	CHEST	10	500	13	14	-	23	14	51	-	-	64
18.	CHEST RIGHT SHOULDER	8 6	277 277	14	2	1	15	2	20	2	4	40
19.	FEET	16	270	16	13	-	-	19	32	-	-	48
20.	CHEST	7	277	7	4	3	-	25	32	3	3	45
21.	SHOULDER	7 3	277	10	9	2	13	13	37	2	1	50
22.	RIGHT KNEE	7	500	7	27	-	-	28	55	-	-	62

DISTRIBUTION OF TIME SPENT IN RADIOLOGY DEPARTMENT - Typical Day*

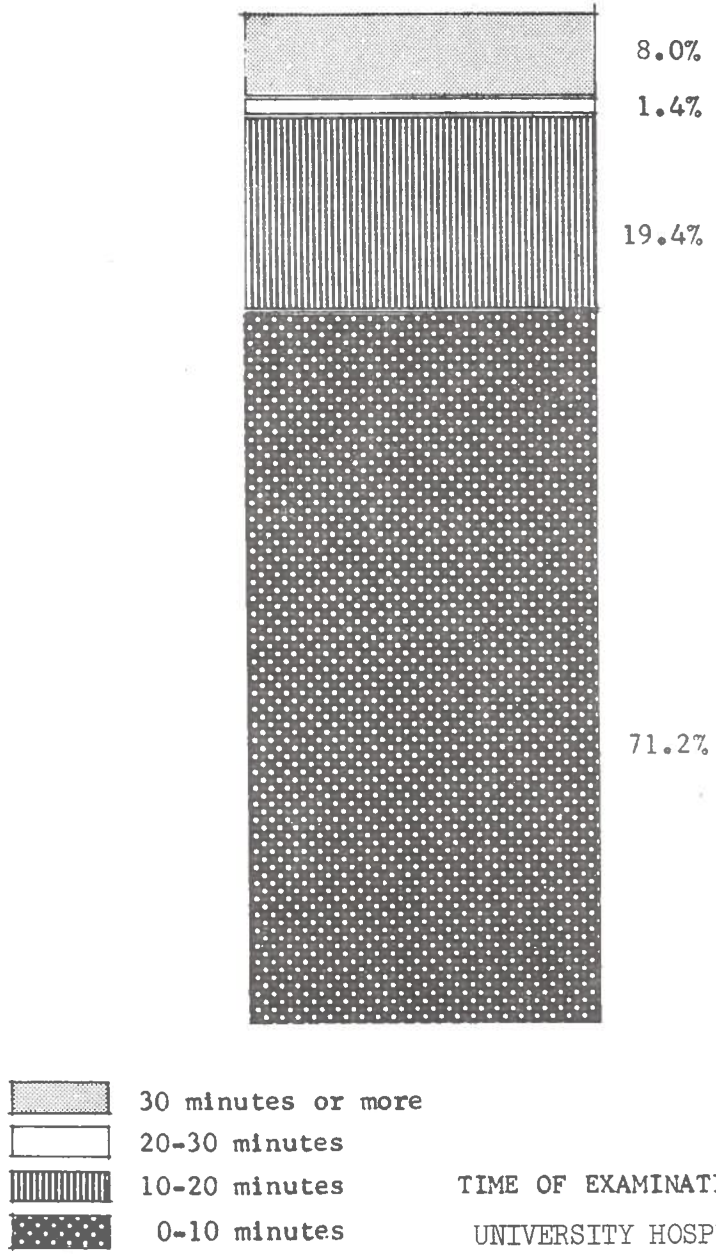
		EXAMINATION TIME			WAITING TIMES				TOTAL
In Patient	Type of Examination	Exam Time	Room Used	Total Exam Time	before Exam	between Exams	after last Exam	Total Waiting Time	Total Time in Radiology
1.	G. I. SERIES	3	500	3	13	-	20	33	36
2.	G. I. SERIES	13 7 9 5	277 500	34	3	- 23 3	35	64	98
3.	RIGHT ANKLE	5	500	5	34	-	26	60	65
4.	G. I. SERIES	12 7	277 500	19	11	3	17	31	50
5.	BARIUM ENEMA	29 8	270 500	37	6	3	28	37	74
6.	BARIUM ENEMA	24	277	24	15	-	35	50	74
7.	I.V.P.	73 4 5	500 500 500	82	0	8 21	14	43	125
8.	LUMBO-SAC SPINE PELVIS	21 10	270 277	31	11	15	14	40	71
9.	RIGHT HIP LUMBO-SAC SPINE	1 50	277 500	51	2	-	122	124	175
10.	ABDOMEN (Stat.)	14	270	14	3	-	6	9	23
11.	CHEST SKULL MANDIBLE	39	277	39	4	-	3	7	46

