A SIMULATION ANALYSIS OF A HOSPITAL EMERGENCY DEPARTMENT

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ABSTRACT

This paper describes the application of a FORTRAN simulation model in evaluating the potential influence of new patient demand patterns and different administrational decision policies upon the effectiveness of a hospital emergency department. In particular, the study investigated the consequences of increased demand, a higher percentage of true emergency patients, installing laboratory and x-ray facilities in the emergency department, triaging patients and scheduling non-urgency patients to smooth the demand. Total patient time in the system, times until first seen by a nurse and physician, and staff utilization percentages were used as measures of effectiveness.

INTRODUCTION

It has been estimated that emergency department visits have increased nationally by 312% from 1954 to the present. This is a larger growth than for any other index of hospital utilization. While emergency department visits accounted for less than one-fifth of all outpatient visits in 1954, by 1969 they accounted for more than one-third. (2).

There are many reasons for this exponential growth. First, there has been an ever-increasing concentration of low-income groups in large urban areas. These groups tend to rely on the hospital serving their area to provide a gamut of services ranging from treatment for colds to intensive care for coronary cases and accident victims. The hospital is needed to provide this broad range of care because of the scarcity of general practitioners. This scarcity is presumably due to the present tendency of physicians to specialize and the proclivity of physicians to move to suburban areas. (5).

In addition, the presence of third-party payers has in many cases rendered emergency department care cheaper for the patient than private physician care. The emergency department has the added advantage of being open 24 hours a day. This, coupled with the disinclination of private physicians to make house calls or evening appointments, is an important drawing card for the emergency department.

Since the large influx of emergency department patients is not primarily caused by an increase in emergencies or accidents, the corresponding percent of true emergencies in the emergency department has been decreasing. In 1966 the Division of Medical Sciences of the National Academy of Sciences reported that more than 2/3 of the 40 million emergency room visits in 1966 cannot be classified as emergencies. (5).

In particular, Springfield Hospital Medical Center has experienced a 44% increase in emergency service patients from 1967 to 1971. A study of three weeks of outpatient records revealed that only 9% of the emergency services patients were true emergency cases. The situation at Springfield was exacerbated by an outmoded facility consisting of one 4-bed room and two 1-bed rooms. It was not uncommon for patients to be treated in the hallways. In addition, the emergency department had no lab or x-ray facility of its own. Emergency services patients had to compete with inpatients for lab and x-ray tests, and the laboratory and x-ray were not conveniently located for the emergency services patients.

In October, 1972, a new emergency unit was opened. This unit is five times larger than the former facility and features a number of special treatment rooms and a holding unit for observing patients whose condition has not yet stabilized. An x-ray is included in the new unit and a laboratory is being contemplated.

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PURPOSE OF STUDY

The primary purpose of this investigation was to predict the effects of various perturbations, both controllable and uncontrollable, upon the emergency services system at Springfield Hospital. Examples of uncontrollable alterations are changes in patient demand and in the mixture of patient types. It is important to classify the clientele according to patient type since it was determined that true emergency patients require significantly more care than the other types in addition to requiring immediate service. Thus, congestion is a function of patient composition. Naturally, increased patient demand, another input not under the control of the administrator, will cause more congestion in the system.

Controllable perturbations are ones which result from policy decisions made by the administrator. The decision to install an x-ray room and/or a laboratory in the emergency department will reduce the patient waiting time in these facilities. Another controllable change in the system is the administrative decision to employ a triage nurse who would separate non-urgency patients from the emergency and urgency patients. The non-urgency patients would in turn be sent to a separate clinic which may or may not be part of the emergency department. Hence, the personnel and facilities intended for critical patients could concentrate on them solely.

The smoothing of non-urgency demand over the course of the day is yet another controllable change. There are different mechanisms for smoothing. The least dictatorial is persuasion, whereby the patient would be informed that he will receive more prompt service by arriving at certain times of the day. If the administrator wishes to be more autocratic (and undoubtedly have more effect on demand), the non-urgency patient could be compelled to arrange for an appointment.

DESCRIPTION OF DATA COLLECTION

Before completely formulating the model, a data collection procedure was organized, and the data were analyzed. Due to the very congested working conditions for both physicians and nurses, it was felt that the presence of additional personnel for the purpose of data collection would cause excessive confusion. Therefore, the receptionist and the nurses were recruited and paid for collecting the data. To minimize the effort on the part of the nurses, we located automatic date-time stamping machines at key positions in the facility. One machine was placed in the receptionist's office, one in each of the two one-bed treatment rooms, and two in the four-bed treatment room.

