NBER WORKING PAPER SERIES

Hospital Utilization: An Analysis of SMSA Differences in Hospital Admission Rates, Occupancy Rates and Bed Rates

by

Barry R. Chiswick

Working Paper No. 2

CENTER FOR ECONOMIC ANALYSIS OF HUMAN BEHAVIOR AND SOCIAL INSTITUTIONS
National Bureau of Economic Research, Inc.
261 Madison Avenue, New York, N.Y. 10016

June 1973

Preliminary; Not for Quotation

Hospital Utilization: An Analysis of SMSA Differences in Occupancy Rates, Admission Rates and Bed Rates

Barry R. Chiswick

" ... the national surplus of hospital beds by no means contradicts the fact that there are frequent shortages in particular communities at particular times."

(New York Times, Editorial, August 26, 1971, p. 36).

Hospital Utilization:

An Analysis of SMSA Differences in Hospital Admission Rates, Occupancy Rates and Bed Rates

Barry R. Chiswick

Table of Contents

[1]This paper has benefited from comments received from Victor Fuchs and Michael Grossman, and at seminars at the National Bureau of Economic Research, the Graduate School, City University of New York, the Center for Health Administration Studies, University of Chicago, and the Health Services Administration, New York City. I also appreciate the research assistance of Carol Breckner, Phyllis Goldberg and Janice Platt. The project was financed by a grant to the NBER from the National Center for Health Services Research and Development (Grant Number 5P01HS00451) and by the Industrial Relations Section, Princeton University. I alone am responsible for any errors of commission or omission.

Chapter I

Introduction and Summary

1. Introduction

A topic of continued public concern is the national level and distribution among areas and individuals of the availability of hospital services. The New York Times in 1971 contained articles stressing the cost in terms of delayed treatment and death of insufficient hospital beds.[1] During the same year, the Times carried articles indicating

---

[1] See, for example, New York Times, January 21, 1971, p. 29, column 1; and September 12, 1971, section IV, p. 9, column 5.

---

the cost to society of unused hospital beds.[2]

---

[2] For example, the Times reported Elliot Richardson, then Secretary of Health, Education and Welfare, as citing "an estimate of $3.6 billion as last year's cost of maintaining unused beds all over the country." (New York Times, August 26, 1971, p. 36). Richardson's (unexplained) figure of $3.6 billion may be contrasted with the $4 billion in federal money spent for hospital construction under the Hill-Burton program since its inception 25 years ago. (New York Times, November 23, 1972, p. 1, column 1.)

Table I-1 presents data for the country as a whole on hospital utilization during the post World War II period for short-term non-federal hospitals. The bed rate (the number of beds per thousand population) increased nearly 25 percent. The admission rate (admissions per thousand population) increased nearly 50 percent. The average bed occupancy rate

Table I-1

Utilization of Short Term General and Specialty non-Federal Hospitals, 1946-1970

Year	Bed Rate[a]	Admission Rate[b]	Occupancy Rate (Percent)	Length of Stay (Days)
1946	3.4	96.6	72.1	9.11
1950	3.3	109.9	73.7	8.15
1955	3.5	115.6	71.7	7.78
1960	3.6	127.1	74.6	7.60
1965	3.8	136.2	76.0	7.77
1967	4.0	135.8	77.7	8.28
1968	4.0	135.9	78.2	8.45
1969	4.1	139.4	78.8	8.41
1970	4.1	142.8	78.1	8.26

Sources:: 1940 to 1960: Historical Statistics of the United States From Colonial Times to the Present, U.S. Bureau of the Census, 1965, Series A-1, B-198, 208, 251, 252.
1965 to 1970: Statistical Abstract of the United States, 1972, U.S. Bureau of the Census, 1972, Table Nos. 2, 104, 107.

[a]Bed Rate = Beds per thousand population

[b]Admission Rate = Admissions per thousand population

(the proportion of days in the year the average bed is occupied) increased during most of the period, but has recently been on the decline.[1]

---

[1]See, for example, Harry T. Paxton, "Whatever Happened to the Hospital Bed Shortage?" Medical Economics, February 28, 1973, p. 33.

These changes are important because hospitals do perform useful services, but at a considerable cost -- a cost which has been growing rapidly.[2]

---

[2]The American Hospital Association reported that the daily cost of caring for patients in short-term general hospitals averaged $81 in 1970, $92 in 1971 and $105 in 1972. The cost has almost doubled from 1966 to 1972. (New York Times, July 31, 1972, p. 36, column 4, and January 15, 1973, p. 23, column 5.)

Although occupancy rates are declining nationally, regional maldistributions and political pressures still induce hospital bed construction.[3]

---

[3]The Government Accounting Office reported the "overbuilding" of hospital facilities in six cities (New York Times, December 18, 1972, p. 78, column 1). Congress still passes legislation to promote hospital bed construction (New York Times, September 21, 1972, p. 36, column 1).

The purpose of this study is to present a model (Chapter II) for analyzing the utilization of short-term general hospitals -- in particular, occupancy rates, admission rates, bed rates and length of stay.

This model is then applied (Chapter III) to a cross-section analysis of regional differences in hospital utilization. The objective is to develop structural equations and hypotheses as to why the measures of hospital utilization vary across communities, and to estimate these equations and test these hypotheses. There is, however, an identity relationship between average length of stay ($\overline{LS}$), and the occupancy rate (OR), admission rate (Adms*) and bed rate (Beds*):

$$OR = \frac{(Adms^*)(\overline{LS})}{(365)Beds^*}.$$

Length of stay is the "redundant" variable for the purpose of this study.

2. Framework

The number of hospital admissions demanded in a year in a community is viewed as a declining function of the cost of such care. This relation, however, need not be the same for all communities. For example, the number of admissions demanded may be greater, the larger the number of surgeons and the more important is health insurance in the community. In addition, more strict rationing of admissions (and hence a smaller number of admissions) may occur when hospitals are very crowded.

The analysis of the supply of hospital admissions is based on both a short run and a long run model of hospital bed availability. In the short run the bed rate (the number of beds per thousand population) is assumed to be fixed and determined by factors outside the model under investigation. If we assume a fixed bed rate (Beds*) and a constant length of stay (LS), the largest possible admission rate would be found by: $Adms* = \frac{(Beds*)(365)}{LS}$. In Figure I this is represented by the point at which the demand curve for admissions intersects the supply curve of admissions and the number of admissions is q_0.

However, this is an unrealistic view of the supply side of the short run model. The demand for hospital beds is not a constant daily quantity but rather a fluctuating one. It is higher on some days than on others.[1] In the case of hospital care, the output cannot

[1] This is true of all markets, and output or productive capacity tends to be "stored" by suppliers or demanders depending on the extent of fixed costs and relative storage costs.

generally be stored by the consumer.[2] This means that if on a given

[2] Preventive medicine may be viewed as a means of "storing" health services.

day there is a greater demand for hospital beds than can be satisfied by the available supply and if non-price rationing is used, some consumers will have to delay (or forego) the satisfaction of their demand for hospital services even though they were willing to pay the current market price. Delayed satisfaction of demand for hospital care is not without cost, as anyone who has ever been in pain or discomfort or has ever faced death is well aware. Thus, a community would want to have

FIGURE I

Short-Run Supply And Demand

For Hospital Admissions

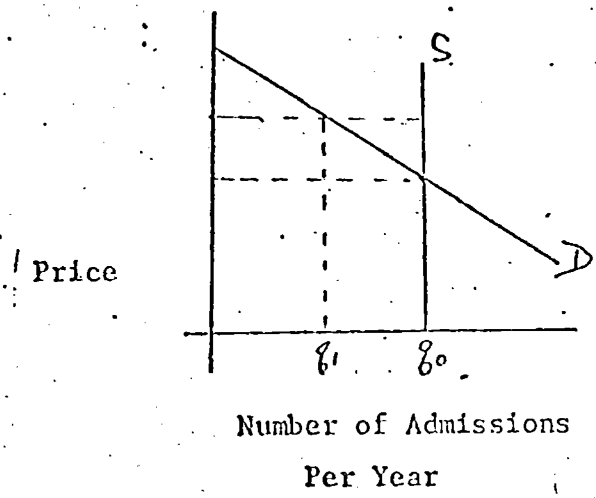
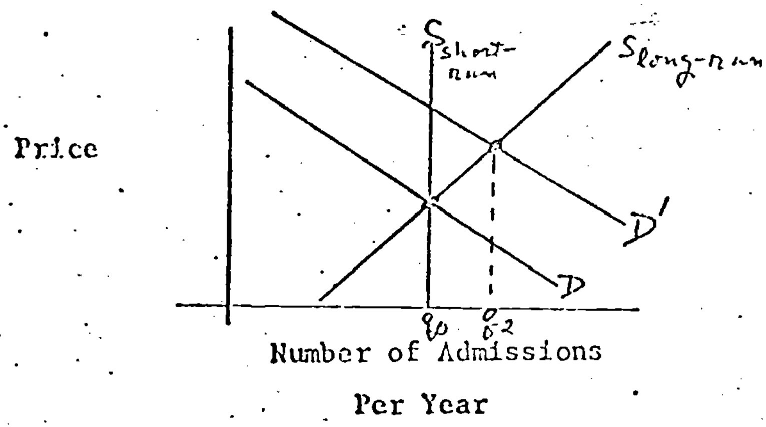


FIGURE II

Long-Run Supply And Demand

For Admissions



what appears to be excess capacity in hospital beds on the average day of the year, so that it could provide some additional in-hospital bed care during periods of high demand.[1]

---

[1]This assumes that "at capacity" the marginal cost of admissions rises steeply. If the marginal cost of providing additional beds and ancillary services did not rise with the quantity supplied in the short run, there would be no economic demand for an "excess supply" on the average day.

A useful measure of "excess capacity" in a community is its average occupancy rate in a year. The average occupancy rate is measured by the ratio of the number of patient days (admissions multiplied by average length of stay in days) to the number of available bed days (the number of beds multiplied by 365 days) -- $OR = \frac{(\text{Admissions})(\text{Length of Stay})}{(\text{Beds})(365)}$. If, for example, the average length of stay is five days, a community with 100 beds and an average bed occupancy rate of 90 percent accommodates 6,570 admissions. ($q_1 = \frac{OR(\text{Beds})365}{LS} = \frac{(0.90)(100)(365)}{5} = 6{,}570$ admissions.) At a 100 percent occupancy rate it could accommodate this number of admissions with 90 beds, but more patients would have to be granted a delayed admission. A delayed (or denied) admission of a serious case is costly. More excess capacity on the average reduces the likelihood of the demand for beds exceeding the number of beds. However, constructing and maintaining excess capacity are costly. Thus, there is some desired average occupancy rate that is less than 100 percent. This is represented in Figure I by a number of admissions equal to q_1, which is less than q_0.

Hospital administrators have control over the occupancy rate through their control of admissions and length of stay. If a lower occupancy rate is desired, they can be more selective in the cases that are admitted and thus decrease the admission rate and/or the average length of stay. The variables that are hypothesized to enter into the process of selecting the community's desired occupancy rate, given a fixed supply of beds, form the framework for the analysis of the occupancy rate equation.

In summary, the short run includes a fixed supply of beds, a hospital admission rate equation and an occupancy rate equation. Both equations are needed to determine the number of admissions and the occupancy rate in a community: a high admission rate causes a high occupancy rate, but a high occupancy rate causes a low admission rate.

In the long run, however, the bed rate (beds per thousand population) is not exogenous to the model. For example, if the demand for admissions is high relative to the number of beds, the occupancy rate is high. Some patients for whom the cost of a delayed admission is high do in fact experience a delayed admission in their community and must either postpone the hospital admission or seek such care elsewhere. The implicit value of an additional admission is now high. If communities respond to this high marginal value of admissions, the number of beds will be increased in the long run (see Figure II).[1]

---

[1]The supply response may come from the public sector, voluntary hospitals or proprietary hospitals.

Our long run analysis , relies on a two equation model: the admission rate is a function of the bed rate, and the bed rate is a function of the admission rate.

This study, therefore, focuses on three inter-related dependent variables: the admission rate, the occupancy rate and the bed rate. Chapter II presents the development of the three equations, one for each dependent variable, and Chapter III presents the empirical estimation and interpretation of these equations.

The Standard Metropolitan Statistical Area serves as the unit of observation in the empirical analysis.[1] SMSAs were selected for

[1]"A standard metropolitan statistical area is a county or group of contiguous counties which contains at least one city of 50,000 inhabitants or more, or two contiguous cities with a combined population of at least 50,000. In New England, however, SMSA's consist of towns and cities rather than counties. Since town and city information is not available, the SMSA's in New England have been replaced by metropolitan State economic areas, which are defined in terms of whole counties." (Hospitals: County and Metropolitan Area Data Book, National Center for Health Statistics, Department of Health, Education and Welfare, 1970.) For simplicity of exposition, non-New England SMSA's and New England metropolitan State economic areas are referred to as SMSAs.

three reasons.[2] First, SMSA borders are designed to represent population

[2]To the author's knowledge, this is the first study of hospital utilization to use SMSAs as the unit of observation. Other studies for the United States have used individuals (microdata), hospitals in a particular geographic area, or states as the unit of observation.

centers and are clearly better suited for this purpose than city, county or state boundaries. It seems reasonable that this is also true for health regions. Potential patients, doctors and hospital administrators are presumably concerned more with "reasonable commutation distances" than with city or county boundaries.[1] While SMSAs may not

---

[1]For example, Santa Monica, Culver City and San Fernando are three cities in Los Angeles county surrounded by Los Angeles city. Yet these separate cities do not appear to constitute separate health communities as there is considerable mobility across city boundaries. At the other extreme are the five counties which comprise New York City. The large proportion of residents who seek hospital services outside of their own county suggests that the populace acts as if the city represents a single medical center. States were not used as the unit of observation because for many states either there are two or more hospital areas between which there is little mobility, or there is commutation across state borders for the purchase of hospital care.

---

be ideal candidates for health regions, they are reasonably good approximations. Second, the data needed for this study are generally available on an SMSA basis.[2] Third, by using SMSAs we obtain a sufficiently

---

[2]The data for hospital utilization are from a 1967 survey of all short term general hospitals in the country. (Hospitals: a County and Metropolitan Area Data Book, National Center for Health Statistics, Department of Health, Education and Welfare, November 1970.) For a discussion of these and the other variables, see Appendix A.

