Estimating Hospital Use in Arkansas

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RECENTLY, a Ralph Nader group charged that a nationwide surplus of 100,000 beds (in addition to a 15 percent emergency reserve) costs the American consumer $2 billion a year (*1*). Moreover, the group alleged that 250,000 beds are occupied by patients who should never have been hospitalized or were hospitalized too long. These beds cost another $5 or $6 billion annually. The report charges that this "national hospital bed overdose" adds $60 to each patient's hospital bill just to pay the estimated $20,000 annual cost of an empty bed.

The president of the American Hospital Association denies that such a large hospital bed surplus exists, pointing to the fact that there are 120,000 fewer hospital beds than in 1960. However, the Department of Health, Education, and Welfare has estimated a national surplus of 60,000 beds.

Where does Arkansas fit in this picture? Arkansans often point to overcrowded conditions in some hospitals and conclude that there are not enough beds to serve the populations needs. Others see empty beds in certain hospitals or at certain times of the year and assert that too many hospital beds are wasting scarce resources.

To try to answer this question with facts, a study of the adequacy of the supply of hospital facilities was conducted. The study had two objectives: first, to develop a model based on demographic and socioeconomic characteristics of the population for estimating the expected use of hospital beds; and second, to compare the expected use of hospital beds in 1980 with the supply existing in 1973. It was necessary to develop and test several models for estimating use and to try several variations of their components, since empirical studies have shown demand factors to vary according to specific context (*2–4*). Additionally, Ro (*5*) has pointed to the potential importance of testing for interactions among categorical variables such as age, sex, and race. Moreover, any plans based on the results of this study will have to consider both the physical conditions of the present hospitals and their location. For example, an apparent oversupply of hospital beds in an area that is emerging as a center for health services might be desirable.

Definition of Terms

The economist defines demand as the amount of a particular commodity or service that a consumer is willing and able to purchase at each possible price during a specified period of time, all other things affecting demand remaining the same. Traditional analysis of economic demand can be extended to examine the demand for medical care, and for one of its components, hospital services. However, certain qualifications must be made to reflect the difference between health care and most other goods and services.

A basic difficulty is the definition of the terms "demand," "need," and "want" as they are applied to health care (*6*). The amount of medical care "needed" is determined by health professionals and is not directly related to economic considerations.

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The amount of medical care "wanted" by a population is based on the amount that consumers believe they ought to have, based on their own interpretation of their health status. Consumer "wants" may differ from "needs" because of the consumer's lack of health information, as well as cultural, educational, and religious factors.

Wants and needs are not necessarily translated into demand for health services. Demand requires that the consumer be able to purchase the commodity in question, and the ability to purchase depends on availability of resources. Translation of needs or wants for medical care into demand depends on the price of medical care, the price of other goods and services, and buyers' incomes.

The determination of the demand for medical care by empirical means is not easy. Prices in a given community at a given time are not usually allowed to vary, and information about the other determinants of demand is often incomplete. It is a widely accepted practice, however, to use actual hospital utilization in a time period as a measurement of the effective demand for hospital services. So widespread is this practice that the terms "demand" and "use" have come to be used synonymously, as they are in this paper.

Methods

The data used in this study were obtained in the Arkansas Health Interview Survey, which was completed in May 1973 (*7*). The survey, a statewide project conducted jointly by the Arkansas Health Statistics Center and the Arkansas Health Systems Foundation, was intended to identify patterns of health service utilization and unmet needs. Information was provided by a sample composed of 4,214 households representing 12,556 persons. The plan for selection of the households was designed to produce a representative probability sample proportional to geographic and demographic population distribution.

The data on hospital beds for each of the State's eight planning and development districts generated from this survey were adjusted to account for residents of a district who used hospital facilities in Little Rock, Ark., or Memphis, Tenn. Information on patients in private hospitals in Little Rock was supplied by the Central Arkansas Planning and Development District, and on patients of the Veterans Administration Hospital, by hospital personnel. Information about patients in Memphis hospitals was obtained from an earlier report (*8*). The adjustments were made as follows: Total admissions for patients from each planning and development district to Memphis and Little Rock hospitals were determined and expressed as a percentage of the total admissions to the district's hospitals. The adjusted number of beds available in each district was obtained by multiplying this percentage by the total number of beds in the metropolitan hospitals. For the Veterans Administration hospitals, adjustments were made in terms of patient days rather than admissions.

