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## SPECIAL ARTICLE

## MARKET AND REGULATORY INFLUENCES ON THE AVAILABILITY OF CORONARY ANGIOPLASTY AND BYPASS SURGERY IN U.S. HOSPITALS

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**Abstract** Using 1983 data on 3720 nonfederal short-term hospitals, we analyzed the influence of local market competition and state regulatory programs on the availability of percutaneous transluminal coronary angioplasty and coronary-artery bypass surgery. The degree of competition for patients with heart disease was measured in terms of the number of hospitals in the local market area that maintained a cardiac catheterization laboratory or facility for open-heart surgery.

When the patient case mix and the hospital's teaching role were controlled for, institutions with more than 20 competitors in the local area were 166 percent more likely to offer coronary angioplasty ( $P < 0.0001$ ) and 147 percent more likely to offer bypass surgery

( $P < 0.0001$ ) than hospitals with no competitors in the local market. Four fifths of the hospitals performing bypass surgery whose annual volume was less than 200 had one or more neighboring hospitals with a facility for open-heart surgery. State rate-regulation programs in New York, New Jersey, Connecticut, Massachusetts, and Maryland significantly reduced the availability of both procedures, with the greatest regulatory effects being observed in the most competitive hospital markets.

We conclude that in the period under consideration, competition encouraged and regulation discouraged the proliferation of these cardiac services. (*N Engl J Med* 1987; 317:85-90.)

A NUMBER of studies<sup>1-6</sup> have documented a strong inverse relation between the number of selected cardiac procedures performed in individual hospitals and the case fatality rates in those institutions. These findings suggest that a policy of regionalization, under which physicians would refer patients needing such services to institutions performing a large number of them, could reduce overall mortality. Substantial economic savings might also result from this process.

Regionalization policies must, however, take into account the distance to the nearest high-volume institution when the closing of a service at a low-volume institution is being considered. Long distances between high- and low-volume hospitals could create substantial delays in transporting patients. Such delays could in turn increase the chance of complications and offset the expected clinical and economic benefits of regionalization. In general, therefore, an appropriately regionalized hospital sector would tolerate low volumes of services in isolated rural areas but eliminate them in urban areas where high volumes were achievable. In an unregionalized hospital system, however, competition among hospitals for physician affiliations and patient admissions could induce a proliferation and duplication of services. This could lower the average volume of procedures performed in hospitals in competitive areas.

This study examined the influence of competition among hospitals for cardiac services on the numbers of coronary-artery bypass operations performed. The degree of competition for patients with heart disease

that each hospital faced was measured in terms of the number of neighboring institutions maintaining a facility for open-heart surgery. The results provide evidence that duplication of cardiac services leads to lower numbers of patients. These lower numbers may lead to poorer clinical outcomes in competitive hospital markets.

The study also examined the influence of both market competition and state regulatory programs on the availability of two cardiac procedures — coronary-artery bypass surgery and percutaneous transluminal coronary angioplasty — and two related hospital services — cardiac catheterization laboratories and facilities for open-heart surgery. The regulatory programs studied included the mandatory hospital rate-regulation programs in New York, New Jersey, Connecticut, Massachusetts, Maryland, and Washington State. The influence of the type of ownership (public, private nonprofit, or investor-owned) on the availability of cardiac services was also examined, with control for market and regulatory effects, the patient case mix, medical school affiliation, and other factors.

## METHODS

## Cardiac Services and Hospital Characteristics

Information about the availability and volume of selected cardiac services and procedures was obtained from the 1983 Survey of Specialized Clinical Services (SSCS). The SSCS was conducted under the auspices of the American Hospital Association, with funding from the National Center for Health Services Research of the U.S. Department of Health and Human Services. This survey has been described elsewhere.<sup>7</sup> The SSCS was mailed to all 5898 short-term general hospitals in the continental United States in June 1983; 3778 hospitals (64 percent) responded by September 1983. Of these, 3720 gave complete answers to all the questions relevant to this study. The respondents were representative of the entire group of U.S. hospitals in terms of ownership, census division, and possession of standard hospital facilities. The SSCS sample, however, contained proportionately more complete information on larger hospitals, which are also more likely to maintain cardiac services. Of the 600 hospitals maintaining facilities for open-heart surgery in

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1982, as reported by the American Hospital Association's Annual Survey, 481 (80 percent) responded to the SSCS. Of the 883 hospitals maintaining cardiac catheterization laboratories, 682 (77 percent) responded to the survey.