SHEET 4

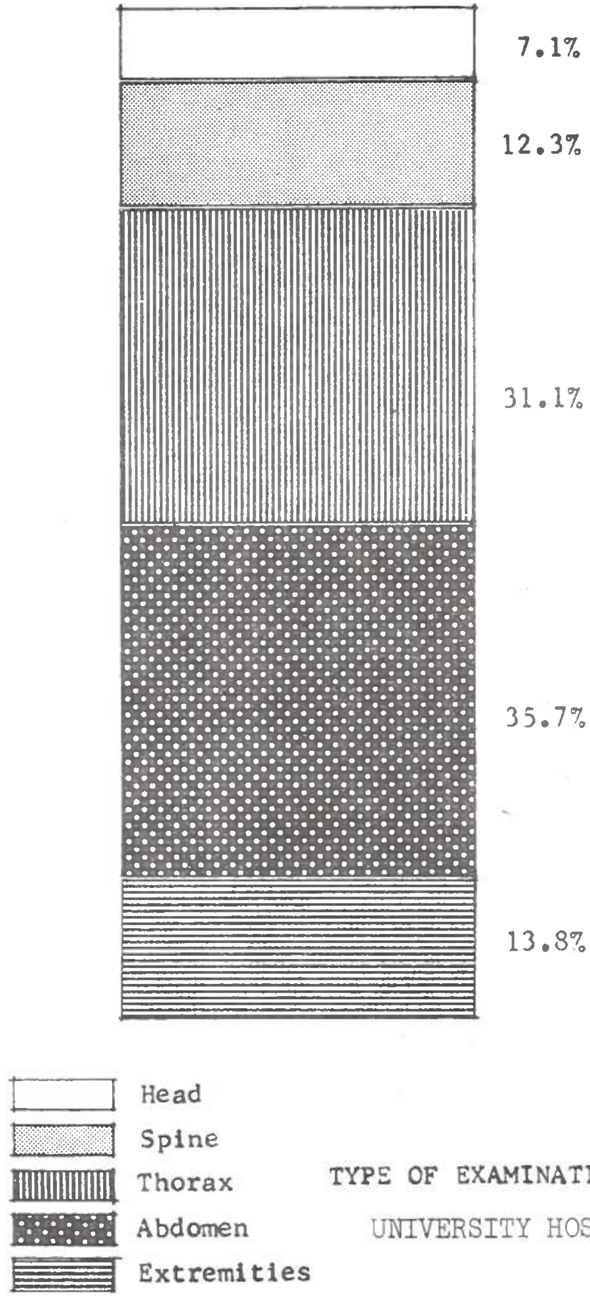
COMMUNITY HOSPITAL

In Patient	Type of Examination	EXAMINATION TIME Exam Time	Room Used	Total Exam Time	WAITING TIMES before Exam	Between Exams	After last Exam	Total Waiting Time	TOTAL Total Time in Radiology
12.	MANDIBLE	16	277	16	22	-	30	52	68
13.	CHEST ABDOMEN	8	270	8	18	-	18	36	44
Emergency Patients									
1.	RIGHT WRIST	5	500	5	6	-	17	23	28
2.	LEFT FOOT	5	270	5	8	-	24	32	37
3.	HUMERUS	10	277	10	5	-	13	18	28
4.	RIGHT HAND	4	500	4	8	-	0	8	12
5.	RIGHT FOOT RIGHT ANKLE	12 3	500	15	11	34	10	55	70

FIGURE C-3



TIME OF EXAMINATIONS
UNIVERSITY HOSPITAL



TYPE OF EXAMINATIONS
UNIVERSITY HOSPITAL

UNIVERSITY HOSPITAL

TABLE C-2

DISTRIBUTION OF TIME SPENT IN RADIOLOGY DEPARTMENT - Typical Day*

		EXAMINATION TIME			WAITING TIME					DRESSING TIME		TOTAL
Out Patient	Type of Examination	Exam Time	Room Used	Total Exam Time	before Undress.	after Undress.	between Exams	after last Exam	Total time	Undress. time	Dress time	Total Time In Radiology
1.	XR CHEST (300) XR STOM DUOD (414)	1 22 10 16	373 f1.2 355 f1.2	49	23	2	37 50	21	133	7	9	198
2.	XR CHEST (300)	2 24 5	373 f1.2 355	31	8	7	55 70	37	177	6	13	227
3.	XR CHEST (300)	2	373	2	18	0	0	10	28	4	4	38
4.	XR CHEST (300)	2 3	373 373	5	6	-	14	15	35	-	-	40
5.	XR BILE DUCT INJ (444) XR STOM DUOD (414)	1 27 16 5	359 359 359 f1.1 355	74	28	19	10 16 to fluor. 77	80	23	4	6	314
6.	QXR BREAST (340)	14	375	14	13	3	0	23	39	7	13	73
7.	XR STOM DUOD (414)	22	f1.2 355		13		101 to fluor.			4		193
8.	XR SKULL (100)	9	359		5	2	0	25	32	-	-	41
9.	XR WRIST (750)	1 2	375 359	3	33	-	25	10	68	-	-	71
10.	(337)	30	f1.1	30	5	15 to fluor. 68		20	108	-	-	138
11.	XR WRIST	3	375	3	18	-	0	23	41	-	-	44

SHEET 2

Out Patient	Type of Examination	EXAMINATION TIME Exam Time	Room Used	Total Exam Time	WAITING TIME before Undress.	after Undress.	between Exams	after last Exam	Total time	DRESSING TIME Undress. time	Dress time	TOTAL Total Time In Radiology
12.	XR THIGH (790)	26	375	26	12	-	0			-	-	38
13.	XR FOOT (830)	7	355	7	25	0	0	24	49	-	-	56
14.	XR HIP (780)		375		23					4		
15.	XR THIGH (790)	43	359	43	28	0	0	0	28	-	-	71
16.	QXR BREASTS (348)	6 10 4	375 373 375	20	12	1	21	0	34	-	-	54
17.	QXR HEART (310)	5 1	373 373	6	10	0	18	13	41	5	3	55
18.	XR BO SUR PELV(709) XR ADDITIONAL EXAM (902)	2 4	375 375	6	8	5	19	4	36	4	8	52
19.	XR LUMBAR SPINE(650)		375 375	6	13	17	13	21	64	6	8	84
20.	XR KNEES (800)	15	359	15	23	0	0	19	42	-	-	57
21.	XR SHOULDER (710)	9 3	355 355	12	3	0	18	0	21	1	3	37
22.	XR COLON W BA (434)	16 2 5	f1.2 355 355	23	51	37	1 34	72	195	4	4	220
23.	XR CERV SPINE (610) XR SHOULDER (710) XR ARM (720)	11 6 5	375 375 359	22	7	5	48 16	2	78	-	-	100
24.	XR CHEST (300)	1	375	1	31	0	0	25	56	1	2	60

SHEET 3

Out Patient	Type of Examination	EXAMINATION TIME Exam Time	Room Used	Total Exam Time	WAITING TIME before Undress.	after Undress.	between Exams	after last Exam	Total time	DRESSING TIME Undress. time	Dress time	TOTAL Total Time In Radiology
25.	XR HIP (780)	11	375	11	16	54	0	11	81		11	103
26.	XR HIPS (788)	19 2	375 375	21	9	0	26	0	35	-	-	56
27.	XR COLON W BA(434)	15 7	f1.2 355	22	12	100 to fluor.	0					
28.	XR ANKLE (820) XR FOOT (830)	16	359	16	16	0	0	6	22	-	-	38
29.	XR CHEST (300)	2 2 2	373 373 373	6	34	6	10 9	0	59	2	2	69
30.	XR BONE AGE (970)	4	359	4	18	0	0	14	32	-	-	36
31.	XR CHEST (300)	1	373	1	23	0	0	16	39	3	2	52
32.	XR CHEST (300)	2	373	2	23	3	0	13	39	2	3	46
33.	XR CHEST (300)	6	359	6	40	0	0	9	49	-	-	55
34.	XR LUMBAR SPINE(650)	10	359	10	11	0	0	0	11	2		23
35.	XR CHEST (300)	3 2 3	373 373 359	8	8	0	13 7	23	51	2	2	63
36.	XR CHEST (300)	9 10	359 359	19	11	2	13	11	37	3	2	61
37.	XR CHEST (300)	20	375	20	6	0	0	14	20	-	-	40
38.	XR TOES ONE FOOT (840)	9	359	9	9	0	0	10	19	-	-	28

SHEET 4

		EXAMINATION TIME			WAITING TIME					DRESSING TIME		TOTAL
Out Patient	Type of Examination	Exam Time	Room Used	Total Exam Time	before Undress.	after Undress.	between Exams	after last Exam	Total time	Undress. time	Dress time	Total Time In Radiolog
39.	XR CHEST (300)	3	373	15	12	0	7	10	29	3	5	52
	XR ABDOMEN PLAIN(400)	7	375									
		5	355									
40.	XR ELBOWS (738)	5	359	9	12	0	18	10	40	-	-	49
		4	359									
41.	XR LUMBO SACRAL (660)	26	375	26	9	0	0	6	15	-	-	41
42.	XR WRIST (750)	8	355	8	38	0	0	11	49	-	-	57