A primary focus of the health interview survey was an examination of the socioeconomic and demographic factors related to the use of hospitals for the year ending May 1973. Several approaches were used to identify and measure the variables that were thought to affect hospital use. The general strategy was to use a multistage approach to gain a successively more precise understanding of the problem. Thus, a major preliminary step was to cross-classify and array selected variables with proportions of the population hospitalized and their average length of hospital stay. The major findings of the cross tabulations were as follows (*9*):

1. Approximately 14 percent of the 12,556 persons in the interview sample had been hospitalized during the year ending May 1973. This rate is about 4 percent above the national average. Among persons aged 65 and over, about 22 percent reported a hospitalization.

2. Hospital admission rates did not vary markedly in relation to income. However, in the childbearing ages of 17–44 years, lower income women generally had higher rates than upper income women. In contrast, upper income respondents aged 65 years and over were more likely to have been hospitalized in the previous year than lower income persons in this age group.

3. Hospital stays were often longer for lower income groups. Thus, although income was not a uniformly important variable in influencing hospital admission rates, it did affect length of stay.

4. Rural-urban differences did not greatly affect hospital admission rates. Although hospitals are generally more accessible to urban residents, rural residence did not appear to deter hospital use substantially.

5. Length of stay was also not generally influenced much by residence, but within some specific age-sex-income groups, rural-urban differences did exist. For example, urban men 45–64 years old averaged 15 days per year compared with 13.3 days for their rural counterparts.

6. Sex differences, although generally moderate, were of course marked during the childbearing years. Women aged 17–44 years had an admission rate of 18 percent, compared with 9 percent for men in this age group. On the other hand, men tended to have longer hospital stays than women, a difference which probably reflects the greater prevalence of cardiovascular illnesses among middle-aged men.

7. Age was highly related to use of hospital services. Hospital admissions plotted by age tended to follow a U-shaped curve, with length of stay increasing steadily with advancing age.

8. Nonwhites tended to have lower hospital admission rates than whites, but, with the exception of the elderly, they averaged longer hospital stays.

On the basis of these findings, we decided to analyze the data using several variations of a least-squares multiple regression model to determine the statistical importance of various socioeconomic and demographic factors in relation to length of hospitalization. This method has been used by other investigators for similar determinations (*3, 5*). We used the following general equation:

$$Y = a + \Sigma_i b_i X_i + \Sigma_j c_j W_j + u$$

where Y equals the total number of hospital bed days for the year ending May 1973, X_i equals the demographic and socioeconomic variables originally cross-classified (for example, age, family income, education of household head), W_j equals the dummy variables representing sex, third-party payments, race, residence, and the eight Arkansas planning and development districts, and u is a stochastic error term (*10*).

The use of dummy variables in the regression equation permits inclusion of nonquantitative variables that cannot be represented easily by numbers. A dummy variable is evaluated at either 1 or 0, the value depending on whether a certain condition is fulfilled or not. For example, a variable for sex might be given a value of 1 for females and 0 for males. Including such a variable in the regression equation determines the effect of sex on the dependent variable. If the value for its coefficient were 5.2, we would know that, other things being equal, females had 5.2 more units of the dependent variable than males had (5.2×1 versus 5.2×0).

A set of dummy variables may be used if a comparison among categories is of interest. In our study, we needed more than one dummy variable to measure the effect of the supply of hospital beds on days of hospitalization in a particular planning and development district, since there are eight districts. We needed only seven variables, however, because the coefficient of each variable was being compared to the situation of being in a particular category (Planning and Development District No. 3, for example) instead of being in the omitted category (Planning and Development District No. 1). That is, the omitted category provided a constant against which comparisons could be made.