---

large sample, 192 observations.

for health regions. Potential patients, doctors and hospital administrators are presumably concerned more with "reasonable commutation distances" than with city or county boundaries.[1] While SMSAs may not

[1] For example, Santa Monica, Culver City and San Fernando are three cities in Los Angeles county surrounded by Los Angeles city. Yet these separate cities do not appear to constitute separate health communities as there is considerable mobility across city boundaries. At the other extreme are the five counties which comprise New York City. The large proportion of residents who seek hospital services outside of their own county suggests that the populace acts as if the city represents a single medical center. States were not used as the unit of observation because for many states either there are two or more hospital areas between which there is little mobility, or there is commutation across state borders for the purchase of hospital care.

be ideal candidates for health regions, they are reasonably good approximations. Second, the data needed for this study are generally available on an SMSA basis.[2] Third, by using SMSAs we obtain a sufficiently

[2] The data for hospital utilization are from a 1967 survey of all short term general hospitals in the country. (Hospitals: a County and Metropolitan Area Data Book, National Center for Health Statistics, Department of Health, Education and Welfare, November 1970.) For a discussion of these and the other variables, see Appendix A.

large sample, 192 observations.

3. Summary of Findings

This study analyzes SMSA differences in the utilization of short-term general hospitals by explicitly examining three dependent (endogenous) variables: the occupancy rate, admission rate and bed rate.

Our analysis of SMSA differences in occupancy rates is based on the randomness of the demand for admissions. Since the demand for admissions fluctuates, the populace and hospital planners in an SMSA are concerned with maintaining an average occupancy rate sufficiently less than 100 percent so as to have an optimal probability that someone desiring an admission will be turned away because the hospitals are at full capacity. It is estimated that under 1967 utilization levels the demand for beds in an SMSA would exceed the supply of beds (on average) in only one week out of 12.8 years.

The empirical analysis strongly supports the predictions of the randomness model for occupancy rates. SMSAs with higher admission rates have higher occupancy rates. More populous SMSAs are better able to take advantage of their smaller relative fluctuations in demand for admissions, and maintain a higher occupancy rate. When there are more hospitals for the same number of beds (and hence the hospitals are smaller), there is a lower occupancy rate. The larger number of hospitals reduces the substitutability among hospital beds, because of a poorer "referral" system between hospitals than within hospitals.

Higher occupancy rates could be obtained by reducing the barriers between hospitals. These barriers include the limited number of hospital affiliations had by most physicians, the required veteran status for entry into federal hospitals, the provision of charity hospitalization primarily by public hospitals, and hospitals restricted to particular demographic (age, sex, etc.) groups.

Occupancy rates are higher in SMSA's with colder winter climates and a larger proportion of nonwhites in the population. These effects are presumably due to longer lengths of stay.

The analysis of hospital admission rates looks at variables which have been hypothesized to effect the height of the demand for, or the price of, a hospitalization. When hospitals are more crowded (high occupancy rate), the admission rate is lower because hospital administrators are more selective in the cases that are admitted in order to reduce the probability of capacity utilization. In addition, admission rates are higher, the more important is hospital and surgical insurance and the more numerous are surgeons in the SMSA's population.[1] The relative number of non-surgical physicians has no effect on the admission rate. Admission rates are also higher, the lower the median family income (elasticity at mean = -0.78), the more numerous are nonwhites in the population, and the colder the winter climate. The effect of nonwhites on admissions may be due to the poorer level of health of nonwhites.

Our third dependent (endogenous) variable is the bed rate. A 10 percent increase in the bed rate results in a 2 percent decrease in the occupancy rate, a 4 percent increase in the average length of stay and a 4 percent increase in the admission rate. This largely supports

---

[1] It is not clear to what extent a larger relative number of surgeons is a cause or a consequence of a greater demand for hospitalization.

Roemer's Law that an increase in beds results in these beds being filled with little change in the occupancy rate. It is, however, noteworthy that a 10 percent increase in admissions increases the number of beds by 9 percent. Thus, the effect of admissions on beds is stronger than the effect of beds on admissions.

Our model for the randomness of demand for admissions suggests several other variables as relevant for an analysis of the demand for hospital beds. Two of these variables, population size and the number of hospitals, have no significant effect empirically. Three other variables, the proportion of beds in federal hospitals, the emergency death rate and median family income, do have an effect.

Beds in federal hospitals are found to be imperfect substitutes for beds in non-federal hospitals presumably because of the required veteran status in the former. The presence of, say, a 130 bed federal hospital in an SMSA with a million inhabitants decreases the number of non-federal beds in the SMSA by approximately 40 beds. The more important are emergencies in an SMSA's case mix, the greater is the expected cost of a delayed admission because of capacity utilization, and hence the greater is the SMSA's demand for beds. The positive effect of income on the bed rate (elasticity at the mean = +0.12) is consistent with the hypothesis that wealthier SMSAs buy more excess capacity than poorer SMSAs through the construction of more beds.

There is an interesting relation between the relative number of nonwhites in the population and hospital utilization. SMSAs with relatively more nonwhites have higher admission rates and a longer average length of stay, but there is no compensating difference in the bed rate. The result is greater hospital crowding and a greater probability that a desired admission will be delayed (or denied) the larger the relative number of nonwhites in the population.[1]

Our theoretical and empirical analyses of hospital occupancy rates, admission rates, bed rates and length of stay indicate that these statistics vary across SMSA's and that this variation can be related systematically to the characteristics of the SMSA.

---

[1]However, the data used in this study do not permit an identification of racial differences in the delay of admission (case mix constant) within SMSAs.

CHAPTER II

The Theory

1. Introduction

This chapter presents the theoretical analysis by which we arrive at the hypotheses and structural equations for the three dependent variables examined in this study: the admission rate, the occupancy rate and the bed rate. The equations should not be estimated by ordinary least squares (single equation) techniques. In our short run model, the occupancy rate is determined simultaneously with the admission rate since each affects the other. In our long run model, the bed rate (beds per thousand population) and the admission rate are mutually determined.

Part (2) of this chapter presents the development of the hospital occupancy rate equation. A model based on the randomness of admissions suggests that the occupancy rate in an SMSA is related to the admission rate, population size and number of hospitals. This forms the basis of the analysis of occupancy rates, and proxy variables are entered in some of the analysis to control for SMSA differences in length of stay.

The admissions equation is developed in part (3). The demand for admissions is assumed to be greater, the lower the price of an admission, or the easier the non-price rationing by hospitals. Thus, hospital and surgical insurance, the presence of physicians, the occupancy rate and the number of hospital beds are shown to enter the admissions equation. Other variables, mainly to hold constant demographic differences across SMSAs, are included.

In Part (4) the bed rate (beds per thousand population) equation is presented. The equation is developed under the assumption that it represents long run supply. The model for the randomness of admissions suggests that the admission rate, the demand for emergency care, the size of the population and the number of hospitals are explanatory variables.

2. Hospital Occupancy Rates:[1/]

1/ The occupancy rate of a region is the total number of patient days in a period of time (e.g., a year) divided by the product of the average number of beds and the number of days in the time period. Bed occupancy rates can be greater than 100% if some beds (e.g., temporary beds in passageways) are not counted in the bed census but their occupants are counted in the total number of patient days.

A. Introduction:

The average occupancy rate in short term general hospitals in an area is neither constant nor purely random. It may be determined by the economic and institutional characteristics of the community. The purpose of this section is to develop a structure which will be used to obtain hypotheses concerning regional differences in occupancy rates.

The maintenance of a hospital bed and its auxiliary equipment and personnel is costly. A bed is productive when it is occupied. This does not mean, however, that average occupancy rates of less than 100 percent represent wasted resources. If there were a known constant number of beds demanded each day for each hospital, occupancy rates less than 100 percent would indeed represent wasted resources. However, since there are fluctuating demands for hospital services, the presence of "excess capacity" on the average day is efficient. That is, up to a point, vacant beds are a productive resource. The extent to which occupancy rates do in fact respond to fluctuations in admissions is a major aspect of our analysis of occupancy rates.[1]

---

[1] Other studies have used the randomness of admissions as a basis for analyzing hospital occupancy rates. See, for example, Hyman Joseph and Sherman Folland, "Uncertainty and Hospital Costs," Southern Economic Journal, October 1972, pp. 367-73; William Shonick, "A Stochastic Model for Occupancy Related Random Variables in General-Acute Hospitals," Journal of the American Statistical Association, December 1970, pp. 1474-1500; M. Long and P. Feldstein, "Economics of Hospital Systems: Peak Loads and Regional Coordination," American Economic Review, May 1967, pp. 119-129, and references therein. This study differs from the others in terms of (1) the specification of the randomness model (including the effects of population size and number of hospitals), (2) treating the admissions variable as endogenous rather than exogenous, and (3) the application of the model to regional differences in hospital utilization rather than to hospital differences within an area.

B. Fluctuating Demands

The rate of admission (p) is the number of admissions in a time period, N, divided by the size of the population (pop). That is, $p = N/pop$. Either an individual is a hospital admission or he is not. Using the binomial theorem, the variance across time periods in the number of hospital admissions is $Var(N) = (pop)\,p(1-p)$.

The number of patient days (PD) of hospital care in a time period is the sum across patients of all of the lengths of stay (LS) within that time period.[2/] It can be thought of as the average length of stay ($\overline{LS}$) multiplied

---

[2/] If we know the number of hospital beds (B), the number of admissions in a time period (N), the length of the time period (D) and the occupancy rate (OR), by a simple identity we know the average length of stay. [$LS = \frac{(OR)\ (D)\ (B)}{N}$.] In this study length of stay is viewed as the redundant variable, and the analysis focuses on the occupancy rate, the bed rate and the admission rate. For simplicity of presentation of the randomness model, the average length of stay is assumed constant across time periods.

by the number of admissions (N). If $\overline{LS}$ does not vary across time periods, the variance in patient days can be written as

(II-1) $$\mathrm{Var(PD)} = (\overline{LS})^2\ (\mathrm{pop})\ (p)\ (1-p).$$

The expected number of patient days is

(II-2) $$E(\mathrm{PD}) = E(\overline{LS}\ N) = \overline{LS}(\mathrm{pop})(p).$$

The coefficient of variation in patient days is

(II-3) $$\mathrm{CV(PD)} = \frac{\mathrm{SD(PD)}}{E(\mathrm{PD})} = \frac{\overline{LS}\sqrt{\mathrm{pop}(p)(1-p)}}{\overline{LS}\ \mathrm{pop}\ p} = \sqrt{\frac{1}{\mathrm{pop}}\ \frac{(1-p)}{p}} = \sqrt{\frac{1}{(\mathrm{pop})}\ \left(\frac{1}{p} - 1\right)}.$$

The relative variation in patient days in a time period is smaller, the larger the size of the population, and the greater the rate of admission.[1/]

[1/] Similar conclusions emerge if length of stay (LS) is not considered constant over time. Let us assume that across time periods (i) the average length of stay and the number of admissions are independent.

(a) $\mathrm{Var}\ (PD) = \mathrm{Var}\ (LS_i \cdot N_i) = (\overline{LS})^2\ \mathrm{Var}\ (N) + \overline{N}^2\ \mathrm{VAR}\ (LS) + \mathrm{Var}\ (LS)\ \mathrm{Var}\ (N)$, if LS_i is independent of N_i Then, since

(b) $\mathrm{Var}\ (N_i) = (pop)\ p(1-p)$ and $\overline{N} = (pop)\ p$.

(c) $\mathrm{Var}\ (PD) = pop\ \{[2\ \mathrm{Var}\ (LS) + (\overline{LS})^2]\ p - [(\overline{LS})^2 + \mathrm{Var}\ (LS)\ ]\ p^2\ \}$.

(d) $CV(PD) = \frac{SD(PD)}{E\ (PD)} = \frac{\sqrt{pop\ \{[2\ \mathrm{Var}\ (LS) + (\overline{LS})^2]\ p - [(\overline{LS})^2 + \mathrm{Var}\ (LS)]\ p^2\}}}{\overline{LS} \cdot pop \cdot p}$

and

(e) $CV(PD) = \sqrt{\frac{1}{(pop)}\ [(\frac{1}{p})\ (2CV(LS)^2 + 1) - (CV(LS)^2 + 1)]}$.

CV(PD) is negatively related to population size and the rate of admission, and positively related to the coefficient of variation of length of stay across time periods. These relationships would hold even if length of stay were not statistically independent of the admission rate, although the equation would be far more complicated. See Leo Goodman, "On the Exact Variance of a Product," Journal of the American Statistical Association, December 1960, pp. 708-713.

Let us assume that the mean and standard deviation of the number of patient days that will be demanded in a time period in a community were known. If the demand for an admission by one individual were independent of that of others, the demand for patient days would be normally distributed.[2] Then, if the community wishes to have

---

[2/] Annual rates of admission are about 15 percent. Assuming independence of individual admissions, the distribution of admissions for, say, a week approximates the Poisson Distribution for a small sample (e.g., a household or a small work group), but approximates a normal distribution for a large sample (e.g., a large factory, census tract or SMSA). For a binomial distribution, if the proportion of successes [in this case the admission rate (p) multiplied by the sample size (pop)] exceeds 10, the number of successes (admissions) approximates a normal rather than a Poisson distribution. For a population of 100,000 and a weekly admission rate of .15/52, admissions $\simeq$ (100,000). $\left(\frac{.15}{52}\right) \simeq$ 300 and the normal distribution is a close approximation to the binomial distribution.

---

beds to satisfy demands for admissions for, say, 97.5 percent of the time, the number of beds should exceed the mean number of patient days by approximately twice the standard deviation of patient days.[2/]

[2/] This assumes perfect pooling of beds among the hospitals in the community. The effects of a lack of perfect pooling among hospitals in an area and the time lag in filling a vacant bed are discussed below. For the normal distribution only 2.5 percent of the observations are more than 1.96 $\simeq$ 2.00 standard deviations above the mean.

