To Subscribe: https://fulfillment.healthaffairs.org

Health Affairs is published monthly by Project HOPE at 7500 Old Georgetown Road, Suite 600, Bethesda, MD 20814-6133. Copyright © by Project HOPE - The People-to-People Health Foundation. As provided by United States copyright law (Title 17, U.S. Code), no part of may be reproduced, displayed, or transmitted in any form or by any means, electronic or mechanical, including photocopying or by information storage or retrieval systems, without prior written permission from the Publisher. All rights reserved.

Not for commercial use or unauthorized distribution
DataWatch

Abstract: More than 25 percent of hospitals in California that offer open-heart surgery performed fewer than the number recommended by minimum volume guidelines in 1991. This DataWatch examines the characteristics of these hospitals and the patients they treat. The analysis suggests that the market share of these providers has remained constant over recent years, despite substantial growth in managed care. Simple explanations—for example, that these hospitals are serving isolated geographic markets or are hospitals in transition—do not explain the phenomenon. Medicare beneficiaries represent approximately half of the patient volume at these facilities. Health maintenance organizations (HMOs) are more likely to send their enrollees to high-volume facilities.

The U.S. health care system has long been criticized as wasteful and inefficient. One form of “waste” is the duplication of expensive, high-technology services that require substantial capital investment and maintenance expenditures. The proliferation of open-heart surgery providers, particularly those performing coronary artery bypass graft surgery (CABG), represents perhaps the most frequently cited example of such “wasteful,” duplication. Given the high fixed costs associated with open-heart surgery facilities, average costs rise when volume per facility drops. Further, several studies indicate a relationship between low volumes and adverse outcomes, suggesting that duplication of open-heart surgery facilities may lower quality. Because of concerns about quality and cost, many professional organizations and state planning commissions recommend minimum volume standards, generally 150 or 200 procedures annually, for hospitals that perform open-heart procedures. Yet many hospitals do not meet these standards.

For advanced cardiac services in particular, it is unlikely that hospitals compete on the basis of price in the absence of selective contracting by...
managed care plans or other insurers. Several researchers have argued, with some empirical support, that nonprice competition in an environment with indemnity insurance and without readily available information on quality of services can lead to the inefficient proliferation of cardiac services.

A regulatory approach to solving the problem of low-volume facilities has had mixed success. Some states have limited the number of open-heart surgery providers through programs such as rate regulation. However, for a variety of reasons, many states do not use strong regulatory approaches to control the proliferation of expensive medical services.

Creation of a more competitive market, if possible by increasing the market penetration of competing managed care plans, has several theoretical advantages over a strong regulatory system. In theory, competition would allow only firms that provide a valued quality/price combination to remain in the market. There would be no need for regulators to decide how many providers should be in the market or when certain providers should be forced to leave the market. However, it is not yet known whether proliferation of managed care will, in practice, “rationalize” the provision of services such as open-heart surgery. In 1995 Michael Chernew reported that managed care penetration reduces the number of hospitals and hospital beds. Steven Hill and Barbara Wolfe provide one of the few studies of the impact of managed care on the provision of capital-intensive services. In a case study of Madison, Wisconsin, they found mixed evidence concerning whether managed care penetration reduces the adoption of expensive, capital-intensive technology.

This DataWatch examines the provision of CABG in low-volume facilities in California. Managed care plans historically have had a strong presence in California. In 1991 the health maintenance organization (HMO) penetration rate was 3.13 percent, the highest in the nation, up from 16.8 percent in 1980. Preferred provider organizations (PPOs) also have a strong presence. Although PPOs were nonexistent in 1980, by 1990, 45.8 percent of Californians worked for employers that offered a PPO option.

Because of this rising level of managed care penetration, California provides an excellent opportunity to assess whether managed care drives low-volume providers from the market. We pose three questions here. First, what types of low-volume facilities survive in this managed care-dominated environment? Second, are the low-volume facilities serving certain market niches, such as isolated geographic areas? Third, are HMOs less likely than other insurers to send their patients to low-volume facilities?