The SSCS asked hospitals if they had performed either coronary-artery bypass surgery or percutaneous transluminal coronary angioplasty in 1982. If bypass surgery had been performed, hospitals were asked the number performed during the year. The survey did not request information about the volume of coronary angioplasties.

The 1982 American Hospital Association Annual Survey was used to obtain information about whether the hospital maintained either of two facilities — an open-heart surgery facility or a cardiac catheterization laboratory. The Association's information about facilities was available for 5774 of the total of 5898 nonfederal short-term general hospitals in the continental United States.

The American Hospital Association survey also provided information about whether the hospital was affiliated with a medical school, whether it was a member of the Council of Teaching Hospitals, and the ratio of physician house staff to hospital beds. Information on ownership status was available to distinguish public hospitals from investor-owned hospitals and private nonprofit institutions. Answers to a number of questions on the American Hospital Association survey provided information that described in general terms the types of patients treated by the hospital. These included questions about the average length of stay in days, the annual number of births, the number of hospital beds, and the percentage of all inpatient days in the year accounted for respectively by acute care, intensive care, long-term care, and chronic-disease care.

### Measurement of Competition

The number of competing hospitals in the local market area was measured according to the latitude and longitude coordinates for each of the nation's hospitals. We used a computer algorithm to search for all the neighboring institutions within a 24-km (15-mile) radius (1800 km<sup>2</sup> [700 square miles]) around each hospital. Straight-line distances between hospitals were calculated from latitude and longitude coordinates with use of the Pythagorean theorem. We then recorded whether each hospital's neighbors maintained open-heart surgery or cardiac catheterization facilities. For each hospital, the market was defined to include all the hospitals within a 24-km radius, plus all the hospitals within 24 km of any of its neighbors, plus those within 24 km of those neighbors, and so on. This clustering algorithm produced a configuration of local markets in which the two closest hospitals in two different markets were separated by at least 24 km.<sup>8</sup> The 24-km distance was chosen as an approximate reflection of the maximal distance a physician will consistently travel between hospitals to conduct daily rounds — the underlying assumption being that competition among hospitals for patients with heart disease in the period through 1982 primarily took the form of competition for affiliations with physicians treating patients with heart disease.

When the degree of competition for each procedure was being measured, however, not every hospital within the local cluster was counted. Rather, the extent of competition was measured in terms of the number of local hospitals that were current or potential providers of the service. When examining the use of percutaneous transluminal coronary angioplasty, we limited the count of competitors to the local hospitals that already maintained cardiac catheterization laboratories. When examining the use of coronary-artery bypass surgery, we limited the count of competitors to the local hospitals that already maintained facilities for open-heart surgery. This approach reflects the principle that entry into a local market by a new hospital is very costly, but entry into the market for a particular service by a local hospital that has previously not offered that service is relatively easy, assuming that the hospital has the requisite backup facilities. In making its decision about whether to offer a particular cardiac service, the hospital administration must take into account the number of potential as well as actual competing institutions.<sup>9</sup> Thus, although actual competitors for patients undergoing coronary angioplasty include neighboring hospi-

tals that offer that procedure, the list of potential competitors includes all the local hospitals that maintain cardiac catheterization laboratories. Local hospitals that do not maintain such a laboratory cannot be considered even potential competitors for coronary angioplasty in the short run, since a catheterization laboratory is an essential precondition for the procedure.

In analyzing the distribution of open-heart surgery facilities and catheterization laboratories, we included in our measure of market structure all the short-term general hospitals in the local area, whether or not they currently maintained cardiac facilities. Small hospitals are substantially less likely to be considered by their neighbors as potential competitors for cardiac services. Nevertheless, no clear cutoff point in terms of number of beds can be identified. According to the American Hospital Association Annual Survey, in 1982 there were five open-heart surgery facilities and 20 cardiac catheterization laboratories in hospitals with less than 100 beds.