SHEET 5

In Patient	Type of Examination	Exam Time	Room Used	Total Exam Time	before Exam	between Exam	after Exam	for Orderly	Total Waiting Time	Total Stay in Radiology
		EXAMINATION TIME			WAITING TIMES					TOTAL
1.	QXR AORTA W I (391)	84	355	84 min.	13 min.	0	24min.	6min.	43 min.	127 min.
2.	XR SKULL (100) XR CHEST (300)	16 6 6	345 345 345	28	2	8 37	2	9	58	86
3.	XR CHEST (300)	3	341	3	1	0	14	3	18	21
4.	XR CHEST (300)	3	341	3	2	0	15	2	19	22
5.	XR ABDOMEN PLAIN (400)	19	333	19	2	0	19		21	40
6.	XR SKULL (100) QXR HEART (310) XR ADDITIONAL EXAM (907)	12 25 16 25	345 341 345 345	78	8	6 13	0	1	28	106
7.	XR CHEST (300)	4	347	4	13	0	8	13	34	38
8.	XR SKULL (100) XR ADDITIONAL EXAM (902)	18	341	18	17	0	0	1	18	36
9.	XR CHEST (300)	4	347	4	12	0	11	10	33	37
10.	QXR HEART (310)	5	347	5	11	o	14	2	27	32
11.		29 5	Fl. 1 355	34	5	76				
12.	XR CHEST (300)	7		7	5	0	23	15	43	50

SHEET 6

		EXAMINATION TIME			WAITING TIMES					TOTAL
In Patient	Type of Examination	Exam Time	Room Used	Total Exam Time	before Exam	between Exam	after Exam	for Orderly	Total Waiting Time	Total Stay in Radiology
13.	QXR AORTA W I (391)	73		73	25	0	35		60	133
14.	XR SKULL ANG W INJ (191)	56	327	56	4	0	12	5	21	77
15.	XR CHEST (300)	4	333	4	5	0	14	26	45	49
16.	XR ABDOMEN PLAIN (400) XR ADDITIONAL EXAM (901)	24	391	24	1	0	8	10	19	43
17.	XR ADDITIONAL EXAM (920)	12	347	12	10	0	13	21	44	116
18.	XR ADDITIONAL EXAM (902)	53	333	53	4	0	8	4	16	69
19.	XR ABDOMEN PLAIN (400) XR ADDITIONAL EXAM (901)	12	347	12	18	0	14	2	34	46
20.	XR CHEST (300)	3		3	50	0	14	5	69	72
21.	XR CHEST (300)	30	345	30	2	0	0	1	3	33
22.	XR SKULL ANG W INJ (191)	34	327	34	74	0	0	9	83	116
23.	XR CHEST (300)	4 3	347 347	7	9	10	0	2	21	28
24.	XR CHEST (300) XR SKULL (100)	6 15 10	345 345 345	31	15	1 21	18	23	78	109

SHEET 7

In Patient	Type of Examination	EXAMINATION TIME Exam Time	Room Used	Total Exam Time	WAITING TIMES before Exam	between Exam	after Exam	for Orderly	Total Waiting Time	TOTAL Total Stay in Radiology
25.	XR CHEST (300)	3 15	333 345	18	17	10	30	30	87	105 min.
26.	QXR SKULL AIR (103)	105	327	105	17	0				170
27.	XR SPINAL CANAL (604)	127	Fl. 1	127	5	0	3	14	23	150
28.	XR CHEST (300) XR COLON W BA (434)	2 14 5	341 Fl. 2 355	21	3 to fluor. 109	0	14		153	174
29.	XR CHEST (300) XR COLON W BA (434)	2 70	341 Fl.	72	2		0	0		74
30.	XR KNEES (308)	71	345	71	5	0	0	4	9	80
31.	XR COLON W BA (434)	39 6	Fl. 2 355	45	26	0	114	10	150	195
32.	XR CHEST (300)	10	333	10	7	0	11	1	19	29
33.	XR HIP (780)	75	Fl. 1	75	59	0				
34.	XR CHEST (300)	7	333	7	3	0	15	2	20	27
35.	XR CHEST (300)	10	341	10	10	0	17		27	37
36.	XR CHEST (300)	6	333	6	16	0	12	5	33	39
37.	QXR HEART (310)	9 2	341 341	11	11	20	15	7	53	64
38.	QXR HEART (310)	7	347	7	10	0	30		40	47

SHEET 8

In Patient	Type of Examination	EXAMINATION TIME: Exam Time	Room Used	Total Exam Time	WAITING TIMES: before Exam	between Exam	after Exam	for Orderly	Total Waiting Time	TOTAL: Total Stay in Radiology
39.	XR ADDITIONAL EXAM (901)	4 8	333 333	12	7	1	10	20	38	50
40.	XR CHEST (300)	10	333	10	7	0	11	1	19	29
41.	XR CHEST (300) XR ABDOMEN PLAIN(400) XR SKULL (100)	20 14	333 345	34	4	36	0	20	60	94
42.	XR ABDOMEN PLAIN (400)	34	333	34	28	0	0	9	37	71
43.	XR SKULL (100)	44	327	44	11	0	0	0	11	55
44.	XR CHEST (300)	3	341	3	3	0		26	29	32
45.	XR LUMBO SACRAL (660) XR SKULL(100)	30 37	341 345	67	10	3	0	0	13	80
46.	XR CHEST (300)	18	333	18	2	0	0	0	2	20
47.	XR CHEST (300)	3	341	3	6	0		11	17	20
48.	XR SKULL (100)		345		14					

