Rural Hospital Costs: an Analysis with Policy Implications

LARRY E. FINCH, MS
JON B. CHRISTIANSON, PhD

RECENTLY, RISING COSTS OF HEALTH CARE, and particularly hospital care, have focused legislative attention on the health care delivery system in the United States. One result of this attention was the National Health Planning and Resources Development Act of 1974, which gave public agencies at the State and local levels responsibility for health care planning. In connection with the act, National Guidelines for Health Planning were issued in August 1977. Among other recommendations, the Guidelines suggest that a maximum of 4 hospital beds per 1,000 people and a minimum occupancy rate of 80 percent for those beds are desirable for an efficient local hospital system (*1*).

Rural hospitals typically exhibit occupancy rates considerably lower than the recommended 80 percent, and rural hospitals often have more than 4 beds per 1,000 residents, although many of the hospitals are quite small. Therefore, one implication of the Guidelines is that reductions in rural hospital capacity may be desirable so long as they do not significantly impair rural residents' access to care for acute illnesses. McClure, among others, has concluded that the greatest savings in the reduction of hospital capacity would occur if entire hospitals were closed (*2*). Furthermore, Berry suggests that economies of size may exist in the provision of hospital services (*3*). If the conclusions based on evidence from research are correct, there seem to be sound economic reasons for closing selected, small rural facilities and providing hospital care with fewer total beds concentrated in larger, more heavily used facilities.

Nevertheless, other considerations must be balanced against the potential cost savings from such a policy. For example, a reduction of rural hospital capacity through closures necessarily would impose increased travel costs on rural residents and, arguably, would subject them to greater risk because of delay in receiving medical treatment. Furthermore, closing entire hospitals could have detrimental effects on the economic viability of rural communities (*4*). Therefore, the desirability of applying the Guidelines in rural areas depends on the magnitude of the potential cost savings from the resulting more intensive use of hospital capacity and from exploitation of economies of size. If these savings are substantial, they could outweigh the adverse effects noted previously and justify strict application of the Guidelines even in the face of opposition from rural communities (*5*). If the economies are relatively small, then a case can be made for giving rural areas further special considerations under the Guidelines. (The Guidelines already provide exemptions for hospitals located more than 30 minutes' travel time from an alternative facility.)

On the basis of the foregoing discussion, it seems important to estimate the costs of providing care in rural hospitals, particularly as these costs relate to hospitals' size and occupancy rates. None of the numerous hospital cost studies in the literature (*3,6–10*) are based on a sample of exclusively rural facilities. Therefore, it may not be appropriate to apply the results of this research to planning and policy decisions for rural areas. The purpose of our study is to supply information on hospital costs that can be used in making decisions relating to the delivery of health care to rural populations.

Mr. Finch is an economist in the Utility Division, Montana Public Service Commission, Department of Public Service Regulation, State of Montana, Helena, Mont. 59620. Dr. Christianson is an associate professor in the Department of Public Policy, Planning, and Administration and the Department of Economics, University of Arizona, Tucson, Ariz. 85721.

Research for this study was funded by grant No. 1–R03–H5–03374–01, from the National Center for Health Services Research, Office of Health Policy, Research, and Statistics, Department of Health, Education, and Welfare, and by the Montana State University Agricultural Experiment Station.

Tearsheet requests to Dr. Christianson.

Table 1. Annual means of selected variables for 116 rural hospitals in Montana, Idaho, Wyoming, Utah, and Nevada, 1971–77

Variable	1971	1972	1973	1974	1975	1976	1977
Total cost of patient care	$515,802	$566,108	$587,757	$674,147	$799,058	$888,500	$1,049,387
Total payroll	$297,920	$312,752	$325,698	$353,880	$420,039	$458,829	$523,218
Total payroll ÷ total cost	.58	.55	.55	.52	.53	.52	.50
Average cost per patient day	$62.45	$73.44	$77.91	$92.67	$106.09	$126.45	$151.25
Average daily census	23.39	22.49	22.24	21.70	22.02	20.84	20.69
Size (number of beds)	40.88	40.32	40.76	40.79	40.11	41.92	42.39
Occupancy rate	.54	.52	.52	.51	.50	.49	.48
Long-term beds	6.73	6.88	7.44	7.52	7.62	8.35	8.66
Admissions	1,239	1,245	1,233	1,240	1,289	1,239	1,267
Length of stay (days)	7.83	7.45	7.89	7.78	7.68	7.67	7.38

Background and Data

The difficulties in determining hospital cost functions are indicated by the disagreement in the literature regarding the theoretical shape of the long run average cost curve and by the lack of consensus among the results of previous empirical studies. Classic economic theory predicts a U-shaped long run average cost curve. Costs initially fall as number of beds increases and hospitals realize the economies of size inherent in the indivisibility of inputs and in the specializaton that is possible in larger facilities but, eventually, costs begin to rise in response to managerial diseconomies. On the other hand, Alchian (*11*) and Hirshleifer (*12*) have provided theoretical justifications for an L-shaped long run average cost curve. Finkler, in applying this alternative to hospitals, argued that the diseconomies discovered in past empirical studies are misleading, reflecting primarily higher costs in large hospitals that result from the inefficient use of highly sophisticated and expensive services (*13*). The empirical literature also yields conflicting evidence concerning the shape of long run average cost curves for hospitals and, in studies concerned with economies of size, there is wide divergence of opinion regarding the cost-minimizing number of beds per facility (*14*).

Given the lack of both theoretical and empirical consensus, in this study we provided estimates of average cost functions for rural hospitals using both quadratic and logarithmic functional specifications. The quadratic specification is consistent with a U-shaped curve and allows estimation of the least-cost number of beds or facility size. The log specification conforms to an L-shaped curve and has no minimum point. We made no attempt to choose the most appropriate functional form; both are used to provide a range for projecting cost savings.