Let us assume there is no cost in shifting patients within the time period of D days. Of course, D may be one day. Let us designate Z_α as the standardized normal variate which indicates that the number of beds is sufficient for all but 100 α percent of occurrences. Then the number of beds in the community is

$$\text{(II-4)} \quad B = [E\ (PD) + Z_\alpha\ SD(PD)]\ \frac{1}{D}\ .$$

That is, for only 100 α percent of occurrences will the number of patient days demanded in the time period of D days exceed $E(PD) + Z_\alpha\ SD\ (PD)$. Then,

$$\text{(II-5)} \quad \frac{B \cdot D}{E(PD)} = 1 + Z_\alpha\ CV(PD)\ .$$

The expected bed occupancy rate (OR) equals $\frac{E(PD)}{(B)(D)}$, if the number of beds is assumed fixed. Then,

$$\text{(II-6)} \quad OR = \frac{E\ (PD)}{(B)\ (D)} = \left(\frac{1}{1 + Z_\alpha CV(PD)}\right)\ .$$

Taking natural logs and using the relation that $Ln(1+a) \approx a$ when a is small,[1/]

[1/]For a population of one million, a daily admission rate of $\frac{.15}{365}$, and and $\alpha = .001$ (i.e., an insufficient number of beds for one-tenth of one percent of occurrences, or $Z_\alpha = 3.0$), $Z_\alpha\ CV(PD) = Z_\alpha \sqrt{\frac{1}{pop}\left(\frac{1}{p} - 1\right)} = 0.22$. If the pooling is done over a week, $Z_\alpha\ CV(PD) = 0.084$. These values of $Z_\alpha\ CV(PD)$ are sufficiently small for the approximation to apply.

(II-7) $LnOR = -(Z_\alpha)\ CV(PD)$.

Combining equations (3) and (7),

(II-8) $Ln(OR) = -Z_\alpha\left(\sqrt{\frac{1}{pop}\left(\frac{1}{p} - 1\right)}\right)$.

The occupancy rate is positively related to the size of the population, to the rate of admission, and to the proportion of occurrences for which the demand exceeds the number of beds (α).[2/] This provides us

---

[2/]The parameter Z_α is smaller, the larger is α. Hence, the larger is α, the larger is LnOR.

---

with two measurable explanatory variables for inter-SMSA differences in occupancy rates: population size and admission rate.

Communities may ⟶ differ in their desired α. If all admissions are "discretionary" [i.e., the cost of a delayed admission is low], the community would be willing to accept a larger number of instances in which the admission of potential patients is either denied or delayed.[3/] If all admissions are "emergencies " [i.e., 3/ The costs of a delay include the extra foregone productivity of the patient, the extra psychic pain or death, and the additional curative costs due to the delay. The benefits of delay include possibly a reduction in curative costs (e.g., due to natural healing) and a smaller average "excess capacity" of hospitals.

the cost of a delayed admission is high], the community would want a lower frequency of occurrences in which admissions are delayed or denied. Holding the admission rate constant, the effect of a differential emergency rate across SMSAs would operate in the long run through the number of beds per capita. SMSAs with more emergencies in their case load would have a higher bed rate and, as a consequence, achieve the objective of a lower occupancy rate.

C. Occupancy Rate Versus Use Rate

The annual occupancy rate of a hospital bed is the sum of the days in a year in which a patient is assigned to and using the bed divided by 365 days. When a bed is vacated, it is not always immediately reoccupied by another patient even if there is queuing for beds. The bed may be vacated too late in the day for the next patient to arrive, or the bed may be reserved for a day or two for a patient who is expected to arrive.[1] The "use rate" of a hospital bed shall be defined as the occupancy rate plus the proportion of days of potential occupancy lost because of a late discharge or because the bed is being reserved. Data on bed use rates do not exist. However, the concept of "use" without occupancy may influence the relation between the admission rate and the occupancy rate.

The total number of bed days "used" in an SMSA in a year is the sum of the bed days of occupancy and the bed days consumed by lags between

[1] See, for example, Harry T. Paxton, "Whatever Happened to the Hospital Bed Shortage?" Medical Economics, February 28, 1973, p. 42.

3/ The costs of a delay include the extra foregone productivity of the patient, the extra psychic pain or death, and the additional curative costs due to the delay. The benefits of delay include possibly a reduction in curative costs (e.g., due to natural healing) and a smaller average "excess capacity" of hospitals.

the cost of a delayed admission is high], the community would want a lower frequency of occurrences in which admissions are delayed or denied. Holding the admission rate constant, the effect of a differential emergency rate across SMSAs would operate in the long run through the number of beds per capita. SMSAs with more emergencies in their case load would have a higher bed rate and, as a consequence, achieve the objective of a lower occupancy rate.

C. Occupancy Rate Versus Use Rate

The annual occupancy rate of a hospital bed is the sum of the days in a year in which a patient is assigned to and using the bed divided by 365 days. When a bed is vacated, it is not always immediately reoccupied by another patient even if there is queuing for beds. The bed may be vacated too late in the day for the next patient to arrive, or the bed may be reserved for a day or two for a patient who is expected to arrive.[1] The

[1] See, for example, Harry T. Paxton, "Whatever Happened to the Hospital Bed Shortage?" Medical Economics, February 28, 1973, p. 42.

"use rate" of a hospital bed shall be defined as the occupancy rate plus the proportion of days of potential occupancy lost because of a late discharge or because the bed is being reserved. Data on bed use rates do not exist. However, the concept of "use" without occupancy may influence the relation between the admission rate and the occupancy rate.

The total number of bed days "used" in an SMSA in a year is the sum of the bed days of occupancy and the bed days consumed by lags between successive occupancies. That is,

(II-9) $$\text{Use} = (\text{admissions})\left(\begin{matrix}\text{length of stay}\\ \text{per admission}\end{matrix}\right) + (\text{admissions})\left(\begin{matrix}\text{lag in filling a}\\ \text{bed per admission}\end{matrix}\right).$$

We obtain the use rate (UR) by dividing both sides of equation (II-a) by (365)(Beds),

(II-10) $$U\,R = \frac{\text{Use}}{(365)(\text{Beds})} = OR + \frac{(\text{admissions})(\text{lag})}{(365)(\text{Beds})},$$

$$\text{since } OR = \frac{(\text{admissions})\ (\text{length of stay per admission})}{(365)\ (\text{Beds})}.$$

Designating the average lag per admission per bed day as $\ell = \frac{\text{lag}}{(365)(\text{Beds})}$,

since admissions = (p)(pop),

(II-11) $$UR = OR + \ell\, p\ (\text{pop}).$$

At full capacity the use rate is unity. Differentiating equation (11) with respect to the admission rate when the hospitals are operating at full capacity,

(II-12) $$\frac{\partial UR}{\partial p} = \frac{\partial OR}{\partial p} + \left(p\frac{\partial \ell}{\partial p} + \ell\right) \text{pop} = 0.$$

Thus, at full capacity (UR = 1.0), the marginal effect of admissions on the occupancy rate is

(II-13) $$\frac{\partial OR}{\partial p} = -\,\ell(1+\epsilon_{\ell,p})\ (\text{pop}),$$

where $\epsilon_{\ell,p}$ is the elasticity of the lag per admission (ℓ) with respect to the admission rate. If the lag exists ($\ell > 0$) but is invariant with respect to admissions ($\epsilon_{\ell,p} = 0$), at full capacity the measured occupancy rate will be less than unity, and a higher admission rate implies a lower occupancy rate. As long as the elasticity of the lag with respect to admissions is larger in algebraic value than minus unity (i.e., $-1 < \epsilon_{\ell p}$), occupancy rates decrease with an increase in admissions at full capacity (UR = 1.0).

Thus, the effect of the admission rate on the bed occupancy rate is expected to be positive for utilization at less than full capacity, but it may be negative at or near use rates equal to unity. Since high occupancy rates may imply capacity utilization, the admission rate may have a negative effect on occupancy rates at very high levels of occupancy.

D. Bed Rate

If an SMSA experiences an increase in its bed rate (beds per thousand population), and the SMSA's admission rate and average length of stay remain constant, the occupancy rate will fall.[1/] The exogenous increase in the bed rate also tends to increase the admission rate. Therefore, SMSAs with larger bed rates may have higher admission rates and lower occupancy rates.[2/] If the bed rate is not held constant in the occupancy rate equation, we could observe a negative partial effect of admissions on occupancy rates. The bed rate is hypothesized to have a negative effect on the occupancy rate.

1/ Recall that, since $OR = \frac{(N)\ (LS)}{(365)\ Beds}$, $\frac{\partial LnOR}{\partial LnBeds} = -1$.

2/ The effect of an increase in the bed rate on admission and occupancy rates is referred to in the literature as "Roemer's Law". Roemer's Law says that exogenous increases in bed rates affect primarily admissions and length of stay, and leave occupancy rates virtually unchanged. That is, patients fill the available supply of beds. (For example, see M.I. Roemer and M. Shain, Hospital Utilization Under Insurance, Hospital Monograph Series, No. 6, Chicago, American Hospital Association, 1959). The coefficient of variation of occupancy rates across SMSAs is considerably smaller than the coefficient of variation in admission rates and bed rates. (See Appendix A.)

E. Communication Among Hospitals

Suppose two communities have the same population, admission rate and desired α . The communities differ in that Community A has one hospital ($H_A = 1$), whereas Community B has k identical hospitals ($H_B = k$), each serving $(\frac{1}{k})$ (100) percent of the population, with no communication of vacancies among hospitals. It can be shown that community B is expected to have more beds and a lower occupancy rate.

By substituting equation (3) into equation (4), for community A,

(II-14) $$B_A(D) = E(PD)\ (1 + Z\ CV\ (PD)\ ) = E\ (PD)\ (1 + Z \sqrt{\frac{1}{pop} \left(\frac{1}{p} - 1\right)}\ ).$$

For Community B,

(II-15) $$B_B\ (D) = k\ \{ \frac{E\ (PD)}{k}\ (1+Z \sqrt{\frac{1}{\frac{pop}{k}} \left(\frac{1}{p} - 1\right)})\ \}$$

$$= E\ (PD)\ (1 + (\sqrt{k}) Z \sqrt{\frac{1}{pop} \left(\frac{1}{p} - 1\right)}),$$

where $k > 1$. Thus, B_B is larger than B_A .

Recall that equation (8) was;

(II-16) $$LnOR = -Z \sqrt{\frac{1}{pop} \left(\frac{1}{p} - 1\right)},$$

Therefore, for Community B,

(II-17) $$LnOR_B = -Z \sqrt{\frac{1}{\frac{pop}{k}} \left(\frac{1}{p} - 1\right)} = (\sqrt{k})\ (-Z \sqrt{\frac{1}{pop} \left(\frac{1}{p} - 1\right)}) = (\sqrt{k})\ LnOR_A .$$

Since the natural log of a number smaller than unity is negative and since $OR_A < 1.0$, $OR_B < 1.0$ and $k > 1$,

(II-18) $$\begin{cases} LnOR_B < LnOR_A, \text{ or} \\ OR_B < OR_A \end{cases} .$$

That is, ceteris paribus, because of less efficient pooling of beds, occupancy rates are lower in SMSAs with more hospitals.

If a bed in one hospital were a perfect substitute for a bed in another hospital, the number of hospitals would have no effect on the bed rate or the occupancy rate. Thus, holding the bed rate and admission rate constant the inclusion of a variable for the number of hospitals in an analysis of occupancy rates tests for the lack of perfect substitution of beds among hospitals.

F. Demographic Control Variables

Holding constant the admission rate and bed rate, the occupancy rate is, by definition, a function of the average length of stay. The average length of stay is a function of the SMSA's case mix and the demographic structure of the population. Although case mix data cannot be included, some of the empirical analysis does control for demographic variables. These variables include the sex, age, and race distributions of the population, the live birth rate and the rate of growth of the population.

There is evidence that nonwhites have a longer average length of stay than whites.[1/] This suggests that, ceteris paribus, occupancy rates are

[1/]For example, in New York City the average length of stay of a white person is shorter than that of a black person, in spite of the younger average age of blacks.

	Average Length of Stay in Days		
	1964	1966	1968
white	10.9	11.2	13.4
Black	13.2	11.6	14.5
Puerto Rican	14.2	12.6	15.0

Source: Donald G. Hay and Morey J. Wontman, "Estimates of Hospital Episodes and Length of Stay, New York City, 1968", February 1972, mimeo.

higher in SMSA's with a greater proportion of the population nonwhite. More rapidly growing SMSA's are hypothesized to have a lower occupancy rate because of a shorter length of stay. The shorter length of stay may be due to both the better health of migrants, and the greater attractiveness to migrants of healthier environments.

G. Climate

Thus far the analysis has assumed that the variables under study do not vary systematically over the year. Given an admission, however, climate may affect the length of stay.[1] It seems reasonable to hypothesize that, holding the admission rate constant, SMSAs in colder winter climates have longer lengths of stay for two reasons. First, since admission rates are higher in colder winter climates,[2] for two SMSAs with the same admission rate, the case mix is expected to be more heavily weighted toward more serious cases in the SMSA with the lower mean January temperature. More serious cases have longer average lengths of stay. Second, holding case mix constant, patients are likely to be kept in the hospital longer, the less amenable is the non-hospital environment to recuperation. Non-hospital care is presumably less productive than hospital care for recuperative purposes in a colder winter climate than in a warmer climate. Since longer lengths of stay increase the occupancy rate, holding the admission and bed rates constant, the partial effect of mean January temperature on occupancy rates is hypothesized to be negative.

1/ The effect of seasonality on admissions is examined explicitly in the admission rate equation.

2/ See, this monograph, chapter III, part 2.

H. Summary

Table II-1 contains the regression equation for the occupancy rate analysis. If hypotheses as to the sign of a variable have been presented above, the sign is indicated.

All but one of the explanatory variables may be viewed in the short run as being "caused" independently of the dependent variable, LN(OR). The one exception is the admission rate (p). The admission rate is, in part, a function of the occupancy rate. At high levels of hospital occupancy, the cost to society of admitting a patient to fill a bed is the sum of the resources consumed because the bed is occupied plus a measure of the cost because a potential patient is denied access (or is granted delayed access) to a bed. This latter cost component does not exist when occupancy rates are low. Thus, we expect admissions to be more selective when occupancy rates are high.[1/]

[1/] For a time series study see John Rafferty, "Patterns of Hospital Use: An Analysis of Short-Run Variations," Journal of Political Economy, January/February 1971, pp. 154-165.

