Cost and Efficiency in the Production of Hospital Services

RALPH E. BERRY, JR.

This paper summarizes the general findings of a research effort designed to complete a detailed analysis to identify and measure the effects of factors which significantly affect the cost and efficiency of the short-term general hospital system in the United States.

The empirical analysis involved data on approximately 6,000 hospitals for the years 1965, 1966, and 1967 and involved a model which expressed hospital cost as a function of the level of output, the quality of services provided, the scope of services provided, factor prices, and relative efficiency. The statistical analysis does provide insight to the factors affecting hospital cost: hospital services are produced subject to economies of scale but the absolute magnitudes are rather insignificant; on the basis of the exceedingly limited data available it can be concluded that quality does affect costs; medical education is a significant factor affecting hospital costs; and product mix has a significant impact on costs.

Three separate analyses are summarized specific to the product mix difference aspect of the production of hospital services, its effect on hospital cost analysis, and techniques that can be employed to account for product mix.

Finally, an analysis of the characteristics of high cost and low cost hospitals is summarized.

Introduction

This paper, like the others in this issue, is intended to summarize the general findings of a specific research effort supported by the Social Security Administration (Berry and Carr, 1973). The primary purpose of the research effort was to complete a detailed analysis to identify and measure the effects of factors which significantly affect the cost and efficiency of the short-term general hospital system in the United States.

The rapid inflation of hospital costs is a well-known phenomenon. Hospital cost inflation is of particular concern to the Social Security Administration because of the less than subtle impact on the Medicare budget. Given its responsibility for the payment of a significant proportion of total expenditures for hospital services, and its responsibility for insuring that these funds are used as effectively as feasible, the Social Security Administration has

both a factual and policy interest in the cost and efficiency of the production of hospital services. Thus the research effort was addressed to an area of signal public importance and concern.

Factors Affecting Hospital Cost

The empirical analysis of the factors affecting hospital cost involved data on approximately 6,000 short-term general hospitals for the years 1965, 1966, and 1967. The basic model utilized in the analysis was of the form:

$$C = f(O, Q, M, P, E)$$

where

C = cost of hospital services
O = level of output
Q = quality of services
M = product mix (complexity of scope of services)
P = factor prices
E = efficiency

i.e., hospital cost is a function of the level of output, the quality of services provided, the scope of services provided, factor prices, and relative efficiency. The estimated cost equations summarized in Table 1 are for 1966 and are representative of the general results of the analysis.

The statistical analysis of the cost of providing short-term general hospital care in the United States does in fact provide insight to the factors affecting hospital cost. A number of inferences can be drawn concerning the relationships among average costs, output, quality, product mix, factor prices, and relative efficiency.

Output, Cost, and Returns to Scale

The specific form of the equation estimated was chosen in order to form the basis for testing various hypotheses concerning returns to scale in the production of hospital services. A careful analysis of the results obtained indicates that hospital services are produced subject to economies of scale initially and decreasing returns to scale eventually. More specifically, since the dependent variable is average cost, hospital services are produced subject to decreasing costs initially and increasing costs eventually. In essence, the

TABLE 1
Summary of Average Cost Regression Equations
for Short-Term General Hospitals in 1966

	Coefficients [a]			
Variable	*All Hospitals*	*Voluntary Hospitals*	*Government Hospitals*	*Proprietary Hospitals*
Constant	−10.2802	−8.4397	−7.9165	−20.5254
Output				
ADC	−0.0162	−0.0164	−0.0372	−0.0952
	(0.0039)	(0.0048)	(0.0082)	(0.0931)
ADC^2	0.00001	0.00002	0.0001	0.0002
	(0.000002)	(0.000003)	(0.000003)	(0.0004)
Quality				
Hospital accredited	2.7909	4.6002	1.6393	1.5212
	(0.5481)	(0.7249)	(0.9244)	(2.3858)
Product mix				
Cancer program	−0.7590	−0.3538	−0.1675	2.3120
	(0.6055)	(0.6206)	(1.6197)	(7.5211)
Residency program	2.5473	2.3647	5.5635	6.5105
	(0.8661)	(0.8799)	(2.7210)	(9.3173)
Internship program	1.5290	−0.2437	6.8730	−6.1715
	(0.9242)	(0.9345)	(2.7986)	(15.9282)
Medical school affiliation	−0.3192	−0.1472	0.7693	[b]
	(0.9759)	(0.9848)	(2.7061)	
Member, Council of Teaching Hospitals	6.2301	3.2337	10.9965	[b]
	(1.1415)	(1.2124)	(2.5436)	
Nursing school	−0.4611	−0.8683	1.3350	2.8359
	(0.7412)	(0.7906)	(1.7691)	(22.7373)
Practical nurse program	0.1816	−0.2057	−0.5232	1.5362
	(0.7736)	(0.8642)	(1.5388)	(6.5094)
Blood bank	1.3621	1.1191	1.2159	2.4005
	(0.4378)	(0.5227)	(0.8220)	(2.1937)
Clinical laboratory	2.1404	2.5371	1.3799	−7.3122
	(1.6394)	(2.0359)	(2.7402)	(8.3226)
Pathology laboratory	1.7586	2.8678	0.9460	−2.0463
	(0.5410)	(0.6689)	(0.9598)	(2.3387)
Electroenceph-alography	1.5403	1.6305	1.5748	−0.6628
	(0.4782)	(0.5299)	(1.0662)	(2.7218)
Dental facilities	−0.3575	−0.9276	1.2310	−1.8709
	(0.4155)	(0.4558)	(0.9209)	(2.3393)

[a] Standard errors are in parentheses.
[b] There were no proprietary hospitals with medical school affiliation and no proprietary hospitals were members of the Council of Teaching Hospitals.