### Regulatory Programs

Information on regulatory programs was obtained from a large study of state rate-setting programs sponsored by the Health Care Financing Administration and conducted by Abt Associates.<sup>10,11</sup> There is considerable variation in state programs in terms of the number of payers covered (Medicare, Medicaid, Blue Cross, commercial insurers, self-paying patients), year of program implementation, and other program characteristics. We limited our evaluation of rate setting to the six states with the strictest regulatory programs — New York, New Jersey, Connecticut, Massachusetts, Maryland, and Washington. Hospitals in states with voluntary rate-regulation programs or with programs that did not cover patients paying charges (thereby allowing charge shifting by hospital administrators) were treated in this study as unregulated hospitals. This created a conservative test of the effectiveness of rate regulation in limiting the duplication among hospitals of cardiac procedures, since minimally regulated hospitals were included in the comparison group along with totally unregulated hospitals.

### Physician and Population Measures

In examining the influence of market competition on the availability of cardiac services, it was essential to control for the size of the local population and the number of local physicians involved in the care of patients with heart disease. Geographic areas with many hospitals are also areas with large populations; only after controlling for population size can one observe the independent effect of the number of local hospitals on the probability that any one institution will offer coronary angioplasty or bypass surgery. Controlling for the number of physicians involved in the care of patients with heart disease is important because areas with many such physicians may have high per capita rates of the use of cardiac services.

We used as our population measure the number of persons residing in each local area as enumerated by the 1980 census of population. We based our measure of physician density on the American Medical Association's master physician file for 1979, which provides a separate enumeration of physicians involved in the treatment of cardiovascular disease. Both measures were obtained through the intermediary of the Area Resource File, a computerized data source maintained by the Bureau of Health Professions of the U.S. Department of Health and Human Services.

The Area Resource File aggregates data at the county level. For our study, data from more than one county had to be aggregated, since many hospital clusters overlapped county boundaries. It would have been inappropriate, however, to assign all the residents and physicians from all the counties overlapped by a hospital cluster to that cluster. Many large counties are overlapped by more than one geographically distinct hospital cluster. We assigned county residents and physicians to individual hospital clusters according to the percentage of hospital beds in the county that were contained in the cluster's hospitals. Thus, if a hospital cluster was located in two counties and included all of one county's hospital beds and half of the other's, its population base was calculated as the sum of the first

county's population and half the second's. Similarly, the cluster was assigned all the cardiac physicians practicing in the first county and half of those practicing in the second county.

**Analytic Techniques**

To examine the distribution of cardiac services among local hospital clusters with different degrees of competition, we divided the sample into four categories according to the number of other institutions in the cluster: no competitors, 1 to 4 competitors, 5 to 20 competitors, and 21 or more competitors. The categories were chosen so as to divide the complete sample of 3720 hospitals into four groups of approximately similar size. To obtain quantitative estimates of the proportion of hospitals with low annual volumes of coronary-artery bypass surgery and the number of patients treated in the hospitals situated in competitive clusters, we sorted the subsample of hospitals performing bypass surgery into low-volume and high-volume groups and into the four market-structure categories. The cutoff point between low- and high-volume hospitals was set at 200 procedures per year, which is consistent with a study by Maerki et al.<sup>12</sup> that found no volume-related improvements in the mortality rate associated with coronary-artery bypass surgery in hospitals performing more than 215 procedures per year.

To examine the distribution of cardiac procedures and facilities among hospitals according to the type of market environment, we calculated the percentage of hospitals within each of the four market categories that performed bypass surgery and coronary angioplasty and the percentages that maintained catheterization laboratories and facilities for open-heart surgery. Multivariate statistical techniques were then used to analyze the separate influence of the number of neighboring competitors on the probability that individual hospitals performed bypass surgery and coronary angioplasty and that they maintained catheterization laboratories and open-heart surgery facilities, with control for the patient case mix, the hospital's teaching role, and the area's population density and number of physicians.