TABLE C-3

TIME REQUIRED FOR X-RAY EXAMINATIONS IN

UNIVERSITY HOSPITAL

	No.	Aver. Time per Exam. (Min.)	Aver. No. of Films	Aver. Hours per Exam.	Hours for Total Exam.	% of Time	% of Exams.	Relative Time for Exam.
Chemopallidectomy	63	212	14.1	3.55	233.7	2.73	.18	15.2
O.R. Cholangiogram	41	133	6	2.2	90.2	1.05	.11	10.4
X-ray Movies	69	120		2	138	1.60	.20	8.0
Angiocardiogram	67	105	23.3	1.75	117.3	1.37	.19	7.3
Cerebral Angiogram	192	104	26.8	1.74	334.1	3.91	.54	7.2
Myelogram	212	92	7.1	1.54	326.5	3.82	.60	6.3
Encephalogram	277	80	11.4	1.33	368.4	4.31	.78	5.5
Aortogram	67	66	12.3	1.12	75.0	.88	.19	4.6
I.V. Pyelogram	1576	61	4.3	1.0	1576	18.4	4.46	4.1
I.V. Cholangiogram	66	60	6	1.0	66	.77	.19	4.1
Extraperitoneal Pneumogram	8	60	6	1.0	8	.09	.02	4.5
Tomogram	192	44	8.4	.74	142.1	1.66	.54	3.1
Radium Localization	160	30	3	.5	80	.94	.45	2.1
Small Bowel	307	25	6	.42	130	1.52	.87	1.74
Temperomandibular Joint	38	25	5.3	.41	15.6	.18	.11	1.64
Pelvimetry	107	19	4	.31	33.2	.39	.30	1.3
Skull	1826	17	6	.28	511.3	5.98	5.17	1.13
Bronchogram	100	17	9	.28	28.0	.38	.283	1.34
Mandible	104	15	4.8	.25	26.0	.30	.294	1.02
Mastoid	106	14	4.2	.23	24.4	.29	.299	.97
Pneumocolon	137	13	6	.22	30.1	.35	.39	.90
Gall Bladder	699	13	6	.22	148.9	1.74	1.98	.87
Spine or Pelvis	4141	11	3	.18	745.4	8.72	11.72	.74
Extremities	4710	10	2.1	.17	800.7	9.37	13.33	.70
Sinuses	516	10	4.0	.17	82.2	.96	1.46	.65
Gastrointestinal Tract	2423	9	8	.15	363.5	4.25	6.86	.62
Abdomen	1178	8	2.0	.13	153.1	1.79	3.33	.54
Enema	1555	8	6	.13	202.2	2.37	4.40	.54
Chest	10992	7	3.1	.12	1319.0	15.4	31.11	.495
Fluoroscopy	3902	7		.12	468.2	5.45	11.04	.49
Total	35315				8554.7			
Misecellaneous	3899							
TOTAL EXAMINATIONS	39214							

Average time per examination = 14.5 min. = .242 hours

TABLE C-4

UNIVERSITY HOSPITAL

CONTROLLED APPOINTMENT PLAN
Department of Radiology
Diagnosis

1. PURPOSE

   A. Coordination of Multiple Appointments.
   B. Control of Physician Time, Patient Load, and Appointment Hours.
   C. Control Patient Waiting Time.

2. Types and interval of time appointments are to be scheduled in Radiology.

   A. Fluoroscopic Examinations

(1)	Chest Fluoroscopy	20 minute interval
(2)	G. I. Series	20 " "
(3)	G. I. and Small Bowel	20 " "
(4)	G. I. and Esophagus	20 " "
(5)	Esophagus	20 " "
(6)	Small Bowel	1 hour int.-Total Time, 1-6 hours.
(7)	Barium Enema	30 minute interval
(8)	Barium Enema and Pneumo-colon	1 hour interval
(9)	Bronchogram	1 " "
(10)	Discogram	2½ " "
(11)	Myelogram	2 " "
(12)	Sinus Tract Injection	1 " "
(13)	Renal Biopsy	2 " "

   B. Other Special Examinations

(1)	I.V. Cholangiograms	1 hour interval
(2)	Tomograms	1 " "
(3)	Tic Injection	1 " "
(4)	Pneumoencephalogram	3 " "
(5)	Ventriculogram	3 " "
(6)	Gynecogram	3 " "
(7)	Angiogram	2 " "
(8)	Bone Survey	1 " "
(9)	Bone Biopsy	1 " "
(10)	Hip Nailing	3 " "
(11)	I.V. Pyelogram	2 " "
(12)	Cystogram	2 " "

   C. Examinations such as Spine, Abdomen, Gall Bladder, that are to be taken prior to the Fluoroscopic Examination are to be scheduled 45 minutes before the appointed Fluoroscopic time.

FIGURE C-4

HOSPITAL WITH A PREPAYMENT PLAN SHOWING PATIENTS PER PROCEDURE AND EXPRESSED AS A PERCENTAGE OF THE TOTAL NUMBER OF PATIENTS.

PROCEDURES	No. OF PATIENTS
1. Mini-film	70
2. Chest	58
3. Spine	19
4. G.I.	18
5. Barium Enema	12
6. Skull	11
7. Gall Bladder	10
8. Foot	9
9. Wrist	8
10. I.V.P.	6
11. Elbow	6
12. Ankle	5
13. Shoulder	4
14. Knee	4
15. Finger	4
16. Hand	3
17. Hips	3
18. Toe	3
19. Laminogram	3
20. Abdomen	2
21. Sinus	2
22. Ribs	2
23. Pelvis	2
24. Pylogram	2
25. Barium Swallow	2
26. Arm	1
27. Nose	1
28. Optic Forearm	1
29. Small Bowel	1