TABLE 1—*Continued*

Variable	Coefficients a			
	All Hospitals	*Voluntary Hospitals*	*Government Hospitals*	*Proprietary Hospitals*
Pharmacy with pharmacist	3.0279 (0.5100)	2.6857 (0.6408)	2.5382 (0.9206)	9.8480 (2.0455)
Occupational therapy	0.9518 (0.7148)	0.6844 (0.7541)	1.7027 (1.6757)	9.3659 (6.2890)
Physical therapy	0.8826 (0.4656)	0.7268 (0.5554)	1.6738 (0.9186)	1.8944 (2.0352)
Premature nursery	–0.1977 (0.4196)	–0.0859 (0.4997)	–1.6412 (0.7853)	2.3422 (2.0709)
Emergency room	–0.3732 (0.8745)	–1.4028 (1.0776)	1.4202 (2.0252)	–0.0178 (2.6988)
Home care program	4.4726 (0.8450)	2.4143 (0.8957)	9.2165 (1.9844)	12.9343 (6.3169)
Operating room	2.0646 (1.9123)	1.3471 (2.3695)	9.4138 (4.1142)	9.4971 (8.2515)
Obstetrical delivery room	–4.1893 (0.9316)	–3.1266 (1.0908)	–11.6384 (2.8794)	–5.7794 (3.0453)
Postoperative recovery room	1.7292 (0.5279)	1.7256 (0.6710)	1.6688 (0.9166)	1.9797 (2.2767)
Social work department	1.7197 (0.9652)	2.1561 (1.0311)	2.0916 (2.3645)	0.4175 (6.4436)
X-ray diagnostic	0.3081 (2.1182)	0.3502 (2.7003)	0.5894 (3.3828)	4.2781 (11.5529)
X-ray therapeutic	–0.7554 (0.5748)	–0.2971 (0.6345)	–1.6945 (1.2971)	–6.1921 (2.6898)
Radioisotope therapy	2.0788 (0.5731)	2.3032 (0.6143)	3.0758 (1.3569)	–1.4691 (3.5486)
Hospital auxiliary	0.9697 (0.5046)	0.7783 (0.6769)	1.0518 (0.8140)	2.4512 (2.4198)
Psychiatric inpatient unit	–1.4540 (0.6068)	–0.9399 (0.6597)	–4.1494 (1.2936)	4.6078 (6.6739)
Rehabilitation inpatient unit	0.5605 (0.7798)	–0.1052 (0.8085)	3.8620 (1.9009)	9.5832 (8.6649)
Cobalt therapy	2.0280 (0.6372)	1.9045 (0.6612)	1.2640 (1.6330)	6.1452 (5.8678)
Radium therapy	–0.1203 (0.5727)	–0.7905 (0.6148)	1.5616 (1.3619)	5.5161 (3.1854)
Outpatient department	–0.6007 (0.4024)	0.1017 (0.4719)	–1.6412 (0.7853)	–4.2913 (2.0606)
Routine chest X-ray on admission	–0.1322 (0.3865)	–0.6626 (0.4381)	0.5111 (0.7957)	0.6390 (2.2207)

TABLE 1—*Continued*

Variable	Coefficients a			
	All Hospitals	*Voluntary Hospitals*	*Government Hospitals*	*Proprietary Hospitals*
Routine blood sugar on admission	−0.2481 (0.4600)	0.3803 (0.5183)	−0.6441 (0.9418)	−6.3044 (2.5032)
Average length of stay	−0.7674 (0.0581)	−0.7695 (0.0747)	−1.3652 (0.1362)	−1.5037 (0.4938)
Obstetric inpatient days/inpatient days	8.0007 (2.5627)	0.3803 (0.5183)	5.7629 (4.8873)	2.0952 (8.5610)
ICU inpatient days/ inpatient days	−0.4799 (3.4578)	2.1904 (5.9049)	−1.1651 (4.7007)	7.9239 (11.6626)
Outpatient visits/ inpatient days	1.6334 (0.1629)	1.7601 (0.2938)	1.2078 (0.1989)	3.8775 (0.9079)
Student nurses/ ADC	0.8327 (1.2676)	1.4124 (1.3689)	0.0794 (2.9102)	−3.6205 (12.5698)
Interns and residents/ADC	31.5818 (4.4895)	54.9247 (5.8928)	5.6487 (8.2197)	−100.9583 (127.0582)
Other Trainees/ ADC	0.7868 (1.4881)	1.0264 (1.4552)	−6.5405 (5.0839)	−30.5541 (22.6756)
Factor Prices				
Predicted annual wage rate	0.0130 (0.0005)	0.0125 (0.0006)	0.0109 (0.0010)	0.0160 (0.0023)
Predicted construction cost index	−0.0808 (0.0336)	−0.1048 (0.0384)	0.0466 (0.0654)	0.0474 (0.2370)
Other Variables				
Empty beds	0.4715 (0.3648)	1.5165 (0.7681)	−0.1578 (0.4276)	−12.1822 (3.0475)
Output change 1965 to 1966	−3.3091 (1.1146)	−1.2953 (1.3399)	−5.5310 (2.8283)	−17.5889 (4.9627)
Output change 1966 to 1967	4.9848 (0.8295)	7.1727 (1.1406)	1.8509 (1.2405)	12.0419 (4.3978)
Government dummy	−0.0752 (0.4887)	—	—	—
Proprietary dummy	3.6050 (0.7949)	—	—	—
$\bar{R}^2$	0.57	0.59	0.58	0.69
Degrees of freedom	2678	1752	647	134