It is for this reason that it is appropriate to use a predicted rather than the observed admission rate in the occupancy rate analysis.

The next section develops an equation with the admission rate as the dependent variable. In the empirical analysis the occupancy rate and admission rate equations are estimated simultaneously.

Table II-1

Occupancy Rate Equation[a]

Dependent Variable: The Natural Log of the Occupancy Rate (LnOR)

	Name	Explanatory Variables	Predicted Sign of Slope
(1)	Admission Rate	P or Adms*	+ in "randomness model" - in "lag model" when near 100% use rate
(2)	Bed Rate	Beds*	—
(3)	Square root of inverse of population	$\sqrt{\frac{1}{pop}}$ = SPOP	—
(4)	Square root of number of hospitals	$\sqrt{Hosp}$	—
(5)	Percent Nonwhite	%NWHT	+
(6)	Percent Change in Population	%CHPOP	—
(7)	Mean January Temperature	JANTEMP	—
(8)	Age, Sex Distribution		

[a]For a more detailed definition of the variables and data sources, see Appendix A.

2. Admission Rate

Economic, demographic and institutional variables are used in this section to generate a model to explain SMSA differences in the rate of admission to short term general hospitals.

(A) Hospital Occupancy Rate

Hospitals appear to be more selective in the cases they admit when beds are scarce than when vacant beds are abundant. Medical conditions for which delay in treatment or alternative treatments are less costly are put lower down on the admissions queue during periods of high occupancy rates. To the extent that higher occupany rates increase the delay before a desired admission can take place, alternative sources of medical treatment (including spontaneous cures) or death may reduce the total number of actual admissions. Alternative sources of medical treatment include home care, specialized hospitals, nursing homes, and hospitals outside of the SMSA. Thus, we expect a negative partial effect of the occupancy rate on the admission rate.

(B) Bed Rate

An alternative hypothesis (Roemer's Law) is that communities maintain a constan occupancy rate and admissions and length of stay are a function of the number of beds in the SMSA.(1) To test a "beds effect" on admissions,

---

[1]The coefficient of variation across SMSAs is much smaller for the occupancy rate than for the admission rate and bed rate.

(Number of observations = 192)

	Coefficient of Variation
1) Occupancy Rate (OR)	0.09
2) Admission Rate (P)	0.24
3) Bed Rate (Beds*)	0.28

Source: See Appendix A.

the bed rate is entered as an explanatory variable.

It could be argued that a positive partial correlation between the admission rate and the bed rate is not due to more beds causing more admissions, but rather is due to a higher demand for admissions causing more hospital beds to be constructed. This suggests that the bed rate should be viewed as an endogenous variable (determined within the model) not an exogenous variable (determined outside of the model) in our analysis of hospital utilization.

In the short run the bed rate (Beds*) is viewed as fixed, and the hospital admission rate and occupancy rate as interacting simultaneously. In the long run, the bed rate is not fixed, and the three variables -- p, BEDS* and LnOR-- are interdependent. As the number of beds adjusts to long run conditions, the occupancy rate variable may lose some of its variability. In the next section a model is developed for predicting the bed rate in an SMSA. The analysis of inter-SMSA differences in admission rates is performed for both a short run model, using predicted LnOR and observed BEDS* as explanatory variables, and a long run model, using predicted BEDS*.

(C) Hospital Insurance

It is often argued that the effect of more extensive hospital and surgical insurance coverage is to increase the amount of hospital care and surgery demanded by patients and their physicians. The effect of insurance is a change from a "fee for service" pricing system to an annual lump sum payment independent of the amount of services to be consumed and (usually) a smaller fee for service. By lowering the direct cost to the patient of an additional unit of medical services the patient has an incentive to purchase more medical services than otherwise. This may be done directly by the patient either through requesting more services or by searching for a doctor who will prescribe these services. The increased use of medical services may also occur if the patient's doctor, seeing the lowered direct price to the patient, suggests or provides more medical care. The additional medical care may show up, in part, as a higher rate of hospital admission. Thus, a greater hospital and surgical insurance coverage is expected to be associated with a higher rate of hospital admission.

(D) Physicians

The number of physicians per capita in an SMSA can be associated with the utilization of their services in several ways. First, the greater the relative number of physicians, holding the demand for their services constant, the lower would be the cost, and consequently the greater the use of their services.[1] Second, if we hold fixed the supply schedule of physicians

---

[1]The cost of physician's services include the direct price (fee), the waiting room time, and the costs incurred due to a delay in receiving care.

services, communities with a higher demand for health care have a larger number of physicians per capita.[2] Finally, it has been alleged that

[2] This suggests that the number of physicians is an endogenous variable. However, in this study the observed number of physicians is used in the empirical analysis.

physicians create their own demand: the larger the number of physicians per capita, the greater the amount of medical care received per capita because "consumer ignorance" results in patients placing a great deal of faith in the physician's advice as to the amount end type of medical care that should be purchased and physicians wish to "fill up" their day.

The effect on hospital admissions of an increase in the purchase of medical care due to the presence of a larger number of physicians depends on whether physicians' services are complementary with or substitutable for hospital services. Surgeons' services are hospital using. It is not clear a priori whether hospital services are substitutes or complements for the medical care provided by non-surgical out-of-hospital physicians. Thus, the number of surgeons per thousand population (SURG*) should have a positive partial effect on admission rates, but the partial effect of non-surgical out-of-hospital physicians per thousand population (GENMD*) is not clear.

It might be asked, "Does the effect of the presence of a larger number of physicians depend on the extent of hospital insurance coverage?"

This question is answered by including two linear interaction variables for hospital insurance and physicians per thousand population.[1]

[1] These variables are (a) (HI)(GENMD*) and (b) (HI)(SURG*).

(E) Income

The variable median family income serves several inter-related functions. First, income may be a proxy variable for health status.[2]

[2] There is evidence that income and good health are negatively correlated among whites but positively correlated among nonwhites. See Michael Grossman, The Demand for Health (NBER, Occasional Paper 119, 1972) and Morris Silver, "An Econometric Analysis of Spatial Variations in Mortality Rates by Age and Sex," V.R. Fuchs, ed., Essays in the Economics of Health and Medical Care (NBER, 1972) pp. 161-227.

Second, it is not clear a priori whether, *ceteris paribus*, hospital admissions increase or decrease with income, holding an initial level of health constant.[3] Thus, no prediction is offered as to the effect

[3] For a given initial level of health, if preventive or early curative care are less hospital using than cure at later stages, those with higher incomes may have a lower admission rate. On the other hand, there may be a positive income elasticity of demand for hospital using curative medicine.

of median family income on the demand for admissions across SMSAs.

F. Climate

Hospital admission rates appear to be seasonal; they tend to be higher in the fall and winter than in the spring and summer.[1] Thus, if

[1] For example, see Helen Hershfield Avnet, Physician Service Patterns and Illness Rates (Group Health Insurance, Inc. 1967) Table 42, p. 110.

all other variables that influence hospital admissions were held constant, communities with more severe winters would tend to have higher admission rates. Mean January temperature is used as a measure of the severity of the winter.

(G) The SMSA as a Medical Center

The dependent variable, the admission rate, is defined as the number of admissions in the short term general hospitals located in the SMSA in 1967 divided by the population of the SMSA in 1966. An admission rate obtained in this manner is a biased estimate of the hospital admission rate of the population of the SMSA. To obtain the population's admission rate, the admissions of non-residents who used the SMSA's hospitals should be subtracted from the data, while the admissions of residents who entered short term general hospitals outside of the SMSA should be included in the data. Unfortunately, it is not possible to make these adjustments.

An alternative procedure is to obtain a proxy for the net in-migration of patients. The net in-migration would be greater, the greater the extent to which the SMSA serves as a health center. An SMSA is more likely to serve as a health center if it has a medical school, and, if a medical school exists, the larger its size. The number of medical school students per hundred thousand population is entered for this purpose.[1]

---

[1] The variable is defined to be zero for SMSA s without medical schools.

(H) Demographic Variables

The probability of a hospitalization in a year is related to the person's age, sex and race. Thus, admission rates by SMSA will vary with the age, sex and race composition of the population. Seven variables are included to capture the effects of sex and age differences.[2] The live birth rate (LBR) is included to control for

---

[2] The seven variables are the percent of the population female (%FEMAL), and the percents of males and females separately, in the age groups 10 to 39, 40 to 54 and 55 years of age and over.

SMSA differences in fertility. Holding the birth rate constant, the sign of %FEMAL is expected to be negative as women tend to be more healthy than men of the same age. The percent of the population who are nonwhite (%NWHT) is hypothesized to have a positive effect on the admission rate since nonwhites have a lower level of health than whites.

It would be desirable to hold constant a measure of the "healthiness" of the SMSA's environment. The mean January temperature captures some of this effect. Holding constant the median family income and the sex, age, and race distributions of the SMSA, the health status of the environment may be highly correlated with the mortality rate. The number of deaths per thousand population (MORT*) and is expected to have a positive effect on admissions.

I. Summary:

Combining the separate analyses presented in this section, Table II-2 presents the admission rate equation and indicates the hypothesized effects of each variable. In Chapter III the admissions equation is estimated simultaneously with the occupancy rate equation and with the bed rate equation.

Table II-2

Admission Rate Equation[a]

Dependent Variable: Admissions per Thousand Population (P)

Explanatory Variables:

	Name	Symbol	Predicted Effect
1)	Natural log of occupancy rate	LnOR	-
2)	Bed Rate	Beds*	+
3)	Hospital and surgical insurance per capita	HSB/C	+
4)	Non-surgical MDs per thousand population	GENMD*	?
5)	Surgical MDs per thousand population	SURG*	+
6)	Insurance non-surgical MD interaction	(HI)(GENMD*)	?
7)	Insurance surgical MD interaction	(HI)(SURG*)	+
8)	Median Family Income	INC	?
9)	Mean January temperature	JANTEMP	-
10)	Medical Students per hundred thousand population	MST*C	+
11)	Percent of the population nonwhite	%NWHT	+
12)	Mortality per thousand population	MORT*	+
13)	Demographic variables		
	a) Live birth rate	LBR	+
	b) Sex	%FEM	-
	c) Age distribution		

[a]For a detailed definition of the variables and data sources, see Appendix A.

4. Bed Rates

A. Introduction

Although ——> the number of hospital beds in an SMSA on January 1 comes prior in time sequence to the number of admissions in that year, this is not a sufficient reason for treating the bed rate as exogenous (determined outside of the model). The number of hospital beds is a function of past demands and expectations of future demands for these beds, and there is a strong time series correlation in the demand for hospital care. The larger the demand for hospital care, the greater are the economic and political incentives for the government, and religious, other not-for-profit and for-profit organizations to increase the number of hospital beds. This section develops a theoretical model to explain SMSA differences in the bed rate.

B. Admission Rate and the Randomness Model

If we divide both sides of equation II-15 by the size of the population (in terms of thousands of inhabitants) and D,

$$\text{(II-19)} \quad \text{Beds*} = \frac{B}{\text{pop}} = \frac{\overline{LS}(P)}{D} \left[1 + Z_{\alpha}\sqrt{\frac{k}{\text{pop}}\left(\frac{1}{p} - 1\right)}\,\right].$$

The bed rate indicated in equation (II-19) is composed of a mean predicted demand $\left[\frac{\overline{LS}\ P}{D}\right]$ plus a demand due to the stochastic nature of admissions $\left[\left(\frac{\overline{LS}}{D}\right)(Z_{\alpha})\sqrt{\frac{k}{\text{pop}}(p - p^2)}\,\right]$. The mean predicted demand in our simplified model is proportional to the admission rate and the length of stay.

The "stochastic demand" is proportional to length of stay, inversely proportional to the square root of the population size, proportional to the square root of the number of hospitals, and positively related to the admission rate (for $p < .5$).

We can test the effect of density on the substitutability of hospital beds. If a greater density increases the substitutability among hospital beds, an SMSA with a smaller land area (holding constant population, admissions and number of hospitals) will have a smaller bed rate.

C. Hospital Administration

If beds under different administrative control (government, voluntary, proprietary) were equally good substitutes for each other, the fraction of beds under a given administration should have no effect on the SMSA's overall bed rate. However, if only veterans can use federal short-term general hospitals, the addition of federal hospital beds has a smaller and indirect effect on bed availability for non-veterans than for veterans. This is expected to increase the number of beds (but by less than the increase in federal beds) and the proportion of beds in federal hospitals. It seems reasonable to assume that state and local government short-term general hospital beds are good substitutes for beds in voluntary hospitals. Although proprietary hospitals charge higher fees than non-profit non-federal hospitals, there are no other special barriers to patient entry. The proportion of proprietary beds in the total bed census is so small, it is unlikely that SMSA variations in proprietary hospital beds have a statistically significant effect on the overall bed rate.[1]

Ftnote from p. II-25

1/ Average across 192 SMSAs of the proportion of beds under each form of administrative control:

Control	Mean Percent of Beds
State and Local government	15.8
Federal government	10.6
Proprietary	4.5
Voluntary	69.1
	100.0

Source: See Appendix A.

Three hospital administration variables are added to the bed rate analysis, the percent of beds in state and local (%SLBEDS), federal (%FEDBEDS) and proprietary (%PRBEDS) hospitals. Insignificant effects are expected for state and local, and proprietary beds. The "veterans effect" is expected to result in a significant positive effect of federal hospital beds on SMSA bed rates.

D. Z_α -- Emergencies and Income

The parameter Z_α is the standardized normal variate indicating the proportion of occurrences (α) for which the demand for beds exceeds the available supply. There are no direct measures of Z_α, but we can postulate that it is a function of two variables, the relative importance of emergencies in the SMSA's case mix and median family income.

The more important are emergencies in an SMSA's case mix, the greater is the expected cost of delayed (or denied) admissions because of the demand for beds exceeding the available supply. Thus, ceteris paribus, the more important are emergencies, the smaller the desired α (larger Z_α), and consequently the larger the bed rate.[1]

---

[1]The emergency variable (EMERG) is the sum of deaths from six causes. The variable is entered as emergency deaths per thousand population (EMERG*). These six causes are:

(a) Arteriosclerotic heart disease, including coronary conditions (HEART)
(b) Vascular lesions affecting the central nervous system (STROKE)
(c) Motor Vehicle accidents (MOTOR)
(d) Other accidents (OTHACC)
(e) Suicide (SUIC)
(f) Homicide (HOMIC) .