Since one goal of the study is estimation of the effects of increasing hospital size through consolidation, number of beds rather than patient days was used as an explanatory variable even though patient days is a more conventional measure of output. In this respect, the analysis is similar to that of Lave and Lave (*6*) and of Davis (*10*), who also estimated size effects explicitly while considering the effects of increasing output, defined as patient days, only implicitly.

The hospital occupancy rate is included as an explanatory variable in both specifications to permit estimation of the short run average cost curve (holding size of facility constant) and the determination of the least-cost occupancy rate, in the case of the quadratic specification. If the estimated curves are found to be relatively flat, then one would predict only small efficiency gains from increasing the occupancy rates of rural hospitals or consolidating rural hospitals to provide care in larger facilities. However, if the curves display steep, downward sloping sections within the relevant range, one would expect substantial savings from consolidation.

The analysis is based on data pertaining to 116 hospitals from 5 Rocky Mountain States—Montana, Idaho, Wyoming, Utah, and Nevada—with annual observations in the period 1971–77. Because there is no established definition of a rural hospital, the inclusion of specific hospitals was a matter of judgment. Generally speaking, a hospital qualified as rural if it was located in a city of less than 12,500 population and in a county with less than 16 people per square mile. Ninety-eight percent of the hospitals in the sample were organized as not-for-profit institutions, and 53 percent were classified as publicly owned.

Table 1 presents trends in the annual means for a subset of variables used in the subsequent analysis. Perhaps the most striking feature is the 142 percent increase in average cost per patient day over the 7 years. This figure amounts to a greater than 20 percent rate of increase annually, and it compares to increases of 103 percent in total cost and 75 percent in total payroll over the same period. These rates of increase suggest that salary expenditures were not primarily responsible for the rapid rise in average cost per patient day. Table

1 also indicates that average occupancy rates dropped 6 percentage points in 7 years. The average number of long-term care beds increased over the period, as did the ratio of long-term care to total beds, while total admissions remained relatively stable. During the last 4 years of the study period, there was a gradual reduction in average length of stay, despite the increase in long-term care beds.

Methodology

The empirical methodology we employed in the study is consistent with past efforts (*3, 6–10, 15–19*). Multiple regression analysis was used to relate average cost per patient day to a set of explanatory variables specified primarily by economic theory (table 2). This process does not yield true technical cost relations in the usual sense, since cost-minimizing behavior by hospital decision makers cannot be safely assumed. Instead, as Evans notes, the results are most appropriately interpreted as "behavioral, . . . representing only the relationship between costs and outputs with present technology and hospital behavior" (*20*). The following are justifications for the inclusion of specific independent variables in the analysis.

Economies of size and efficiencies in capacity utilization. The quadratic specification, in which number of beds and the square of this number are used simultaneously in the analysis, indicates a U-shaped cost function if the coefficient on the number of beds variable is negative and the beds-squared variable has a positive coefficient. The logarithmic specification hypothesizes that costs are a decreasing, but not a constantly decreasing function of hospital size. In this model, the marginal impact of size on average hospital costs diminishes as the number of beds in the hospital increases.

Inclusion of the occupancy rate as an explanatory variable permits calculation of the change in total hospital costs that results from admitting an additional patient (that is, the marginal cost of a patient day). The coefficient on the occupancy rate variable is expected to be negative, since it is assumed that hospitals staff to meet peak demands and regulatory requirements and that this relatively fixed component of costs is dispersed over a larger number of patient days as occupancy rates increase, thereby reducing average cost per patient day. A U-shaped short run average cost function is indicated if the coefficient on the occupancy-squared variable is positive in the quadratic specification.

Controlling for variations in the content of a patient day. The patient day is clearly not a homogenous, unambiguous measure of hospital output. Therefore, variation in measured average costs per patient day could reflect variations in the nature of a patient day, as well as variation in costs. These possibilities make interpretation of the empirical estimates difficult. Therefore, some researchers have proposed the use of alternative output measures, such as "weighted patient days" (*8,9,21*). More frequently, rather than trying to adjust measures of output directly, researchers have included explanatory variables designed to control for variation in the nature of the patient day *(10,22,23)*. The same procedure was adopted for this study.

The intensity of use of hospital services can vary from hospital to hospital for a specific diagnosis. This variation is likely to be related to several factors, including diagnosis-specific length of stay and the availability of specialized facilities and services. It is expected that longer stays reduce average cost per patient day by reducing the proportion of more expensive hospital days (typically, the day of admission and of discharge) in the total number of patient days. It is assumed that the presence of specialized services in a hospital also increases average costs in that the services stimulate provision of care which otherwise might not be given. The availability of various services is incorporated in the model through the use of binary variables (*10*). For each service listed in table 2, a value of 1 was assigned if the service was present and 0 if it was absent. The mean for each variable (table 2) represents the proportion of the 116 hospitals offering the service.

A second potential source of variation in the nature of a hospital day from facility to facility is variation in the mix of patients' diagnoses. Case mix variables have proved to be significant in explaining average hospital costs in previous studies (*9*), but no detailed case-mix data were available pertaining to the rural hospitals in this study. Therefore, births per 1,000 population and percent of the area's population over age 65 were adopted as surrogate variables. Admissions for childbirth are associated with short stays and relatively uncomplicated medical procedures. On the other hand, illnesses of the aged often require long hospital stays and intensive use of hospital resources. When length of stay is held constant, one would predict that average costs would be negatively related to births per 1,000 and positively related to the population over 65.

