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Medicare Participating Heart Bypass Center Demonstration

Volume I
Final Report

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1 Introduction and Overview of Key Findings

1.1 Rationale for the Demonstration

In 1980, the federal government spent $36.4 billion on the Medicare program (Letsch *et al.,* 1992, Table 4). By 1991, the figure had reached $120.2 billion, an average increase of 11.4% annually. For hospital care alone, the federal Medicare Program spent $26.4 billion in 1980 versus $73.3 billion in 1991 (Letsch *et al.*, 1992, Table 21). Spending on physician services rose even faster from $7.9 billion in 1980 to $32.8 billion in 1991.

The Health Care Financing Administration (HCFA) has been very active in responding to these high rates of program outlays. On the hospital side, the Congress passed Tax Equity and Fiscal Responsibility Act (TEFRA) legislation in 1982 that put per case ceilings on hospital reimbursements. Then, a year later, it passed Diagnosis Related Group (DRG) prospective payment for all short-term acute hospitals receiving Medicare payments. In terms of physician reimbursement, the Congress passed, and HCFA implemented, the physician fee freeze in the mid-1980s, followed by overpriced procedure rollbacks in the late 1980s, and, finally, the Medicare Fee Schedule in the early 1990s designed to link payments more closely to work effort and the costs of each service.

Besides legislated reform, HCFA also has undertaken many cost containment demonstrations. One approach involved negotiating global payment rates for all Medicare hospital insurance (Part A) and Medicare medical insurance (Part B) inpatient services

associated with coronary artery bypass graft surgery (CABG). Expenditures on heart bypass surgery have been particularly worrisome. Every year, the government spends several billion dollars on the inpatient care for bypass patients. Outlays continued to grow rapidly in the 1980s with the growth in procedure rates. With the implementation of DRG per case payment to hospitals in 1983, the Part A payment per case for bypass surgery has been capped at the annual update in Medicare hospital rates nationally. However, the growth in Part B physician outlays remained unconstrained, except for rollbacks on the surgeon's fee. Mitchell (1993) estimates that total allowed charges grew 12-14% for bypass surgery from 1985-88, even after adjusting for updates in allowable fees.

A major concern of both hospital managers and policy makers in controlling inpatient costs for high-tech procedures is the asymmetry of financial incentives faced by hospital staff versus physicians. Currently, hospitals are paid for bypass surgery on a per case basis (primarily within DRGs 106 and 107). Except for extraordinary outlier costs, they are paid a fixed amount regardless of the intensity of care provided each patient. Although surgeons, like hospitals, receive a bundled fee for inpatient services, other physicians, by contrast, are paid for every additional service they provide, including routine daily hospital visits and consultations. Surgeons, too, are paid more for more complicated surgeries requiring more bypassed lesions. Moreover, all hospital services are essentially "free" to physicians because they bear none of the financial risk of keeping patients in the intensive care unit (ICU) longer, or using more expensive drugs, etc. So long as physicians operate under different payment incentives, hospital managers have had difficulties implementing pre efficient

practice patterns. A global fee that includes physician services would align incentives and encourage physicians to use institutional resources in a more cost effective manner.

1.2 Overview of Demonstration Design

In 1988, the Health Care Financing Administration solicited bids from hospitals and physicians to participate in the Medicare Participating Heart Bypass Center Demonstration. In response to a solicitation mailed to 734 hospitals, HCFA received 209 pre applications. After initial review, 42 hospitals were requested to submit extensive formal applications that detailed their qualifications and bypass volumes. Applicants were then asked to give their best price covering all inpatient institutional and physician services for Medicare patients discharged in DRGs 106 and 107, bypass with or without catheterization. Twenty-seven entities submitted bids, and an expert panel of multi disciplinary experts including physicians recommended ten finalists. At this point, Agency staff, with the assistance of staff from Lewin-VHI and Health Economics Research, the evaluation contractors, conducted an in-depth evaluation of each proposal. Ten criteria were used to rank applicants based on quality and price considerations. (See Chapter 3 for details.) The HCFA administration selected four of the ten finalists. The Agency then negotiated contracts with four applicants:

- Saint Joseph's Hospital of Atlanta;
- St. Joseph Mercy Hospital in Ann Arbor;
- The Ohio State University Hospitals in Columbus;
- University Hospital in Boston.

These sites were chosen based on price and other factors, including geographic dispersion. The intent was to maximize the policy information derived from the novel payment arrangement as well as to test the feasibility of negotiating and then paying bundled global rates. Negotiated global bundled payment prices were established which represented a discount to Medicare.

Under the demonstration, Medicare paid each of these applicants a single global rate for each discharge in DRGs 106 and 107. This rate included all inpatient hospital and physician services. The standard Medicare hospital passthroughs were also included, i.e., capital and direct medical education, on a prorated basis. Any related readmissions were also included in the rate. Pre- and post-discharge physician services were excluded except for the standard inclusions in the surgeon's global fee. All four participants agreed to forego any outlier payments for particularly expensive cases. However, an outlier amount based on the hospital's previous experience was included on the global price.

Hospitals began receiving payments in May and June of 1991. The length of demonstration was set at three years, ending in June of 1994. Participants were required to assemble all physician bills along with the hospital discharge abstract and submit the package to HCFA Central Office for payment. The hospital and physicians were free to divide up the payment any way they chose. Rates were updated annually according to existing hospital prospective payment and physician fee schedule rules.

Applicants were required to collect a predetermined financial obligation from Medicare patients. This included any Part A hospital and Part B physician deductibles plus

the 20% Part B coinsurance. Ordinarily, the coinsurance amount varies by the amount of physician services each patient receives, but under the demonstration the Agency set a fixed actuarial amount per discharge adjusted to be below the (estimated) negotiated Part B amount for a typical admission.

The government placed few requirements on participants other than those already imposed by the program. Hospitals were still subject to the usual utilization review activities that monitored necessity for admission. Physicians were not allowed to balance bill patients, nor could they bill for outpatient services normally included in their global inpatient fee. When the Agency reclassified most DRG 108 bypass patients back into DRGs 106 and 107 in 1992, these patients became part of the demonstration as well. Similarly, when the Congress passed the Medicare Fee Schedule that rolled back many surgical fees, the Agency made downward adjustments in the Part B component of the global rates.