If the availability of a hospital bed is viewed as a superior good, higher income SMSA's would prefer a smaller α (larger Z_α) to reduce the probability that a desired hospital admission would be delayed. This implies a positive effect of income on the bed rate.

E. Percent Nonwhite

Since nonwhites have been subjected to discrimination in the provision of other public services,[2] they may have been subject to

---

[2]For discrimination in public school expenditures, see Richard Freeman, "Labor Market Discrimination," paper presented at Econometric Society Meeting, December 1972, or Finis Welch, "Black-White Differences in Returns to Schooling," American Economic Review (forthcoming).

---

past (and perhaps also current) discrimination in the provision of hospital services. In addition, since non-profit hospitals are financed to a large extent by voluntary contributions from wealthy individuals and foundations, discrimination by these sources against nonwhites implies that SMSAs with a larger fraction of the population nonwhite have a smaller bed rate. To test these hypotheses, a variable for the proportion of nonwhites in the SMSA's population is added to the bed rate analysis.

F. Other Variables

Holding the admission rate and number of hospitals constant, SMSAs which serve as medical education centers are likely to have a larger bed rate. This can be due to both a longer average length of stay and a larger Z_α (to reduce the probability of rejecting an "interesting" case) in hospitals affiliated with medical schools.

The number of medical students per hundred thousand population (MST*C) is used to capture the medical center effect on the bed rate.

The bed rate in an area is a function of the way its denominator, population, changes. If hospital construction lags behind population growth, the greater the increase in population, the smaller the bed rate. If the community anticipates future demands on the basis of current population growth rates, a positive partial relation would exist between the bed rate and the rate of growth of population (%CHPOP). In terms of equation (19), holding the admission rate constant, the population growth rate effect would appear as short-run variations in Z_α.

G. Summary

Table II-3 presents a listing of the variables which enter the bed rate analysis and the hypothesized effects of these variables. The empirical analysis uses a predicted admission rate (rather than the observed admission rate) since the admission rate and the bed rate are simultaneously determined in the long run.

Table II-3

Bed Rate Equation[a]

Dependent Variable: Beds Per Thousand Population (Beds*)

Explanatory Variables

	Name	Symbol	Hypothesized Sign
1)	Admission rate	P	+
2)	Square root of inverse of population $(\sqrt{\frac{1}{pop}})$	SPOP	+
3)	Square root of number of hospitals	$\sqrt{Hosp}$	+
4)	Median family income	INC	+
5)	Emergency deaths per thousand population	EMERG*	+
6)	Medical students per hundred thousand population	MST/C	+
7)	Area (square miles) per thousand population	Area*	?
8)	Percent change in population	%CHPOP	?
9)	Percent nonwhite	%NWHT	-
10)	Percent of beds in state and local hospitals	%SLBeds	0
11)	Percent of beds in federal hospitals	%Fed Beds	+
12)	Percent of beds in proprietary hospitals	%PRBeds	0

[a]For a detailed definition of the variables and data sources, see Appendix A.

Chapter III

Empirical Analysis

Chapter II developed hypotheses and three structural equations to explain regional differences in short term general hospital occupancy rates, admission rates and bed rates. This chapter presents an empirical estimation of the equations and tests of the hypotheses using the Standard Metropolitan Statistical Area as the unit of observation.[1]

---

[1]The analysis is for 192 SMSAs. Data for nine additional SMSAs were available, but, because of extreme values for the proportion of beds in federal hospitals and for length of stay, it was felt that long term care or specialty care hospital facilities were included in what was supposed to be short term general hospital data. (See Appendix A.) The two stage least squares regressions for the full sample of 201 SMSAs, as well as the ordinary least squares regressions for both sample sizes, are presented in Appendix B.

The data for hospital occupancy, admission and bed rates are from a 1967 survey of all short-term general hospitals in the United States.[2]

---

[2]Hospitals: A County and Metropolitan Area Data Book, National Center for Health Statistics, Department of Health, Education and Welfare, November 1970. For the sources of the data for the explanatory variables, see Appendix A.

---

1. Occupancy Rate Equation

a. Randomness Model

If we designate the randomness model variables by $V = \sqrt{\frac{1}{pop}\left(\frac{1}{p} - 1\right) k}$, we can write equation II-17 as

(III-1) $\ln OR = - Z_{\alpha} V.$

If the assumptions of the model are valid, the regression of the natural log of the occupancy rate on the structure of the randomness model (V) will not have an intercept but will have a negative slope coefficient. Using the normal distribution, the slope coefficient indicates the average proportion of occurrences for which the demand for beds exceeds the available supply (α).

Table III-1 presents the regressions when the admission rate is the annual probability of an admission, divided by 52, that is, the explanatory variable assumes the time period D is one week.[1]

---

[1]Because of the simultaneous determination of the admission rate and the occupancy rate, the predicted admission rate is used. The variables used to obtain the predicted admission rate are the exogenous variables in Tables B-3, #2 and B-6, #2.

When an intercept is allowed, it is insignificant (t=- 1.58). Thus, we accept the hypothesis that the intercept is zero. When the regression is forced through the origin, the slope coefficient is highly significant, has a negative sign, and its magnitude indicates that

TABLE III-1

Randomness Model Analysis of the Occupancy Rate

Dependent Variable: LnOR

Independent Variable	Linear Regression coefficient	Linear Regression t ratio	Regression Forced Through Origin coefficient	Regression Forced Through Origin t ratio
V[a]	-2.409	-6.63	-2.974	-4.43
Intercept	-0.051	-1.58	—	—

$^{a}V = \sqrt{\frac{1}{pop}\left(\frac{1}{p} - 1\right)k}$, where p is the predicted admission rate per thousand population (for exogenous variables, see Tables B-3, #2 and B-6 #2) divided by (1,000)·(52).

Source: See Appendix A.

the demand for beds exceeds the number available in only 0.15 percent of the weeks ($\alpha = 0.0015$).[1] The value of α can be computed for

---

[1]For $Z_\alpha = 2.973$, using the upper tail of the normal distribution, $\alpha = 0.0015 = 0.15$ percent.

---

various time periods (D). For example, on approximately 13 percent of the days, some potential patients would be rejected and be subject to either a delayed or a denied admission.[2]

---

[2]For a daily admission rate $p^* = \frac{p'}{7}$, since $\frac{1}{p'} - 1 \doteq \frac{1}{p'}$ because p' is small, $\text{Ln OR} \doteq \left(\frac{-2.973}{\sqrt{7}}\right)\sqrt{\frac{1}{pop}\left(\frac{1}{p^*} - 1\right)k}$, or Z_α (one day) $= 1.12$ and α (one day) ≈ 0.13.

The findings in Table III-1 provide empirical support for the randomness model developed in Chapter II. The regression in Table III-2, which uses a looser form of the randomness model variables as well as other control variables, provides additional support for our theoretical analysis of occupancy rates.[3]

---

[3]The ordinary least squares equation (i.e., the equation using the observed admission rate) explains over 40 percent of SMSA variation in the natural log of the occupancy rate.

In Table III-2, the annual admission rate has a positive effect on the occupancy rate.[4] The mean annual admission rate is 170 per

Table III-2

Two Stage Least Squares Analysis of
SMSA Differences in Occupancy Rates
Dependent Variable = LnOR
N = 192 SMSAs

Variables	coefficient	t ratio
$\hat{ADMS}$*	.0015	1.94
BEDS*	-.038	-2.61
SPOP66	-78.556	-3.54
SRHOSP	-.016	-3.26
%NWHT	.0017	2.23
%CHGPO	-.00035	-1.65
JANTEMP	-.0028	-3.91
LBR	-.00055	-1.22
%FEMAL	.021	0.80
%M1039	.012	0.37
%M4054	-.014	-0.37
%M55	.016	0.51
%F1039	-.0058	-0.18
%F4054	.023	0.58
%F55	-.011	-0.36
const.	3.112	2.18

$\hat{ADMS}$* = Predicted Admission Rate -- using exogenous variables in this table and Table B-6 #2

Source: See Appendix A.

---

[4]The first stage equation used to predict the admission rate has an R^2 of approximately 77 percent. Because predicted admissions and the square of predicted admissions are very highly correlated (R = 0.98), it was not possible to test for non-linear effects of admissions on the log of the occupancy rate.

---

thousand, with a standard deviation of 40.4 per thousand. An increase in the admission rate from 130 per thousand to 210 per thousand (from approximately one standard deviation below to one standard deviation above the mean) predicts an increase in the occupancy rate of approximately 9 percentage points.[1]

---

[1]Since $\frac{\partial LnOR}{\partial Adms^*} = +0.0015$, $\frac{\partial OR}{\partial Adms^*} = (.77)(+0.0015) = +0.001155$.

Then, $\Delta OR = +0.001155\ (210-130) = +0.092$.

The mean occupancy rate is .77 and the standard deviation is 0.067.

When hospital admissions are viewed as random events, larger populations have a more stable relative demand for hospital beds and, therefore, are able to maintain a higher occupancy rate. The variable SPOP66, the square root of the inverse of the population of the SMSA($\sqrt{\frac{1}{pop}}$), has a significant effect on the occupancy rate. Going from an SMSA of one-quarter of a million to one of one million inhabitants increases the occupancy rate by six percentage points.[2]

---

[2]Since $\frac{\partial LnOR}{\partial SPOP66} = -78.66$, and $\overline{OR} = .77$, at the mean,

$\frac{\partial OR}{\partial SPOP66} = -60.57$.

$$\Delta OR = (-60.57)\left(\frac{1}{\sqrt{1,000,000}} - \frac{1}{\sqrt{250,000}}\right) = -60.57\ (.001-.002)$$

$$= +0.0606 \text{ or } 6 \text{ percentage points.}$$

The difference in occupancy rates between an SMSA with 50,000 inhabitants and one with one-quarter of a million is 15 percentage points.

$$(\Delta OR = -60.57\left(\frac{1}{\sqrt{250,000}} - \frac{1}{\sqrt{50,000}}\right) = -60.57\ (.002-.00447) = .1496)$$

The randomness model also predicts that if beds in different hospitals are not perfect substitutes for each other, the larger the number of hospitals in an SMSA, the lower the occupancy rate. The model suggests the variable SRHOSP = $\sqrt{\text{number of general hospitals}}$, which has a significant negative effect on the occupancy rate. Going from four hospitals to sixteen hospitals decreases the bed occupancy rate by 2.5 percentage points.[1]

---

[1]The mean and standard deviation of $\sqrt{Hosp}$ are 3.2 and 1.92 respectively. Using Table III-2, $\frac{\partial LnOR}{\partial \sqrt{Hosp}} = -0.016$,

$\frac{\partial OR}{\partial \sqrt{Hosp}} = -0.01232$, and $\Delta OR = -0.01232\ (4-2) = -0.02464$.

Note that a four fold increase in the number of hospitals and in the population size leaves unchanged the number of hospitals per capita, but the occupancy rate need not be unchanged. An increase in the number of hospitals from 4 to 16 and an increase in population size from one-quarter million to one million results in a net increase in occupancy rates.[1] The increase in occupancy rates with population size when

---

$$^{1}dLnOR = \frac{\partial LnOR}{\partial SPOP66} dSPOP66 + \frac{\partial LnOR}{\partial \sqrt{Hosp}} d\sqrt{Hosp}$$

$$\Delta LnOR = (-78.66)(.001-.002) + (-0.016)(4-2)$$

$$= (+0.0787) + (-0.032) = +0.0467$$

$$\Delta OR = (.77)(+0.0755) = +0.036$$

---

hospitals per capita is unchanged suggests that there is substitution among hospitals but that this substitution is less perfect between than within hospitals.[2]

---

[2] That is, an SMSA with k hospitals of equal size does not behave as if it were k separate SMSAs each with one -kth of the SMSA's population.

Similar but weaker results emerge when the regression in Table III-2 is computed without the bed rate variable.

	Slope	t ratio
a) SPOP66	-33.12	-2.54
b) $\sqrt{Hosp}$	-0.011	-2.58

$$dLnOR = \frac{\partial LnOR}{\partial SPOP66} dSPOP66 + \frac{\partial LnOR}{\partial \sqrt{Hosp}} d\sqrt{Hosp} = 0.011$$

---

b. Other Variables

The bed rate has a significant negative effect on occupancy rates. A 10 percent increase in the bed rate decreases the occupancy rate by two percent.[1] This provides only partial support for Roemer's Law

---

[1] From Table III-2,

$$\frac{\partial LnOR}{\partial LnBeds} = \frac{\partial LnOR}{\partial Beds^*}\overline{Beds^*} = (-0.038)(5.22) = -0.198$$

---

that an increase in the bed rate results in these beds being filled, with no change in the occupancy rate. Since the admission rate is held constant, and the elasticity of response of OR to Beds* is significantly different from minus unity, length of stay increases with an increase in the bed rate.[2]

---

[2] Since $OR = \frac{(p)(LS)(pop)}{(365)Beds}$, and Beds* = Beds/pop,

$LnOR = Ln(p) + Ln(LS) - Ln(Beds^*) - Ln(365)$. Then,

$\frac{\partial LnOR}{\partial Ln(Beds^*)} = \frac{\partial Ln(p)}{\partial Ln(Beds^*)} + \frac{\partial Ln(LS)}{\partial Ln(Beds^*)} - 1$. In the previous footnote we found $\frac{\partial LnOR}{\partial Ln(Beds^*)} = -0.20$ In the analysis of SMSA differences in admission rates (this chapter, part 3), $\frac{\partial Lnp}{\partial Ln(Beds^*)} = +0.41$. These terms imply that the elasticity of length of stay with respect to the bed rate is $\frac{\partial Ln(LS)}{\partial Ln(Beds^*)} = +0.39$.

It is hypothesized that there is a negative partial effect of mean January temperature on the mean length of stay and, consequently, on the occupancy rate.[1] Empirically, mean January temperature has a

[1]The effect of temperature on occupancy rates through the admission rate is held constant when we use predicted admissions.

significantly negative effect on occupancy rates.[2] The variable

[2]The average January temperature is 36°F, with a standard deviation of 12°F. The occupancy rate for SMSAs one standard deviation above the mean is lower by approximately 5.5 percentage points than the OR for SMSAs one standard deviation below the mean.