A third control for variation in case mix was introduced through use of an explanatory variable defined as the number of long-term care (nursing home) beds as a proportion of total beds. Ideally, since the primary concern of this study is explaining cost variation for short-term care in rural hospitals, costs for long-term care should be netted out of the data. However, the data did not permit this adjustment, necessitating use of the variable. The coefficient of this variable is anticipated to be negative, indicating that the greater the percentage of long-term beds at an institution, the lower the average cost per patient day. Finally, it is likely that facilities offering specialized services attract patients with serious illnesses and conditions. Use of the binary variables already described should help to control for this possible effect.

A third source of variation in the nature of a hospital day relates to quality of care. Hospitals with the same case mix and the same intensity of services conceivably could differ in quality of care. In theory, comparison of the costs per patient day at different facilities should be made for patient days of equal quality. Measuring quality of hospital care is a difficult problem which researchers have addressed with little success. To control for quality differences, a binary variable indicating accreditation status has been employed in hospital cost analysis (*3,8*). We adopted this procedure in our study with full realization of its inadequacies (*8*). The hypothesis is that accredited hospitals provide higher quality, more expensive hospital care.

Table 2. Summary statistics on selected variables for 116 rural hospitals

Variables	*Mean*	*Standard deviation*	*Range*
Dependent variable			
Average cost per patient day	$99.38	$48.32	$14.73–$331.85
Independent variables			
Size (number of beds)	41.17	21.84	9–133
Size-squared	2,172.30	2,440.50	81–17,689
Occupancy rate [1]	.507	.170	.063–.969
Occupancy-squared	.287	.176	.004–.938
Length of stay (days) [2]	7.67	6.65	2.8–64.16
Accreditation	.32	.47	...
Ratio of long-term beds to total beds	.15	.256	0–.873
Average salary [3]	$6,158.70	$1,565.59	$2,487–$15,000
Percent of population over 65	10.59	3.18	4–19
Births per 1,000 population	192.64	46.67	89–355
Ownership:			
County	.404	.491	...
City	.015	.120	...
City-county	.019	.138	...
Hospital district or authority	.088	.283	...
Church operated	.093	.290	...
Other	.356	.479	...
Corporation	.024	.154	...
Service or facility:			
Postoperative recovery	.44	.50	...
Intensive cardiac care	.30	.46	...
Intensive care unit	.46	.50	...
Pharmacy	.72	.45	...
Radiology	.14	.35	...
Histopathology	.09	.28	...
Blood bank	.42	.49	...
Inhalation therapy	.42	.49	...
Premature nursery	.16	.37	...
Physical therapy	.46	.50	...
Psychiatric services	.11	.32	...
Organized outpatient services	.13	.34	...
Emergency department	.83	.37	...
Social services	.11	.31	...
Volunteers (auxilliary)	.63	.48	...
Electroencephalography	.07	.26	...
Other services	.25	.74	...
Other medical services	.01	.12	...

[1] Average daily census divided by the average daily number of available beds.
[2] Total patient days divided by the number of admissions.
[3] Total payroll divided by the number of employees.
SOURCES: All data were taken from the "American Hospital Association Guide to the Health Care Field," except the data on percent of population over 65 years and on birth rate per 1,000 which were obtained from the "County City Data Book" for the years 1970 and 1975. Estimates of the values for other years in the study were obtained through straight line interpolation.

Other factors. One problem frequently encountered in hospital cost analysis is the existence of geographic differentials in wages. It has been shown, for example, that wages paid to hospital employees in urban and rural areas differ considerably (*7*). Data detailing the mix of personnel and wage rates at the institutions in the sample were not available. Therefore, to control for wage rate variation, the average wage rate, defined as total payroll divided by number of full-time employees, was used as an explanatory variable (*10*). If variation in the average wage is caused primarily by variation in personnel mix, and if personnel mix can be predicted accurately by other independent variables such as the service mix and facility size, then the estimated coefficient on the average wage variable should be insignificant. Conversely, a positive and significant coefficient is expected if variation in the average wage variable is related primarily to variation in wage rates.

It is also possible that variation in average cost can be explained partly by the form of hospital ownership and the management incentives that this implies. Specifically, it is expected that for-profit institutions will have lower costs than their nonprofit counterparts (*3*). Ownership form was introduced through a series of binary variables (table 2).

Since the regression analysis used cost data collected over 7 years, it is highly probable that costs rose during this period due to general inflation. To control for this time trend, a variable defined as the year of the observation was used. The coefficient of this variable measures the addition to average costs due primarily to the passage of 1 year—that is, to general economic inflation, holding constant all of the other factors described previously (*6*). Finally, in some regressions binary variables representing the different States in the sample were introduced. Their purpose was to control for variations in regulatory environments that might influence average costs.

Table 3. Determinants of average costs in rural hospitals: statistical results based on a quadratic specification