When the patient arrived, the receptionist stamped the arrival time and recorded the sex and the outpatient record number on a card. This card was retained by the patient until he was discharged from the emergency department or admitted to the hospital. When a nurse serviced the patient, she recorded the time at the beginning and end of the service. In some cases more than one nurse serviced the same patient simultaneously; also, some patients required more than one service from the same nurse, and these were all recorded. Nurses also recorded the start and finish of all physician services. When a patient required a lab or x-ray test, the time of departure (to the hospital proper) and the time of return was noted on the card by a nurse. The receptionists relieved the patient of his card upon discharge and recorded the discharge time. Since no formalized triage procedure existed, determination of patient type (emergency, urgency, non-urgency) was made post facto by the Director of Emergency Services.

We are confident of the accuracy of the data for the following reasons:

(1) The nurses were provided with financial incentive for their extra effort required to collect the data. In general, they were quite enthusiastic and conscientious in their efforts.

(2) A member of our research team was available at the emergency department in the event that any questions or problems arose.

(3) The number of data cards was very close to the number of patients recorded on the emergency department outpatient records. This demonstrated that nearly all arrivals had been noted.

(4) Although a few service completion times were missing during the first day, over 98% of these times were recorded in subsequent days.

The data collection period consisted of the eight-hour shift from 7:00 a.m. to 3:00 p.m. on July 26-28, July 31, and August 1, 1972. These were all weekdays. Financial and operational considerations precluded a longer collection period and the weekend was excluded since, historically, the emergency department has had a lower demand on weekends. We don't feel that this is a serious drawback, however, since only service times have to be collected by direct observations and these probably will not vary significantly on an hourly, daily, or seasonal basis. Quantities such as arrival rates and patient-type percentages, which will show this type of variation, can always be collected retrospectively from outpatient records.

ANALYSIS OF DATA

In order to analyze the arrival data, each 8-hour day was subdivided into 1-hour intervals. An analysis of variance model was then used to test for significant hour and day effects. (3). It was determined that arrival rates do not differ significantly according to day of week but do differ significantly according to hour of day. Table 1 presents the number of arrivals by hour and day.

Since arrival rates differ according to patient type and since it was desirable to test the option of controlling non-urgency arrival rates, it was decided to generate arrivals according to number of arrivals per patient type for each hour of the day. The hourly interarrival times for each patient type were found to fit the exponential distributions with the mean varying according to hour of day and patient type. The exponential hypothesis was corroborated by using the Kolmogorov-Smirnov test at the 0.01 level to show that the arrivals during the course of each 1-hour period were independent and uniformly distributed during the period. (6).

The service time distributions (for first nurse service and first physician service) were found to be lognormally distributed. This was verified by a chi-square goodness of fit test at the 0.05 level. (4).

SIMULATION MODEL ASSUMPTIONS

The following are some of the more important assumptions made in the construction of the computer simulation model. These assumptions were based on the characteristics of patient flow in the system.

(1) There are three types of patients (emergency, urgency, and non-urgency) entering the system.

(2) Emergency patients have first priority followed by urgency patients and then non-urgency patients. This means that regardless of order of entry to the emergency department, emergency patients will be serviced first. After all emergency patients have been serviced, the urgency patients will be serviced, followed by the non-urgency patients.

(3) Emergency patients have preemptive priority. This means that service of non-urgency patients and urgency patients will be interrupted in that order to tend to emergency patients. Urgency patients do not preempt non-urgency patients.

(4) The patient always sees the nurse first. Although the next service for the patient may be another nurse visit, each patient is always treated by a physician.

(5) A second physician service is required in the event of laboratory or x-ray tests.

(6) Sometimes a second nurse service is required. The probability of a second service differs according to whether or not a second physician service is required.

(7) Physician and nurse services may occur simultaneously. In view of the possibility of second services, this means that either the physician or the nurse service may commence first and either may end first during this period of overlapping services.

(8) There is never more than one nurse treating a patient at any specific time; there is never more than one physician treating a patient at any specific time.

(9) If a patient receives two physician (or two nurse) services, they are always performed by the same physician (or nurse).

These assumptions are generalizations derived from the data collection. Although some of them were not invariably true, we felt that their omission would have unnecessarily complicated the model with little gain in portraying reality.

VALIDATION OF SIMULATION MODEL

This study relied on the most common validation process, which consists of demonstrating that the computer model produces results (values for the output variables) similar to those obtained in the week of data collection when the same input values are used.