[a] Standard errors are in parentheses.

average cost curve of hospital services was found to be "U" shaped.[1]

Although the results are statistically significant, perhaps a more important question is how significant are the absolute magnitudes of the economies of scale? In effect, given that the average cost curve is "U" shaped, how steep or how shallow is the "U"? In fact, the average cost curves are rather shallow—the absolute magnitudes of the economies of scale are rather insignificant. A few straightforward calculations can serve to put the cost-output relationship into perspective. Thus, for example, the equations in Table 1 imply the following four cost-output relationships for 1966:[2]

(1) All hospitals $AC = 44.56 - .0162\,ADC + .00000967\,(ADC)^2$

(2) Government hospitals $AC = 42.11 - .0372\,ADC + .0000146\,(ADC)^2$

(3) Voluntary hospitals $AC = 45.46 - .0164\,ADC + .0000191\,(ADC)^2$

(4) Proprietary hospitals $AC = 48.93 - .0952\,ADC + .000168\,(ADC)^2$

These relationships in turn provide the basis for comparing average costs at various levels of output. The data outlined in Tables 2 and 3 indicate the relative insignificance of the absolute magnitude of economies of scale in the production of hospital services.

In Table 2, the comparisons are delineated in terms of the mean average daily census and the optimal average daily census. The mean *ADC* is the actual mean that prevailed in 1966. The optimal *ADC* is that level of output which corresponds to minimum average cost. In each case it would require a several-fold increase in the level of output to bring about minimum average costs. Further, the

[1]The equations estimated were cost equations of the form:

$$AC = a \pm b_1\,ADC \pm b_2\,(ADC)^2 \pm b_i X_i$$

where the factors other than output are represented by the vector X. The relationship between average cost and the level of output is then represented by the sign and statistical significance of b_1 and b_2. In fact the sign of b_1 is negative in each case while the sign of b_2 is positive in each case. The level of significance for both b_1 and b_2 is greater than .01 in all cases except that of proprietary hospitals.

[2]These equations are derived from those in Table 1 by assigning the mean values for each of the independent variables other than the output variables.

TABLE 2

Summary of Comparative Cost and Output at Mean Average Daily Census and Optimal Average Daily Census

	Output			Average Cost at		
	Mean ADC	*Optimal ADC*	*% Increase in Output*	*Mean ADC*	*Optimal ADC*	*% Decrease in Cost*
All hospitals	128	838	555	42.64	37.78	−11.4
Voluntary hospitals	146	429	194	43.48	41.94	−3.5
Government hospitals	108	1274	1080	38.26	18.42	−52.9
Proprietary hospitals	50	283	466	44.59	35.44	−20.5

TABLE 3

Summary of Comparative Cost and Output at Mean Average Daily Census and 110 Percent of Mean Average Daily Census

	Average Cost at		Decrease	
	Mean ADC	*110 % of Mean ADC*	*Dollars*	*%*
All hospitals	42.64	42.47	0.17	0.40
Voluntary hospitals	43.48	43.32	0.16	0.37
Government hospitals	38.26	37.89	0.37	0.97
Proprietary hospitals	44.59	44.20	0.39	0.87

minimum average cost in most cases is not much below the prevailing average cost.

Since the optimal sizes are so much larger than the mean sizes, the comparisons are delineated in Table 3 in terms of the mean average daily census and an average daily census 10 percent larger than the mean. In each case a 10 percent increase in the level of output would result in less than a 1 percent decrease in average cost. Hence, albeit hospital services are produced subject to economies of scale, the absolute and relative magnitudes of the potential savings are such that they probably do not provide much of an incentive for exploitation. In fact, these cost estimates are exclusively in

terms of internal money costs and take no account of travel costs or the costs associated with inconvenience to patients, attending physicians, or visitors. Since travel costs and inconvenience would necessarily increase if hospitals were larger and consequently served a larger catchment area, it would seem that the relative insignificance of the magnitude of economies of scale may explain the large number of relatively small hospitals.[3]

The relative changes in output from 1965 to 1966 and from 1966 to 1967 were included in the 1966 equations outlined in Table 1 to assess the impact on costs of short-term output changes. The results indicate that an increase in output from the previous year to the current year is associated with lower current average cost. Conversely, an increase in output from the current year to the succeeding year is associated with higher current average cost. If these relative changes in output are indicative of random short-run variations, then the results are consistent with decreasing costs but not consistent with either constant costs or increasing costs (see Berry and Carr, 1973: 45-47). If these relative changes in output are indicative of growth in output over time, then the results are probably a reflection of the discontinuities that are characteristic of additions to capacity, particularly additions to the physical plant.[4]