The influence of rate-regulation programs on the availability of cardiac services was also measured on the basis of the multivariate statistical regressions. Proportional reductions in the availability of each service in each regulated state were calculated by subtracting the expected fraction of hospitals in that state that would have offered the service (in the absence of regulation) from the actual fraction offering the service, and dividing this figure by the expected fraction offering the service. Percentage reductions were computed by multiplying these quotients by 100. The fraction of regulated hospitals that would be expected to offer each procedure or service was first calculated with all the hospitals in unregulated states included, and then with only the hospitals with more than 20 competitors in unregulated states included. This permitted calculations of the effect of state rate-regulation programs on hospitals in all types of markets and of the effect of regulatory programs on hospitals in the most competitive local markets separately.

**RESULTS**

Table 1 shows the distribution of institutions with low volumes and those with high volumes of coronary-artery bypass operations across hospital markets, with 200 procedures per year used as the cutoff point. These figures reveal that a substantial majority of facilities performing bypass surgery with annual volumes under 200 were located in markets with other facilities for open-heart surgery. In these areas, the clinical, psychological, and economic cost of referring patients to other hospitals would be quite small. Forty percent of all hospitals responding to the SSCS in which bypass surgery was performed in 1982 reported an annual volume of less than 200 cases. Of these, 84 percent were located in markets with one or more oth-

**Table 1. Hospitals with High and Low Volumes of Coronary-Artery Bypass Operations, According to the Number of Neighboring Institutions with Facilities for Open-Heart Surgery, 1982.**

NO. OF BYPASS OPERATIONS	NO. OF OTHER LOCAL HOSPITALS WITH FACILITIES FOR OPEN-HEART SURGERY, 1982				TOTAL
	0	1-4	5-20	≥21	
≥200					
No. of hospitals	41	83	92	45	261
No. of patients	14,287	42,639	39,298	23,030	119,254
<200					
No. of hospitals	28	60	44	39	171
No. of patients	3,602	6,986	4,745	4,540	19,873
All hospitals					
No. of hospitals	69	143	136	84	432
No. of patients	17,889	49,625	44,043	27,570	139,127

er institutions maintaining facilities for open-heart surgery.

Low-volume hospitals represented a proportionally smaller fraction of all the bypass procedures performed. Fourteen percent of the bypass operations performed in hospitals that responded to the SSCS were done in institutions reporting an annual volume below 200. Eighty-two percent of the procedures performed in low-volume hospitals were performed in institutions that had one or more neighboring hospitals with facilities for open-heart surgery in the same local market. It should be emphasized that these figures represent the lower boundary of the number of bypass procedures performed in low-volume hospitals within competitive cardiac-surgery markets, since the SSCS does not include 20 percent of the hospitals with facilities for open-heart surgery, as reported in the 1982 American Hospital Association Annual Survey.

Table 2 shows percentages of hospitals offering each of the four cardiac services according to the number of neighboring institutions, after adjustment for the nonmarket characteristics of hospitals and their environments that influence the likelihood that hospitals offer particular services: patient case mix, teaching role, size, ownership, demographic and physician characteristics in the area, and state regulatory programs. These figures document the extensive duplication of cardiac services in competitive hospital markets.

The percentage of hospitals performing coronary-artery bypass surgery within each type of local market increased with the number of competitors in the market, when competitors were defined as hospitals maintaining facilities for open-heart surgery. Hospitals in the most competitive local markets were 146 percent more likely to offer bypass-graft surgery than otherwise similar hospitals in markets with no competitors (P<0.0001). Hospitals with 21 or more neighbors maintaining cardiac catheterization laboratories were 166 percent more likely to perform percutaneous transluminal coronary angioplasty than otherwise similar hospitals with no nearby catheterization laboratories (P<0.0001).

**Table 2. Adjusted Percentages of Hospitals with Selected Cardiac Services, According to the Number of Competing Hospitals in the Local Market, 1982.\***

CARDIAC SERVICE	NO. OF COMPETING HOSPITALS			
	0	1-4	5-20	≥21
	<i>percent</i>			
Coronary-artery bypass surgery†	8.5	13.3	12.3	20.9
Percutaneous transluminal coronary angioplasty‡	7.0	11.9	11.1	18.6
Facility for open-heart surgery§	10.2	10.6	16.6	14.4
Cardiac catheterization laboratory	16.0	16.8	19.5	20.0

\*The percentages are adjusted to control for differences between hospitals in medical school affiliation, membership in the Council of Teaching Hospitals, ratio of house staff to hospital beds, six state regulatory programs (New York, New Jersey, Connecticut, Massachusetts, Maryland, and Washington), years of certificate-of-need controls, size of area population, number of area physicians treating cardiovascular disease, ownership, average length of stay, annual number of births, percentages of annual inpatient days accounted for respectively by acute care, intensive care, long-term care, and chronic-disease care, three size categories (numbers of beds), and three region categories.