In our study we encountered a problem in the validation process. Initially the model was not reflecting the high level of congestion in the system. One reason for this was the procedure used for collecting statistics at the end of each day. A "day" was defined as an eight hour shift, and the 7:00 a.m.-3:00 p.m. shift was simulated because that period was the most congested. Initially, statistics were not collected for patients already in the system whose service hadn't been completed at the end of the eight hours. Consequently, the resulting congestion was not representative of the actual system because the statistics were lost for patients who frequently had long service times.

This situation was remedied by running the simulation for several days and not collecting the data until the end of the simulation. The decision produced realistic results since the arrival rates at the beginning of the 7:00 a.m.-3:00 p.m. shift were typically quite low. Hence the system didn't become unrealistically congested as a result of patients from the previous day.

Once the model was running with the proper statistical collection procedures, various values for "busy time" were inserted in the model in order to reproduce the congestion actually measured in the emergency service. "Busy time" is assigned to each physician and nurse at the conclusion of each patient service. This time is for the purpose of cleaning up, filling in patient records, etc. A time was also inserted between the arrival of each patient and the time he would be ready for treatment by a nurse. This accounts for the time spent with the receptionist.

"Busy time" was not measured directly. However, since all other critical data were collected by actual observation, we felt justified in selecting busy times so as to obtain the most accurate model.

The "busy times" selected were probabilistic with a mean of 3.5 minutes and a variance of 1.9 minutes for physicians and a mean of 10.2 minutes and a variance of 8.1 minutes for nurses. These times appeared intuitively correct to the staff, but obviously the lack of hard data on "busy times" is a weakness of the study. These times should be collected directly in the future but we note that such an effort would probably require the use of expensive, awkward and unpopular time-study techniques.

The data collected last summer failed to distinguish any difference between urgency and non-urgency patients in terms of service time, waiting times to see the nurse and physician, or time in the system. Yet the simulation model, with its built-in priority system, reflected significant differences in waiting times and time in the system for these two types of patients. Moreover, the values for the urgency patients were higher than they should have been, and those for the non-urgency were lower. The discrepancy between the actual and predicted results was apparently due to the fact that, operationally, the nurses did not distinguish between urgency and non-urgency patients.

The obvious recourse was to incorporate the urgency and non-urgency patients into one patient class, thereby reducing the number of patient types to two. Once this was done, the resulting values in the simulation model for waiting times and time in the system were commensurate with those obtained in the data collection. Different random number seeds and different lengths (in terms of days) were utilized in the usual manner in order to determine the point at which the results were relatively invariant with respect to increased duration of the simulation and different seed numbers.

The accuracy of the computer model in reflecting the actual system is evident in Tables 2 through 6. Tables 2 and 3 demonstrate how close the simulation output variables are to those observed in the data collection, and Tables 4-6 verify that the service distributions input into the computer are actually being assigned properly. In all cases, the hypothesis that the means were equal was accepted at the 0.05 level using a Z statistic having a sampling distribution which is (approximately) the standard normal distribution. (4).

DESCRIPTION OF SIMULATION MODEL

The computer model is a next event stochastic simulation written in FORTRAN IV. In the initial construction GASP II was considered but eventually disregarded due to the special nature of the model and the need to conserve core space.

Although the model is of a multi-state queuing nature, it is unique in that a patient can be serviced simultaneously by both a physician and a nurse. These must be considered as independent services as they need not start nor end at the same time. In fact, it is possible for a physician service to overlap two separate nurse services.

The model is further complicated by the fact that a patient may be undergoing a service while waiting in a queue for a different type of service. An example of

TABLE 1

Arrivals by Hour and Day

	Monday	Tuesday	Wednesday	Thursday	Friday	Total
7:00-7:59	2	1	1	0	5	9
8:00-8:59	4	3	6	3	0	16
9:00-9:59	8	4	7	4	5	28
10:00-10:59	6	7	9	6	4	32
11:00-11:59	7	3	7	11	7	35
12:00-12:59	13	9	8	8	8	46
1:00-1:59	9	10	12	11	10	52
2:00-2:59	10	3	6	6	8	33
Total	59	40	56	49	47	251

TABLE 2

Comparison of Output Variables
(Non-emergency Patients)

	Actual System	Computer Model
Av. Waiting Time for 1st Nurse Service	16.88	15.79
Av. Waiting Time for 1st Physician Service	29.10	30.83
Av. Total Time in System	59.03	57.32

All times are in minutes.