Unlike the current Medicare program, the Agency required that it have the right to review and approve any promotional materials used by the hospitals and physicians under the demonstration. One of the marketing strategies proposed by applicants was to forego the deductible and copays for patients without supplemental insurance. The Agency finally ruled against this request on the grounds that it would discriminate against third-part insurers (and their subscribers) who would still be liable. Providers were not willing to forego deductibles and copays on all demonstration patients.

In the spring of 1993, the government expanded the demonstration to include three more participants:

- St. Luke's Episcopal Hospital in Houston;
- St. Vincent's Hospital in Portland, Oregon;
- Methodist Hospital in Indianapolis.

All six of the remaining ten applicants from the first round were invited to submit new bids, but only St. Luke's, St. Vincent's, and Methodist Hospital did so. These hospitals began receiving payments in the second quarter of 1993 under three-year contracts. The original four hospitals all agreed to continue being paid global rates under the demonstration after their contracts ended in the summer of 1994.

1.3 Evaluation Issues

Many issues were addressed in the evaluation. Some of the more important ones included:

- **Feasibility**

Was it possible for the government to negotiate discounts with providers that included both hospital and physician services? Could this process be fair and efficient? What data and other requirements were required on the government's part? On the provider side, would any hospitals and physicians be able to work together and submit a single packaged rate? Could they provide the data necessary for the government to evaluate the quality of their services and the extent of the discounts they were offering?

- **Implementation**

In order to begin paying global rates, what payment processes had to be changed? What requirements would providers have to meet for payment? How should demonstration billings and payments be integrated with the on-going systems of Fiscal Intermediaries and Carriers? How should the patient obligations be determined? How would changes in Medicare payment policies be applied to the demonstration? What kinds of routine reporting by participants would be required?

- **Volume Growth**

Did the imprimatur of being named a Medicare Participating Heart Bypass Center result in increased bypass volumes among the participants? How did participants promote the demonstration? Did they increase volume at the expense of local competitors? How did competitors react to the demonstration?

- **Program, Beneficiary, and Hospital Savings**

How large were the discounts that the government negotiated with participants? How much did Medicare beneficiaries (and their insurers) benefit as a result of the discounts? Did post-discharge utilization and costs change as a result of bundling all inpatient physician services into a single rate? Did any gains in market shares of demonstration hospitals result in further program savings at the market level? By aligning physician with hospital incentives under a per case payment, did practice patterns change that generated lower hospital costs?

- **Patient Outcomes**

Did patient outcomes change under the demonstration, as measured by inpatient mortality and complication rates? Did one-year post-discharge outcomes change, as measured by mortality, angina relief, and readmissions? Were there any systematic differences in outcomes among participants?

- **Appropriateness of Care**

Did the overall level of appropriateness of care change under the demonstration? If so, did the changes vary by clinical presentation, i.e., stable vs. unstable angina, acute myocardial infarction? What was the extent of disease among demonstration patients and how did that change over the demonstration period?

- **Patient and Hospital Management**

Did physicians change the way in which they managed patients in the hospital under the demonstration? Were there changes in ICU, surgery, catheter lab, pharmacy, and routine nursing services? Were there any changes in the use of consulting physicians under a single fixed global payment? Did hospitals introduce significant management changes to lower costs and improve service efficiency over-and-above changes in patient management?

- **Marketing Programs**

How did participants market their selection as a demonstration hospital? Did they employ different strategies towards patients, referring physicians, and insurers? Were

participants in a better position to compete for managed care contracts because of the demonstration? What impacts did marketing have on volumes? How did competitors respond in their marketing efforts?

- **Physician Payments**

Once the hospital received the bundled payment, how was it divided up between the institution and physicians? How were consulting physicians that were not routinely involved in a case reimbursed? Did physicians share in any of the cost savings that may have resulted from changes in their practice patterns? What impact did the Medicare Fee Schedule rollbacks on certain bypass-related procedures have on physician payments?

- **Reimbursement Difficulties**

What problems did participants encounter in receiving payment from the government? What problems did they encounter in billing third-party payers for the supplemental insurance?

- **Achievement of Goals**

How satisfied were hospitals and physicians with the demonstration? Did they feel that the demonstration helped them gain volume and market share? Did it force them to improve their patient and cost reporting for management purposes? Did they feel that the alignment of incentives led to significant improvements in hospital and patient management? Did they believe that the demonstration resulted in a closer working relationship between the

hospital and clinical staffs? Were participants disappointed with any aspect of the demonstration?

1.4 Evaluation Approach

To provide answers to these questions, the Health Care Financing Administration initially contracted with Lewin-VHI and Health Economics Research (HER). Their interdisciplinary staff of economists, physicians, and marketing experts were responsible for assembling a variety of data bases and conducting numerous on-site interviews with participants as part of an extensive quantitative and subjective evaluation of the program. The staff also assisted HCFA in the evaluation of the bids of the ten finalists. Then, in 1995, the Agency awarded a contract to HER for an extended evaluation to cover the remaining years of the demonstration.

Databases. The principal data bases used in the evaluation included:

- all MedPAR discharge records for DRGs 106, 107, and 108 for seven years, 1990-96;
- all National Claims History Part B claims for patients identified on the MedPAR files;
- detailed hospital micro-cost information on each patient;
- detailed medical records information on each demonstration patient;
- follow-up patient outcome status one year post-discharge;
- the Medicare enrollment file information on all demonstration patients;
- angiographic films and reports for a sample of 120 patients in six sites;
- detailed patient volumes, marketing, and referral information from all seven sites;
- primary surveys of patients and physicians.

Natural Bypass Trends. The Medicare claims were used to document national trends in Medicare bypass (and angioplasty) volumes, patient demographics, lengths of stay, mortality rates, and costs. Trends were decomposed by hospital location, teaching status, and bedsize. Physician costs were decomposed into three segments representing 30 days prior to bypass surgery, inpatient, and 90 days post-discharge. Inpatient physician costs were further separated by specialty. Finally, national Medicare bypass expenditure regressions were used to isolate the trend and hospital and patient factors explaining the variation in hospital DRG and hospital plus Part B physician expenditures.

Market Shares. When subsetted to the demonstration hospitals and their competitors in local markets, the claims data supported quantitative analyses of shifts in market shares and comparative differences in patient demographic mix, costs, and lengths of stay. These analyses involved statistical tests of the differences in shares and other characteristics between 1990, the baseline year, and 1996, the last year of the demonstration.