---

**Study Methods**

Discharge data routinely compiled by the California Office of Statewide
Health Planning and Development (OSHPD) were used to determine CABG and open-heart surgery volumes at each hospital in California for the period 1986-1991. For each discharge, the OSHPD data report five procedure codes and five diagnostic codes as well as descriptive data, including the patient’s age, sex, race, ZIP code of residence, and principal source of payment. Hospital characteristics were taken from the American Hospital Association (AHA) survey of hospitals. Distances between hospitals and between patients and hospitals were computed using latitude and longitude coordinates provided by Geographic Data Technology, Inc. Unless otherwise specified, the results reported here pertain to analysis of 1991 data.

Only hospitals that performed at least five CABGs and at least ten open-heart surgery procedures (CABGs, open-heart valve surgeries, and other miscellaneous procedures) were included in the analysis. In any given year a hospital was classified as high volume if it performed more than 200 CABG procedures. A hospital was classified as low volume if its volume of open-heart surgery procedures did not exceed 150. All other hospitals were classified as intermediate-volume facilities. The need for an intermediate classification stems from uncertainty surrounding the appropriate threshold between high- and low-volume providers.

Study Findings

Survival of low-volume facilities. Despite the increased managed care presence in California, the number of low- and intermediate-volume CABG providers in the state has remained relatively stable and significant both in terms of numbers and share of volume (Exhibit 1). Consistently from 1986 to 1991, approximately thirty hospitals were low volume, performing a bit less than 10 percent of total open-heart surgery volume.

One potential explanation for the existence of low-volume CABG providers is that they are hospitals in transition; they might not be consistently low volume over time. However, the evidence suggests that low-volume hospitals generally remain so for some time. Of the thirty-two low-volume hospitals in 1986, sixteen were still low volume in 1991. Two eventually left the market, ten made the transition to intermediate volume, and only four became high-volume providers.

The set of low-volume providers is dominated by persistent low-volume providers and new entrants. Of the thirty-two low-volume providers in 1991, sixteen had been low volume in 1986. Of these sixteen providers, twelve had been low volume in each of the previous five years, and none had been a high-volume provider in any of the previous five years.

Thirteen of the low-volume providers in 1991 entered the market be-
between 1987 and 1991. It remains to be seen how many of these new entrants will reach higher volume levels. The data suggest that approximately five years after entry, the percentage of new entrants that were low volume on entry approximates the overall percentage of low-volume providers. Of the fifteen hospitals that entered the market in 1987 or 1988 and remained until 1991, five were low volume in 1991, six were intermediate volume, and only four were high volume. Of the eleven hospitals that entered after 1988 and were still providing CABG services in 1991, eight were low volume, two were intermediate volume, and one was high volume.

**Market niches.** There does not appear to be a particular geographic niche served by low-volume facilities. In fact, low-volume facilities are typically close to other low-volume hospitals or to high-volume hospitals (Exhibit 2). Although not depicted in Exhibit 2, intermediate-volume providers were similarly surrounded by other CABG providers, with 58 percent located within five miles of another provider and 90 percent located within twenty miles of at least one other provider. Given that the median travel distance for open-heart surgery is about nine miles in Los Angeles County, and 25 percent of patients travel more than twenty-three miles, the presence of so many providers in such close proximity suggests that closure of low-volume facilities would not necessitate substantially greater travel. In fact, approximately 42 percent of patients who went to low-volume providers were closer to a high- or intermediate-volume provider than to the low-volume hospital that was chosen. Only approximately 4 percent of patients who received care at low-volume facilities...
(about 0.4 percent of all patients) would have had to travel more than twenty extra miles to reach a high- or intermediate-volume facility.

### Characteristics of low-volume providers

Low-volume open-heart surgery providers have significantly fewer beds than higher-volume providers have. The mean number of beds at low-volume hospitals is 258, compared with 369 at intermediate-volume hospitals and 370 at high-volume hospitals. Low-volume hospitals are also much less likely to be members of the Association of American Medical Colleges’ Council of Teaching Hospitals (3 percent for low-volume hospitals, compared with 17 percent and 15 percent for intermediate- and high-volume hospitals, respectively).

For-profit hospitals are represented disproportionately among low-volume providers (Exhibit 3). However, because of the small number of for-profit open-heart surgery providers, they represent only about 22 per-

### Exhibit 2

Low-Volume Providers Of Open-Heart Procedures, Relative To Neighboring Providers. 1991

<table>
<thead>
<tr>
<th>Neighbors within 5 miles</th>
<th>Neighbors within 20 miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of neighbors</td>
<td>Low-volume neighbors Total</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>0</td>
<td>28%</td>
</tr>
<tr>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td>2 to 9</td>
<td>41</td>
</tr>
<tr>
<td>10 or more</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Hospital discharge data provided by the California Office of Statewide Health Planning and Development. Distances between hospitals based on data from Geographic Data Technology, Inc.