†For coronary-artery bypass surgery, competing hospitals are defined as all the hospitals within the market area that maintain a facility for open-heart surgery.

‡For percutaneous transluminal coronary angioplasty, competing hospitals are defined as all the hospitals within the market area that maintain a cardiac catheterization laboratory.

§For facilities for open-heart surgery and cardiac catheterization laboratories, competing hospitals are defined as all the short-term general hospitals in the market area.

The third row of Table 2 shows the influence of competitive pressures on hospitals' decisions to maintain basic facilities for open-heart surgery. When competitors were defined to include all the short-term general hospitals in the market, hospitals with 5 to 20 competitors were 63 percent more likely to offer open-heart surgery than were comparable hospitals without nearby neighbors ( $P < 0.0001$ ). Hospitals with 21 or more neighbors were 41 percent more likely to maintain a facility for open-heart surgery than were hospitals with no nearby neighbors but a similar case mix, teaching role, size, type of ownership, demographic and physician characteristics, and regulatory influences ( $P = 0.0126$ ). These figures probably underestimate the extent of competition-related duplication of basic heart-surgery facilities because of the very broad definition of "competitors" that was used. The restricted definition of heart-surgery competitors, used for coronary-artery bypass surgery in the first row of the table, produces a much steeper competition-services gradient.

The fourth row of Table 2 shows analogous figures for cardiac catheterization laboratories. The percentage of hospitals maintaining such laboratories rose steadily with the number of short-term general hospitals in the local markets. Hospitals with 21 or more neighbors were 25 percent more likely to maintain a catheterization laboratory than were comparable hospitals with no nearby competitors ( $P = 0.0355$ ).

Table 3 shows percentage reductions in the probability that individual hospitals offer each of the four cardiac services due to the in-

fluence of broad-coverage, mandatory programs of hospital rate regulation at the state level. The figures in Table 4 show the effect of rate-regulation programs in New York, New Jersey, Connecticut, Massachusetts, and Maryland. The regulatory program in Washington was also evaluated, but no consistent effects were found. The comparison group of hospitals for these figures contained all the hospitals that responded to the SSCS in unregulated states.

Rate-regulation programs in New York, New Jersey, Connecticut, Massachusetts, and Maryland substantially reduced the percentage of hospitals that performed coronary-artery bypass surgery and percutaneous transluminal coronary angioplasty relative to the percentage that would have been expected to perform these procedures, given the characteristics of hospitals and hospital markets in the regulated states. The programs in New York and New Jersey exerted stronger effects than those in the other three states. The effects in Maryland, although large in absolute terms, were not statistically significant.

Strong regulation-related effects on the percentage of hospitals maintaining facilities for open-heart surgery were observed in four states, as indicated in the third row of Table 3. The effects were weaker for cardiac catheterization laboratories. The reductions achieved by the Maryland program were not statistically significant at conventional confidence levels.

Table 4 shows the percentage reductions associated with rate regulation in the availability of the four cardiac services when the analysis was limited to regulated and unregulated hospitals in clusters with at least 20 competitors. These figures permit insights into the effect of regulation on the acquisition of cardiac services in the most competitive local markets. These are the markets in which, according to the evidence presented in Table 2, competition-related duplication of services would be most pronounced in the absence of regulation.