Ro (*5*) has indicated that there may be interactions among variables in a hospital demand equation. To test for this possibility, variables representing interactions among age, sex, family income, insurance, race, residence, and family size were included. Additionally, the age variable was represented by linear, squared, and cubic transformations, since the cross tabulations of the household survey data as well as the results of other studies of hospital use have underscored the importance of the age variable. The dependent variable—number of hospital bed days in the year ending May 1973—was converted to natural logarithms to correct for the high standard deviation for bed days among older men.

Several variations of the full model were tested, stepdown procedures being performed to reveal those variables that contributed the least to the regression equation. Separate analyses were performed for males and females in an effort to explain a greater proportion of variance. However, the minimal increase in explanatory power did not outweigh the advantage of using a single model.

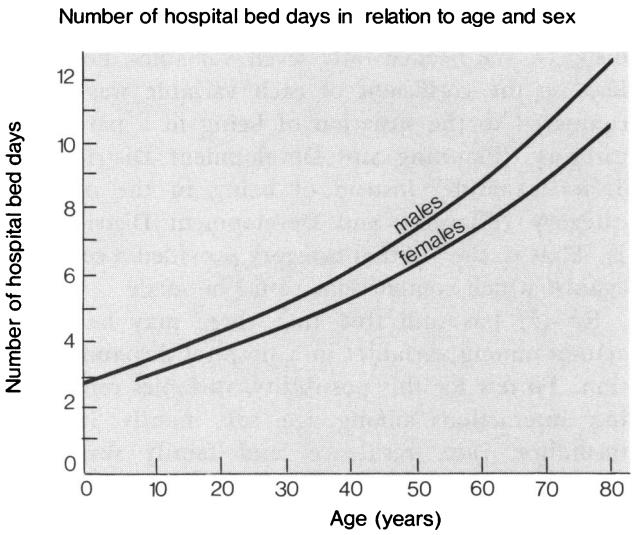
Results

The most statistically significant variables affecting the number of hospital bed days were age and sex. Age was five times better as a predictor than any other single variable, and only linear age and sex were significant at the 0.05 level of probability. The simplest reduced model with the most predictive power was as follows:

$$Y = e\ (1.147 - 0.07\,X_1 - 0.176\,X_2)$$

$$(R^2 = 0.19)$$

where e equals 2.718, the Y-intercept is e 1.147, X_1 is linear age in years, and X_2 is female (0 is male). The t values for the regression coefficients are 16.371 for X_1 and $-$ 3.386 for X_2. Logarithmic conversions of Y were done by computer. The calculated regression equation (converted from logarithms) for the State is pictured in the chart.



The *Y*-intercept is extremely important in a regression model of this type. It suggests a base level of operation. The number of bed days per person hospitalized indicated by the constant term *a* tells how many bed days can be expected regardless of the demographic makeup of the area. The regression equation fitted a line between the observations relating age and bed days. A great deal of variation may be seen about that line. Nineteen percent of that variation can be explained by the regression equation itself. Such a low level of explanatory power is not uncommon in studies of the demand for health care, since the cross-sectional data contain wide variations in individual behavior patterns. The very randomness of illness increases the variation that cannot be explained by a mathematical model.

The reduced model is useful in estimating the number of hospital beds that might be needed in the future. Comparisons between the projected use and existing supply can help to identify communities in which existing hospital facilities are likely to be either underused or insufficient. To illustrate, the number of beds that would be needed statewide to accommodate the expected use by persons 35–44 years old may be calculated as follows:

1. The probability of the members of any age-sex group entering a hospital in a given year is obtained by dividing the number of persons in the group who were hospitalized in that year by the total number in the group. Of the 600 men aged 35–44 years in the Arkansas household survey sample, 58, or 9.67 percent, reported that they had been hospital inpatients during the study year.