Variable	Model I Estimate	Model I t-value	Model II Estimate	Model II t-value	Model III Estimate	Model III t-value	Model IV Estimate	Model IV t-value
Constant	−805.13	...	−641.65	...	−606.47	...	−512.09	...
Year	12.91	[1] 20.77	10.79	[1] 16.30	11.23	[1] 17.93	9.84	[1] 15.85
Size	.0057	.026	−0.23	−1.21	−.251	−1.37	−.657	[1] −3.62
Size-squared	.0011	0.57	.0014	0.90	.0021	1.34	.0029	1.90
Occupancy	−98.59	[1] −2.8	−218.22	[1] −6.92	−294.79	[1] −9.05	−321.32	[1] −10.42
Occupancy-squared	−15.16	−0.45	113.98	[1] 4.39	205.00	[1] 6.58	221.03	[1] 7.47
Length of stay			−2.10	[1] −11.56	−1.42	[1] −6.77	−1.25	[1] −6.27
Accreditation			13.74	[1] 5.49	12.40	[1] 5.22	9.51	[1] 4.19
Average salary			.0052	[1] 6.01	.0043	[1] 5.17	.004	[1] 5.16
Long-term beds ÷ total beds					−31.85	[1] −5.55	−24.34	[1] −4.39
Percent of population over 65					−2.94	[1] −8.33	−2.25	[1] −6.61
Births per 1,000 population					−.067	[1] −2.82	−.051	[1] −2.23
R^2	.52		.65		.69		.75	
Postoperative recovery							9.40	[1] 4.23
Intensive cardiac care							.19	.09
Intensive care unit							13.30	[1] 5.93
Pharmacy							−1.66	−0.73
Radiological services							−1.72	−0.58
Histopathology laboratory							20.72	[1] 5.27
Blood bank							1.61	0.77
Inhalation therapy							2.16	0.87
Premature nursery							1.11	.41
Physical therapy							−1.27	−0.50
Psychiatric services							5.30	1.62
Outpatient services							−3.52	−1.22
Emergency department							7.49	[1] 2.71
Social services							−8.61	[1] −2.51
Volunteers							7.58	[1] 3.41
Electroencephalography							3.13	0.83
Other services							−1.40	−0.92
Other medical services							8.78	1.12

[1] Significant at the .95 level.

Statistical Results

Tables 3 and 4 present the regression results for the quadratic and log specifications. Variables are added in stages to understand better the relationships between different independent variables and to determine which coefficient estimates are robust. (Robustness refers to the degree to which the coefficient of a particular variable is impervious to changes in the cost function specification.)

Table 3 contains the results of the regression using the quadratic cost function specification. Year of the observation, percent occupancy, occupancy-squared, length of stay, accreditation, average salary, the ratio of long-term to total beds, percentage of the population over 65, and births per 1,000 population were all statistically significant variables at the 95 percent confidence level. The coefficient on the size variable did not attain significance until the linear model was fully specified (stage IV), suggesting that controlling for the service mix is important in estimating economies of size in rural hospitals. The coefficient on the size variable was negative while the coefficient on size-squared was positive and significant at the 94 percent level. When the service mix was included in the specification of the average cost function, the sign and magnitude of the coefficients on the size and size-squared variables suggest a long run average cost curve (LRAC) that has a relatively shallow U-shape. The coefficient on the occupancy variable was negative and that of the occupancy-squared variable was positive, and both were highly significant, suggesting a short run average cost curve (SRAC) that is U-shaped.

Table 4. Determinants of average costs in rural hospitals: statistical results based on a logarithmic specification

	Model I		*Model II*		*Model III*		*Model IV*	
Variable	*Estimate*	*t-value*	*Estimate*	*t-value*	*Estimate*	*t-value*	*Estimate*	*t-value*
Constant	3.720	...	1.602	...	3.349	...	3.387	...
T1	.123	[1]2.51	.106	[1]3.25	.108	[1]3.41	.071	[1]2.45
T2	.186	[1]3.83	.144	[1]4.43	.155	[1]4.90	.112	[1]3.80
T3	.336	[1]6.96	.261	[1]7.90	.273	[1]8.55	.218	[1]7.28
T4	4.64	9.48	.366	[1]10.75	.381	[1]11.55	.313	[1]10.04
T5	.620	[1]12.72	.477	[1]13.64	.493	[1]14.53	.415	[1]12.76
T6	.766	[1]15.74	.609	[1]16.61	.634	[1]17.78	.540	[1]15.80
ln size	.008	0.32	−.019	−1.04	−.036	[1]−1.92	−.155	[1]−7.39
ln occupancy	−.499	[1]−14.72	−.274	[1]−10.75	−.265	[1]−10.60	−.341	[1]−13.61
Accreditation			.120	[1]5.90	.118	[1]6.00	.087	[1]4.77
ln length of stay			−.440	[1]−23.16	−.443	[1]−22.43	−.381	[1]−19.49
ln average salary			.372	[1]8.82	.328	[1]7.95	.313	[1]8.28
ln long-term beds ÷ total beds					−.024	−1.25	−.0099	−0.55
ln percent of population over 65					−.206	[1]−6.91	−.618	[1]−6.03
ln births per 1,000 population					−.160	[1]−4.11	−.138	[1]−3.75
R^2	.50		.78		.79		.84	
Postoperative recovery							.098	[1]5.35
Intensive cardiac care							−.004	−0.22
Intensive care unit							.127	[1]6.95
Pharmacy							.013	0.71
Radiological services							−.021	−0.86
Histopathology laboratory							.128	[1]4.08
Blood bank							.029	1.68
Inhalation therapy							.025	1.20
Premature nursery							.022	0.97
Physical therapy							−.016	−0.77
Psychiatric services							.048	1.79
Outpatient services							−.038	−1.58
Emergency department							.060	[1]2.65
Social services							−.051	−1.81
Volunteers							.049	[1]2.68
Electroencephalography							.035	1.12
Other services							.0007	0.06
Other medical services							.059	0.92

[1] Significant at the .95 level.