Empty beds as a proportion of the average daily census were included in the analysis to assess the effect of unused capacity on average cost. One would expect, a priori, that unused capacity would tend to raise average cost. The results reflected in Table 1 appear mixed. Empty beds do lead to higher average costs for voluntary hospitals and for all hospitals—the latter undoubtedly because voluntary hospitals dominate in the all hospitals equation. But empty beds lead to lower average costs for proprietary hospitals and government hospitals. In the case of government hospitals the result is not statistically significant, but it is quite significant in the case of proprietary hospitals. A difference in the relative magnitude of the effect of unused capacity on average costs

[3]In fact, if travel costs and costs associated with inconvenience rise more rapidly than internal costs fall, then hospital services are produced subject to increasing *total* costs.

[4]Thus, the lower current average cost associated with an increase in output from the previous year may be a result of the inability to increase all inputs proportionately (e.g., the capital may be used more intensively in the current year); while the higher current average cost associated with an increase in output from the current year to the succeeding year may be a consequence of the current addition of relatively fixed inputs in anticipation of future growth.

between voluntary and proprietary hospitals would be expected because of the rather significant difference in their respective capital intensities, but a difference in the direction of the effect is difficult to explain.

Quality and Cost

The quality of hospital services is a factor of signal importance. Unfortunately, there is little information that is empirically useful concerning the quality of hospital care. It is to be expected that higher-quality services are more costly to produce than lower-quality services, but there is no index of quality available that can be employed to derive the relationship between quality and cost directly.

The accreditation status of each hospital was included in the regression analysis and allows a first approximation of the quality-cost relationship.

In addition, there are a number of facilities and services that tend to enhance the quality of basic hospital services rather than to expand the complexity of the scope of services offered. These services and facilities include a blood bank, pathology laboratory, postoperative recovery room, premature nursery, and a pharmacy with a registered pharmacist.

A certain insight into the relationship between quality and cost can be gained from the data in Table 4. These data summarize the relationship between average cost and certain quality-related variables. Hospitals which are accredited have higher average costs, other things equal. To the extent that accreditation reflects quality, there is a positive relationship implied between quality and average cost. The relationship is generally statistically significant. Of course accreditation status is a dichotomous variable and quality is undoubtedly a continuous variable, but the results do allow a first, albeit rough, approximation to the quality-cost relationship.

The several relationships between average cost and the several quality-enhancing services and facilities are generally positive and often statistically significant. In fact, with the exception of the premature nursery, the pattern is consistent and significant, particularly for voluntary hospitals and all hospitals.

On balance, on the basis of the exceedingly limited data available, it seems reasonable to conclude that quality does affect hospital costs—higher-quality hospital services cost more to produce than lower-quality services.

TABLE 4
Summary of the Relationship Between Average Cost and Certain Quality-Related Variables

Variable	"t" Statistics [a]			
	All Hospitals	*Voluntary Hospitals*	*Government Hospitals*	*Proprietary Hospitals*
Hospital accredited	5.09[c]	6.34[c]	1.77[b]	0.64
Blood bank	3.11[c]	2.14[b]	1.48	1.09
Pathology laboratory	3.25[c]	4.29[c]	0.99	–0.88
Pharmacy with pharmacist	5.94[c]	4.19[c]	2.76[c]	4.81[c]
Premature nursery	–0.47	–0.17	–2.09[b]	1.13
Postoperative recovery room	3.28[c]	2.57[c]	1.82[b]	0.87

[a] For regression results in Table 1.
[b] Significant at the .05 level.
[c] Significant at the .01 level.

Product Mix and Cost

The product mix of hospitals varies in two important dimensions. First, hospitals may engage in the provision of patient care, teaching, and research. Second, the complexity of the scope of services provided varies among hospitals. These product differences affect hospital costs. Hospitals are in fact an extreme case of multiproduct firms and, unfortunately, a classic example of firms for which it is virtually impossible to differentiate completely among the several services produced.

Some forty approvals, facilities and services available, and other product-mix related variables were included in the average cost-regression equations to account for product mix and to allow for an assessment of the effect of product-mix differences on hospital costs. Some insight to the relationship between product mix and cost can be gained from the data in Tables 5 and 6. The data in Table 5 summarize the relationship between average cost and teaching activities. The data in Table 6 summarize the relationship between average cost and the scope of services provided.

Albeit certain care must be exercised in interpreting the results, the data in Table 5 clearly indicate that average costs are higher in those hospitals that are involved in medical education.