Medicare Savings. The Part A and B claims data, along with the negotiated global prices provided by HCFA, were also used to measure the extent of program and beneficiary savings under the demonstration. Negotiated prices were compared with predicted Medicare prospective payment rates and physician inpatient outlays to derive the immediate savings from the demonstration. To test for shifts in services post-discharge, the other claims associated with demonstration patients 30-days prior and 90-days post-discharge were compared, year-by-year, with what might have been expected in lieu of the demonstration, based on 1990 average outpatient payments at each demonstration hospital updated by the

national growth in outlays for the same two pre- and post-discharge "windows". Finally, any market share savings were derived by taking the difference between the negotiated prices and what other competitors were being paid by Medicare and multiplying by the shift in cases.

Patient Costliness. The micro-cost information was used to evaluate trends in institutional costs and profits on demonstration patients. Each of the four original participants submitted cost data on each patient by individual service and/or by department for a baseline 1990 period and for the 1991-93 demonstration period. (After 1993, HCFA decided not to fund additional micro-cost analysis.) Average total and variable costs were derived, then compared, showing overall gains in costliness and profits per case. Per case costs, within DRG, were also decomposed by department to isolate the source of any efficiency gains.

Patient Outcomes. Every demonstration hospital provided a set of clinical information on each patient throughout the demonstration period, including discharge status (died, other), risk indicators, comorbid conditions, admission priority, type of coronary heart disease, age, gender, height, whether they had had a previous bypass operation, and ejection fraction. Additional information was provided on disease anatomy, e.g., number of lesions, percent occlusion by lesion, and intra- and post-operative complications, e.g., return to the operating room for bleeding, infection. Extensive descriptive analyses were performed comparing the seven hospitals in terms of mortality, stratified by risk factor and other relevant variables. Logistic analyses were then conducted explaining inpatient mortality, complication rates, and lengths of stay. The demonstration effect was tested in these models

using a monthly time trend over the demonstration period. The mortality analyses were extended to 90-day and one-year follow-up using the Medicare enrollment files that record dates of death that may have occurred after discharge.

Patient Satisfaction and Health Status. Because detailed medical records data were not available from a set of control hospitals, a primary care survey was conducted on a sample of bypass discharges from demonstration and competitor hospitals at a point in time. The survey included questions on the reasons patients and referring physicians selected a particular hospital for surgery, how satisfied they were with the attention and care they received, and their health status before and after the operation. The responses were then analyzed using tabular and multivariate methods holding selected patient risk factors constant.

Demo Versus Competitor Outcomes. To further supplement the analysis, Medicare claims data were used to construct patient risk factor profiles in all demonstration and competitor hospitals. Spanning the 1991-96 period of the demonstration, these indicators were then used in multivariate analysis to explain differences in levels and trends in inpatient bypass mortality between demonstration and competitor hospitals. Using the detailed clinical data as a "gold standard," the claims-based risk factors were first validated by comparing inpatient mortality coefficients generated from the two data sources in demonstration facilities.

Appropriateness of Care. To test for any changes in the appropriateness of bypass surgery, a special panel of clinical experts was convened to rate the appropriateness of bypass

surgery along several dimensions, including clinical presentation, surgical risk, number and type of arterial vessels occluded, extent of drug therapy, and ejection fraction. These ratings were merged onto the clinical data base according to each patient's mix of appropriateness criteria. Descriptive and multivariate analyses were then performed testing the change in appropriateness ratings depending upon the period in which the patient was discharged.

Appropriateness depends in part on the degree of vessel stenosis, or blockage. A concern over systematic differences in physician interpretations of the degree of stenosis resulted in a methodological study in which six of seven demonstration hospitals voluntarily submitted 20 films and angiographic reports for reinterpretation by an expert investigator. Again, descriptive and multivariate analyses were performed on over 300 lesions reported for the 120 patients using either the visual or computer-generated differences between the hospital and the expert as the dependent variable.

Referral Patterns. How successful hospitals were at marketing the program was determined by collecting detailed information from each site on their Medicare and non-Medicare bypass volumes. Data was also gathered on the location of patients and referring physicians. Descriptive analyses of trends over time in volumes and shifts in referrals were then conducted.

In-depth Case Studies. In addition to the quantitative analyses using primary and secondary data, a team of three evaluators visited all seven sites once and the four original sites a second time for in-depth interviews with managers and clinical staffs. These interviews were designed to fill in the gaps and help explain the results of the quantitative

analyses. Interviews were conducted with hospital CEOs, COOs, CFOs, demonstration managers, department managers, marketing and managed care directors, billing/collection personnel, micro-cost data managers, operating room and floor nurses, and utilization review and quality of care directors. Interviews were also conducted with thoracic surgeons, cardiologists, anesthesiologists, catheter lab clinicians, and other consulting physicians. Questions regarding operational changes were asked of each respondent and whether they were the result of participating in the demonstration. Respondents were also asked why they decided to participate, how successful the demonstration had been, and what problems were encountered.

To supplement the interviews in the demonstration hospitals, interviews were conducted in two competitor hospitals with managers and physicians. (Attempts to interview in the two other original sites were unsuccessful.) These interviews focused on marketing and competitive issues.

1.5 Summary of Findings

1.5.1 National Trends in Medicare Bypass Surgery

The number of Medicare heart bypass cases in the United States grew by 40 percent between 1990 and 1996, with over 180,000 procedures performed in the latter year. Over the seven-year period, 1990-96, total Medicare program costs on bypass surgery alone increased by roughly $2.8 billion to **$7.3 billion by 1996**. This estimate includes not only an extra $1.9 billion in hospital payments, but a **175% increase in 90-day post-discharge**

outlays as well. **Home health costs grew four fold and skilled nursing costs increased eleven fold over the period.**

National Medicare inpatient mortality rates fell from 1990 through 1996 by one percentage point to 5.4% in 1996. Rates were 1.5 points higher in small (under-200 bed) hospitals. Significant differences in inpatient mortality rates exist across hospitals more generally. Ten percent of the roughly 900 bypass hospitals have mortality rates less than 2% versus another 10% with rates above 9.0%. Hence, the issues of quality and regionalization of bypass surgery in larger hospitals provide a strong motivation for the demonstration.

Substantial reductions in inpatient stays also took place while mortality rates were falling. As recently as 1990, the average bypass stay was 15 days. Six years later, it had **fallen to 9.9 days**. Yet, as with mortality rates, significant variation in lengths of stay of nearly a week remained between the top and bottom 10% of hospitals.