### Exhibit 3

Size Distribution Of Hospitals Providing Coronary Artery Bypass Graft (CABG) Surgery, By Ownership Type

<table>
<thead>
<tr>
<th>Ownership</th>
<th>Mii of hospitals</th>
<th>Mii of low-volume hospitals</th>
<th>Distribution of hospitals across size class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low volume</td>
</tr>
<tr>
<td>Government owned</td>
<td>14.0%</td>
<td>12.5%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Private, for-profit</td>
<td>14.0%</td>
<td>21.9%</td>
<td>43.8%</td>
</tr>
<tr>
<td>Private, not-for-profit</td>
<td>72.0%</td>
<td>65.6%</td>
<td>25.6%</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>28.1%</td>
</tr>
</tbody>
</table>

Source: Hospital discharge data provided by the California Office of Statewide Health Planning and Development.

Notes: The first two columns report the mix of hospitals by ownership status. For example, 14 percent of all CABG providers were private, for-profit, and 21.9 percent of all low-volume CABG providers were private, for-profit. The remaining columns report the distribution of hospitals by size class within any ownership category. For example, 43.8 percent of private, for-profit hospitals that provided CABG were low volume, 18.8 percent were intermediate volume, and 37.5 percent were high volume. The hypothesis that ownership type is independent of size class cannot be rejected at the .05 level.
cent of all low-volume providers. Conversely, private, not-for-profit hospitals are disproportionately less likely to be low or intermediate volume. Because they dominate the market for open-heart surgery, approximately two-thirds of all low-volume providers fall into this category.

**Patient characteristics.** Analysis of age and diagnostic information reveals little association between these variables and hospital size class. However, patients admitted via an emergency room are much more likely than patients admitted from other facilities or from the community to receive CABG at low-volume facilities (Exhibit 4). This suggests that, at least in part, patients (or their physicians) who have more time to choose a hospital are more likely to avoid low-volume facilities. Nevertheless, because fewer than 20 percent of CABG patients are admitted from an emergency room, they represent only about a third of the volume at low-volume facilities. Approximately 32 percent of patients receiving treatment from low-volume facilities were admitted through an emergency room, compared with 19 percent in aggregate.

The typical CABG patient at a low-volume hospital is a Medicare beneficiary (Exhibit 5). Even if low-volume hospitals attracted no non-Medicare patients, they would still retain more than half of their patients. This is not because Medicare patients are more likely than others to choose low-volume providers, but because Medicare beneficiaries represent the largest single group of CABG patients. Although low-volume providers receive patients represented by all types of payers, they disproportionately treat Medicaid patients.

**Where HMOs send patients.** HMOs’ ability to drive low-volume providers from the market depends upon the degree to which such plans

| Exhibit 4
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distribution Of Coronary Artery Bypass Graft (CABG) Volume Across Size Classes Of Hospitals, By Admission Source</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of admission</th>
<th>Mix by admission source</th>
<th>Low-volume mix by admission source</th>
<th>Distribution of hospitals across size class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low volume</td>
<td>Intermediate volume</td>
<td>High volume</td>
</tr>
<tr>
<td>Emergency room</td>
<td>18.9%</td>
<td>32.5%</td>
<td>15.1%</td>
</tr>
<tr>
<td>Other facility</td>
<td>21.2</td>
<td>8.8</td>
<td>3.6</td>
</tr>
<tr>
<td>Other (routine)</td>
<td>59.9</td>
<td>8.6</td>
<td>17.9</td>
</tr>
<tr>
<td>All sources</td>
<td>100.0</td>
<td>100.0</td>
<td>8.8</td>
</tr>
</tbody>
</table>

Source: Hospital discharge data provided by the California Office of Statewide Health Planning and Develop ment.