TABLE 5

Summary of the Relationship Between Average Cost and Certain Variables Related to Teaching Activities

Variable	"t" Statistics [a]			
	All Hospitals	*Voluntary Hospitals*	*Government Hospitals*	*Proprietary Hospitals*
Residency program	2.94[d]	2.69[d]	2.05[c]	.070
Internship program	1.65[c]	–0.26	2.46[d]	–0.39
Interns and residents/ADC	7.04[d]	9.32[d]	0.69	–0.80
Medical school affiliation	–0.33	–0.15	0.28	[b]
Member, Council of Teaching Hospitals	5.46[d]	2.67[d]	4.32[d]	[b]
Nursing school	–0.62	–1.10	–0.76	0.13
Student nurses/ ADC	0.66	1.03	0.03	–0.29
Practical nurse program	0.24	–0.24	–0.34	0.24
Other trainees/ ADC	0.53	0.71	–1.29	–1.35

[a] For regression results in Table 1.
[b] There were no proprietary hospitals with medical school affiliation and no proprietary hospitals were members of the Council of Teaching Hospitals.
[c] Significant at the .05 level.
[d] Significant at the .01 level.

The first five variables listed in Table 5 are all related to medical education, and the results should be interpreted collectively rather than individually.[5] On balance, these data suggest medical education as a significant factor affecting hospital costs.

The results imply that other types of teaching do not have a significant effect on costs. The existence of a professional nursing

[5]Thus, for example, the variable Member of Council of Teaching Hospitals is undoubtedly picking up the variation that might in its absence be picked up by the variable Medical school affiliation. Similarly, Internship program is very significant for government hospitals but very insignificant and actually negative for voluntary hospitals, while Interns and residents per ADC is very significant for voluntary hospitals but insignificant for government hospitals. It appears most likely that the Internship program variable is picking up the variation for government hospitals that Interns and residents per ADC is picking up for voluntary hospitals.

school has a negative but insignificant effect on costs. The number of student nurses per patient has a positive but insignificant effect on costs. The other relationships are mixed and all insignificant.

The data in Table 6 are indicative of the relationship between average cost and the scope of services provided. A number of factors are implicit in these data. First, some of the facilities and services which represent an expansion in the complexity of the

TABLE 6
Summary of the Relationship Between Average Cost and Certain Variables Related to the Scope of Services Provided

	"t" Statistics [a]			
Variable	*All Hospitals*	*Voluntary Hospitals*	*Government Hospitals*	*Proprietary Hospitals*
Electroencephalography	3.22[c]	3.08[c]	1.48	–0.24
Dental facilities	–0.86	–2.04[b]	1.34	–0.80
Physical therapy	1.90[b]	–1.31	1.82[b]	0.93
X-ray therapeutic	1.31	–0.47	–1.31	–0.23
Radioisotope therapy	3.63[c]	3.75[c]	2.27[b]	–0.41
Cobalt therapy	3.18[c]	2.88[c]	0.77	1.05
Radium therapy	–0.21	–1.29	1.15	1.73[b]
Psychiatric inpatient unit	–2.40[c]	–1.43	–3.21[c]	0.69
Occupational therapy	1.33	0.91	1.02	1.49
Home care program	5.29[c]	2.70[c]	4.65[c]	2.05[b]
Social work department	1.79[b]	2.09[b]	0.89	0.07
Rehabilitation inpatient unit	0.79	–0.13	2.03[b]	1.11
ICU inpatient days/ inpatient days	–0.14	0.37	–0.25	0.68
Outpatient visits/ inpatient days	10.03[c]	5.99[c]	6.07[c]	4.27[c]
Average length of stay	–13.20[c]	–10.31[c]	–10.02[c]	–3.05[c]

[a] For regression results in Table 1.
[b] Significant at the .05 level.
[c] Significant at the .01 level.

scope of inpatient services provided have significant positive relationships with average cost, as would be expected. ECG, physical therapy, radioisotope, and cobalt therapy are all associated with higher average cost. Second, some of the variables which are characteristic of a hospital engaged in community medical services in addition to strict inpatient activity have significant positive relationships with average cost. The most characteristic and the most significant in this context is the number of outpatient visits as a proportion of total inpatient days, but the availability of a home care program and a social services department display a similar relationship. It would appear that in general, more complex inpatient services and the provision of community medical services are significant factors affecting hospital costs.

Finally, the results summarized in Table 6 also imply a significant length of stay effect on hospital costs. Some types of patient care are less expensive per day to provide on average than other types of patient care. This phenomenon is explicit in the significant negative relationship between average cost and psychiatric inpatient care and undoubtedly implicit in the significant negative relationship between average cost and average length of stay. Also, of course, the significant negative relationship between average length of stay and average cost is indicative of the well-documented fact that for any given type of patient care the early days of hospitalization are generally more expensive to provide than the later days of hospitalization.[6]

Factor Prices and Costs

In all the analysis undertaken, the wage rate was consistently the most significant variable in terms of explaining average cost. In essence the results outlined in Table 1 are representative of the relative significance of the wage-rate/cost relationship. In fact differences in wage rates across hospitals explain a significant part of the differences in average costs across hospitals.

Wage rates may vary for a number of reasons. Hospitals in different labor markets may face different wage rates as a result of local labor market differences, for example. Further, the labor in-

[6]Of course, this result does not imply that longer lengths of stay are less expensive, only that the average cost per day of a longer stay is lower. The total cost depends on both the cost per day and the number of days. Unnecessary extra days undoubtedly add to total hospital costs even though their impact on average cost is to lower it.

put requirements may differ for differences in quality, scope of services, and complexity of services.