Despite shorter stays, **Medicare outlays per case for bypass surgery**, including a 90-day post-discharge follow-up period, **rose 15% over six years to $40,124**. Inpatient costs, including associated physician services, rose $2,148 to $31,582; post-discharge costs rose by $2,780. When hospital location, size, and patient age and gender are controlled for, surgery in **major teaching hospitals cost the government almost $9,000 more** than in nonteaching hospitals, including both institutional and physician bills.

1.5.2 Feasibility of Bundled Payment

The federal government received 209 letters of interest to its initial request for bids to bundle both Medicare Part A hospital and Part B physician services. Forty-two qualified bidders were recommended by the pre applicant review panel to apply; 27 responded with full bids. Of these, four hospitals were chosen initially, later expanded to seven. Thus, it is clear that **many hospitals can work jointly with their medical staffs to develop a single bid.**

Without question, substantial data are required on the applicant's part to establish a bid for all services. The Health Care Financing Administration also requires all hospital and physician bills associated with previous discharges from applicants in order to evaluate the discounts being offered and how they relate to average payments elsewhere in the local market. Fortunately, **HCFA's new 100% claims files support such detailed evaluation.**

Finally, through a series of follow-up questions, hospitals and physicians were able to answer many detailed questions relating to quality assurance, components of the bid price, what services and specialties were covered, the definition of related readmissions covered under the global rate, and similar technical questions. All successful applicants were also **willing to forego any outlier payments and balance billing**; thereby bearing all the risk for costly cases.

1.5.3 Implementation Issues

Major changes in reimbursement methods were required under the demonstration. First, **hospitals and physicians were prohibited from billing their Fiscal Intermediaries and Carriers**. Instead, they had to assemble a package of bills and submit them to HCFA Central Office for payment. For payment, the package had to include the hospital discharge abstract plus all physician bills or at least the three principal physician bills (surgeon, anesthesiologist, and cardiologist) with other associated bills to follow. Hospitals, in order to avoid double billing carriers, had to **identify prospective demonstration patients as soon as possible**. It is often several days before an inpatient is operated on. During this time, many physician consultants may have seen the patient and already billed for services rendered. Hospitals developed elaborate identification protocols to avoid most of these situations, but in some cases they still had to reimburse carriers for overpayments.

Determining the patient's obligation was a challenge. The government decided that every patient discharged in the same DRG from the same demonstration hospital should be liable for a **fixed coinsurance amount**, after paying any outstanding deductibles. Ordinarily, patient responsibilities vary depending upon the number and kinds of physician and supplier services they use while an inpatient. Developing a fixed actuarial amount was a challenge in determining a typical bundle of physician services. Even more difficult was the hospital's task of collecting the fixed obligation from third-party supplemental insurers (see section 1.5.12).

1.5.4 Volume Growth

During the course of the demonstration, **Ohio State University Hospital and St. Joseph Mercy Hospital in Ann Arbor experienced statistically significant increases in Medicare bypass market shares.** University Hospital in Boston had a significant decrease in its share while St. Joseph's Hospital in Atlanta increased market share mid-demonstration before losing these gains by 1995. Among the three new participants who entered the demonstration during 1993, **all three sites experienced a significant decline in market share during the course of the demonstration.**

All seven hospitals exhibited DRG proportions that differed from their local competitors. Hospitals in Atlanta, Boston, Portland, and Houston had disproportionately more DRG 107 referral patients than their competitors, implying that they serve more as referral institutions. (DRG 107 patients have had their angiography completed on a separate admission, usually at another hospital.) Hospitals in Columbus and Ann Arbor had remarkably high proportions of cases in DRG 106 compared to their competitors.

When all competitor hospitals were pooled across sites, **St. Joseph's Hospital in Atlanta had stays that averaged 2.8 fewer inpatient days; St. Vincent's Hospital in Portland averaged 2.4 fewer inpatient days.** This was true controlling for DRG mix and patient age and gender. Compared to their own set of competitor hospitals, both St. Joseph's Mercy in Ann Arbor and Methodist in Indianapolis had lengths of stay 1.5-2 days shorter on average. **All seven hospitals exhibited strong declines in lengths of stay ranging from**

one-half to one full day per year. Only Methodist Hospital, however, had declines in stays that exceeded the downward trend taking place among local competitors.

1.5.5 Program, Beneficiary, and Hospital Cost Savings

From the start of the demonstration in May-June, 1991, through its conclusion in June, 1996, the **Medicare program saved $42.3 million on bypass patients** treated in the demonstration hospitals. **The average discount amounted to roughly 10%** on the $438 million in expected spending on bypass patients, including a 90-day post-discharge period. Eighty-six percent of the savings came from HCFA-negotiated discounts on the Part A and B inpatient expected payments. Another 5% came from lower-than-expected spending on post-discharge care, while 9% came from shifts in market shares in favor of lower-cost demonstration facilities.

In addition, **beneficiaries (and their insurers) saved another $7.9 million** in Part B coinsurance payments. Thus, **total Medicare savings are estimated to have been $50.3 million in five years.**

St. Joseph's Hospital in Atlanta generated $15.0 million in program savings; the most of any hospital. Of this total, $8.0 million came from negotiated discounts and another $4.1 million from post-discharge savings. Savings from its gain in market share accounted for an additional $2.9 million. University Hospital and St. Joseph's Hospital in Ann Arbor generated $7.0 million and $10.0 in savings, respectively. Ohio State University Hospital generated $5.4 million in savings, the least of the original four hospitals, in spite of the fact

that it had by far the largest negotiated inpatient discount per case (roughly $10,000 including teaching costs and other pass-throughs in the early years of the demonstration). It also saw the fewest demonstration patients. Among the expansion sites, program savings over the course of the demonstration ranged from $1.7 million at Methodist Hospital in Indianapolis to $2.1 million at St. Vincent's Hospital in Portland.

The demonstration clearly saved the program money, but what about hospitals that offered discounts to participate? Did the alignment of physician and hospital incentives result in less costly care as well as lower program costs? **Three of four original hospitals were able to make major changes in physician practice patterns and hospital operations that generated significant cost savings.** St. Joseph Mercy Hospital and St. Joseph's Hospitals, along with University Hospital in Boston, experienced absolute decreases in per case costs ranging from 2% to over 23% between 1990 and 1993, depending on DRG and hospital. The Atlanta hospital had the highest average reduction: 9-13% per case in the two DRGs. Assuming 5% annual inflation in hospital input wages and other prices, one could expect a three-year increase of over 15%, not counting the secular trend towards more intensive care of older patients with more coronary vessel disease. Thus, the reductions in real resource costs in three hospitals may have ranged between 18% and 40%. Ohio State University Hospital, by contrast, experienced average cost increases in both DRGs of 10 to 24%. After adjusting for expected inflation, however, these rates are not exceptionally high.