Notes: The first column reports the share of CABG volume by admission source. The second column reports the equivalent data for only the low-volume hospitals. The remaining columns report the distribution of patients across hospital size class, within any admission source category. For example, 15.1 percent of patients admitted through the emergency room went to low-volume facilities. The hypothesis that admission source is independent of size class can be rejected at the .001 level.
Exhibit 5
Distribution Of Coronary Artery Bypass Graft (CABG) Volume Across Size Classes Of Hospitals. By Payer

<table>
<thead>
<tr>
<th>Payer</th>
<th>CABG market share</th>
<th>Distribution of hospitals across size class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low-volume hospitals</td>
<td>Low volume</td>
</tr>
<tr>
<td>Medicare</td>
<td>51.2%</td>
<td>8.7%</td>
</tr>
<tr>
<td>Medicaid</td>
<td>5.0</td>
<td>14.4</td>
</tr>
<tr>
<td>HMO (including Kaiser)(^a)</td>
<td>21.7</td>
<td>6.5</td>
</tr>
<tr>
<td>HMO (excluding Kaiser)(^a)</td>
<td>16.9</td>
<td>8.3</td>
</tr>
<tr>
<td>BCBS/commercial(^b)</td>
<td>17.5</td>
<td>10.1</td>
</tr>
<tr>
<td>Other government</td>
<td>2.5</td>
<td>9.7</td>
</tr>
<tr>
<td>Other private</td>
<td>2.1</td>
<td>8.8</td>
</tr>
<tr>
<td>All payers</td>
<td>100.0</td>
<td>8.8</td>
</tr>
</tbody>
</table>

Source: Hospital discharge data provided by the California Office of Statewide Health Planning and Development.

Notes: The first two columns report the share of CABG volume by payer, for all providers and low-volume providers. For example, Medicare was reported as the principal payer for 51.2 percent of all CABG patients (though some of these persons may have been enrolled in TEFRA HMOs), and 50.9 percent of patients in low-volume hospitals had Medicare as their reported principal payer. The remaining columns report the distribution of patients across hospital size class, within any payer category. The hypothesis that the payer mix is independent of size class can be rejected at the .001 level.

\(^a\) HMO is health maintenance organization.

\(^b\) BCBS is Blue Cross/Blue Shield.

direct their enrollees to high-volume facilities. The ability to steer enrollees to certain providers differs among different types of HMOs. While all types of HMOs exist in California, group- and staff-model HMOs are considered best able to direct their enrollees to particular facilities. The largest HMO in California, Kaiser Foundation Health Plan, directs its enrollees to high-volume facilities only. Both of the Kaiser hospitals that perform open-heart surgery are high volume (787 and 474), and the hospitals with which Kaiser contracts for open-heart surgery are high volume also.

With the exception of one county-owned HMO that enrolls only Medi-Cal (California Medicaid) recipients and performs all open-heart surgery at county-owned hospitals, none of California’s group- and staff-model HMOs contracts with low-volume providers for open-heart surgery.\(^21\) Kaiser and the non-Medi-Cal HMOs concentrate their enrollees in approximately ten hospitals. One of these hospitals was classified as an intermediate-volume provider, performing 172 CABG procedures annually. However, when other open-heart surgery procedures, predominantly valve surgeries, were included, this hospital performed more than 400 open-heart surgery procedures annually. Thus, group- and staff-model HMOs appear to successfully steer enrollees away from low-volume CABG providers.

The evidence suggests that other types of HMOs also direct their enrollees to high-volume facilities, although to a much lesser extent than
their group- and staff-model counterparts. HMO patients who did not receive care at Kaiser hospitals (largely members of nongroup- and nonstaff-model HMOs) are marginally less likely than persons who are insured by commercial carriers (including Blue Cross/Blue Shield) to receive care at low-volume facilities (8.3 percent compared with 10.1 percent) and more likely to receive care at high-volume facilities (76.5 percent compared with 69.9 percent). Multivariate statistical analysis, controlling for patient demographics, county of residence, patient comorbidities, source of admission, and the number of high-volume and other providers in the patient’s vicinity, indicates that HMO enrollees are more likely than enrollees in commercial plans to receive care from high-volume providers (p < .01).22 If all patients not receiving treatment at Kaiser facilities were enrolled in HMOs, low- and intermediate-volume facilities would attract about 11 percent fewer patients. The effect would be even stronger if group- or staff-model HMOs enrolled a disproportionate share of these patients.23

The finding that nongroup- and nonstaff-model HMOs are less likely than group- and staff-model HMOs to direct their patients to high-volume providers is consistent with the results of Roger Feldman and colleagues, who found that individual practice associations (IPAs) were not as successful as staff/network plans at steering enrollees to certain providers.24 The ability of low-volume providers to attract some managed care patients may reflect aggressive pricing to managed care plans. The percentage of patient volume at low-volume facilities attributable to HMOs roughly doubled between 1986 and 1991. We believe that this reflects the growth in HMO market share, particularly among nongroup and nonstaff models, in California over this period.