Figure 1. Estimated long run average cost curves for rural hospitals

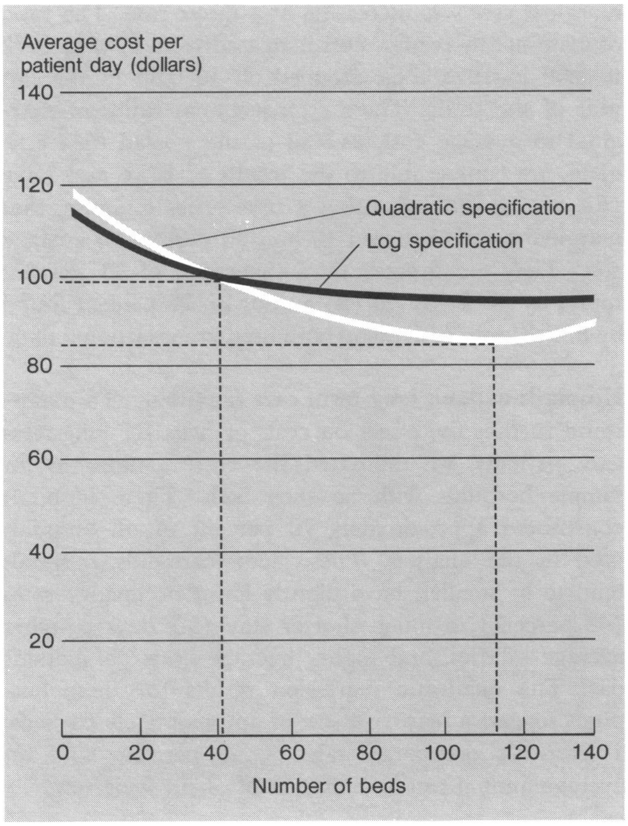
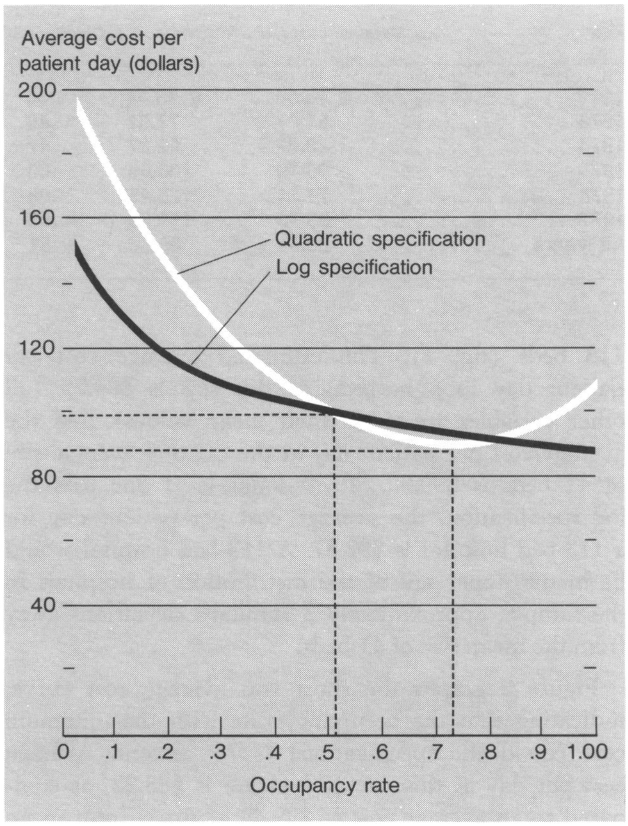


Figure 2. Estimated short run average cost curves for rural hospitals



In addition to these results of primary interest, the statistical analysis supported the following hypotheses: longer stays were reflected in lower average costs per patient day, accreditation and higher salaries led to higher average costs, greater proportions of long-term care beds were associated with lower average costs, as were higher percentages of the population over 65 and greater numbers of births per 1,000 population. These results are all consistent with expectations, with the exception of the percentage of the population over 65. The independent variables as a group explained 75 percent of the observed variation in average costs ($R^2 = .75$).

In the results of the log specification (table 4) the independent variables explained 84 percent of the observed variation in the log of average costs. Use of binary variables for the years in the study provided estimates of the annual rates of inflation over the period. The estimated average inflation rate was 9 percent. This specification also indicates the potential for economies of size and a reduction in average costs through increased occupancy rates. The other variables in the model once again had the same general effect on average cost as in the quadratic specification. A direct comparison of the goodness-of-fit of the two models on the basis of the reported R^2 values is not possible since the dependent variables are defined differently in the two regressions (*24*).

Additional regression results (not reported) tested hypotheses regarding form of ownership and the State in which the facility is located. No significant differences in cost per patient day between for-profit and not-for-profit institutions was found, nor was any significant pattern of cost differences relating to the five States uncovered. The coefficients pertaining to the explanatory variables in tables 3 and 4 were not altered materially by the addition of these variables. The full quadratic specification also was estimated using binary variables for each year, with no appreciable change in the R^2 value. (For a more detailed exposition of results concerning these and other hypotheses see Finch and Christianson (*25*).)

Facility size and occupancy rate. Figures 1 and 2 present the LRAC curves and the SRAC curves for the estimated quadratic and log models reported in tables 3 and 4. If one uses the quadratic specification, the size of the minimum cost facility is approximately

Table 5. Marginal cost per day of increasing the average hospital census by one patient

Year	Marginal cost (MC)	Average cost (AC)	MC ÷ AC
1972	$ 26.30	$ 73.44	.36
1973	31.07	77.91	.40
1974	43.37	92.67	.47
1975	63.19	106.09	.60
1976	71.31	126.45	.56
1977	83.73	151.25	.55
All years	50.61	99.38	.51

113 beds (fig. 1). The estimated average cost per patient day in a hospital of this size is $84.23 (all other variables are set at their mean values), and the average cost per patient day at the existing average size of 41 beds is $99.38 (1974 dollars). If one uses the log specification, the average cost per patient day for a 113-bed hospital is $92.87. A 113-bed hospital would lie in the upper tail of the distribution of hospitals in the sample, approximately 3 standard deviations away from the mean size of 41 beds.