The three hospitals with declines in average costs experienced statistically significant declines of 10-40% in direct ICU and routine nursing expenses. The two

nonacademic medical centers also had **significant declines of roughly 30% in pharmacy costs per case**. Laboratory costs fell between 20 and 60%. Operating room costs, by contrast, rose 10-20% across all institutions, but, again, this is not controlling for wage and other price increases.

Declining costs per case in Atlanta resulted in increases in average profit margins of $3-4,000 from 1990 to 1993. St. Joseph Mercy achieved an $8,500 increase in DRG 106, although margins fell by $1,300 in DRG 107 even though costs fell slightly. Ohio State University Hospital experienced major declines (=$7-10,000) in average per case margins due to a combination of sizable initial discounts to HCFA, no updates for three years, and 10-24% increases in per case costs.

Average margins reflect long-run profitability per case. What is more important to financial managers is short-run profitability based on variable margins. A demonstration patient will be profitable if payment more than covers the additional costs incurred plus contributing something towards fixed costs. On this basis, **all four original demonstration hospitals enjoyed significant positive variable margins**. St. Joseph's Hospital in Atlanta increased its variable margins by 80-111% while St. Joseph Mercy in Ann Arbor increased its DRG 106 variable margin by 62%. By contrast, the **two academic medical centers saw their variable margins decline** (although remaining positive) by 12-19% in University Hospital and 45-68% in Ohio State University Hospital.

1.5.6 Patient Outcomes

Participants Only. By the end of 1996, over 10,000 discharges were available for testing demonstration effects on clinical outcomes. **Holding many patient risk factors constant, a statistically significant, negative, trend in inpatient mortality rate was found among demonstration hospitals**. Although somewhat sensitive to included risk factors, the best estimate is an average annual decline in mortality of approximately 8 percent, or slightly less than half a percentage point around an overall mean of 5 percent. **The seven demonstration hospitals together also had a much lower overall inpatient mortality rate (4.6% averaged over 1991-96) compared with Medicare national rates (6.5% in 1990; 5.4% in 1996).**

Statistical differences were found in inpatient mortality rates among some of the seven demonstration hospitals, even after controlling for patient severity and other risk factors. Key risk factors controlled for included whether the patient had had a previous bypass, in which case the risk of dying was approximately 3 times higher, whether the insertion of a balloon pump was required (also tripling the risk of dying), or was admitted on an emergency basis (3.2 times more likely to die), or over 80 years old (twice as likely to die), or being admitted with renal disease (2.1 times more likely to die). **Risk-adjusted inpatient mortality exhibited a 4-fold difference across demonstration sites**. However, **the two sites with above-average mortality rates experienced statistically significant declines over the demonstration period.**

Over the course of the demonstration, there was **some evidence of a growing severity in case mix**, including a higher percentage of patients over 80 years of age and more with comorbid conditions undergoing their second bypass.

One-year cumulative mortality after bypass surgery in demonstration hospitals averaged approximately 50 percent higher than inpatient mortality. However, based on demonstration patients discharged through December 31, 1995, **one-year, post discharge mortality rates in participating hospitals declined 8 percent on an annual basis**, almost identical to the inpatient mortality decline.

Multivariate analysis also showed a significant impact of post-operative complications on inpatient mortality rates. Renal failure, for example, increased the risk of dying by approximately 5-fold and strokes by 2.3-fold while return to the operating room for bleeding increased the likelihood by 1.8-fold. These complications, naturally, were only controlled for after interpreting the trend and hospital differences separately. **A small positive trend in the rate of reported complications was found over the demonstration period (at the 10% confidence level)**. This was true controlling for patient pre-operative risk factors. The estimated rate, however, was quite small, i.e., 2.4 percent annually. Any increase in reported complications apparently was offset by better clinical care during the stay, as mortality rates fell even allowing for increasing complications. It is also quite likely that most patient complications are outside the hospital's and surgeon's control and may have been increasing in frequency due to unmeasured changes in patient severity. Assuming

complications are out of the clinician's control and treating them like additional risk factors results in a 10 percent annualized decline in inpatient mortality.

Participants Versus Competitors. Inpatient mortality models based on claims data were found to predict the likelihood of death almost as well in demonstration hospitals as those using medical records abstracts (68% versus 72%, respectively). **The significant downward mortality trend in demonstration hospitals was unaffected by the data source used to quantify patient risk factors.**

Both demonstration and competitor hospitals were found to have a statistically significant declining mortality trend controlling for claims-based risk factors. Of the seven demonstration market areas, four exhibited statistically significant declining mortality rates; none had rising rates. One demonstration hospital's mortality rate fell significantly faster than its competitors', which was also declining. **No demonstration hospital's mortality rate rose relative to its competitors over the demonstration period.**

1.5.7 Appropriateness of Care

Under the assumption that no demonstration patients were candidates for angioplasty, 97.7% of the bypass operations among all seven hospitals fell into the appropriate range according to the criteria of an expert panel of surgeons and cardiologists. **If every patient were assumed a candidate for angioplasty, then only 72.7% of operations would have been deemed appropriate**; the rest being equivocal or

inappropriate. Alternatively, 0.1 percent of patients could be considered inappropriately operated on if not a candidate for angioplasty versus 3.7% if all were candidates.

No significant time trend was found in the overall average appropriateness rating of patients discharged from the four original hospitals, regardless of whether they were candidates for angioplasty or not. A slight downward trend in appropriateness was found among patients with unstable angina, left main, and 3-vessel disease. Any trends, however, remained well within a clinical margin of error in quantifying appropriateness.

Statistically significant differences were found in the average appropriateness level among the four hospitals but were of little clinical relevance due to their small absolute size. With nearly 3,000 observations, almost any difference was likely to be significant.