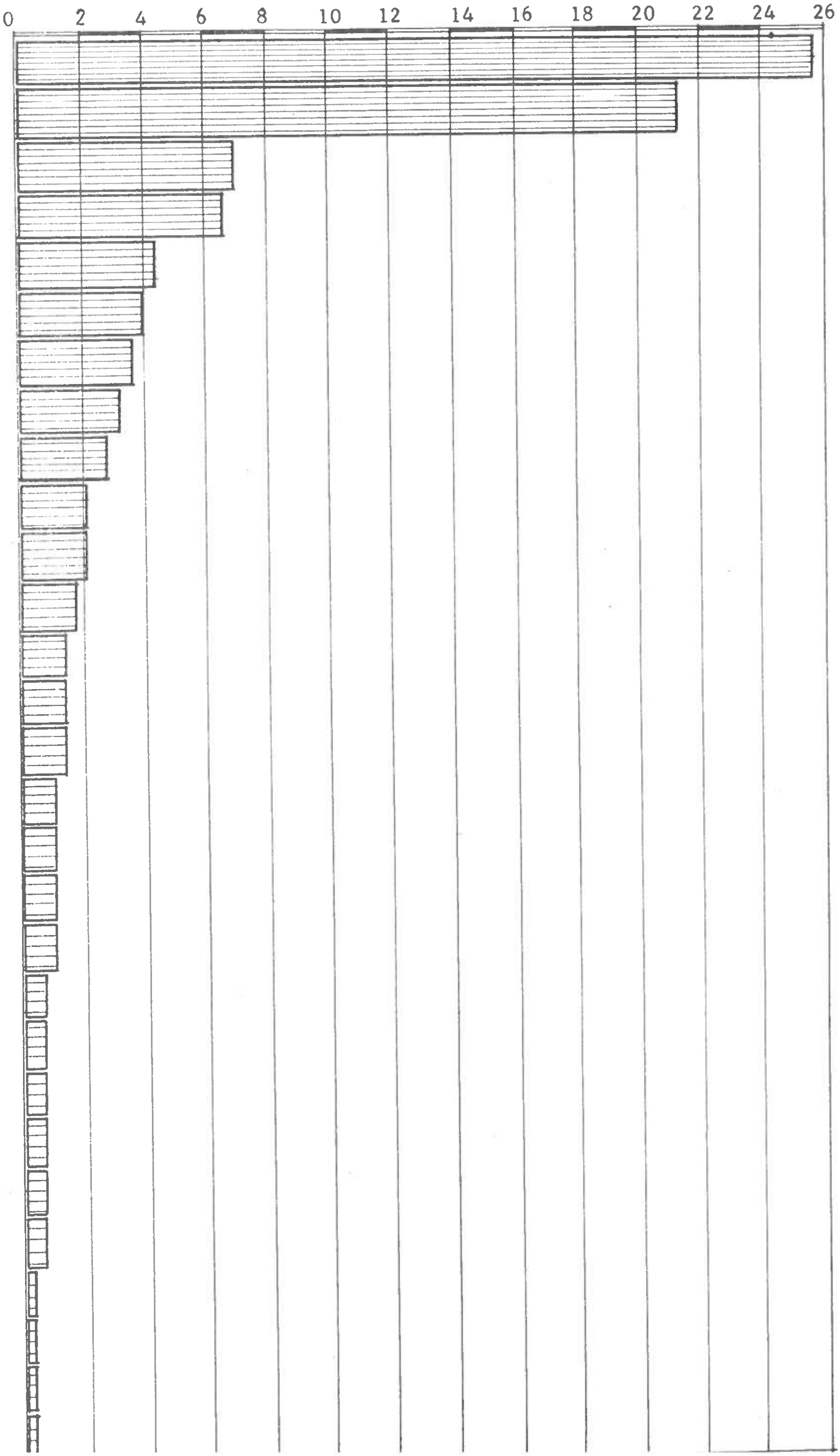


TABLE C-5

TIME REQUIRED FOR X-RAY EXAMINATIONS IN A HOSPITAL WITH A PREPAYMENT PLAN

	Daily Av. No.	Daily Av. %	Av. Unit Time Req'd.	Daily Av. Total Time Required	% of Total Time
1. Mini-film	70	25.8%	1.7 Minutes	119.0 Minutes	6.2%
2. Chest	58	21.3%	3.0 "	173.6 "	9.0%
3. Spine	19	7.0%	10.9 "	207.5 "	10.8%
4. Gastro Intes.	18	6.7%	11.6 "	209.5 "	10.9%
5. Barium Enema	12	4.4%	16.7 "	200.3 "	10.4%
6. Skull	11	4.1%	9.7 "	107.1 "	5.6%
7. Gall Bladder	10	3.7%	11.3 "	112.5 "	5.8%
8. Foot	9	3.3%	5.3 "	47.9 "	2.5%
9. Wrist	8	2.9%	7.2 "	57.3 "	3.0%
10. I.V.P.	6	2.2%	9.3 "	148.5 "	7.7%
11. Elbow	6	2.2%	5.7 "	34.2 "	1.8%
12. Ankle	5	1.8%	5.6 "	28.1 "	1.4%
13. Shoulder	4	1.5%	3.8 "	15.0 "	0.8%
14. Knee	4	1.5%	5.7 "	22.6 "	1.2%
15. Finger	4	1.5%	4.6 "	18.3 "	1.0%
16. Hand	3	1.1%	6.2 "	18.7 "	1.0%
17. Hips	3	1.1%	7.8 "	23.5 "	1.2%
18. Toe	3	1.1%	5.6 "	16.9 "	0.9%
19. Laminogram	3	1.1%	27.0 "	81.0 "	4.2%
20. Abdomen	2	0.7%	9.3 "	18.5 "	1.0%
21. Sinus	2	0.7%	11.1 "	22.2 "	1.2%
22. Ribs	2	0.7%	6.5 "	13.0 "	0.7%
23. Pelvis	2	0.7%	4.5 "	9.0 "	0.5%
24. Pylogram	2	0.7%	30.0 "	60.0 "	3.1%
25. Barium Swallow	2	0.7%	15.0 "	30.0 "	1.6%
26. Arm	1	0.4%	9.8 "	9.8 "	0.5%
27. Nose	1	0.4%	15.0 "	15.0 "	0.8%
28. Optic Forearm	1	0.4%	30.0 "	30.0 "	1.6%
29. Small Bowel	1	0.4%	14.0 "	14.0 "	0.7%
		100.0%			100.0%

TABLE C-6

TABLE SHOWING AVERAGE TIME PER PROCEDURE IN A HOSPITAL WITH A PREPAYMENT PLAN

	PROCEDURES	AVERAGE MINUTES
1.	Laminogram	27.0
2.	Barium Enema	16.7
3.	Gastro Intes.	11.6
4.	Gall Bladder	11.3
5.	Spine	10.9
6.	Skull	9.7
7.	I.V.P.	9.3
8.	Hips	7.8
9.	Hand	6.3
10.	Elbow	5.7
11.	Toe	5.6
12.	Pelvis	4.5
13.	Chest	3.0
14.	Mini-film	1.7

APPENDIX D

TABLE D-1

CHARACTERISTICS

COMMUNITY HOSPITAL

Year		Beds Available	Total Patient Days	Patients Discharged	Average Daily Census	% of Bed Utilization	Emergency Visits
1963		205	56,964	7,234	156.07	76.13	13,349
1962	Average	201.1	56,842	7,542	155.73	77.44	11,784
1961		211	54,709	7,672	149,89	71.04	9,787
1960		198	54,863	7,429	149.90	75.59	10,427
1959		210	56,295	7,809	154.20	73,40	10,481
1958		217	57,107	8,135	156.46	72.10	10,784
1957		201	56,697	8,355	155,30	71.60	11,619
1956		201	54,354	8,035	148.51	73.88	
1955		201	54,234	8,184	148.59	73.92	
1954		201	56,140	8,917	153,80	76.50	
1953		201	57,477	9,260	157.47	78,34	
1952		208	56,542	8,660	155.00	74.00	12,231
1951		187	52,783	7,987	144.60	77.00	11,086
1950			49,613		136.00	75.00	10,600
1949			43,533		119.20	66.00	9,458
1948			41,717		114.00	61.60	8,863