TABLE 3

Comparison of Output Variables
(Emergency Patients)

	Actual System	Computer Model
Av. Waiting Time for 1st Nurse Service	4.6	3.99
Av. Waiting Time for 1st Physician Service	7.8	4.49
Av. Total Time in System	70.1	64.97

All times are in minutes.

TABLE 4

Comparison of Input Variables
(Non-emergency Patients)

	Actual System	Computer Model Results
Av. Nurse 1st Service Time	6.0	5.61
Av. Nurse 2nd Service Time	4.8	4.04
Av. Physician 1st Service Time	9.9	9.63
Av. Physician 2nd Service Time	6.9	6.31

All times are in minutes.

TABLE 5

Comparison of Input Variables
(Emergency Patients)

	Actual System	Computer Model Results
Av. Nurse Service Time	18.7	21.52
Av. Physician Service Time	29.1	30.63

TABLE 6

Lab and X-Ray Comparisons

	Actual System	Computer Model Results
Av. Time Required for Lab	47.6	46.72
Av. Time Required for X-ray	51.6	49.98

this situation would occur when a patient is presently being serviced by a nurse and, in addition, requires a physician service although a physician or the physician is unavailable. Another complication occurs when a patient must wait in two separate queues (physician and nurse) or when a service is preempted because of the arrival of an emergency patient.

The simulation program contains two main files, a next event file and the queue file. The next event file can contain multiple entries of up to 18 different types of events. A coding system is employed which allows a patient to be entered as undergoing a service in the next event file while simultaneously waiting for a different type of service in the queue file. This system also allows for the updating of requests for different types of services while a patient is waiting in the queue file.

Upon entering the system, each arrival is coded with respect to the numbers and types of services that will be required. Although the actual flow is too complex to describe in detail in this paper, some insight can be gained by observing the basic types of flows. For the purpose of the discussion, it will be assumed that there are two basic flows. The first includes one physician service and one or two nurse services. The second includes a laboratory and/or x-ray service, two physician services and one or two nurse services.

The general sequence of events for the first type of flow can be described as follows. An arrival to the system first incurs a receptionist wait after which a first nurse request time is generated. The nurse service is then initiated at or after this request time depending upon the availability of a nurse. If a second nurse service is required, the request time is generated at the completion of the first nurse service. The physician request time is generated when the first nurse service is initiated and otherwise is independent of the nurse service or services. Upon completion of all services, the patient exits from the system.

The second type of flow is initially similar to the first except that upon completion of both the first nurse and physician services the patient is scheduled for a laboratory and/or x-ray service. Upon completion, the request time, or times, for the second physician and second nurse service, if required, are generated. As before, when all services are complete, the patient exits from the system.

It should be noted that each nurse and each physician are treated as separate servers rather than as two multiple servers. This is necessitated by the requirement that all second services be performed by the identical nurse or physician and also allows for the collection of individual statistics.

The input variables to the simulation include:

- the number of nurses and physicians,
- probabilities of laboratory and/or x-ray services,
- probability of second services,
- random number seed and duration of simulation,
- distributions by patient type of hourly arrival rates, first nurse service, second nurse service, first physician service and second physician service,
- distributions of laboratory and/or x-ray service, preemption increment, and request times,
- the occurrence and duration of nurse and physician breaks.

The format of the input has been constructed such that all service times, arrival rates and request times can be treated as distributions or histograms.

The output from the simulation includes pertinent input information in addition to statistics on the following variables:

- times for first and second nurse and physician services.
- waiting times prior to first nurse

and physician services.

- times for laboratory and x-ray services.

- total time in system.

- number of patients in system.

- nurse and physician utilization.

In addition, almost all the above statistics are output according to patient type.

The simulation was programmed on the UMASS time share system which employs a CDC 3600 as a central processor. Simulation times are very sensitive to the number of nurses and physicians and the level of congestion within the system. Run times averaged 10 seconds of central processor time per eight hour day for a system with four nurses and three physicians under congested conditions.

RESULTS

For all computer runs to be discussed, the nurse and physician service times are those resulting from the data collection and the validation procedure. The data collection also revealed the following probabilities for each patient:

prob. of an x-ray only .20

prob. of a lab test only .05

prob. of both an x-ray and a lab test = .05

prob. of a second nurse service given that there is a second physician service = .35

prob. of a second nurse service given that there is no second physician service = .10

It is assumed in the model that all physicians and nurses are given a 15-minute break in the morning and afternoon and a 30-minute break for lunch.