The wage-rate variable in the equations outlined in Table 1 represents a predicted average annual wage. The wage rate for each hospital was estimated as a function of the proportion of personnel in various occupational categories, geographic location, size of the standard metropolitan area, hospital size, product mix, union status, and market structure. These predicted wage rates are intended to represent differences in wages associated with labor-market differences and product-mix differences. Again, the results are quite consistent and very significant.

Construction-cost indexes were estimated as a function of geographic location and the size of the standard metropolitan area and included as a surrogate for the cost of capital in the equations outlined in Table 1. The results indicate that differences in construction costs are not consistently significant in explaining differences in average cost; in fact, the indicated relationships are quite mixed.[7] On the one hand, the relationship between the predicted construction cost and average cost is positive but statistically insignificant in the cases of government hospitals and proprietary hospitals. On the other hand, the relationship is negative and significant in the case of voluntary hospitals. The same general result obtains for all hospitals undoubtedly because of the dominance of voluntary hospitals in the all hospitals equation.

Interpretation of these results is a complex matter and inferences should be drawn with some care. First, of course, these predicted construction-cost indexes represent construction costs that prevail in the geographic proximity of each hospital. Hence they would reflect differences in the cost of capital in instances of additions to the physical plant, but they would not necessarily reflect differences in the cost of capital equipment. Further, differences in construction costs would only have a direct effect on average costs if construction were in fact undertaken. Thus, for example, the results obtained for voluntary hospitals would be consistent with a set of circumstances where relatively high construction costs were a disincentive to capital accumulation such that where capital costs are high, lower-cost services are produced—lower-cost services in the sense of lower-quality services, less complex services, and a narrower scope of services. The effect of this phenomenon might be exaggerated for voluntary hospitals which

[7]On balance, it must be obvious that the predicted construction cost index is at best an imperfect surrogate for the cost of capital.

are often in receipt of a fixed amount of funds from philanthropic sources, especially for additions to the physical plant. Any increase in construction cost must necessarily reduce proportionately the quantity that can be funded with a fixed sum.

In fact, when separate regressions were run for groups of hospitals producing different product mixes, the negative relationship between average cost and predicted construction cost occurred only for the groups of hospitals producing the more basic services. The groups of hospitals producing more complex services and a broader scope of services were characterized by a positive relationship between average cost and predicted construction cost.

Differences in wage rates are consistently significant in explaining differences in average costs among hospitals; differences in construction costs are not. This is consonant with the fact that wage rates vary more than capital prices in general or the predicted construction cost indexes in particular.[8]

Hospital Control and Cost

The results in Table 1 provide some insight into the effect of hospital control on hospital costs. Dummy variables were included in the all-hospital equation for government and proprietary control. The regression coefficients on these dummy variables indicate the effect on average cost of government and proprietary control, respectively, relative to voluntary control. The regression coefficients and "*t*" statistics were:

	Coefficient	"*t*" Statistic
Government	–0.0752	–0.17
Proprietary	3.6050	4.54

[8]The relative variation of the factor price variables are as follows:

	Relative Variation[a]			
Variable	*All Hospitals*	*Voluntary Hospitals*	*Government Hospitals*	*Proprietary Hospitals*
Predicted average annual wage rate–1966	11.47	9.93	12.72	17.01
Predicted construction cost index–1966	6.98	6.44	7.65	7.75

[a]The standard deviation as a percentage of the mean.

Thus, the effect of government control relative to voluntary control is to lower average cost very slightly, but the result is quite insignificant statistically. The effect of proprietary control relative to voluntary control is to raise average cost by some $3.61, other things equal, and the result is statistically very significant.

Given the fairly common assumptions that proprietary hospitals (a) operate more efficiently, and (b) select relatively lower-cost patients for admission, this result may seem unexpected. In fact, however, the result is quite consistent with a hypothesis that proprietary hospitals produce hospital services at lower total cost.

The results imply that costs in proprietary hospitals are $3.61 higher per day than they are in voluntary hospitals, other things equal. But, in fact, the mean average length of stay in proprietary hospitals is some 1.11 days shorter than the mean average length of stay in voluntary hospitals.[9]

It was noted above that the relationship between average cost and average length of stay was negative in part because earlier days of hospitalization were more likely to be more expensive than later days of hospitalization. In this context, most of the product-mix measures included in the equations indicate the availability of facilities and services but not their level of utilization. It is quite likely that proprietary hospitals utilize their facilities more intensively per patient per day and consequently incur a higher cost per patient day but a lower total cost per patient, other things equal. This conclusion has been questioned. J. Pettengill (1973: 349) states "for-profit hospitals have higher expenses per day and per admission." His conclusion is apparently based on comparisons of for-profit and voluntary hospitals of similar size in 1971. Two points are worthy of note. First, "other things equal" in our analysis includes more than size. Second, the data don't completely support Pettengill's conclusion—in fact, of the six size categories he reports, cost per admission is higher for for-profit hospitals in four categories but lower in two. Further, the data reported by the American Hospital Association (1971) imply that cost per admission is higher for for-profit hospitals in three size categories, lower in three size categories, and approximately the same in one

[9]The mean average lengths of stay are:

All Hospitals	— 7.63 days
Voluntary hospitals	— 7.79 days
Government Hospitals	— 7.52 days
Proprietary hospitals	— 6.68 days

size category. In 1966, cost per admission in for-profit hospitals was higher in three size categories and lower in three size categories.