Discussion

Despite the prevalence of managed care in California, much duplication of expensive, high-technology services, such as CABG, remains.25 In part, the desire to offer CABG services may reflect the relationship between CABG capabilities and other hospital services. Most importantly, the ability to provide open-heart surgery is a prerequisite to the provision of percutaneous transluminal coronary angioplasty (PTCA). Hospitals that want to compete seriously in the large market for treating coronary heart disease must have an open-heart surgery facility.26

This market may be attractive to many hospitals, particularly because a substantial portion of their volume comes from Medicare enrollees, who tend to remain outside of managed care plans. If reimbursement from public or nonmanaged care payers is sufficiently high (which is plausible, given the historically generous reimbursement rates for these services), provision
of CABG may be profitable even at low volumes. It also may give hospitals a level of prestige that increases the general demand for their services and their ability to attract managed care contracts. However, many hospitals survive without providing technologically advanced cardiac services.

More research is needed to determine whether the existence of low-volume facilities is sometimes justified because they help to support needed PTCA providers. However, since most low-volume CABG providers are located near high- or intermediate-volume providers (all of which provide PTCA), the quality of and access to PTCA services may not be affected by the loss of these facilities.

The evidence presented here regarding the flow of patients enrolled in group- and staff-model HMOs offers some hope that low-volume providers can be driven from the market. This subset of HMOs appears to direct their enrollees to high-volume facilities. Should the penetration rate of these types of organizations grow, managed care may live up to its expectations and help eliminate duplication of expensive services.

The fiscal impact of infrastructure changes that are attributable to managed care may be greater for services that have not yet been widely adopted than for open-heart surgery. For existing services, the benefits of managed care include halting further proliferation (only about 25 percent of California hospitals now offer open-heart surgery), eliminating recurrent fixed costs, and any improvement in outcomes associated with the elimination of low-volume providers.

However, if we accept the widely held premise that limitations on the proliferation of expensive, capital-intensive services such as open-heart surgery are worthwhile, then changes in the behavior of large public payers—particularly Medicare—may be necessary if real change in the hospital market infrastructure is to occur. Without changes in the degree to which public payers direct patients away from low-volume facilities, or perhaps changes in the amount of reimbursement for these services, low-volume facilities appear able to earn sufficient revenue to remain viable.

The authors thank the California Office of Statewide Health Planning and Development, Homero Lomas, and Carolyn Pagupa for providing the data for this study and for their insights on California hospitals. They also thank Harold Luft and two anonymous referees for their helpful comments.

NOTES

1. A portion of the fixed costs associated with open-heart surgery, such as the cost of modifying an operating room, would not be recovered if hospitals were forced to abandon existing open-heart surgery programs, Other costs, such as a portion of equipment costs and the fixed staff costs associated with such programs, would be saved. However, if managed care halts future proliferation of capital-intensive, high-
technology services, all of the expenses associated with these services would be saved. H. Luft et al., “The Role of Specialized Clinical Services in Competition among Hospitals,” Inquiry (Spring 1986): 83-94.

2. The strengths and weaknesses of the evidence on the relationship between hospital volume and outcomes are reviewed by H. Luft et al., Hospital Volume, Physician Volume, and Patient Outcomes: Assessing the Evidence (Ann Arbor, Mich.: Health Administration Press, 1990). Luft and colleagues note that there are fewer studies examining the relationship between physician volume and outcomes and that it is difficult to separate surgeon and hospital effects statistically. The connection between hospital volume and outcomes may reflect the existence of stable, high-volume surgical teams at high-volume hospitals.


5. Ibid. California had a certificate-of-need law that was repealed in the beginning of 1986 (before this analysis). Interviews with personnel from the Office of Statewide Health Planning and Development in California suggest that this law was not considered an effective barrier to entry.