The figures in Table 4 reveal a strong and consistent pattern of regulatory effects on hospitals in competi-

**Table 3. Percentage Reductions in the Availability of Selected Cardiac Services Associated with Rate-Regulation Programs in New York, New Jersey, Connecticut, Massachusetts, and Maryland.\***

CARDIAC SERVICE	NEW YORK	NEW JERSEY	CONNECTICUT	MASSACHUSETTS	MARYLAND
Coronary-artery bypass surgery	61.9†	68.7†	51.8‡	44.1§	14.8
Percutaneous transluminal coronary angioplasty	60.4†	60.1¶	43.9§	35.7	47.3
Facility for open-heart surgery	60.1†	60.8†	57.3¶	51.8†	39.0
Cardiac catheterization laboratory	43.0†	28.9§	7.3	40.8¶	24.9

\*The percentages are adjusted to control for differences between hospitals in the number of competitors in the market area (defined as in Table 2), medical school affiliation, membership in the Council of Teaching Hospitals, ratio of house staff to hospital beds, years of certificate-of-need controls, size of area population, number of area physicians treating cardiovascular disease, ownership, average length of stay, annual number of births, percentages of annual inpatient days accounted for respectively by acute care, intensive care, long-term care, and chronic-disease care, three size categories (numbers of beds), and three region categories. The analysis also tested for the influence of the rate-regulation program in Washington, but found no statistically significant effects.

† $P < 0.0001$ .

‡ $P < 0.01$ .

§ $P < 0.05$ .

¶ $P < 0.001$ .

tive local markets. The effects are larger for each service and each state program than the effects reported in Table 3 for all types of markets combined. The effects of the Maryland program on the availability of bypass surgery and coronary angioplasty are considerably larger than those in Table 3 and are statistically significant ( $P = 0.0288$  for bypass surgery,  $P = 0.0188$  for coronary angioplasty).

Table 5 shows the percentages of hospitals with each type of ownership (public, private nonprofit, and investor-owned) that offered bypass surgery or coronary angioplasty or that maintained a facility for open-heart surgery or a cardiac catheterization laboratory in 1982. These percentages are adjusted to control for differences between individual hospitals in their local market and state-regulatory environments, patient case mix, teaching role, and other relevant factors, and thus to capture the independent influence of the type of ownership itself on the probability that a hospital engages in various forms of cardiac care.

A consistent gradient was observed across all four procedures and facilities. In 1982, public hospitals were the least likely to offer the four procedures and facilities, and investor-owned hospitals were the most likely, with private nonprofit hospitals taking an intermediate position. The differences between public and private nonprofit hospitals were statistically significant at the 90 percent confidence level ( $P = 0.0361$  for bypass surgery,  $P = 0.0720$  for coronary angioplasty,  $P = 0.0686$  for open-heart surgery facilities, and  $P = 0.0820$  for catheterization laboratories). The differences between investor-owned and private nonprofit hospitals were not statistically significant ( $P > 0.4000$  in all cases).

**DISCUSSION**

Duplication of cardiac services in competitive local markets reduces the annual volume of coronary-artery bypass operations performed in individual hospitals within those markets. Low volumes of a procedure may be justified in isolated hospitals, where the clinical, psychological, and economic costs of patient transfers are high. Yet, over four fifths of the hospitals performing fewer than 200 bypass procedures in 1982 were situated in local markets in which one or more other hospitals maintained facilities for open-heart surgery (Table 1).

**Table 5. Adjusted Percentages of Hospitals with Selected Cardiac Services, According to Type of Ownership, 1982.\***

CARDIAC SERVICE	HOSPITAL OWNERSHIP		
	PUBLIC	PRIVATE NONPROFIT	INVESTOR-OWNED
	<i>percent</i>		
Coronary-artery bypass surgery	10.1	12.1	13.2
Percutaneous transluminal coronary angioplasty	8.9	10.6	11.1
Facility for open-heart surgery	11.4	13.2	13.8
Cardiac catheterization laboratory	16.7	18.6	19.5

\*The percentages are adjusted to control for differences between hospitals in local market structure (defined as in Table 2), state rate-regulation programs, medical school affiliation, membership in the Council of Teaching Hospitals, ratio of house staff to hospital beds, years of certificate-of-need controls, size of area population, number of area physicians treating cardiovascular disease, average length of stay, annual number of births, percentages of annual inpatient days accounted for respectively by acute care, intensive care, long-term care, and chronic-disease care, three size categories (numbers of beds), and three region categories.

Some insights into the clinical benefits of regionalizing cardiac services may be obtained with use of figures on mortality rates associated with bypass surgery from two studies that used different data sources but arrived at broadly similar conclusions. Using 1972 data, Maerki et al.<sup>12</sup> estimated that 37 deaths following bypass surgery could be avoided for every 1000 patients transferred from hospitals performing 215 or fewer procedures per year to hospitals performing more than 215 per year. The cutoff point of 215 procedures was chosen empirically as reflecting the volume above which no significant improvements in mortality could be realized as a result of transferring patients.