2. The regression equation is used to calculate the expected number of hospital bed days for any age group. The regression coefficient for age is multiplied by the midpoint for that age group. The calculation to estimate bed days for Arkansas men aged 35–44 years is:

$$Y = e\,[1.147 + 0.017\,(40)]$$
$$= e\,(1.147 + 0.68)$$
$$= e\,1.827$$

A natural logarithm table is then used to convert 1.827 to 6.22 days of hospitalization. The calculation for women in the 35–44 age group is:

$$Y = e\,[1.147 - 0.01017\,(40) - 0.176]$$
$$= e\,1.651$$
$$= 5.21 \text{ days of hospitalization}$$

3. To estimate the total number of bed days that will be used by a population segment in a given year, the probability of hospitalization (as determined by step 1) is multiplied by the projected population for that year and by the number of bed days per person hospitalized (as determined by step 2). For men 35–44 years old, the calculation for 1980 is:

$$\text{Expected bed days} = 0.0967 \times 111{,}448 \times 6.22$$
$$= 67{,}033$$

For women in the same age group, the calculation is:

$$\text{Expected bed days} = 0.1466 \times 115{,}990 \times 5.21$$
$$= 88{,}592$$

Thus, the total number of hospital bed days expected for this age group in 1980 is 155,626.

4. The formula for estimating the number of hospital beds that will be needed in 1980 is:

$$\text{Number beds} = \text{total annual bed days} \div 365 \times \text{usage rate}$$

Thus, for the age group 35–44 years, the calculation is:

$$\text{Number beds} = 155{,}625 \div 365$$
$$= 426$$

at a usage rate of 100 percent. With an average rate of 60 percent, which allows a margin for peak periods, 710 beds will be needed.

Estimates of the number of beds that will be needed statewide in 1980 by each age group are given in table 1. Data for each planning and development district, similarly calculated, are given in table 2. Comparison of the estimated bed needs with

Table 1. Use of hospital beds expected in 1980 in Arkansas, by age and sex

Age-sex group	Probability of hospitalization	Estimated 1980 population	Bed days per person hospitalized	Total expected bed days	Beds needed, 100 percent usage	Beds needed, 60 percent usage
0–14 years	.....	.....	....	155,343	426	710
Male	0.0910	274,330	3.55	88,622		
Female	0.0851	263,099	2.98	66,721		
15–24 years	.....	.....	....	175,410	481	802
Male	0.0767	179,399	4.42	60,819		
Female	0.1705	181,156	3.71	114,591		
25–34 years	.....	.....	....	189,752	520	867
Male	0.0694	148,005	5.24	53,823		
Female	0.1957	157,859	4.40	135,929		
35–44 years	.....	.....	....	155,625	426	710
Male	0.0967	111,448	6.22	67,033		
Female	0.1466	115,990	5.21	88,592		
45–54 years	.....	.....	....	197,247	540	900
Male	0.1427	95,281	7.37	100,207		
Female	0.1483	105,882	6.18	97,040		
55–64 years	.....	.....	....	267,471	733	1,222
Male	0.1851	93,456	8.74	151,191		
Female	0.1463	108,580	7.32	116,280		
64–96 years	.....	.....	....	655,575	1,796	2,993
Male	0.2161	121,624	12.30	323,280		
Female	0.2022	159,553	10.30	332,295		
All ages	.....	.....	....	1,796,423	4,922	8,204
Male	.....	1,023,543	....	844,975		
Female	.....	1,092,119	....	951,448		

Table 2. Estimated number of beds needed in Arkansas in 1980 in comparison with number existing in 1973, by planning and development district

Planning and development district	Expected bed days	Beds needed, 100 percent usage	Beds needed, 60 percent usage	Number of hospital beds, 1973	
				Actual	Adjusted [1]
Northwest	249,962	684	1,140	1,310	1,355
White River	157,930	431	718	636	950
Central (includes Little Rock)	373,150	1,024	1,707	4,297	3,000
Southeast	175,255	480	800	735	1,081
Southwest	156,335	428	713	1,019	1,238
East	309,674	848	1,413	1,154	1,647
West	210,492	557	962	905	944
West Central	203,319	557	928	970	1,338
State total	1,836,117	5,029	8,382	11,026	11,553

[1] Adjusted for Arkansas residents who were hospitalized in Little Rock or in Memphis, Tenn., but lived elsewhere.

the number of hospital beds existing in the State in 1973 leads to the conclusion that there is an ample supply to oversupply of hospital facilities in all districts. Thus, on the basis of these figures, Arkansas appears to fit the national pattern of a surplus of hospital beds.