Figure 2 graphs the short run average cost curve, indicating that the occupancy rate with the minimum cost (quadratic specification) is 73 percent. Average cost per day at this occupancy rate is $88.22, as compared to an average cost of $99.38 at the current mean occupancy rate of 51 percent (again, all other variables are equal to their mean values). For the log specification, the average cost per day at 73 percent occupancy is $93.42.

Marginal cost. The cost of adding a patient to the average hospital census (that is, the marginal cost of a patient day) is presented in table 5. This table displays the marginal cost estimates derived from separate yearly regressions using the quadratic specification, as well as a marginal cost estimate based on the pooled data sample. To derive the marginal cost of an additional patient day, first the estimated average cost function was converted to a total cost function by multiplying it by total patient days. The total cost of providing care for the average hospital census was projected by substituting mean values for the independent variables in the total cost function. Then the occupancy rate variables were adjusted upward to reflect the hypothetical addition of another patient, and a new total cost figure was projected. The difference between these two total cost estimates was taken to be the marginal cost of an additional patient.

Results are presented for only the last 6 years in the study because the occupancy rate variables were not significant for the year 1971. Marginal and average costs were both increasing throughout the period, but marginal cost was increasing at a faster rate. The ratio of marginal to average cost increased from 0.36 in 1972 to 0.60 in 1975 then dropped off to 0.55 in the last year of the study. These cross-sectional ratios of marginal to average cost, as well as the pooled data estimate, are comparable to the results of Lave and Lave (*6*), who concluded, using a time series estimate, that marginal cost is between 40 and 60 percent of average cost. They are greater than the ratios of 21 percent found by M. Feldstein (*9*) and of 21–27 percent found by P. Feldstein (*16*), who both used cross-sectional data.

Hospitals without long-term care facilities. To understand further the effect on costs of beds for long-term care patients, we estimated the cost relationship for sample hospitals with no such beds. These hospitals constituted approximately 70 percent of all hospitals used in the analysis. These acute-care-only hospitals tend to be smaller, have slightly lower occupancy rates (48 percent), a much shorter stay (5.2 days), higher average salaries, and higher average costs per patient day. The quadratic regression results for these hospitals suggest a least-cost size of approximately 64 beds, a least-cost occupancy rate of 63 percent, and an average annual rate of inflation of about 9 percent.

Policy Implications

The statistical results that we have reported can be used to estimate the savings that would arise if hospital care resources in rural areas consisted of fewer beds concentrated in larger, better utilized facilities than at present. Since the log specification is a constantly decreasing function, it cannot provide estimates of the least-cost size and occupancy rate for the sample of rural hospitals. These were derived by use of the quadratic specification. The estimates of least-cost size and occupancy reported previously are used subsequently as examples of how cost reductions can be estimated. Following that, the estimated reductions for various combinations of size and occupancy rates are presented for both specifications.

Least-cost size. How much could the total costs of providing hospital care to a rural population be reduced by using only hospitals of a size that minimizes the average cost per patient day, on the assumption that a quadratic specification is appropriate? It was pointed out previously that such a hospital would contain 113 beds (both acute and long-term care) and that the average cost per patient day is lower by $15.15 in hospitals of this size. The sample of 116 hospitals with an average of 41 beds and an average occupancy rate of 51 percent provides 885,329 total patient days of hospital care annually. Therefore, if it is assumed that total hospital days are not affected, the potential savings from using least-cost size hospitals are $15.15 × 885,329 = $13,412,734 annually. In this case, 42 hospitals of 113 beds each with occupancy rates of 51 percent could provide the same number of patient days that 116 hospitals provide.

Use of the log specification results in smaller estimates of cost savings, since it generates a much flatter long run average cost curve. According to this specification, the reduction in average cost from using 113-bed hospitals is $6.51 per patient day. This reduction results in annual savings of $6.51 × 885,329 = $5,763,492 for care in 42 hospitals.

Least-cost occupancy rates. Construction of larger facilities to replace existing hospitals in rural areas is unlikely. Therefore, a more interesting policy question is: How much could the total cost of providing hospital care to a rural population be reduced by increasing occupancy rates to the least-cost level of 73 percent as compared with the current level of 51 percent? The quadratic regression results indicated that average cost per patient day could be reduced by $11.15 if occupancy rates were increased to the higher level. If the total patient days were provided in hospitals with occupancy rates of 73 percent, an annual savings of $11.15 × 885,329 = $9,871,418 would result. This savings could be accomplished by using 81 facilities of 41 beds each. The savings with the log specification are estimated at $5.06 × 885,329 = $5,276,561 annually.

Current national guidelines advocate an occupancy rate of 80 percent compared with the least-cost rate of 73 percent (63 percent for acute hospitals only) suggested by this analysis. Implementing the 80 percent occupancy level reduces savings by $1,115,515 (quadratic specification) if 885,329 patient days are provided, but increases savings by $1,177,487 if the log specification is used. This saving is accomplished if 74 hospitals of 41 beds each are used.

Combining least-cost size and occupancy rate. As a benchmark, it also is useful to ask what savings are possible through provision of care at hospitals that minimize average cost per patient day with respect to both number of beds and occupancy rate. Because the savings that result from using larger hospitals while maintaining current occupancy rates and the savings that result from increasing occupancy rates while maintaining the current average bed size are additive in the models employed, the total savings from using institutions of 113 beds with occupancy rates of 73 percent are $26.30 per patient day, using the quadratic specification. Total annual savings in providing the current number of patient days are therefore $26.30 × 885,329 = $23,284,153. Care can be provided in only 29 hospitals. Table 6 presents the savings in average cost per patient day for several combinations of size and occupancy rate for the quadratic and log model specifications. The annual savings in providing the current number of patient days can be estimated by multiplying the value for a particular size-occupancy rate combination by 885,329.