Initially, there are 3.6% emergency patients, 45.5% urgency patients, and 50.9% non-urgency patients. Whenever the percent of emergency patients was increased, the ratio of urgency to non-urgency patients remained the same.

For the different cases that were considered, there was very little difference in the waiting times or in the average time in the system for emergency patients. This is due to the preemptive priority which they are accorded. Consequently, the congestion in the system can be detected primarily from the waiting times and time in system of urgency and non-urgency patients (together called non-emergency patients).

In Table 7, the input conditions for each of 15 runs are described. Tables 8 and 9 present the resulting output for each of these runs. The following is a discussion of this output.

Run 2 indicates the effect of adding an x-ray room to the emergency department. The total average time for an x-ray decreases to about 15 minutes, and the average time in the system for non-emergency patients decreases by about 5 minutes. The overall improvement is a modest one but is quite significant for the 20% of emergency services patients requiring x-rays. An x-ray unit was installed during the course of the study and so runs 3 to 15 assume a 15-minute average x-ray time.

Runs 3, 4, and 5 demonstrate the non-linear effect of increased demand upon waiting times. A 10% increase has an almost imperceptible effect, but the 21% and 33% increases (representing a 10% increase in demand over two years and three years respectively) cause considerable congestion. For a 33% increase in demand, the average overall time in the system for non-emergency patients increases by almost 45 minutes or by 85%.

Runs 6 and 7 indicate that doubling or even tripling the percent of emergency patients doesn't add significantly to the congestion. In Run 8, however, when a slight increase in demand occurs in addition to the tripling of emergency patients, the system becomes intolerably crowded. Run 9 demonstrates that this congestion would be alleviated appreciably by adding a physician and nurse to the system.

A comparison of Runs 10 and 11 indicates that the installation of a laboratory in addition to the new x-ray room will have nearly the impact of hiring an additional physician and nurse. Although the waiting times for a physician and nurse are considerably longer in the former case, the overall average time in the system for non-emergency patients is increased only by approximately 5 minutes.

Run 12 demonstrates the influence of triaging (specifically, detecting the distinction between urgency and non-urgency patients) upon the waiting times and the time in the system. After comparing Run 12 with Run 2, it appears as if the decrease in waiting time experienced by urgency patients is about equal to the increase experienced by non-urgency patients. This result is intuitively reasonable since there are approximately the same number of urgency and non-urgency patients. The triaging capability appears desirable, however, since it is more important to treat the urgency patient promptly as opposed to the non-urgency patient.

TABLE 7

Contents of Each Run

Run	
1	the conditions at the time of the data collection
2	the conditions at the time of the data collection except that the x-ray wait has been decreased to a 15-minute average (the previous average was 51.57 minutes)
3	the same as Run 2 except the overall demand has been increased by 10%
4	the same as Run 2 except the overall demand has been increased by 21% (10% compounded over 2 years)
5	the same as Run 2 except the overall demand has been increased by 33% (10% compounded over 3 years
6	the same demand as Run 2 but the percent of emergency patients has doubled from 3.6% to 7.2%
7	the same demand as Run 2 but the percent of emergency patients has tripled from 3.6% to 10.8%
8	the percent of emergency patients if 10.8% and the demand has increased by 10%
9	the same as Run 8 except a physician and nurse have been added to the system (there are now 4 physicians and 5 nurses)
10	the same as Run 2 except the lab wait has been decreased to a 16-minute average (the previous average lab wait was 53.85 minutes)
11	the same as Run 1 except that a physician and nurse have been added to the system (there are now 4 physicians and 5 nurses)
12	the situation in Run 1 with the triaging capability to distinguish between urgency and non-urgency patients
13	Run 12 with the pattern of non-urgency arrival altered so as to smooth the overall demand throughout the day
14	The facility has been split into two portions. One part is the emergency department which services only emergency and urgency patients and has 2 physicians and 2 nurses. The other section is a clinic with 1 physician and 2 nurses which services only non-urgency patients. The personnel in each section are not allowed to help out in the other section. Otherwise the inputs are the same as in Run 2.
15	the same as Run 14 except the demand for the non-urgency clinic has been smoothed throughout the day

A comparison of Runs 12 and 13 illustrates that the waiting times and time in system for non-urgency patients are reduced dramatically when the non-urgency patients arrive at the same rate for each hour of the day. The average amount of time that non-urgency patients wait for a physician can be reduced by almost 50% (46.63 to 25.35).