Product Differences

The nature of the hospital industry is such that product-mix differences are of particular importance. Whatever else may be characteristic of them, the units of production in the hospital industry certainly do not produce a homogeneous product.

Since hospitals should be viewed as multiproduct firms in both the sense of patient care-teaching-research and the complexity of each, a considered attempt was made to deal with the phenomenon of product differences. The available data representative of product-mix differences in hospitals were analyzed in order to ascertain whether or not the multidimensional character of hospital output could be rationalized. The results of the analysis provided additional insights into the product-mix phenomenon.

Three separate albeit related analyses were undertaken specific to the product-difference aspect of the production of hospital services, its effect on hospital cost analysis, and techniques that can be employed to account for product mix. The results of these analyses were consistent and reinforcing. They serve to emphasize the importance of product mix and the implications of product differences.

First, a factor analysis served to delineate the dimensions of product mix in hospital output. This factor analysis is described in detail by Berry (1970: 67-75) and also by Berry and Carr (1973: 48-55). Eight common factors were generated that explained a significant proportion of the variation in the variables related to product mix. Among the more significant factors identified were: a medical school factor; a basic services factor; a complex services factor; a length of stay factor; and an outpatient activities factor.

This factor analysis has a number of implications. Primarily, it provides evidence that the approach to adjusting for product mix employed in the regression analysis of this study was certainly reasonable. Further, the factors identified provide a basis for reducing significantly the dimensionality of the problem of adjusting for product mix. Finally, since the factors are orthogonal, the extent of multicollinearity may be significantly reduced in further regression analysis.

Second, an analysis of the available data served to indicate that there is a systematic pattern to the expansion of facilities and services in short-term general hospitals (Berry, 1973; or Berry and

Carr, 1973: 55-68). There is such a thing as a basic-service hospital. As hospitals add facilities and services there is a strong tendency to first add those that enhance the quality of the basic services. Only after the services that enhance the quality of the basic services have been acquired do short-term general hospitals display a tendency to expand the complexity of the scope of services provided. The final stage of the expansion process for certain hospitals occurs when they add those facilities and services that essentially transform them from inpatient institutions to community medical centers.

The results of this analysis of the pattern of expansion of facilities and services contain a number of implications. It would seem that the results of this analysis support the contention that there are significant differences among short-term general hospitals and indicate that it is possible to identify groups of similar hospitals. The groups of hospitals formed in the analysis are distinct, they cover the range of services provided, and they seem to have a significant intuitive appeal.

The range of services provided in hospitals extends from the most basic services provided in a small institution with exceedingly limited facilities, through a somewhat higher quality of essentially basic services, through the more complex services, to the services provided in a hospital which serves as a community medical center in addition to its role as an inpatient institution. Different patients presumably need different services. For some the services of the basic service hospital would be quite appropriate. Others need higher-quality basic services or more complex services. Still others can only be treated adequately in a community service hospital. This is related to the question of the appropriate mix of available capacity—what is the optimal mix of types of hospitals? The importance of this question is emphasized by the significant differences in average cost per patient day among the four types of hospitals. The cost dimension of the issue is representative of the implications of this analysis and indicative of the potential value of the analysis.

Indeed, the cost implication was the primary concern of a third analysis specific to the product difference aspect of the production of hospital services. A comparative analysis was made of the extent to which hospital costs are explained by what hospitals have the capacity to provide and by what they actually do provide for a sample of hospitals for which diagnostic data were available. This analysis is described in detail in Berry and Carr (1973: 68-76). The diagnostic information for a sample of New England hospitals was gathered as part of a study entitled "International Comparative

Study of Medical Care," under the direction of Osler Peterson, Gerald Rosenthal, and others, sponsored by the Division of Hospitals and Medical Facilities of USPHS (NIH 00237-01). The results indicated that the capacity to provide services explains hospital costs better than the actual services provided explains them.

This result has significant policy implications. The result is not profound, or even surprising, but it does lend support to the position that hospital costs depend more on what hospitals "gear up to do" than on what they actually end up doing. It would seem that much more attention needs to be paid to the question of what the appropriate mix of available capacity is and how public policy might best control that mix.

Much hospital cost analysis has been preoccupied with the question of what is the optimal size of hospitals. A more fundamental question is what is the optimal mix of complexities of scope of services or what is the optimal mix of types of hospitals.

Characteristics of High-Cost and Low-Cost Hospitals

The primary empirical analysis of the factors which affect hospital costs involved the regression equations designed to measure the influence of such factors as output, quality, product differences, and factor prices on hospital costs. The estimated cost equations, however, provided the basis for additional considerations.

Since the estimated equation takes output, quality, product mix, and factor prices into account, an analysis of the residuals of the equation was employed as a mechanism to identify hospitals with unusually high or unusually low costs after allowance for these several factors. This analysis of residuals provided insight to certain characteristics of such high-cost or low-cost institutions. This analysis is described in detail in Berry and Carr (1973: 89-95).