The estimated savings, calculated previously, from increasing hospital size to 113 beds and occupancy rates to 73 percent may be overestimated because we

Table 6. Predicted reductions in average cost per patient day relative to sample averages for hospital size and occupancy

Occupancy rate	*Hospital size (number of beds)*									
	20	*30*	*41*	*50*	*60*	*70*	*80*	*90*	*100*	*110*
					Quadratic specification					
.50	−10.08	−4.96	...	3.54	6.92	9.72	11.94	13.58	14.64	15.12
.60	−2.34	2.78	7.74	11.28	14.66	17.46	19.68	21.32	22.38	22.86
.70	0.96	6.08	11.04	14.58	17.96	20.76	22.98	24.62	25.68	26.16
.73	1.08	6.20	11.16	14.70	18.08	20.88	23.10	24.74	25.80	26.28
.80	−0.18	4.94	9.90	13.44	16.82	19.62	21.84	23.48	24.54	25.02
					Log specification					
.50	−5.82	−2.46	...	1.45	2.82	3.87	4.81	5.60	6.33	6.93
.60	−2.86	0.50	2.96	4.41	5.78	6.83	7.77	8.56	9.29	9.89
.70	−0.49	2.87	5.33	6.78	8.15	9.20	10.14	10.93	11.66	12.26
.73	0.14	3.50	5.96	7.41	8.78	9.83	10.77	11.56	12.29	12.89
.80	1.47	4.83	7.29	8.74	10.11	11.16	12.10	12.89	13.62	14.22

used mean sample values for the independent variables in making average cost projections. Larger hospitals may have different configurations of services, personnel, or other characteristics that could result in higher average costs. To assess the potential importance of this consideration, we constructed an example in which mean values for a subsample of hospitals in the 80–110 bed range were employed in conjunction with the 113-bed and 73-percent assumptions in estimating cost savings. Average costs per patient day (quadratic specification) under these circumstances were reduced by $9.67, relative to the average costs of the "mean hospital" in the sample. This figure is comparable to the estimated reduction of $26.30 described previously, when mean values for hospital characteristics of the entire sample are used for the projections. Therefore, there is a strong indication that the values in table 6 overestimate cost savings when characteristics peculiar to larger hospitals are taken into account.

Conclusions

Based on the empirical analysis of rural hospitals we have presented it appears that:

1. Economies of size occur over the range of hospital sizes observable in rural areas for both the quadratic and log cost function specifications. Only the quadratic specification provides an estimate of the number of beds that results in the lowest average costs, however. According to this specification, the hospital size which minimizes average cost per patient day is estimated to be 113 beds. Such hospitals have average costs per patient day that are from $6.51 (log specification) to $15.15 (quadratic specification) below the average costs in hospitals of 41 beds (the average size of hospitals in the sample) if other factors are held constant.

2. Cost savings per patient day can be achieved in rural hospitals by increasing occupancy rates (assuming number of patient days is held constant). The occupancy rate that minimizes average cost per patient day is estimated to be 73 percent. Hospitals with this occupancy rate have average costs per patient day which are $5.96 (log specification) to $11.15 (quadratic specification) lower than the average costs in hospitals with 51 percent occupancy rates (the average for hospitals in the sample) if other factors are held constant.

These empirical results support the presumption implicit in the National Health Planning Guidelines that providing hospital care in rural areas with fewer beds concentrated in larger, better utilized facilities would lower average costs per patient day. The estimates we have presented should help to clarify the magnitudes of these potential cost savings. However, they do not provide a *prima facie* case for the desirability of rural facilities with more beds and higher occupancy rates than existing facilities. Macstravic has argued that existing low occupancy rates in rural hospitals are consistent with fluctuations in the demand for services (*26*). Furthermore, potential cost savings must be balanced against the increased travel costs and risk which necessarily result from hospital closures in rural areas (*27*), as well as the possible impact of closures on the economies of rural communities (*4*). Also, to the extent that rural institutions provide outpatient and ambulatory services, hospital closures might impose additional costs upon users who are not necessarily inpatients. Finally, the estimates of total cost savings from hospital closure presented in table 6 may overestimate cost savings in practice. Larger facilities with higher occupancy rates might offer more services than are typical of existing facilities. As the empirical example indicates, this shift probably would increase average costs and therefore reduce cost savings.

In addition to the foregoing considerations, there are other reasons to believe that definition of an appropriate public policy toward rural hospitals is a complex task. One important factor contributing to reductions in rural hospital occupancy rates over the past decade has been a national trend toward fewer admissions and shorter hospital stays for certain medical conditions. Given the experience of health maintenance organizations in reducing hospital utilization even further (*28*), there appears to be ample opportunity for this trend to continue. Also, as comprehensive health insurance becomes increasingly available in rural areas, the difference in consumers' out-of-pocket hospital charges between rural hospitals and more sophisticated, capital-intensive urban facilities will decrease. This circumstance could increase rural demand for care in urban hospitals and result in decreases in the patient census of rural facilities. Factors that could mitigate further census reductions in rural hospitals include rising gasoline prices, which increase travel costs to urban facilities for rural residents, and an apparent trend toward population increases in rural areas. One challenge for policymakers will be to predict accurately the impact of these diverse influences and their implications in light of the empirical results presented in this paper.