Run 14 demonstrates the effect of dividing the emergency department into two separate services, one for emergency and urgency patients (with two physicians and two nurses) and one for non-urgency patients (with one physician and two nurses). This run can be compared with Run 12, which has the same arrival distribution and the same overall staffing as Run 14. It is clear that both urgency and non-urgency patients will be affected adversely by the division. The average time in the system for urgency patients rises from 42.86 to 97.10 (about 103%), and the average time in the system for non-urgency patients rises from 72.92 to 84.42 (about 16%).

Run 15 represents the same situation as Run 14 except that the arrival rates for non-urgency patients have been smoothed so that there is a constant demand throughout the day. The total number of non-urgency arrivals is the same, however.

TABLE 8

Runs		1	2	3	4	5	6	7	8	9	10	11
Av. Waiting Time for 1st Nurse	Emerg.	3.99	3.88	4.09	4.04	4.12	3.92	3.93	3.82	3.92	3.81	3.88
	Non-Emerg.	15.79	17.11	24.32	39.58	46.22	18.53	21.78	33.30	14.44	16.30	12.66
Av. Waiting Time for 1st Physician	Emerg.	4.44	4.39	4.57	4.55	4.64	4.39	4.41	4.32	4.49	4.39	4.35
	Non-Emerg.	30.83	32.54	42.00	61.11	77.00	34.61	39.59	83.56	21.25	26.07	17.43
Av. Time in System	Emerg.	70.82	62.39	66.79	64.83	76.76	57.02	62.02	66.14	61.41	56.87	55.07
	Non-Emerg.	57.32	52.65	62.11	80.02	96.89	55.00	60.54	105.64	41.42	44.83	39.04
Av. No. in System		6.49	5.97	8.03	11.69	15.04	6.66	7.08	13.29	5.50	4.87	4.63

TABLE 9

Runs		12	13	14	15
Av. Waiting Time for 1st Nurse	Emerg.	3.72	3.86	4.07	4.07
	Urg.	9.91	6.79	48.22	48.22
	Non-Urg.	32.24	9.25	18.63	10.76
Av. Waiting Time for 1st Physician	Emerg.	4.18	4.33	4.58	4.58
	Urg.	16.09	14.16	65.50	65.50
	Non-Urg.	46.63	25.35	61.37	43.19
Av. Time in System	Emerg.	69.58	69.03	58.35	58.35
	Urg.	42.86	44.39	97.10	97.10
	Non-Urg.	72.92	50.98	84.42	67.03
Av. No. in System		7.00	5.60	5.84 E & U 3.95 NU	5.84 E & U 2.99 NU

Contrasting Run 15 with Run 12 indicates the combined effects of both dichotomizing the emergency department and smoothing the non-urgency demand. When both policies are instituted, the total time in the system decreases by about 8% for non-urgency patients (72.92 to 67.03). The urgency patients are the ones who suffer, however. They spend an average of 97.10 minutes in the system compared with 42.86 previously, a 103% increase. The true emergency patients are not really affected since they always receive immediate service unless all staff are busy with other emergency patients.

FUTURE WORK

The inefficiency of the emergency department system (and a myriad of other systems involving queues) is largely due to the sporadic demand of the facility. At certain times of the day the staff is idle and at other times hopelessly overworked. One means of ameliorating this situation is to alter the arrival patterns of non-urgency patients by persuasion or coercion. The impact of this policy has already been evaluated and discussed.

Another means which can be used to reduce this inefficiency is the alteration of working shifts in a manner such that there is more staff during the busy periods of the day and less staff during the quiet periods. The administrators at Springfield feel that two viable methods for altering shifts are by having two separate 4-hour shifts (as opposed to one continuous 8-hour shift) and by staggering shifts.

Staggering shifts refers to the policy of having more than three different 8-hour shifts during the course of the day. If, for instance, there is a very high arrival rate from 3:00 p.m.-5:00 p.m. and a low arrival rate from 7:00 a.m.-9:00 p.m., one shift can be scheduled from 7:00 a.m.-3:00 p.m. and another from 9:00 a.m.-5:00 p.m. This will provide more help from 3:00 p.m.-5:00 p.m. and less help from 7:00 a.m.-9:00 a.m.

The simulation model may be used to investigate policies involving the alteration of working shifts either separately or in conjunction with policies for altering the arrival pattern. It is expected that the combination of both types will prove to be the most effective.

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