FIGURE D-1

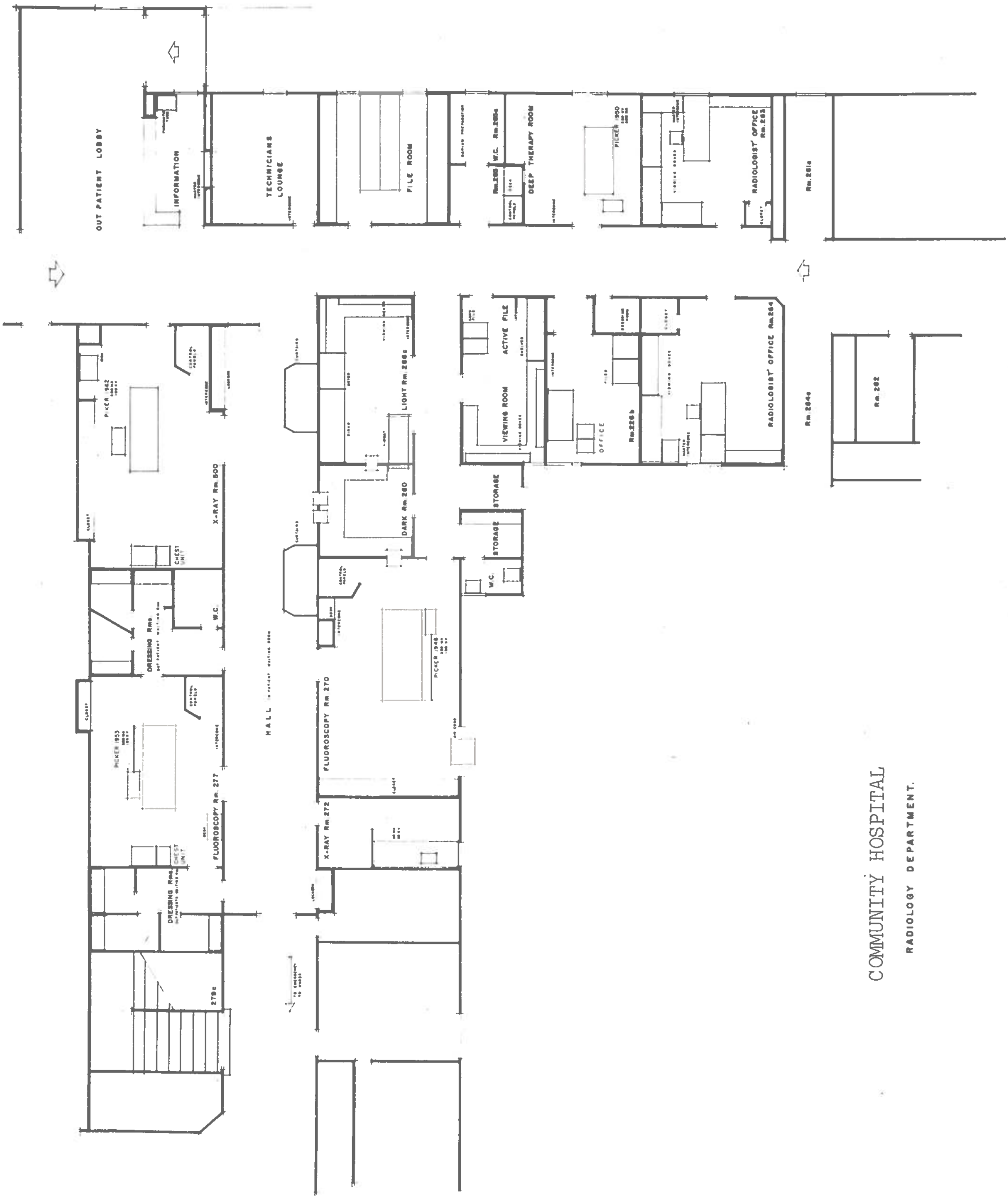

OUT PATIENT LOBBY
INFORMATION
TECHNICIANS LOUNGE
FILE ROOM
W.C.
DEEP THERAPY ROOM
RADIOLOGIST OFFICE Rm.263
LIGHT Rm.266c
ACTIVE FILE
VIEWING ROOM
OFFICE
RADIOLOGIST OFFICE Rm.264
Rm.262
X-RAY Rm.800
DARK Rm.260
STORAGE
STORAGE
W.C.
DRESSING Rms
W.C.
HALL
FLUOROSCOPY Rm.270
FLUOROSCOPY Rm.277
X-RAY Rm.272
DRESSING Rms
279c
COMMUNITY HOSPITAL
RADIOLOGY DEPARTMENT.

TABLE D-2

COMMUNITY HOSPITAL

LIST OF EQUIPMENT AND SUPPLIES

X-RAY ROOM 500

X-Ray Equipment as specified
sink
mirror
towel holder
wall clock
soap dispenser
wastebasket
wooden screen
chair
tape dispenser
two sets of glove hangers
coat hangers
portable hanger for intervenous bottles
foot stool
light control
X-Ray cones
ashtrays
thermometer
intercom
feather pillow
oxygen tank on two wheeled cart
laundry basket
thin rubber mat
thin plastic mat
matches
newspaper

control room
- -cassets (5 types and sizes)
- -bulletin board
- -instruction sheets
- -lead marker
- -procedure code
- -plastic timer
- -dental films

utility table
- -razor
- -scissors
- -lead pillows
- -2 foam rubber forms

supply closet
- -pharmaceutics (same as for 270)
- -other supplies
  - paper cups
  - cotton buds
  - surgical sponges
  - paper slippers
  - baywipes
  - straws
  - paper napkins
  - syringes
  - needles
  - strap for X-Ray table
  - stopcocks
  - emesis basins (1 steel and 1 plastic)
  - bowls
  - yardstick
  - various extra machine parts
  - felt marker
  - surgical lubricant (Lubafax)
  - catheter
  - towel
  - boxes
  - bed pan
  - extra oxygen tank
  - rubber-lead sheet for film protection
  - list of supplies

LIST OF EQUIPMENT AND SUPPLIES

DRESSING ROOMS

used laundry basket (outside dressing rooms, 1 for every 3 rooms)
seats
magazine holder
magazines and newspapers
mirror
ashtray on wall
bell connected to information desk
small wastebasket
curtains

IN-PATIENT WAITING AREA (Main Hall)

bell connected to information desk located on wall
two chairs
screen
two curtains on semi-oval rods which can be drawn for privacy
lockers for personnel
lockers for clean linens
boxes for requisitions
boxes for film envelopes
light control system

PHYSICIAN'S VIEWING ROOM

standard view boxes
viewing box for industrial films
card files
envelope files
working table
chair
stool
wastebasket
intercom
telephone
desk supplies
paper cutter

LIST OF EQUIPMENT AND SUPPLIES

X-RAY ROOM 270

X-Ray equipment as specified
wall clock
foot stool
tape dispenser
wastebasket
ashtrays
glove hanger
coat hanger
red lights
desk equipment (pencils etc.)
vertical bucky
chair with lead protection
intercom
lead coats
lead gloves
air conditioning
thermometer
X-Ray cones
pillow

control room
- -cassets (5 types and sizes)
- -bulletin board
- -instruction sheets
- -procedure code
- -lead marker

supply closet
- -pharmaceutics
  - hipaque
  - alcohol
  - methiolate
  - normal saline
- -other supplies
  - paper cups
  - cotton buds
  - surgical sponges
  - disposable tips for B.E.
  - light bulbs
  - paper slippers
  - baywipes
  - straws
  - napkins
  - enema bags
  - syringes
  - hypodermic needles
  - strap for X-Ray table
  - surgical lubricant
  - needle for spinal injection
  - yardstick

supply closet (continued)
- disposable face masks
- steel bowl
- oxygen tanks
- catheters
- skull
- 5 lead pillows
- clamps
- rubber tubes
- syringe needle protectors
- rubber gloves
- flashlight
- stopcocks
- disposable emesis basins
- renographin
- gastrographin
- R.C.A.
- electronic tubes and fuses for machine