Since, $\frac{\partial LnOR}{\partial Jantemp} = -.0028$, $\frac{\partial OR}{\partial Jantemp} = (-.003)(.77) = -0.00231$.

Then, $\Delta OR = -0.00231\ (48-24) = -0.05544$.

maintains its slope and standard error even after a South-NonSouth dummy variable or a New England dummy variable is added to the regression equation (see Appendix B).

The proportion of the population of an SMSA who are nonwhite appears to have a significant positive effect on the SMSA's occupancy rate.[3] Going from an SMSA with no nonwhites to one with 20 percent

[3]This is not capturing an income effect. When median family income is included in the occupancy rate equation, income is not significant and does not change the effect of percent nonwhite (see Appendix B).

nonwhite (i.e., from approximately one standard deviation below to one standard deviation above the mean) increases the predicted occupancy rate by almost three percentage points.[1] The positive

[1]The mean percent nonwhite is 10.68 and its standard deviation is 10.5 percent. Using Table III-2, $\frac{\partial LnOR}{\partial \%NWHT} = 0.00173$,

$\frac{\partial OR}{\partial \%NWHT} = (0.00173)(.77) = 0.00133$ and $\Delta OR = (0.00133)(20.0-0.0) = 0.0266$.

effect of percent nonwhite, when the admission rate and bed rate are held constant, suggests there is a longer average length of stay for nonwhites.[2]

[2]There is other evidence of a longer nonwhite length of stay. For example, the average length of hospital stay in New York City in 1964 was

	Male	Female (excluding deliveries)
White	13.8	10.5
Nonwhite	16.0	16.4
Puerto Rican	19.9	14.4

Source: Hospital Discharges and Length of Stay, New York City, 1964 (New York City, Population Health Survey, September 1966, Report Number H-1), Table 8.

The variable "percent change in population" has a negative effect (significant at the 10 percent level) suggesting that more rapidly growing SMSAs have shorter lengths of stay, either because of a healthier population or environment. Eight other variables are added to the occupancy rate equation to control for SMSA differences in length of stay due to differences in the live birth rate (LBR), the sex distribution (%FEMAL = percent of the population female), and the age distribution. These demographic variables are generally not separately significant.

c. Summary

The empirical analysis of SMSA differences in occupancy rates permits a test of the hypotheses developed in Chapter II, Part 2. The findings confirm the predictions of the randomness model. There is a positive effect of the admission rate on the occupancy rate: SMSAs with higher admission rates have higher occupancy rates. More populous SMSAs are able to take advantage of the effect of population size and maintain a higher occupancy rate. A larger number of hospitals decreases the occupancy rate, presumably because of a poorer referral system between than within hospitals. Communication does occur across hospitals, as shown by the higher occupancy rate when population size and number of hospitals are increased proportionately.

Holding the admission rate constant, a higher bed rate implies a lower occupancy rate (the elasticity is -0.2). Thus, an increase in beds is associated with both an increase in length of stay (elasticity is +0.39) and a decrease in the occupancy rate. This is only partial support for Roemer's law that when more beds are available they tend to be filled.

Longer lengths of stay explain the findings that occupancy rates are higher in SMSAs in colder winter climates and with a larger fraction of the population nonwhite.

The empirical analysis indicates that occupancy rates vary across SMSAs and that this variation can be related systematically to the characteristics of the SMSA.

2. Admission Rate Equation

a. Introduction:

The second dependent variable examined theoretically in Chapter II is the hospital admission rate. The admission rate is defined as the total number of admissions in a year in the SMSA's short term general hospitals divided by the population in thousands of the SMSA. The mean and standard deviation of the admission rate are 170 and 40, respectively, and the range is from 60 to 290.[1/]

[1/] The data are for 192 SMSAs. See Appendix A.

The regression equation developed in Chapter II for explaining SMSA differences in the hospital admission rate is estimated simultaneously with the occupancy rate in our "short run" model (Table III-3), and simultaneously with the bed rate in our "long run" model (Table III-4)[2/].

---

(2) The model explains 68 percent of inter-SMSA variation in the admission rate in the ordinary least squares regression analysis (See Appendix B).

---

b. Endogenous Explanatory Variable: Occupancy Rate

The cost to the hospital or society of a patient occupying a bed depends, in part, on the space (beds) available. The more crowded are hospitals (higher bed occupancy rate), for a fixed number of beds, the more likely it is that accepting an admission precludes (or delays) accepting another patient with a more "urgent" demand for hospital care.

As expected, the predicted natural log of the occupancy rate has a significant negative effect on the admission rate. A one percentage point increase in occupancy rates, *ceteris paribus*, decreases the admission rate by over four admissions per thousand population per year.[1/]

[1/] In Table III-3, regression 2, at the mean OR,

$$\frac{\partial Adms^*}{\partial LnOR} = \frac{\partial Adms^*}{\partial OR}\overline{OR} = -341.9$$

$$\frac{\partial Adms^*}{\partial OR} = \frac{-341.9}{\overline{OR}} = \frac{-341.9}{.77} = -444.0 \ .$$

Thus, a one percentage point increase in the occupancy rate ($\Delta OR = 0.01$), in the neighborhood of the mean OR, results in a decrease in admissions per thousand population by 4.44.

Holding the predicted occupancy rate constant, a larger bed rate (Beds*) implies a larger absolute number of vacant beds per capita. A larger absolute number of vacant beds per capita implies a lower probability that an admission will preclude or delay the admission of a patient with a more serious illness. The variable Beds* does indeed have the expected significant positive partial effect on the admission rate (Table III-3). An increase of one bed per thousand population is associated with an 11.2 per thousand population increase in the admission rate.[2/]

[2/] The mean and standard deviation of bed rate are 5.22 and 1.44, respectively. A one bed per thousand increase represents nearly a 20 percent increase in the stock of beds.

Table III-3

Two Stage Least Squares
Analysis of SMSA Differences in Hospital Admission Rates
Dependent Variable = ADMS*
N = 192 SMSAs

	1. W/LnOR (Table B-3, #1)		2. W/LnOR (Table B-3, #2)	
Variables	coef.	t ratio	coef.	t ratio
$\hat{LnOR}$	-362.350	-3.27	-341.875	-3.23
BEDS*	10.627	3.60	11.191	4.05
HSB/C	2.296	2.03	2.999	2.98
GENMD*	-101.480	-0.80		
SURG*	545.074	2.73	469.103	3.17
HI*XMD*	2.343	0.96		
HI*XSG*	-9.497	-2.43	-7.615	-2.71
INC	-19.901	-3.28	-22.896	-4.36
JANTEMP	-1.961	-3.80	-1.839	-3.65
%TRADE	1.068	0.75		
%NWHT	1.053	2.48	.938	2.23
LBR	-.248	-1.15		
%FEMAL	-24.682	-2.32	-22.219	-2.22
MORT*	-4.702	-1.11	-4.346	-1.04
%M1039	-37.894	-3.27	-33.188	-3.08
%M4054	-54.915	-3.65	-48.251	-3.43
%M55	-34.035	-2.77	-29.365	-2.56
%F1039	38.133	3.24	33.517	3.01
%F4054	58.752	3.64	52.413	3.40
%F55	33.668	2.80	29.029	2.58
NENGL	-15.864	-1.23	-16.329	-1.33
MST*C	-.061	-0.65		
const	2899.88	3.60	2653.57	3.82

$\hat{LnOR}$ = Predicted Log Occupancy Rate -- using exogenous variables in this table and in Table B-3, #1 and #2.

Source: See Appendix A.

The net cost to the patient of a particular hospitalization is lower, the greater the extent that insurance pays for hospital and surgical expenses. The insurance variable used in this study is an estimated value of the benefits from hospital and surgical insurance per capita in the SMSA.[1/] It is expected to have a positive effect on the

[1/] The estimation procedure is discussed in Appendix A.

admission rate.[2/]

[2/] In principle, the causation could run in the opposite direction. That is, SMSAs with larger hospital admission rates for some reason other than insurance might have an incentive to buy more dollars worth of insurance. This effect is not likely to be important in this study as the hospital insurance variable is computed from an interstate regression of state values for hospital insurance on several explanatory variables which are exogenous to the model of the hospital sector developed in this study. See Appendix A.

Variables are included to test the effect of the presence of physicians per thousand population. Non-surgical M.D.s (GENMD*) and surgical M.D.s per thousand population (SURG*) are entered separately. It is argued in Chapter II that it is not clear a priori whether more non-surgical M.D.s per thousand population increases the use of hospitals (since the cost of medical care is cheaper and more of all medical care is purchased) or decreases the use of hospitals (since hospital care and out-of-hospital non-

surgical M.D.

care may be alternative means of improving one's health). Since the care provided by medical doctors specializing in surgery is hospital-using, a larger SURG* is expected to be associated with a greater admission rate. Surgical and non-surgical hospital treatment are less expensive to the patient, the greater the extent of insurance coverage.

Insurance (HSB/C) and surgeons (SURG*) have significant positive effects and the insurance-surgeon interaction variable has a significant negative effect on the admission rate. The number of non-surgical M.D.s has no effect on hospital admissions. The significant negative slope for the insurance-surgeon interaction variable says that the effect on the admission rate of an extra surgeon per thousand population is smaller the greater the amount of insurance. That is, the more insurance benefits the SMSA receives, the greater the amount of hospitalization; but this incremental effect is smaller, the larger the number of surgeons per capita. This negative effect is contrary to our expectations. The effect on admissions of the number of surgeons is positive at the mean level of insurance.[1/]

[1/] For Table III-3, regression 2, since $\overline{HSB/C} = 50.5$,

$$\frac{\partial Adms^*}{\partial Surg^*} = 469.1 + (-7.615)\ (\overline{HSB/C}) = 84.5$$

Median family income in the SMSA has a negative effect on hospital admissions. This may be due to the higher value of time for families with greater income and the substitution of less time consuming out-of-hospital care for in-hospital treatment. It may also reflect a greater efficiency in producing health outside of the hospital on the part of those with more schooling.[1/]

[1/] The average median family income is $5,808, and the standard deviation is $838. The equation says that going from an SMSA with a $5,000 median family income to one with a $6,600 income decreases admission rates by 37 per thousand per year. (Inc is in thousands of dollars.) The elasticity of admissions with respect to income at the mean is -0.78 . Source: Table III-3, regression 2.

The proportion of the population of the SMSA who are nonwhite has a significant positive effect on the rate of admission to short-term general hospitals. [2/] The effect occurs after controlling for median family income,

[2/] $\frac{\partial Adms^*}{\partial \%NWT} = 0.938$. The mean and standard deviation of percent nonwhite are 10.68 and 10.5, respectively. A ten percentage point increase in the proportion nonwhite increases the admission rate by 9 per thousand population.

among other variables. There are two possible interpretations of the nonwhite effect. First, since nonwhites are on the average poorer than whites, for two SMSAs to have the same median income, the one with the larger percent nonwhite has a lower mean and a larger variance of income. A simple non-linear Engel curve for hospital admissions could generate a negative partial effect on admissions for the variable percent nonwhite.[1/] Second, ceteris paribus, nonwhites have higher hospital

[1/] For the i^{th} family let

$$Adm_i = a_o + a_1 I_i + a_2 I_i^2$$

where $a_o > 0$, $a_1 > 0$, $a_2 < 0$.

Computing the mean of both sides of the equation,

$$\overline{Adm} = a_o + a_1\bar{I} + a_2(\bar{I}^2 + Var(I)) ,$$

where Var(I) is the variance of family income. A larger income reduces admissions if $\frac{\partial \overline{Adm}}{\partial \bar{I}} = a_1 + 2a_2 I < 0$ or if $-a_1 > 2 a_2 \bar{I}$. The empirical analysis did find that larger median incomes reduced admission rates, and mean and median incomes are highly correlated across areas. A larger variance of income (mean constant) reduces admissions as long as $a_2 < 0$.

admission rates than whites.

SMSAs with colder winter temperatures have higher hospital admission rates.[2/]

[2/] This effect is not due to regional differences. Dummy variables for South and New England were statistically insignificant and do not alter the climate effect.

Attempts to find a medical center effect on admissions were unsuccessful. In Table III-3, regression 1, the number of medical students per hundred thousand population is insignificant. Other attempts using variables for medical schools and the extent to which the SMSA is a center for trade and commerce were also unsuccessful.

c. Endogenous Explanatory Variable: The Bed Rate

While it may be appropriate for a short-run model to view the bed rate as exogenous, this is clearly not correct for a long-run model. Economic theory predicts that in the long run the bed rate is a positive function of the admission rate. Using the observed bed rate rather than the predicted bed rate biases the effect of beds on the admission rate.

Table III-4 presents the estimated admission rate equation for the long-run model using the predicted bed rate and without the occupancy rate variable.[1] The predicted bed rate has a significant positive effect on the admission rate. A one bed per thousand increase in the bed rate increases the admission rate by 13.2 per thousand. This implies a long-run response elasticity of admissions to beds of 0.41.[2] This elasticity is larger than the response of admissions to beds

[1] The interpretation of the statistical significance and direction of effects of the other (exogenous) variables is the same as in Table III-3, except that percent nonwhite becomes statistically insignificant.

[2] The elasticity of admissions with respect to predicted beds is

$$\varepsilon p,b = \frac{\%\Delta Adms}{\%\Delta Beds} = \frac{\Delta Adms}{\Delta Beds}\ \frac{\overline{Beds}}{\overline{Adms}} = (13.17)\ (\frac{5.?}{17?}) = 0.41 .$$

Table III-4

Two Stage Least Squares
Analysis of SMSA Differences in Hospital Admission Rates
Dependent Variable = ADMS*
N = 192 SMSAs

Variables	coefficient	t ratio
$\hat{\text{BEDS}}$*	13.176	5.30
HSB/C	1.290	2.04
SURG*	261.804	2.79
HI*XSG*	-3.189	-1.79
INC	-18.419	-4.53
JANTEMP	-.659	-2.66
MST*C	-.117	-1.75
%NWHT	.136	0.56
LBR	-.044	-0.29
%FEMAL	-21.363	-2.79
%M1039	-25.924	-3.28
%M4054	-31.978	-3.48
%M55	-23.291	-2.73
%F1039	24.003	3.07
%F4054	28.831	3.00
%F55	20.741	2.52
const.	1372.16	3.10

$\hat{\text{Beds}}$* = Predicted Bed Rate -- using exogenous variables in this table and in Table B-9, #2.