Coronary angiography results are one of the major determinants of the choice of treatment for coronary artery disease as well as the overall necessity of intervention. A separate, blinded, evaluation of 119 angiogram films from six of seven hospitals in 1993 found that **hospitals' estimates of the extent of stenosis, or occlusion, was significantly greater than those based on quantitative angiography**. Hospitals' visual estimates were also 6-15 points greater (on a scale of 1 to 100) than the expert visual estimates. Multivariate analyses showed one hospital consistently understated the degree of stenosis by 10-15 points relative to other participants. Two other hospitals were 5-8 points lower than the three hospitals with the highest overestimates.

Hospitals' overestimates varied inversely with the degree of stenosis, with more accurate readings at higher levels of occlusion. Angiographic quality was poor in 5-35% of

cases depending upon hospital. Moreover, many catheter reports were incomplete with respect to clinical indications for catheterization, type of contrast agent, number of catheters used, etc.

1.5.8 Hospital Choice, Satisfaction, and Health Improvements

Only a small minority (6-7 percent) of the patients treated in the demonstration and competitor hospitals considered the possibility of being treated in another hospital apart from the one they selected. Thus, overall, bypass patients did not engage in any comparative analysis of hospitals prior to making their selection. The patients learned about the reputation of the hospital they chose from several sources. About half of the patients heard about the reputation of the hospital from their physician, and another third from family members or friends. Very few patients heard about the hospital from the media. The most important factors affecting patient choice of hospital were overall reputation of the hospital and reputation of the heart surgery program, and advice of their referring physician. However, **cost of surgery was a more important consideration for demonstration patients compared to non-demonstration patients**, while location of the hospital was a more important factor in the choice for the non-demonstration patients. **Among demonstration patients, 36 percent knew about the demonstration status of the hospital** while only 19 percent of the non-demonstration patients had this same knowledge (significant at the 1 percent level). However, **only 32 percent of the demonstration patients who knew about the demonstration responded that knowledge of the**

demonstration status of the hospital affected their decision to use the demonstration site.

Two-thirds of referring physicians indicated they were aware of the demonstration status of the hospitals; however, this knowledge had little or no effect on physician referral patterns. The major factors affecting referring physicians' choice of hospital were their relationship with the hospital staff, the demonstrated superiority of surgical outcomes, and overall hospital reputation.

Satisfaction with care received at the hospital chosen by patients was high among both those treated at demonstration and at competitor hospitals, but there is some evidence that the demonstration patients were more pleased with their experience. **A significantly greater proportion of demonstration patients reported they were very satisfied with the overall skill of the nurses and that their length of stay was appropriate.** This result is especially meaningful, given that demonstration hospital patients on average had shorter stays than their non-demonstration counterparts. **Demonstration patients also received fewer bills for their surgery and found the billing process to be easier than expected.**

Overall, there were no systematic differences in self-reported health outcomes between demonstration and non-demonstration patients. More than 50 percent of the demonstration and the non-demonstration patients reported their health to be excellent or very good after bypass surgery. About 75 percent of both demonstration and non-demonstration patients reported that the surgery helped them "a lot." In a few instances the patients who were admitted to the demonstration hospitals did appear to be in better health

after surgery than those treated at competitor hospitals. For instance, demonstration patients had fewer readmissions for heart-related problems and a higher proportion of them reported improvement in ability to walk and garden. Thus, we can conclude that the bundling of the payments did not have a negative impact on the health improvements of the demonstration patients.

1.5.9 Patient and Hospital Management

Three of four original demonstration hospitals made major improvements in their micro-cost data systems. A fourth hospital initially remained on the traditional departmental cost-to-charge system of patient cost finding. This caused serious problems working with surgeons in trying to change practice patterns. The three additional sites all had micro-cost systems and were in the process of linking costs to clinical information. **Only where hospitals could link specific services to patients and attach meaningful direct costs to them were they able to convince physicians of the need for more cost effective decision making**. Hospitals with detailed cost systems were able to conduct special studies in the operating room, the pharmacy, the ICU, and the catheter lab, that showed surgeons the frequency of brand and generic drugs, costly angiographic agents, etc.

Interestingly, few of the financial managers closely monitored the cost and profitability of demonstration patients. Rather, they hired an outside consultant to work with surgeons to change practice patterns. Comparative data from other hospitals provided by the

consultant seemed crucial in supporting cost-effective drug substitutions and reductions in resource use.

A primary focus was the four components of length of stay: admission to catheterization; catheterization to surgery; ICU length of stay; and post-ICU length of stay. As a result, **most hospitals reduced ICU stays by one full day and routine stays by another two to three days.**

Hospital managers also noted that the best costing system was of limited use without the surgeon's active involvement. **Aligning surgeon with hospital incentives to reduce costs was absolutely critical in changing practice patterns and improving department efficiency.** In the one hospital without a micro-cost system, the surgeons resisted practice changes and little was accomplished during the first two years of the demonstration. (Other barriers to change are summarized below.)

Most nonacademic institutions made major staffing reductions over the course of the demonstration in response to declining inpatient utilization. Shorter ICU stays meant more turnover and fewer nursing days per patient. Early extubation and quicker ambulation were key factors.

Hospitals also introduced a **major innovation by designating Clinical Nurse Specialists to be in charge of each bypass patient's stay.** Their main job was to assure a smooth transition from service to service, to avoid costly complications, and to improve communications among specialists making clinical decisions. They also reviewed standing orders and recommended changes. It is interesting that specialists in other areas such as

orthopedics resisted hospital attempts to introduce nurse specialists. Managers felt that they had no financial incentives to change their practice patterns.

Another novel change was the implementation of **same-day surgery for DRG 107** patients who had their diagnostic catheterization performed elsewhere. Again, physician incentives to avoid an extra day's stay helped, although many now seem challenged to get patients in and out of the hospital as quickly as possible regardless of payment methods. Nurses argued that changing both physician and patient mindsets about how long they would be staying was key; that several days were unnecessary in the recuperation process and were better spent at home.

Pharmacists cited **several drug substitutions** that explained the savings reported earlier. One hospital reported saving $50,000 annually in cardioplegic solutions during surgery. Two other hospitals were saving $100,000 per year by substituting generic for brand narcotics. Twenty to forty thousand dollars was saved in vasopressors, anti-coagulants, and diuretics at a couple of participating hospitals. Pharmacists emphasized the importance of having the surgeon support, inviting them to meetings, discussing possible substitutions, and asking for special studies.