Limitations and Cautions

These estimates of the number of beds needed in 1980 may somewhat understate actual needs, for two reasons. First, although an adjustment was made for Arkansans who are hospitalized outside the State, no data were available to adjust the estimates for non-Arkansans using Arkansas facilities. Second, the survey did not include persons who were hospitalized at the time of the survey, those who died in the hospital, or residents of nursing homes.

To get some idea of hospital use by the last two of these groups, we asked hospital and nursing home administrators for estimates. The administrator of the Washington Regional Medical Center in Fayetteville reported that 1.7 percent of the patients admitted in 1974 died while in the hospital. Operators of three nursing homes estimated that 40 percent of the residents of their homes were hospital inpatients during 1974 and that they stayed an average of 10 days each. Thus, an additional 142 hospital beds would be needed to accommodate the 13,000 Arkansans in nursing homes in 1971.

The figures representing the number of hospital beds available should also be accepted with caution. Although there is normally a direct relationship between the number of beds and the number of services provided by a hospital, the two are not necessarily synonymous when numbers are added to obtain a regional total. Forty-four of the 75 counties in Arkansas have fewer than 60 hospital beds. Many of the rural hospitals have 25 or fewer beds and provide only the most basic services. Only regional medical centers can afford the large financial outlays necessary for the new medical equipment developed in recent years. Also, consumers may prefer to bypass the small local hospital to take advantage of a large regional hospital that can provide specialized facilities if they are needed. Therefore, even though the numbers of beds for a region may indicate an oversupply, some hospitals in the region may have bed shortages while others have empty beds.

Another factor affecting hospital bed needs is the seasonal variation in use. Usage rates are calculated for a yearly average, but facilities must be provided to handle the peak periods of demand, such as during an influenza outbreak.

Conclusions

With the preceding limitations and cautions in mind, we can state that so long as current patterns of hospital use prevail and current demographic patterns remain relatively unchanged, no district in Arkansas is expected to experience a serious shortage of hospital beds in the near future (table 2). The districts most likely to need new hospital facilities are the East and White River Districts.

This is not to say, however, that no new hospital facilities will be needed. Some hospitals, for example, may need to be replaced. Or hospitals may need to be expanded or new ones built to meet population growth in a particular community or to provide more sophisticated facilities for diagnosis and treatment.

Changes in the types of services provided by existing hospitals may also be needed. Increasing use of hospital emergency and outpatient facilities denotes the emerging role of the hospital as the provider of primary care. Like it or not, hospital planners must recognize and provide for this role. Information on the age and sex distribution of the population in a region may indicate a need for increased geriatric, obstetric, or pediatric facilities.

References

1. Report charges surplus of U.S. hospital beds. The News and Courier (Charleston, S.C.) 173: 2, May 8, 1975.
2. Rosenthal, G. D.: The demand for general hospital facilities. Hospital Monograph Series No. 14. American Hospital Association, Chicago, 1964.
3. Joseph, H.: Empirical research on the demand for health care. Inquiry 8: 61–71, March 1971.
4. Feldstein, M. S.: Economic analysis for health service efficiency. Amsterdam, North Holland, 1967.
5. Ro, K.-K.: Interactions among variables affecting hospital utilization. Health Ser Res 8: 298–308, Winter 1973.
6. Jeffers, J. R., Begnanno, M. F., and Bartlett, J. C.: On the demand versus need for medical services and the concept of "shortage." Am J Public Health 61: 46–63, January 1971.
7. McCoy, J. F.: Personal health care survey documents needs of 4,200 Arkansas households. Technical Report No. 1. Arkansas Health Statistics Center, Little Rock, 1973.
8. Mid-South Medical Council: Patient origin study for Memphis area and Southwest Tennessee. Memphis, Tenn., Apr. 11, 1973.
9. Grinstead, M. J., McCoy, J. F., and Green, B. L.: Patterns of hospital use in Arkansas, May 1, 1972, to April 30, 1973. Arkansas Agricultural Experiment Station Special Report 26. Fayetteville, Ark., February 1976.
10. Grinstead, M. J., Doyle, R., McCoy, J. F., and Green, B. L.: A model for estimating hospital usage in Arkansas, by planning and development districts. Arkansas Agricultural Experiment Station Bull. 809. Fayetteville, Ark., August 1976.