Source: See Appendix A.

in the short-run model where the bed rate is viewed as an exogenous variable.[1/]

[1/] The elasticity of admissions with respect to observed beds is

$$\epsilon p,b = \frac{\%\Delta Adms}{\%\Delta Beds} = (11.2)(\frac{5.2}{170}) = 0.34 .$$

Source: Table III-3, regression 2.

Thus, there is a "beds effect" -- more beds, ceteris paribus, mean more patients (admissions) will occupy the beds. Since the elasticity is less than unity, the occupancy rate decreases, or the length of stay increases in response to an increase in the bed rate not due to an increase in admissions.

d. Summary

The empirical estimation of the admission rate equation indicates a significant negative effect of the (predicted) occupancy rate on the admission rate. A one percentage point increase in the occupancy rate decreases the admission rate by 4.4 per thousand population. There is also a positive effect of the bed rate on the admission rate. A one bed per thousand increase in the observed stock of beds (short run model) increases admissions by 11.2 per thousand; the elasticity at the mean is +0.34. When the bed rate is treated as an endogenous variable (the long run model), the elasticity is +0.41.

The "hospital and surgical insurance" variable and the number of surgeons per capita have positive effects on the admission rate. However, there appears to be no relation between the number of non-surgical MDs and the admission rate.

Median family income is negatively correlated with admissions, with an elasticity of -0.78. SMSAs with a higher proportion of the population nonwhite and with colder winter climates have higher hospital admission rates. The attempt to identify a medical center effect on the admission rate was not successful.

The empirical analysis indicates that hospital variables (occupancy rate, bed rate), hospital insurance, surgeons per capita, income, climate and demographic variables all play a role in determining a Standard Metropolitan Statistical Area's admission rate for short term general hospitals.

3. Bed Rate Equation

This section presents the empirical analysis of SMSA differences in the number of short-term general hospital beds per thousand population.1/

(u) The explanatory power of the ordinary least squares equation is 76 percent. The regression in Table III-6 contains only the variables with t-ratios greater than 1.0 in Table III-5.

Although the number of beds in an SMSA can be viewed as being fixed in the short run, this is not an appropriate assumption for a long-run analysis. The admission rate and the bed rate equations are estimated simultaneously because of their interdependence: a higher demand for admissions increases the supply of beds, and a greater supply of beds increases the number of admissions. The mean and standard deviation of the bed rate are 5.2 and 1.4 respectively, and the range is from 2.0 to 9.2.[2/]

[2/] The data are for 192 SMSAs. See Appendix A.

The predicted admission rate has a strong positive effect on the observed bed rate (Table III-5). The elasticity of the bed rate with respect to the predicted admission rate is 0.92[3/] Thus, a one percent increase

[3/] $$\epsilon b,\ p = \frac{\%\Delta Beds}{\%\Delta Adms} = \frac{\Delta Beds}{\Delta Adms}\ \frac{\overline{Adms}}{\overline{Beds}} = 0.028\ \left(\frac{172}{5.2}\right) = 0.92$$

in the admission rate due to forces exogenous to the model increases the bed rate by nine-tenths of a percent. The effect of the predicted admission rate on

Table III-5

Two Stage Least Squares
Analysis of SMSA Differences in Hospital Bed Rates
Dependent Variable = BEDS*
N = 192 SMSAs

Variables	coefficient	t ratio
$\hat{ADMS}$	.028	9.63
INC	.106	1.32
MST*C	.0045	2.30
%NWHT	-.0065	-1.05
SPOP66	-162.704	-0.99
SRHOSP	-.011	-0.23
%CHGPO	-.00068	-0.35
EMERG*	.347	5.16
%SLBED	.00023	0.07
%FDBED	.045	10.25
%PRBED	.0026	0.38
AREA*C	-.000012	-0.15
const.	-1.641	-2.02

$\hat{ADMS}$* = Predicted Admission Rate -- using exogenous variables in this table and in TAble B-8, #2.

Source: See Appendix A.

Table III-6

Two Stage Least Squares
Analysis of SMSA Differences in Hospital Bed Rates
Dependent Variable = BEDS*
N = 192 SMSAs

Variables	coefficient	t ratio
$\widehat{\text{ADMS}}$	.025	10.44
MST*C	.0055	3.15
EMERG*	.372	6.20
%FDBED	.047	11.90
INC	.137	1.76
%NWHT	-.0044	-0.76
const.	-1.961	-2.36

$\widehat{\text{ADMS}}$ = Predicted Admission Rate -- using exogenous variables in this table and in Table B-8, #2.

Source: See Appendix A.

the bed rate is, therefore, considerably stronger than the effect of the bed rate on the admission rate.[1/]

[1/] Recall from Part 2 of this chapter that the elasticity of admissions with respect to beds was 0.41 in the long run model.

The model of the randomness of demand for hospital admissions predicts positive partial effects on the bed rate of our measure of population size, $\sqrt{\frac{1}{pop}}$, and our measure of the number of hospitals, $\sqrt{Hosp}$. In spite of the significance of these variables for explaining SMSA differences in occupancy rates, they play no role in determining the bed rate.

The randomness model of admissions also hypothesizes that the number of beds in a community is a function of the probability that patients will have to be granted a delayed or denied admission. The greater the cost of a delayed admission, the greater the demand for beds, <u>ceteris paribus</u>. The cost of a delayed admission is greater, the more important are emergencies in the SMSA's health picture. An emergency variable (Emerg*), measured as the death rate from "emergency" causes per thousand population, is included in the bed rate equation.[2/] It has a significant positive effect

---

[2] They . are arteriosclerotic heart disease, strokes, motor vehicle and other accidents, suicides and homicides.

---

on the bed rate.

In the full equation for the bed rate, median family income has an insignificant positive effect (Table III-5). When variables with t-ratios less than unity are deleted, income has a significant positive slope (Table III-6) and an elasticity of +0.12[1/] This may reflect a positive

---

2/ $$\frac{\%\Delta Beds^*}{\%\Delta INC} = \frac{\Delta Beds^*}{\Delta INC}\,\frac{\overline{Beds^*}}{\overline{INC}} = (0.137)\left(\frac{5.2}{5.81}\right) = +0.12\ .$$

---

income elasticity of demand for "excess capacity" to reduce the probability that a desired admission will be delayed.[2/]

2/ The mean and standard deviation of income are $5,808 and $833, respectively. Going from an SMSA one standard deviation below the mean to an SMSA one standard deviation above the mean implies an increase of two-tenths of a bed per thousand population, or 223 beds in an SMSA with a population of one million.

$$\Delta Beds^* = 0.137\Delta INC = 0.137(1.63) = 0.223$$

INC is in thousands of dollars.

To test the hypothesis that SMSAs which serve as medical centers have larger bed rates, the analysis includes the variable the number of medical students per hundred thousand population (MST*C). It has a significant positive effect. The slope coefficient implies that the addition of a 400 student medical school (100 students per year) to an SMSA with one-million inhabitants increases the number of beds per thousand population by two-tenths of a bed, or the number of beds by 220.[3]

3/ $$\Delta Beds^* = .0055\,(\Delta MST^*C) = .0055(40) = .22\ .$$

The three explanatory variables for administrative control (the proportion of beds in federal, state and local, and proprietary hospitals) would have insignificant effects on the bed rate if beds in these hospitals were perfect substitutes for beds in voluntary hospitals. Explicit barriers to admission or imperfect referral systems would result in positive effects. The effects are insignificant for state and local and proprietary hospitals, but positive and highly significant for federal hospitals. This presumably reflects the required veteran status for entry into federal hospitals.[1] A one percentage point increase in

---

1/ Note that this positive partial effect of the proportion of beds in federal hospitals on the bed rate cannot be explained by federal hospitals attracting admissions from outside the SMSA. The effect of federal hospitals on admissions appears in the predicted admissions variable in the bed rate equation.

---

the proportion of beds in federal hospitals increases the bed rate by +0.047. However, if there were no response of non-federal beds to an increase in federal beds, at the mean, a one percentage point increase in federal beds would increase the bed rate by +0.055.[2] An increase in

---

2 The mean bed rate is 5.22 and the mean percent of beds in federal hospitals is 10.64 percent. (Source: Appendix A.)

---

federal beds is associated with an increase in the overall bed rate, and a decrease in the non-federal bed rate.[3]

(footnote 3 from previous page (III-24))

[3] Since $\overline{\text{Beds*}}$ = 5.22 and $\overline{\text{\%FDBEDS}}$ = 10.64, $\overline{\text{FedBeds*}}$ = 0.555 and $\overline{\text{NonFedBeds*}}$ = 4.664. A one percentage point increase in federal beds implies an increase in FedBeds* by 0.067, if the number of non-federal beds is constant. However, a one percentage point increase in the percent of federal beds increases the bed rate by 0.047. Since ΔBeds* = ΔNonFedBeds* + ΔFDBeds*, ΔNonFedBeds* = -0.20. For an SMSA with a population of one million, an additional 134 bed federal hospital decreases the number of non-federal beds by 40, for a net increase of only 94 beds.

Thus, we reject the hypothesis that a bed in a federal hospital is a perfect substitute for a bed in a non-federal hospital.

The proportion of nonwhites in the population has no effect on the bed rate. Recall, however, that SMSAs with more nonwhites have higher admission rates and occupancy rates. The higher occupancy rate in SMSAs with more nonwhites (holding the admission rate and bed rate constant) appears to be due to a longer length of stay of nonwhites. The two remaining variables, the rate of growth of the population and the area of the SMSA, appear to play no role in explaining SMSA differences in the bed rate.

The empirical analysis indicates that the bed rate varies systematically across SMSAs. The (predicted) hospital admission rate, the importance of emergencies in the SMSA's case mix and the proportion of beds in federal hospitals are the most important variables and have positive effects on the bed rate. SMSAs which are wealthier or serve as medical centers tend to have larger bed rates, but these variables are of lesser overall importance.

Appendix A
Data Appendix

Table A-1, The Variables, presents a listing of the variables used in this study, their symbols, and a code for the source of the data. Table A-2, Sources, has the detailed bibliographic information on the sources. Table A-1 also presents the mean, standard deviation and coefficient of variation for each of the variables for the sample of 192 Standard Metropolitan Statistical Areas.

The empirical analysis is performed for the samples of 192 and 201 SMSAs. Although the data exist for all 201 SMSAs, nine are excluded to form the smaller sample because of either an excessively large fraction of beds in federal hospitals or very long computed lengths of stay.[1] Either variable suggests the presence of long term care facilities in the data.

1

	Percent of Beds in Federal Hospitals	Average Length of Stay
(A) Nine SMSAs		
Ann Arbor, Michigan	21.78	12.4
Augusta, Georgia	76.13	22.4
Durham, North Carolina	31.96	11.6
Galveston, Texas	8.71	13.6
Little Rock, Arkansas	60.59	18.8
Providence, Rhode Island	7.30	18.0
Sioux Falls, South Dakota	36.70	10.0
Tacoma, Washington	0.0	23.6
Topeka, Kansas	60.96	22.0
(B) 192 SMSAs		
Mean	10.64	8.8
Standard Deviation	13.95	1.9

Data on hospital and surgical insurance coverage per capita or per household do not exist on an SMSA basis. State data are used to predict the SMSA insurance variable. The insurance variable is "total hospital and surgical insurance benefits" in the state divided by the population of the state (HSB/C). States without SMSAs and across which there is considerable commutation are excluded from the state regression. This leaves a sample of 41 states. The equation used to predict SMSA values for HSB/C is an inter-state weighted regression (see Table A-3) and is the "best" equation obtained after experimenting with the data. The explanatory variables are the percent of the state's labor force employed (a) by local governments, (b) by the federal government, (c) in manufacturing and (d) in white collar jobs. The coefficient of determination adjusted for degrees of freedom is seventy percent.

Table A-1 The Variables

Hospital Utilization

N = 192 SMSAs

Variable Name (Units)	Symbol	Mean	Standard Deviation	Coefficient of Variation	Source
A) Endogenous Variables					
1) Admission Rate (admissions per thousand)	p or ADMS*	169.55	40.38	.24	7, Tables 2 and 3
2) Occupancy Rate (Percent)	OR	77.28	6.72	.087	7, Table 2
3) Natural Log of Occupancy Rate	LnOR	4.34	.091	.021	7, Table 2
4) Bed Rate (beds per thousand)	BEDS*	5.22	1.44	.28	7, Table 2
B) Exogenous Variables					
1) Population of SMSA, 1966 (thousands)	POP 66	641.16	1237.6	1.93	7, Table 2
2) % Change in Population, 1950-1960	%CHGPO	33.10	33.34	1.01	4, Table 63
3) % Non-white	%NWHT	10.68	10.50	.98	4, Table 63
4) Median Family Income (thousand $)	INC	5.81	.83	.14	4, Table 142
5) % of General Hospital Beds which are in State and Local Government Hospitals, 1967	%SLBED	15.82	18.36	1.16	7, Table 3
6) % of General Hospital Beds which are in Federal Hospitals, 1967	%FDBED	10.64	13.95	1.31	7, Table 3
7) % of General Hospital Beds which are in Proprietary Hospitals, 1967	%PRBED	4.49	8.56	1.91	7, Table 3
8) South/Non-South dummy, South = 1	SOUTH	.37	.48	1.30	3
9) Land Area of SMSA (in square miles)	AREA	1607.3	2421.6	1.51	6, 1962, Table 3, Var. 1