8. Ibid. These authors examined computed tomography (CT) scanners, radiation therapy units, magnetic resonance imagers (MRIs), lithotripters, and positron emission tomography (PET) units.


12. Coordinates were based on the coordinates of the centroid of each hospital’s or patient’s ZIP code.

13. The analysis was restricted to hospitals performing at least ten open-heart surgery procedures annually because of the possibility that these records reflect coding errors. Harold Luft and Patrick Romano use a similar restriction. See H. Luft and P. Romano, “Chance, Continuity, and Change in Hospital Mortality Rates,” Journal of the American Medical Association 270, no. 3 (1993): 331-337.

14. CABGs were identified by International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes ranging from 36.10 to 36.19. Joyce Kelly and Fred Hellinger report significantly better outcomes in hospitals performing more than 200 CABGs annually. See J.V. Kelly and F.J. Hellinger, “Heart Disease and Hospital Deaths: An Empirical Study,” Health Services Research 22, no. 3 (1987): 369-395. Susan Maerki and colleagues estimate mortality improvements associated with increasing CABG volume to 215. See S. Maerki et al., “Selecting Categories of Patients for...
Regionalization," Medical Care 24, no. 2 (1986): 148-158.

15. The threshold of 150 is based on minimum volume guidelines set by the American College of Surgeons. Non-CABG open-heart procedures are dominated by valve surgeries (ICD-9-CM codes 35.10-35.99). Heart transplants, ventricular aneurysm procedures, and other coronary artery procedures were included as well with the appropriate ICD-9-CM codes. Our goal was to give hospitals the benefit of the doubt with regard to their open-heart surgery volumes. In this spirit, if a hospital performed multiple procedures on a given patient, the procedures were counted twice. This pushed two hospitals, representing 0.5 percent of CABG volume, from the low-volume to the intermediate-volume category. Without this convention these hospitals had open-heart surgery volumes of 146 and 149.

16. Support exists for both definitions. Much of the literature on the volume/quality relationship indicates that a CABG volume of about 200 is a meaningful demarcation point between high- and low-volume facilities. However, some of the volume guidelines put forth by various organizations use a total bypass volume of 150 as the relevant cutoff.

17. One of these twelve performed fewer than ten open-heart surgeries in 1987.

18. Outside of Los Angeles County, the median travel distance is 12.1 miles, with 25 percent of all patients traveling at least 3 1.8 miles.

19. The California data identify admissions as emergency, urgent, or elective. Although these definitions are subjective, the data support the conclusion that low-volume hospitals are more likely than other hospitals to get emergency cases.

20. The coding of Medicare beneficiaries enrolled in HMOs is inconsistent in the California data. Generally, these persons are coded as Medicare enrollees, but in some cases they may be coded as HMO enrollees. In 1994 about 22 percent of the Medicare population in California was enrolled in an HMO, through either cost or risk contracts. Health Care Financing Administration, Office of Managed Care, “Medicare Managed Care Program Update” (Unpublished report, 1995).

21. Another Medicaid HMO contracted with a high- and an intermediate-volume provider but would pay for care at any facility where the surgeon had practice privileges.

22. Patients receiving treatment at Kaiser facilities were excluded from the multivariate analysis. Parameter estimates are available from the authors. The conclusions are not sensitive to a variety of different specifications or assumptions regarding the distribution of the error (probit and logit specifications were run).

23. Although HMO enrollees not receiving treatment at Kaiser-operated facilities are less likely than commercially insured persons to receive care at low-volume facilities, this relationship disappears when county of residence is held constant, suggesting that the primary shift in location of care associated with a non-Kaiser HMO, generally non-group/nonstaff-HMO enrollment, is from intermediate- to high-volume facilities.


25. It is unlikely that the results presented here would change if the analysis were updated through 1994. Managed care was already strong in California by 1991, and the aggregate number of CABG providers rose 2.5 percent between 1991 and 1994, while the volume of cardiovascular surgeries rose 2.7 percent. While some of the increased volume between 1991 and 1994 may have increased volume at low-volume facilities, the increase in the number of providers and the trend from 1986-1991 suggest that many low-volume facilities remained.

26. The volume of cardiac catheterization (including PTCA) rose 77 percent in California between 1986 and 1994. Much of this increase was driven by growth in PTCA volume.