In essence, the estimated equation provided a predicted cost for each hospital on the basis of its output, quality, product characteristics, and factor prices. This predicted cost was compared to the actual cost for each hospital. In fact, an analysis was undertaken of those hospitals with the 50 highest and 50 lowest relative residuals where relative residual is defined as the difference between actual and predicted cost as a proportion of the predicted cost. Comparisons among such characteristics as the qualifications of administrators, regions of the country, the ratio of personnel expense to total expense, occupancy rate, and bed size, were made. The im-

plications of this analysis are of some interest, and they can be summarized briefly.

First, with respect to the administrative background of administrators, the results indicated that low-cost hospitals were more likely to have administrators with medical qualifications (M.D., D.D.S., R.N.). It is of some interest to speculate on this phenomenon in terms of the probable interests, abilities, and goals of the various groups and the alternatives available to them.

Since physicians (and dentists), generally, form a very competent and highly motivated group, it may be that only those with exceptional interest and ability in administration would be willing to give up the earnings and other benefits available to most practicing physicians. Registered nurses usually attain the position of administrator only after advancing through the administrative hierarchy of the nursing department. The initial pool of candidates is usually large, and comparisons can be made among individuals in comparable administrative positions, resulting in a highly competitive situation.

In contrast, the nonmedical administrator group appears to consist generally of those who have drifted into the hospital field after indifferent success in other endeavors. This even appears to be true among hospital administration program graduates.

Another possible explanation for lower cost in hospitals with medical administrators is that those with medical knowledge and authority may be able to interact with the medical staff to some administrative advantage. Thus, for example, it is quite likely that medical administrators are able to resist the demands of the medical staff for additional equipment and the like in certain instances when their nonmedical counterparts would not be able to do so.

A second characteristic considered involved regional differences. There was a significant difference among the proportions of high- and low-cost hospitals in the nine Census Divisions of the United States. This difference, of course, was that existing after regional and urban-rural differences in factor prices had been taken into account. The New England and Pacific states tended to be high-cost and the southern states low-cost. It is possible to speculate on the likely causes of these regional differences, and perhaps some research effort should be directed to this apparent phenomenon in the future.

The third characteristic was indicative of differences in factor intensities in the production process. It is of considerable interest that the ratio of personnel expense to total expense was higher in low-cost hospitals than in high-cost hospitals. The mean ratio for

low-cost hospitals was 0.656 while for high-cost hospitals the mean ratio was only 0.558. This difference in apparent labor intensity may be related to the fact that the cost of capital is abnormally low for voluntary, and, possibly, government hospitals. Hospitals which face lower than market prices for capital may be expected to use too much capital for optimum efficiency. The inefficient capital intensity could well be reflected in higher than expected average costs.

Fourth, hospitals with relatively high occupancy rates were found to have lower costs. The median occupancy rate for low-cost hospitals was 70.7 percent and for high-cost hospitals 64.5 percent. Since these cost differences were observed after the number of empty beds had been taken into account in the regression equation, it appears likely that occupancy rate was acting as a surrogate variable for other factors peculiar to very high- and very low-cost hospitals. In other words, the low-cost hospitals all may have been operating near an optimal occupancy rate of 70 percent while the high-cost hospitals were operating over a suboptimal lower range.

The fifth characteristic considered was bed size. As expected, there was no significant difference in the proportion of high- and low-cost hospitals by bed-size category, since size had already been taken into account in the regression equation. However, there appeared to be some tendency for low-cost hospitals to group around the middle of the size range. This may reflect a phenomenon similar to that discussed with respect to occupancy rate.

Some degree of care must be exercised in interpreting the results of the residual analysis. The residuals should be interpreted in the perspective of the regression analysis which generated them. In fact, the original regression equation included surrogates for output, quality, product factor prices, and certain other variables. If the surrogate included to account for each of the several factors did in fact do its job, that is, if it picked up the influence of the factor it was intended to represent, then the residuals would be distributed randomly over that factor. Thus, for example, a dummy variable was included to represent hospital control. In fact, an analysis of the residuals indicated that neither the high-cost group nor the low-cost group was characterized by disproportionate numbers of any of the three hospital control types (voluntary, government, or proprietary).

On balance, the residual analysis is a useful mechanism for identifying hospitals which have relatively high or relatively low costs. Given the institutions identified by the analysis of the residuals it is possible to identify certain characteristics which high-

cost or low-cost hospitals have in common. In the last analysis, of course, further research would be necessary in order to test any hypotheses that might be suggested by the analysis of residuals.

In Sum

The primary purpose of this research effort was to complete a detailed analysis to identify and measure the effects of factors which significantly affect the cost and efficiency of the short-term general hospital system in the United States. The empirical analysis did serve to delineate in some detail the interaction of many factors with one another and with hospital costs. Further, the analysis of the product-mix phenomenon, its effect on hospital cost analysis, and certain techniques that can be employed to some advantage in dealing with product mix should prove useful in future hospital cost and production research. Finally, the identification of certain characteristics of particularly high-cost and particularly low-cost hospitals may provide the basis for further research.

It is hoped that the analysis outlined in this report will make some contribution to the general understanding of the hospital cost phenomenon.

Ralph E. Berry, Jr., PH.D.
Harvard School of Public Health
677 Huntington Avenue
Boston, Massachusetts 02115

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