Operating room managers observed a significant increase in the complexity of bypass surgery which they ascribed to angioplasty and fewer single and double-vessel bypasses. Nevertheless, they saw improvements in operating room times. Bypass operations that used to take 8.5 hours in 1992 were taking 5 hours in 1994, for example. Due to improvements in angioplasty and the rapid growth in the frequency of stents, none of the hospitals kept an

operating room and surgical team standing by for failures. Now, the operating room is on a next-available basis.

Efficiencies have been realized in the catheter lab as well, beginning with the substitution of ionic for nonionic contrast agents. One hospital saved $500,000 annually by using the cheaper agent half the time, without adverse reactions. With the cardiologists' support, managers have been able to narrow the number of device vendors from seven to two, thereby increasing their negotiating power and getting greater discounts.

1.5.10 Marketing Programs and Local Competition

Competition increased markedly in all but the Portland market area, according to both demonstration managers and local competitors. (Portland, Oregon, already was dominated by managed care, even for Medicare patients.) First, hospitals could no longer rely on cost-based reimbursement. Second, managed care plans were now very active in all areas. Third, the diffusion of new catheter labs was having profound effects on referral patterns. And fourth, a few local competitors were being very aggressive in their marketing and networking with local physicians.

All hospitals engaged in direct patient advertising to varying degrees, but **emphasized quality, not lower price**. This was particularly true of the nonacademic medical centers in Atlanta and Ann Arbor that concentrated on building a national reputation (and succeeded). The imprimatur of being a Medicare Participating Heart Bypass Center was marketed heavily as a quality indicator to reassure patients when referred by physicians or

managed care plans to their facility. By contrast, the academic medical centers in Boston and Columbus, Ohio, found themselves switching marketing strategies away from the "pursuit of science "to a" caring environment". After seeing their bypass market shares fall over the early years of the demonstration, both centers launched more aggressive advertising campaigns.

The nonacademic medical centers were very active building referral networks. Most bought primary care practices in surrounding suburbs. Deans in the academic hospitals, by contrast, were slow to react to the changing heart bypass surgery market and, for awhile, continued to espouse a "they will come" philosophy. Finally, when volumes dropped precipitously, surgeons and marketing staff convinced them to emphasize clinical care much more. Still, building referral networks for academic hospitals is difficult because of the tensions surrounding admitting privileges and lack of outside physician access to patients once admitted. Recognizing the need to build referring physician relationships, University Hospital opened its cath lab to outside cardiologists.

All hospitals felt they were in a better position to negotiate managed care contracts because of the demonstration. "We have expensed the experience," as one manager put it, implying that the hospital was forced to make the front-end investment in data systems, physician relationships, billing and collection systems, and critical care nurses that was now being put to use in the private market. The nonacademic medical centers had negotiated several global heart contracts with Delta, Prudential, and Aetna in Atlanta, and with First American Bank, and Consumers' Power, Inc., in Ann Arbor. St. Luke's Episcopal

Hospital in Houston had already established global payment contracts with Tennaco and several international clients. Weak data systems, high teaching costs, HMOs seeking full service contracts, and even resistant surgeons, initially held back the academic medical centers in negotiating bundled rates for heart care. Over the last three years, however, both Boston and Columbus made great strides in managed care contracting.

Interviews with managers and surgeons in academic medical centers (AMCs), both in and outside of the demonstration, highlighted major obstacles in a global budget environment. First, and foremost, they have a teaching and research mission and a cumbersome educational bureaucracy to overcome in responding to a fast-moving market. Closed staffs, limited operating room time, inefficient residents, very costly overhead services, and an impersonal community image all constrain how far they can go towards expanding the clinical side of their operations. Years ago, these hospitals were totally dominant in their markets for complex bypass surgery. Today, hundreds of nonacademic hospitals are performing bypass surgery and angioplasty. Indeed, in the majority of demonstration sites, the AMC was not the largest open heart facility. Academic reputation alone is not enough to assure a viable number of bypass patients. Their far-flung referral networks were shrinking as new providers opened up around the state, forcing them to concentrate their marketing efforts locally. Finally, some academic surgeons are not anxious to compete for patients by changing practice patterns and lowering costs, which they see interfering with their teaching obligations. This raises the question of who will pay for teaching under a comprehensive managed care system of global budgeting. Nevertheless,

by the end of the five demonstration years, both AMCs had made great strides in becoming more competitive.

1.5.11 Physician Payments

The negotiated global price between the government and the participants was based on separate estimates of Part A hospital and Part B physician outlays. Bidders then discounted each component either across the board or differentially by category. All hospitals began allocating the single payment according to amounts agreed-upon in their bid. The four major specialties always involved in a bypass admission, namely, **the surgeon, the anesthesiologist, the cardiologist, and the radiologist, all received fixed capitated amounts** regardless of the services provided different patients. Consulting physicians were usually paid their regular allowable Medicare fees out of a set-aside pool in the Part B component. A percentage holdback on payments to the four capitated physicians was used to pay these fees. Any savings on the pool at year's end were returned to them.

The fact that consulting physicians could not bill Medicare directly proved contentious in several sites, especially outside the AMCs. Surgeons also cut back on their use of consultants, which aggravated them even more. In one site, pulmonologists, neurologists, and other consultants alleged that the quality of care was being compromised. When hospital management asked that they provide evidence of poorer quality, they were unable to do so.

As the demonstration progressed, two important changes took place in physician payments. First, the Congress introduced the Medicare Fee Schedule which had the effect of reducing HCFA payments on the Part B component of the bundled payment. No hospital adjusted their physician payments for the reduction; hence, **physicians under the demonstration were effectively sheltered from RBRVS rollbacks** on bypass surgery, catheterization and other overpriced procedures. Hospitals also made some minor adjustments in radiologists' payments (downwards) and cardiologists' payments (upwards) for technical reasons or errors in original estimates.

The second change in physician payments came from **sharing in hospital cost savings in the nonacademic medical centers**. In Ann Arbor, St. Joseph Mercy "shared" the savings it realized from changes in surgeon practice patterns by extending them more operating room time and by converting their physician assistants in surgery and nurse specialists into hospital employees. In Atlanta, St. Joseph's Hospital instituted a Cost Reduction Allocation Program that provided bonuses to individual surgeons based on documented savings to the institution. To be eligible, the surgeon had to meet stringent quality and volume criteria. The bonus formula assured every surgeon of receiving at least the originally negotiated payment, thus insulating them from RBRVS rollbacks, plus one-quarter of any hospital cost savings they personally generated.