LIST OF EQUIPMENT AND SUPPLIES

X-RAY ROOM 277

X-Ray equipment as specified
wall clock
chair with lead protection
feather pillow
wastebasket with foot control
glove hangers
coat hangers
ashtrays
ropes and pullies (hanging from ceiling)
pencil sharpener
common chair
foot stool
utility tray on wheels
vertical bucky
thermometer
light control system
intercom
X-Ray cones
tape dispenser
lead coats
container for used linen
red lamps
guerney sheets

control room
- cassets (5 types and sizes)
- bulletin board
- instruction sheets

supply closet
- pharmaceutics (same as for 270)
- other supplies
  - paper cups
  - cotton buds
  - surgical sponges
  - paper slippers
  - baywipes
  - straws
  - paper napkins
  - hyperdermic syringes
  - needles
  - strap for X-Ray table
  - stopcocks
  - emesis basins (plastic and metal)
  - surgical trays
  - yardstick
  - bedpan

Contents of Supply Closet Con't
- spinal fluid manometer
- catheters
- rubber gloves
- gauze pads
- air pump
- surgical lubricant
- disposable B.E. Tips
- special apparatus for Pneumo-encephalograms

utility table
- razor
- scissors
- lead pillows
- foam rubber forms

LIST OF EQUIPMENT AND SUPPLIES

DARK ROOM

2 sets of shelves for film storage
film marker
portable film marker
film hangers
telephone
Xomat
wastebaskets
film bins
ventilator
typewriter
film delivery boxes
film sinks
towels
3 red-lamps
box for used identification slips

STORAGE ROOMS

chair
portable X-Ray table
film supplies
2 containers of acid
2 wastebaskets
old film corner cutter
mop
bucket
various old X-Ray machine parts

LIST OF EQUIPMENT AND SUPPLIES

RECEPTION DESK

3 telephones
central intercom
electric signals from waiting hall
appointment book
daily sheet
master schedule book
various rubber stamps
box for old fluoroscopy exams
1 typewriter
1 typewriter table
lost of examination costs
new requisition forms
old requisition forms
wastebasket
patient information forms
scotch tape
slips for extra examinations
stapler
ashtrays, cigarettes etc.
doctor's call list
phone books
note pad
pils and instruction sheets for fluoroscopy patients
requisitions (both blanks and partially completed)
desk supplies (pens, pencils, etc.)
pneumatic tube station
box for filing patients' bills

LIST OF EQUIPMENT AND SUPPLIES

DRY ROOM

Wall Clock
pipe to clean Xomat
small crane over Xomat
foot stool
film sinks
film dryer
film hangers
standard viewboxes
bulletin board
blackboard
special viewing lamp
shelf for filing envelopes
- envelopes containing films for fluoroscopy patients
- films to be read by Radiologist I
- films to be read by Radiologist II
- X-Ray envelopes

shelf for general storage
telephone
intercom
wastebasket
ashtray
assorted desk supplies
- pencil sharpener
- identification slips
- scotch tape
- markers
- ruler
- glue
- colored tapes used for filing purposes

consultation books
signal button to main hall used to signal the completion of films
cardboard 'viewer' for facilitating eye adaptation

TABLE D-3

COMMUNITY HOSPITAL

X-RAY FEE SCHEDULE

HEAD

Skull	$30.00
Encephalogram, ventriculogram	60.00
Mastoids	30.00
Sinuses, orbits	22.50
Facial bones	25.00
Nasal bones	15.00
Routine mandible (incl. lateral laminagrams of T-M joints).	30.00
Temporomandibular joints	30.00
Salivary glands, plain films	15.00
Teeth, full mouth	20.00
Teeth, upper or lower	15.00
Teeth, single area	10.00

SPINE

Cervical	25.00
Lumbosacral	30.00
Thoracic	17.50
Coccyx and sacrum	17.50
Complete spine	55.00
Cervical and dorsal	37.50
Cervical and lumbar	45.00
Dorsal and lumbar	35.00
Lumbo-dorsal junction	15.00
Myelogram, one area	45.00
Myelogram, more than one area	60.00

EXTREMITIES

Finger, toe	10.00
Hand, wrist	12.50
Os calcis, ankle, foot	15.00
Ankle and foot	20.00
Forearm, humerus, elbow, tibia	15.00
Femur	15.00
Shoulder, scapula, clavicle	15.00
Pelvis and/or hips	17.50
Hip-nailing	40.00
Extremities in surgery (port.) add	7.50
Knee	15.00
Leg length	25.00
Both hands, arth., PA only, on 1 film	10.00

VASCULAR

Cerebral angiography with serialograms:	
unilateral	100.00
bilateral	150.00
Femoral or brachial arteriography	50.00
Aortography, without serialograms	50.00
with serialograms	75.00
Venography	40.00

CHEST

Chest or heart, PA and lateral	$15.00
Third film	20.00
Fourth film or fluoroscopy	25.00
Fifth & subsequent films, ea., add	2.50
Bronchograms	40.00
with anesthesia	50.00
Mammography	30.00
Ribs or sternum	20.00
Ribs, bilateral	25.00
Ribs and sternum	30.00
Ribs and chest	30.00

ABDOMEN

Abdomen or KUB	17.50
Abdomen, 4 film	27.50
Retrograde pyelograms	35.00
Cystograms	30.00
Intravenous urograms (I.V.P.)	37.50
Cholecystograms.	25.00
Intravenous common duct series	45.00
Utero-salpingograms	25.00
Direct cholecystograms	35.00
Pelvimetry and placentography	25.00
Scout film in surgery	15.00
Cholecystogram, repeat	15.00

G.I. TRACT

Esophagus or barium swallow	25.00
G. I. Series	35.00
Small bowel series with G. I.	50.00
Barium enema	30.00
Barium enema plus air contrast	40.00
Soft tissue neck	15.00
Small bowel study only.	40.00
Miller-Abbot tube fluoroscopy	25.00

SPECIAL SERIES

Metastatic survey (skull, chest, abdomen, pelvis)	35.00
Bone age survey (lateral skull, 1 hand, 1 knee)	15.00
Bone age (single PA film left hand and wrist)	10.00
Mouth to anus survey for FB in child	15.00
Fluoroscopy only, without films	10.00

SPECIAL EXAMINATIONS

Laminagrams	35-50.00
Extended use of diagnostic room per hour	25.00
Bedside films add	10.00
Films in surgery add	7.50
Night rate add	5.00

BIBLIOGRAPHY

Anderson, U.M., and Graubau, A. "Routine Tuberculin Testing in Infants and Young Children," American Journal of the Diseases of Children, 111:31-34, January 1966.