Hospital Utilization
N = 192 SMSAs

Variable Name (Units)	Symbol	Mean	Standard Deviation	Coefficient of Variation	Source
10) % of Labor Force Employed in Wholesale & Retail Trade, 1960	%TRADE	18.47	2.57	.14	6, 1962, Table 3, Var. 34 &
11) Mean January Temperature, 1960	JANTMP	36.10	12.03	.33	6, 1962, Table 6, Var. 456
12) Number of Medical Schools in SMSA per 100,000 population	MSCL*C	.047	.10	2.13	1; and 7, Table 2
13) New England dummy, New England = 1	NENGL	.057	.23	4.03	3
14) Non-federal General Practice MDs and Medical Specialists in Patient Care, per thousand population, in 1967	GENMD*	.51	.12	.24	2; and 7, Table 2
15) The Square Root of the Number of Hospitals	SRHOSP	3.20	1.92	.60	7, Table 2
16) Non-federal Surgical Specialists in Patient Care, per thousand Population in 1967	SURG*	.35	.090	.26	2; and 7, Table 2
17) % of Males, 10-39, in 1960	%M1039	43.73	3.48	.080	5, Table 20
18) % of Males, 40-54, in 1960	%M4054	17.47	1.67	.096	5, Table 20
19) % of Males, ≥ 55, in 1960	%M55	15.51	3.45	.22	5, Table 20
20) % of Females, 10-39, in 1960	%F1039	43.35	2.84	.066	5, Table 20
21) % of Females, 40-54, in 1960	%F4054	17.44	1.57	.090	5, Table 20
22) % of Females, ≥ 55, in 1960	%F55	17.42	3.68	.21	5, Table 20
23) % of Population, Female, 1960	%FEMAL	50.86	1.16	.023	5, Table 20
24) % Change in Population, 1950-1960, Squared	%CHGPO2	2201.0	7218.4	3.28	4, Table 63
25) Land Area of SMSA (in square miles) per 100,000 population	AREA*C	559.50	786.24	1.41	6, 1962, Table 3, Var. 1; and 7, Table 2
26) Deaths from Arteriosclerotic Heart Disease, Including Coronary, per thousand population	HEART*	2.51	.78	.31	7, Table 2; and 9

Variable Name (Units)	Symbol	Mean	Standard Deviation	Coefficient of Variation	Source
(27) Deaths from Vascular Lesions affecting Nervous System - Strokes per thousand population	STROKE*	1.00	.27	.27	7, Table 2; and 9
(28) Deaths from Motor Vehicle Accidents per thousand population	MOTOR*	.21	.068	.32	7, Table 2; and 9
(29) Deaths from Other Accidents per thousand population	OTHACC*	.29	.061	.21	7, Table 2; and 9
(30) Suicide per thousand population	SUIC*	.11	.037	.34	7, Table 2; and 9
(31) Homicide per thousand population	HOMIC*	.050	.037	.74	7, Table 2; and 9
(32) Deaths from 6 Leading Emergency Situations (Sum of variables (26) to (31))	EMERG*	4.16	.93	.22	7, Table 2; and 9
(33) Insurance X Number of Non-surgical out-of-hospital Physicians per thousand population ((39) x (14))	HI*XMD*	26.40	10.58	.40	2; 6, 1967, Table 3, Var. 24, 25, 58, and 60; and 7, Table 2
(34) Number of Medical Students per 100,000 population	MST*C	14.96	32.53	2.17	1; and 7, Table 2
(35) Total Deaths per thousand population	MORT*	8.91	1.64	.18	7, Table 2; and 9
(36) Live Births per 1000 women aged 17-46, 1967	LBR	93.81	16.06	.17	5, Table 20; and 10
(37) Numbers of Medical Students per Medical School, per 100,000 population (0 if schools =0)	ST/SH*C	12.98	29.91	2.30	1; and 7, Table 2
(38) Square Root of 1/population 1966 (population not in thousands)	SPOP66	.0019	.00079	.42	7, Table 2

Hospital Utilization
N = 192 SMSAs

Variable Name (Units)	Symbol	Mean	Standard Deviation	Coefficient of Variation	Source
(39) Hospital and Surgical Insurance Benefits per Capita (in dollars)	HSB/C	50.51	13.21	.26	6, 1967, Table 3, Var. 24, 25, 58, and 60; 7, Table 2; and 8
(40) Insurance X Number of surgeons per thousand population ((39)X(16))	HI*XSG*	17.91	6.91	.39	2; 6, 1967, Table 3, Var. 24, 25, 58, and 60; and 7, Table 2

Table A-2

SOURCES

1. Table 1: "Approved Medical Schools and Schools of Basic Medical Sciences." The Journal of the American Medical Association, Education Number, 210 (November 24, 1969), 1462-3.

2. Table 14: "Medical Practice Data by Metropolitan Area." Haug, J.N. and Roback, G.A. Distribution of Physicians, Hospitals, and Hospital Beds in the U.S. - 1967 by Region, State, County and Metropolitan Area. Chicago: American Medical Association, 1968.

3. U.S. Bureau of the Census' definition of states by region and division.

4. U.S. Department of Commerce, Bureau of the Census. Census of Population: 1960. Vol. I: Characteristics of the Population. Part I: United States Summary. Washington, D.C. : U.S. Government Printing Office, 1964.

5. U.S. Department of Commerce, Bureau of the Census. Census of Population: 1960. Vol. I: Characteristics of the Population. Parts II-LII: [The States]. Washington, D.C.: U.S. Government Printing Office, 1963.

6. U.S. Department of Commerce, Bureau of the Census. County and City Data Book(s), 1962 and 1967. (A Statistical Abstract Supplement). Washington, D.C.: U.S. Government Printing Office, 1962 and 1967.

7. U.S. Department of Health, Education, and Welfare, Public Health Service. Hospitals: A County and Metropolitan Area Data Book (PHS Pub. No. 2043, Section 1). Rockville, Maryland, November 1970.

8. Reed, Louis S. and Carr, Willine. "Private Health Insurance, Enrollment, Premiums and Benefit Expense, by Region and State, 1966." Research and Statistics Note No. 14 - 1968, U.S. Department of Health, Education and Welfare, Social Security Administration, July 29, 1968.

9. Table 9-8: "Deaths from 59 Selected Causes for Standard Metropolitan Statistical Areas of the United States: 1960." U.S. Department of Health, Education, and Welfare, Public Health Service. Vital Statistics of the United States, 1960. Vol. II: Mortality, Part B. Washington, D.C.: U.S. Government Printing Office, 1963.

10. Table 1-55: "Live Births by Live-Birth Order and Race, for SMSA's of the U.S.,1967." U.S. Department of Health, Education, and Welfare, Public Health Service. Vital Statistics of the United States, 1967. Vol. I: Natality. Washington, D.C.: U.S. Government Printing Office, 1970.

SOURCES

11. U.S. Department of Commerce, Bureau of the Census. U.S. Census of Population: 1960. Selected Area Reports. State Economic Areas. Final Report PC (3) -1A. Washington, D.C.: U.S. Government Printing Office, 1963.

Table A-3
Hospital and Surgical Benefits Per Capita

Variable Name (units)	Symbol	Mean	Standard Deviation	Coefficient of Variation	Source for state and SMSA data
		Number of Observations, 41 States			
A) Endogenous Variable					
1) Hospital and Surgical Bene-fits per capita	HSB/C	41.65	10.69	.26	4, Tables 9; 6, 1967, Tables 1 and 3, Variables 23, 24, 25, 58, and 60; 7, Table 2; and 8.
B) Exogenous Variables					
1) % of Employed in 1960, in Manufacturing in 1960	%MANUF	22.81	10.14	.44	6, 1967, Tables 1 and 3, Variables 23 and 24
2) % of Employed in 1960, White Collar in 1960	%WC	38.92	4.54	.12	6, 1967, Tables 1 and 3, Variables 23 and 25
3) % of Employed in 1960, in Local Govern-ment in 1962	%LOCAL	6.79	1.07	.16	6, 1967, Tables 1 and 3, Variables 23 and 58
4) % of Employed in 1960, in Federal Go-vernment in 1965	%FED	3.92	2.20	.56	6, 1967, Tables 1 and 3, Variables 23 and 60
5) % of Popula-tion not in an SMSA, in 1960	%NOTSMSA	48.30	24.80	.51	4, Table 18

C) States Excluded: (a) No SMSA's: Vermont, Idaho, Wyoming, and Alaska. (b) Substantial commutation across state borders: New York, New Jersey, Connecticut, Virginia, Maryland, and District of Columbia

D) Weighted Regression (weighted by state's population)

$$HSB/C = -38.992 - 2.5774(\%LOCAL) + .7215(\%MANUF) + 2.1672(\%WC) - 1.3556(\%FED)$$

APPENDIX B - TABLES

Analysis of SMSA Differences in Bed Occupancy Rates
Table B - 1 -
Dependent = LnOR
N = 192 SMSAs

	1. OLS		2. 2SLS W/ADMS* (Table B -4, #2)	
Variables	coef.	t ratio	coef.	t ratio
ADMS*	.00034	1.44		
$\hat{\text{ADMS}}$*			.00094	1.30
BEDS*	-.022	-3.02	-.035	-2.11
SPOP66	-41.177	-3.27	-52.299	-2.91
SRHOSP	-.012	-2.71	-.013	-2.80
HSB/C	.00054	0.78	.00033	0.45
INC	-.0023	-0.18	.00068	0.05
%NWHT	.0018	2.61	.0017	2.36
%CHGPO	-.00037	-1.69	-.00038	-1.69
JANTEMP	-.0027	-3.28	-.0027	-3.30
BR	-.00061	-1.49	-.00058	-1.37
%FEMAL	.0029	0.13	.013	0.52
%M1039	-.017	-0.70	-.0041	-0.15
%M4054	-.043	-1.58	-.025	-0.73
%M55	-.0091	-0.36	.0031	0.10
%F1039	.021	0.90	.0094	0.34
%F4054	.052	1.81	.034	0.95
%F55	.013	0.54	.0025	0.09
%SLBED	.00043	1.34	.00045	1.37
%FDBED	.00090	1.44	.0014	1.65
%PRBED	-.00091	-1.26	-.00095	-1.28
NENGL	-.041	-1.69	-.039	-1.56
const.	4.066	3.29	3.481	2.45

R^2 .4346

SOURCE: See Appendix A

Analysis of SMSA Differences in Bed Occupancy Rates
Table B - 2 -
Dependent = LnOR
N = 201 SMSAs

	1. OLS		2. 2SLS W/ADMS* (Table B -5, #2)	
Variables	coef.	t ratio	coef.	t ratio
ADMS*	-.00011	-0.58		
$\hat{ADMS}$*			.00036	.070
Beds*	-.0016	-0.37	-.0079	-1.04
SPOP66	-34.900	-2.75	-46.453	-2.70
SRHOSP	-.012	-2.75	-.014	-2.89
HSB/C	.00074	1.06	.00063	0.88
INC	.00010	0.008	.0023	0.17
%NWHT	.0018	2.46	.0016	2.10
%CHGPO	-.00044	-1.98	-.00048	-2.10
JANTMP	-.0021	-2.63	-.0019	-2.26
LBR	-.00039	-0.96	-.00032	-0.76
%FEMAL	.0097	0.46	.016	0.71
%M1746	-.0088	-0.39	.00074	0.03
%M4761	-.036	-1.34	-.020	-0.64
%M62	.0020	0.08	.011	0.43
%F1746	.017	0.76	.0077	0.31
%F4761	.043	1.53	.028	0.85
%F62	.0044	0.19	-.0040	-0.16
%SLBED	.00043	1.36	.00050	1.53
%FDBED	.00046	0.82	.00072	1.14
%PRBED	-.0013	-1.70	-.0013	-1.77
NENGL	-.031	-1.29	-.027	-1.07
const.	3.448	3.05	3.113	2.61
R^2		.4009		

Source: See Appendix A

Analysis of SMSA Differences in Bed Occupancy Rates
Table B - 3 -
Dependent = LnOR
N = 192 SMSAs

	1. 2SLS W/ADMS* (Table B -6, #1)		2. 2SLS W/ADMS* (Table B -6, #2)	
Variables	coef.	t ratio	coef.	t ratio
ADMS*	.0010	1.39	.0015	1.94
BEDS*	-.035	-2.11	-.038	-2.61
SPOP66	-53.019	-2.92	-78.556	-3.54
SRHOSP	-.013	-2.70	-.016	-3.26
HSB/C	.00019	0.26		
INC	.0024	0.17		
%NWHT	.0018	2.47	.0017	2.23
%CHGPO	-.00037	-1.61	-.00035	-1.65
JANTEMP	-.0027	-3.23	-.0028	-3.91
LBR	-.00061	-1.46	-.00055	-1.22
%FEMAL	.014	0.56	.021	0.80
%M1039	-.0036	-0.13	.012	0.37
%M4054	-.026	-0.74	-.014	-0.37
%M55	.0072	0.24	.016	0.51
%F1039	.011	0.39	-.0058	-0.18
%F4054	.033	0.92	.023	0.58
%F55	-.000052	-0.002	-.011	-0.36
%SLBED	.00040	1.19		
%FDBED	.0014	1.68		
%PRBED	-.0010	-1.39		
const.	3.329	2.33	3.112	2.18

SOURCE: See Appendix A

Analysis of SMSA Differences in Hospital Admission Rates

Table β - 4

Dependent = ADMS*

N = 192 SMSAs

	1. OLS		2. 2SLS W/LnOR (Table β -1 #2)	
ariables	coef.	t ratio	coef.	t ratio
nOR	-14.029	-0.60		
$\hat{n}$OR			-365.576	-3.28
EDS*	16.952	11.09	10.703	3.63
SB/C	.768	1.10	2.379	2.08
ENMD*	-61.644	-0.71	-86.295	-0.67
URG*	226.056	1.88	534.509	2.67
I*XMD*	1.104	0.66	2.016	0.81
I*XSG	-3.442	-1.45	-9.238	-2.36
NC	-15.918	-3.97	-19.934	-3.30
ANTMP	-.767	-3.00	-1.936	-3.75
SCL*C	-17.794	-0.54	-37.462	-0.76
T/SH*C	-.090	-0.77	.058	0.33
TRADE	2.202	2.36	.908	0.63
NWHT	.307	1.24	1.032	2.43
BR	-.054	-0.39	-.257	-1.20
FEMAL	-20.784	-2.89	-24.660	-2.31
MORT	-6.818	-2.38	-4.769	-1.12
M1039	-27.429	-3.62	-37.719	-3.26
M4054	-29.156	-3.34	-55.118	-3.66
M55	-24.006	-2.96	-33.789	-2.75
F1039	27.522	3.58	37.932	3.22
F4054	30.213	3.26	58.944	3.65
F55	24.798	3.10	33.377	2.77
ENGL			-15.230	-1.17
onst.	1218.73	2.91	2914.57	3.63
R^2	.6784			

OURCE: See Appendix A