More recent evidence from a study of 18,994 bypass-graft procedures performed in 77 California hospitals in 1983, conducted by Showstack et al.,<sup>2</sup> confirmed this general pattern. Both studies controlled for the severity of the case mix in the various hospitals.

The findings presented in this paper add to a growing literature indicating that competitive pressures are responsible for a significant proportion of the duplication of clinical services among hospitals within small geographical areas. The influence of market competition on the availability of open-heart surgery facilities and cardiac catheterization laboratories reported here is consistent with that reported by Luft et al.,<sup>13</sup> who used 1972 data and a somewhat different method. Farley<sup>14</sup> and Cromwell and Kanak<sup>15</sup> have found that hos-

**Table 4. Percentage Reductions in the Availability of Selected Cardiac Services Associated with Rate Regulation in Hospitals with 21 or More Neighboring Institutions.\***

CARDIAC SERVICE	NEW YORK	NEW JERSEY	CONNECTICUT	MASSACHUSETTS	MARYLAND
	<i>percent</i>				
Coronary-artery bypass surgery	71.4†	75.2†	54.5‡	56.0‡	60.9§
Percutaneous transluminal coronary angioplasty	68.8†	68.7¶	47.7§	51.6‡	71.5§
Facility for open-heart surgery	66.7†	65.7†	59.1‡	56.0¶	49.6
Cardiac catheterization laboratory	50.5¶	31.9§	82.0‡	48.5¶	28.6

\*The percentages are adjusted to control for differences between hospitals in local market structure (defined as in Table 2), medical school affiliation, membership in the Council of Teaching Hospitals, ratio of house staff to hospital beds, years of certificate-of-need controls, size of area population, number of area physicians treating cardiovascular disease, ownership, average length of stay, annual number of births, percentages of annual inpatient days accounted for respectively by acute care, intensive care, long-term care, and chronic-disease care, three size categories (numbers of beds), and three region categories. The analysis also tested for the influence of the rate-regulation program in Washington, but found no statistically significant effects.

† $P < 0.0001$ .      ‡ $P < 0.01$ .      § $P < 0.05$ .      ¶ $P < 0.001$ .

pitals in more competitive areas offer more services than those in less competitive areas. Those two studies do not, however, distinguish between cardiac and noncardiac services. Two studies of the diffusion of CT scanners and magnetic resonance imagers suggest the importance of market factors without being able to measure them.<sup>16,17</sup>

The duplication of clinical services may be responsible for high economic costs as well as poor clinical outcomes in competitive hospital markets. Farley<sup>14</sup> and Robinson and Luft<sup>18,19</sup> have found the average cost per patient admission in 1972, the late 1970s, and 1982 to be 20 to 25 percent higher in competitive than in noncompetitive hospital markets, with case mix, teaching role, wage rates, and other relevant factors controlled for.

The findings on rate-regulation programs provide some of the strongest evidence to date that regulatory programs can exert at least some influence on the diffusion of hospital services. Cromwell and Kanak<sup>15</sup> have found that rate regulation in New York and New Jersey restrained the diffusion of facilities for open-heart surgery during the 1970s. Using state data from 1979, Joskow<sup>20</sup> has found rate regulation to be negatively and significantly associated with the diffusion of CT scanners. Romeo et al.<sup>21</sup> have found mixed effects of rate regulation on the diffusion of a number of low-cost noncardiac procedures.

This evidence of the effect of rate regulation is important for current policy debates, since a prospective-payment strategy has been adopted by an increasing number of health insurance providers since 1982. Medicare and a number of state Medicaid programs have adopted a schedule of fixed rates per case, based on diagnosis-related groups. In California and a number of other states, Medicaid programs and some private health insurance plans are contracting with hospitals for fixed rates per patient day. The results of this study suggest that these new financing arrangements may reduce the amount of service duplication in competitive hospital markets, thus reducing the number of hospitals that perform small numbers of bypass operations and other cardiac procedures.

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