Blumberg, Mark S. "Electronics Can Expand X-Ray Capability," The Modern Hospital, November 1964, p. 14.

Bordonare, Albert J. "The Rational Approach to Charges," Hospital Topics, January 1963, pp. 54-59.

Brueschke, Erich, et al. "Infrared Thermoprofile Analysis in Clinical Medicine," The American Journal of Medical Electronics, April-June 1965, pp. 65-67.

Cadmus, Robert R. "Efficient Layout of the Radiology Department," Hospitals, 40:63-70, May 1, 1966.

Chapanis, Alphonse. Research Techniques in Human Engineering. John Hopkins Press, 1959.

Commission on Professional and Hospital Activities. "Frequency of Laboratory Tests and X-Rays," The Record, Vol. 2, No. 3, July 1, 1964.

Commission on Standards in Radiologic Practice. Manual of Radiology Department Administration. Chicago: American College of Radiology, 1964.

Donaldson, S.W. "The Practice of Radiology in the United States: Facts and Figures," American Journal of Roentgenology and Radium Therapy, 66:929-946, December 1951.

Donaldson, S.W., and La Vielle, Carroll J. "A Supplementary Report to 'The Practice of Radiology in the United States: Facts and Figures'" American Journal of Roentgenology, Radium Therapy and Nuclear Medicine, June 1959, pp. 1-8.

Flagle, Charles D., et al. (eds.). Operations Research and Systems Engineering. John Hopkins Press, 1960.

Gershon-Cohen, J. "Contrast Enhancement with Television Technics: Gallbladder Lesions," Radiology, 70:390-391, March 1958.

Gershon-Cohen, J., and Cooley, A.G. "Telognosis, Telephone Transmitted X-Ray Facsimiles as Used During Past Eight Years," ACTA Radiologica Inter-Americana, 6:75-77, No. 2, 1956.

Gitlin, J.N., and Lawrence, P.S. Population Exposure to X-Rays: U.S. 1964. U.S. Public Health Service Publication 1519.

Hospital Review and Planning Council of Southern New York, Inc. Impact of Medicare on the Demand for and Financing of Health Facilities and Services in Southern New York. August 1965.

Linder, Forrest E. "The Health of the American People," Scientific American, 214:21-29, June 1966.

Lindheim, Roslyn. "Putting Research to Work," A.I.A. Journal, February 1966.

McCormick, E.J. Human Factors Engineering. New York: McGraw-Hill, 1957.

Medical Economics, "The Big Sleeper in the Medicare Law," January 24, 1966, p. 110.

Moore, J.M. Plant Layout and Design. New York: Macmillan Co., 1962.

Nadler, Gerald. Work Design. Homewood, Ill.: R.D. Irwin, Inc., 1963.

The National Advisory Committee on Radiation. Report to the Surgeon General on Protecting and Improving Health Through the Radiological Sciences. Chicago: American College of Radiology, April 1966.

New York Times, "Mass Testing for TB is Planned in Schools to Wipe Out Disease," January 20, 1965.

The Nuffield Provincial Hospitals Trust. Towards a Clearer View: The Organization of Diagnostic X-Ray Departments. Oxford University Press, 1962.

Picker X-Ray Corporation. Handbook for Hospital X-Ray Department Planning. White Plains, New York.

Potsaid, Majic S., et al. "Computer Analysis of Radiographs," Medical Science, March 1966, pp. 35-42.

Present, Arthur J. "How Much Radiology Should Hospitals Do?" Modern Hospital, Vol. 101, September 1963.

Reeves, John D. "Progressive Patient Care in Radiology," Radiology, Vol. 73, November 1959.

Robbins, Laurence L. "Future Trends in Radiology," Hospitals, May 5, 1965, pp. 68-72.

Scott, Wendell G., et al. Planning Guide for Radiologic Installations. 2d ed. Baltimore: Williams and Wilkins Co., 1966.

Shapiro, Sam, et al. "Evaluation of Periodic Breast Cancer Screening with Mammography," Journal of the A.M.A., 195:731-738, February 28, 1966.

Steinle, John G. "How Many Examining Rooms Should Normally be Provided for the X-Ray Load of the Hospital?" Hospital Topics, April 1965.

Taylor, Wilbur R., et al. "Diagnostic X-Ray Suites for the General Hospital," Architectural Record, October 1959, pp. 217-224.

Tibbitts, Samuel J. "Relations Between Hospital-Based Specialists and Hospitals," Hospital Forum, June 1966, pp. 17-18, 27.

U.S. National Health Survey. Volume of X-Ray Visits, United States, July 1960-June 1961. U.S.P.H.S. Publication No. 584-B-38, October 1962.

U.S. Public Health Service. Hospital Profiles: A Decade of Change, 1953-1962. U.S.P.H.S. Publication No. 930-C-7, March 1964.

Unkelbach, M.J. "The Challenge of Portable Radiography," Hospital Progress, February 1966, pp. 40-50.

Wall Street Journal, "TB Attack: Test on Mountaineers in Kentucky May Help End the Disease in U.S.," November 2, 1965.

Wall Street Journal, "A.M.A. Delegates Call for Hospital Boycotts by Some Specialists," July 1, 1966.

Wall Street Journal, "And Now 'Medicaid': Seeping Health Plans Open to All Age Groups May Dwarf Medicare," July 11, 1966.

Westman, Curt E. "Planning New Diagnostic Departments," British Journal of Radiology, Vol. 35, April 1962, pp. 265-268.

Wheeler, E. Todd. Hospital Design and Function. New York: McGraw-Hill, 1964.

Yerushalmy, Jacob. "Recent Developments in Applications of Statistics to Tuberculosis Control Programs," Proceedings of the International Statistical Conferences, Vol. III, 1947, pp. 576-592.

Yerushalmy, Jacob. "Problems in Radiological Interpretation," California Medicine, Vol. 70, January 1949, pp. 1-5.

Yerushalmy, Jacob. "The Reliability of Chest Roentgenography and Its Clinical Implications," Diseases of the Chest, Vol. 24, August 1953, pp. 133-148.

Yerushalmy, Jacob. "The Reliability of Chest Radiography in the Diagnosis of Pulmonary Lesions," American Journal of Surgery, Vol. 89, January 1955, pp. 231-240.

Yerushalmy, Jacob. "The Importance of Observer Error in the Interpretation of Photoflurograms and the Value of Multiple Readings," International Tuberculosis Yearbook, 26:110-124, January-April 1956.