References

1. Zwick, D. I.: Initial development of national guidelines for health planning. Public Health Rep 93: 407–420, September–October 1978.
2. McClure, W.: Reducing excess hospital capacity. National Technical Information Service, report HRP–0015194, Springfield, Va., 1976.
3. Berry, R. E.: Product heterogeneity and hospital cost analysis. Inquiry 7: 67–75 (1970).

4. Christianson, J. B., and Faulkner, L.: The contribution of rural hospitals to local economies. Inquiry 18: 46–60, spring 1981.
5. Fort, R. D., and Christianson, J. B.: Determinants of public service provision in rural communities: evidence from voting on hospital referenda. Am J Agricultural Economics 63: 228–236 (1981).
6. Lave, J. R., and Lave, L. B.: Hospital cost functions. Am Economic Rev 60: 379–395 (1970).
7. Cohen, H. A.: Variations in cost among hospitals of different sizes. Southern Economic J 33: 355–366 (1967).
8. Cohen, H. A.: Hospital cost curves with emphasis on measuring patient care output. *In* Empirical studies in health economics, edited by H. E. Klarman. Johns Hopkins Press, Baltimore, Md., 1979, pp. 279–293.
9. Feldstein, M. S.: Economic analysis for health service efficiency. Markham Publishing Company, Chicago, 1968.
10. Davis, K.: Theories of hospital inflation: some empirical evidence. J Hum Resour 8: 181–201 (1973).
11. Alchian, A.: Costs and outputs. *In* The allocation of economic resources: essays in honor of B. F. Haley, edited by M. Abramovitz. Stanford University Press, Stanford, Calif., 1959, pp. 23–40.
12. Hirshleifer, J.: The firm's cost function: a successful reconstruction? J Business 35: 235 (1962).
13. Finkler, S. A.: On the shape of the hospital industry long run average cost curve. Health Serv Res 14: 281–289 (1979).
14. Berki, S.: Hospital economics. D.C. Heath and Company, Lexington, Mass., 1972.
15. Ro, K-K.: Determinants of hospital costs. Yale Economic Essays, 8: 185–257 (1968).
16. Feldstein, P. J.: An empirical investigation of the marginal cost of hospital services. University of Chicago, Chicago, 1961.
17. Francisco, E. W.: Analysis of cost variations among short-term general hospitals. *In* Empirical studies in health economics, edited by H. E. Klarman. Johns Hopkins Press, Baltimore, Md., 1979, pp. 321–322.
18. Berry, R. E.: Returns to scale in the production of hospital services. Health Services Res 2: 123–139 (1967).
19. Ingbar, M. L., and Taylor, L. D.: Hospital costs in Massachusetts, an econometric study. Harvard University Press, Cambridge, Mass., 1968.
20. Evans, R. G.: "Behavioral" cost functions for hospitals. Can J Economics 4: 198–215 (1971).
21. Saathof, D. D., and Kurtz, R.: Cost per day comparisons don't do the job. Mod Hospital 99: 14–16 (1962).
22. Feldstein, M. S.: Hospital cost variation and case-mix differences. Med Care 3: 95–103, April–June 1965.
23. Lee, M. L., and Wallace, R.: Problems in estimating multiproduct cost functions: an application to hospitals. Western Economic J 11: 350–363 (1973).
24. Box, G. E. P., and Cox, D. R.: An analysis of transformations. R Stat Soc, series B: 211–243 (1964).
25. Finch, L. E., and Christianson, J. B.: Determinants of the costs of care in rural hospitals: Statistical estimates and policy implications. Bull 725, Agricultural Experiment Station, Montana State University, Bozeman, 1980.
26. Macstravic, R. E. S.: Average life-cycle occupancy: A radical new approach to bed needs and appropriateness review decisions. Health Care Planning and Marketing Q 1: In press.
27. Christianson, J. B., and Render, S. G.: Cost benefit analysis and health planning: An application to rural hospital closure. Research report. Agricultural Experiment Station, Montana State University, Bozeman, 1981.
28. Luft, H. D.: How do health maintenance organizations achieve savings? Rhetoric and evidence. N Engl J Med 298: 1336–1343, June 15, 1978.

SYNOPSIS

FINCH, LARRY E. (Montana State Public Service Commission), and CHRISTIANSON, JON B.: *Rural hospital costs: an analysis with policy implications. Public Health Reports, Vol. 96, September–October 1981, pp. 423–433.*

The 1977 National Guidelines for Health Planning suggest a maximum of 4 hospital beds per 1,000 population and a minimum occupancy rate of 80 percent for those beds as desirable for an efficient local hospital system. Rural areas often have more than 4 hospital beds per 1,000 population and generally exhibit occupancy rates well below the rate specified by the Guidelines. Hence, there appears to be an opportunity for reducing the cost of hospital services in rural areas by providing care with fewer beds concentrated in larger, better utilized facilities.

This paper presents estimates of the annual savings that would result from following such a policy in rural areas. The statistically estimated cost curves are based on data from a sample of 116 rural hospitals for the years 1971–77. With a quadratic specification for the cost function, the hospital size that minimizes average costs is estimated to be 113 beds, and the occupancy rate that minimizes costs is 73 percent. Hospitals with 113 beds are estimated to have average costs per patient day that are from $6.51 (logarithmic specification) to $15.15 (quadratic specification) below the average cost per patient day of a 41-bed hospital, the average size of the hospitals in the sample. Hospitals with a 73 percent occupancy rate are estimated to have average costs that are $5.96 logarithmic specification to $11.75 (quadratic specification) lower than the average costs in hospitals with 51 percent occupancy rates, the average in the sample, if other factors are held constant. These benefits can be weighed by health policy analysts against the increased cost of travel and ambulance service, and the accompanying increase in risk to patients, to determine if the present structure for the delivery of acute care in rural areas warrants change.