A final benefit to physicians was the willingness of each hospital to take responsibility for collecting any deductible and coinsurance amounts on both Part A and B. In general, physicians were paid promptly by the hospital upon discharge or within two

weeks, except for late billers. Delays of several months in collecting the coinsurance from supplemental insurers resulted in significant cash flow problems for hospitals instead of physicians.

1.5.12 Reimbursement Difficulties

The demonstration involved major changes in reimbursement arrangements. First, providers had to bundle all physician inpatient bills with the hospital bill and submit them to HCFA Central Office for payment. No physician could bill carriers for inpatient services provided demonstration patients. Second, HCFA developed a fixed copay for each patient by hospital and DRG.

According to providers and patients, **patients were quite pleased with a single copay amount**. This simplified the payment process. They also liked the idea of a bundled copay amount for both hospital and physician services.

Hospitals, in general, were also **pleased with the prompt payment received by HCFA** Central Office, which was done by wire within thirty days. The one difficulty with came with **delays in updating rates for the Medicare Fee Schedule in the first quarter of 1994**. Instead of continuing to pay under the old rates, HCFA stopped paying any discharges from January through mid-April until it established the new rates. This **created a cash flow problem of several million dollars until it was resolved.**

Supplemental insurers responsible for paying patient deductible and coinsurance amounts **were uniformly displeased** with the flat actuarial payment calculated by HCFA.

It was incompatible with their computer systems that require itemized charges, services, and payments by CPT code. Also, patients differed in their policies in terms of coverages, deductibles, and coinsurance amounts. A flat rate assumed all patients had identical supplemental policies. Many insurers also wanted to pay less when their patients used fewer physician services. In fact, the Medicaid programs in Michigan and Ohio refused to pay any amounts based on the flat rates for joint Medicare-Medicaid eligibles, arguing that their fee schedule was less than the flat rate. One insurer captured the feelings of many others by noting that "we didn't agree to participate in the demonstration". While the government has made extraordinary efforts to explain the change to insurers, it still regards the supplemental payment issue to be a provider problem. In fairness, HCFA explicitly adjusted the Part B copay amounts of the global payment so as to underestimate the average patient obligation.

Certainly, **the single largest administrative burden for hospitals under the demonstration involved billing and collection**. Most sites significantly underestimated both the effort to assemble a complete package of bills and invoice the government as well as trying to collect the supplemental insurance. (Bundling appeared to be a minor problem at St. Luke's because of the familiarity of the physicians with global pricing arrangements.) HCFA, the sites acknowledged, made many concessions and contacted many insurers, but the reimbursement changes inevitably required a whole new layer of billing/collection staff and procedures. As costly as it was, one financial manager considered it "expensed experience" that had to be made in order to win private sector contracts of a similar nature.

1.5.13 Achievement of Goals

Overall satisfaction with the demonstration was mixed. Some goals were achieved, some were not. Some hospitals were more successful than others. All sites were hoping to increase their bypass volumes and market shares. That rarely happened. **Several hospitals felt that the government had abandoned them by not actively promoting the demonstration or allowing them to waive patient copays for the uninsured**. Not having a "Centers of Excellence" imprimatur to market further limited their marketing.

On the positive side, **nearly all of the hospitals did sign major new private managed care contracts bundling payment of heart surgery**. Most had made the necessary investments in data systems, joint physician contracting arrangements, changes in practice patterns, and new billing systems. The acceptability of bundled pricing to employers and insurers clearly differed across the areas, however. Areas already dominated by full capitation were less responsive to DRG-specific global rates.

Certainly, **the most salient accomplishment of the demonstration was the reduction in hospital costs in three of four hospitals where micro-cost data were analyzed**. As one demonstration manager put it, "we set a target of reducing our bypass costs by $1,000, and we did it." While cost reduction was a goal in most hospitals, there was some skepticism that physicians would change their practice patterns. In three of the four original hospitals, staff were surprised at how quickly physicians were able to reduce lengths of stay, substitute generic for brand drugs, and reduce unnecessary testing and other services. In this regard, surgeon support for the clinical nurse specialists implementing critical

pathways was crucial. In the one hospital where surgeons resisted attempts to change practice patterns, costs continued to rise. High costs were much less an issue in the three additional sites, although cost savings were achieved as well through more cost effective practice patterns.

Another goal of hospital staff was to achieve a closer working relationship with their physicians. All hospitals felt they had made progress towards this goal, but tensions remain in some places with surgeons and consulting physicians. **Aligning physician and hospital incentives, respondents agreed, was key to the change in attitudes.**

Although quality improvements were never an explicit goal--all hospitals felt they were providing high quality already--nurses and quality assurance directors in most institutions believed that quality had improved. The primary reason was the increased emphasis of surgeons and other physicians on avoiding complications through closer patient monitoring. The fact that complication rates rose slightly during the demonstration is inconsistent with their subjective impressions, however, and may be due to changes in coding or unmeasured increases in patient severity. The heightened activity of QA departments may also contribute to more thorough coding of complications during the demonstration.

The one uniform disappointment was the difficulties encountered in billing and collection. Nearly all sites felt they should have received extra payments to cover the novel billing arrangements. Now that internal procedures and computer systems are in place, however, these sunk costs are felt to be outweighed by the imprimatur of being a Medicare Participating Heart Bypass Center.

2 National Medicare Trends In Heart Bypass Surgery: 1990-96

2.1 Introduction: The Heart Bypass Demonstration in Perspective

This chapter presents trends in heart bypass surgery from 1990 to 1996 for the nation as a whole. National trends are presented to provide a background to the focused evaluation and to serve as a point of reference in measuring the performance of the participating demonstration hospitals and their competitors. The national statistics presented include the number of hospitals performing heart bypass surgery on Medicare beneficiaries during the seven years, the number of discharges, the distribution of volumes of cases per hospital, trends in patient characteristics (age, gender, and race), in-hospital mortality rates, lengths of stay, and Medicare program outlays on bypass surgery.

The chapter also presents similar trend information on angioplasty. Examining angioplasty is important since procedure volumes have grown rapidly during the decade, and for some patients angioplasty may be considered as a less invasive alternative to bypass surgery.

2.2 Data Sources and Methods

Data for this study come primarily from two sources: HCFA's MedPAR and National Claims History data files. Hospital characteristic information comes from the 1992

American Hospital Association (AHA) file as well as HCFA's 1996 Provider Specific File. The file construction process is summarized in Exhibit 2-1.

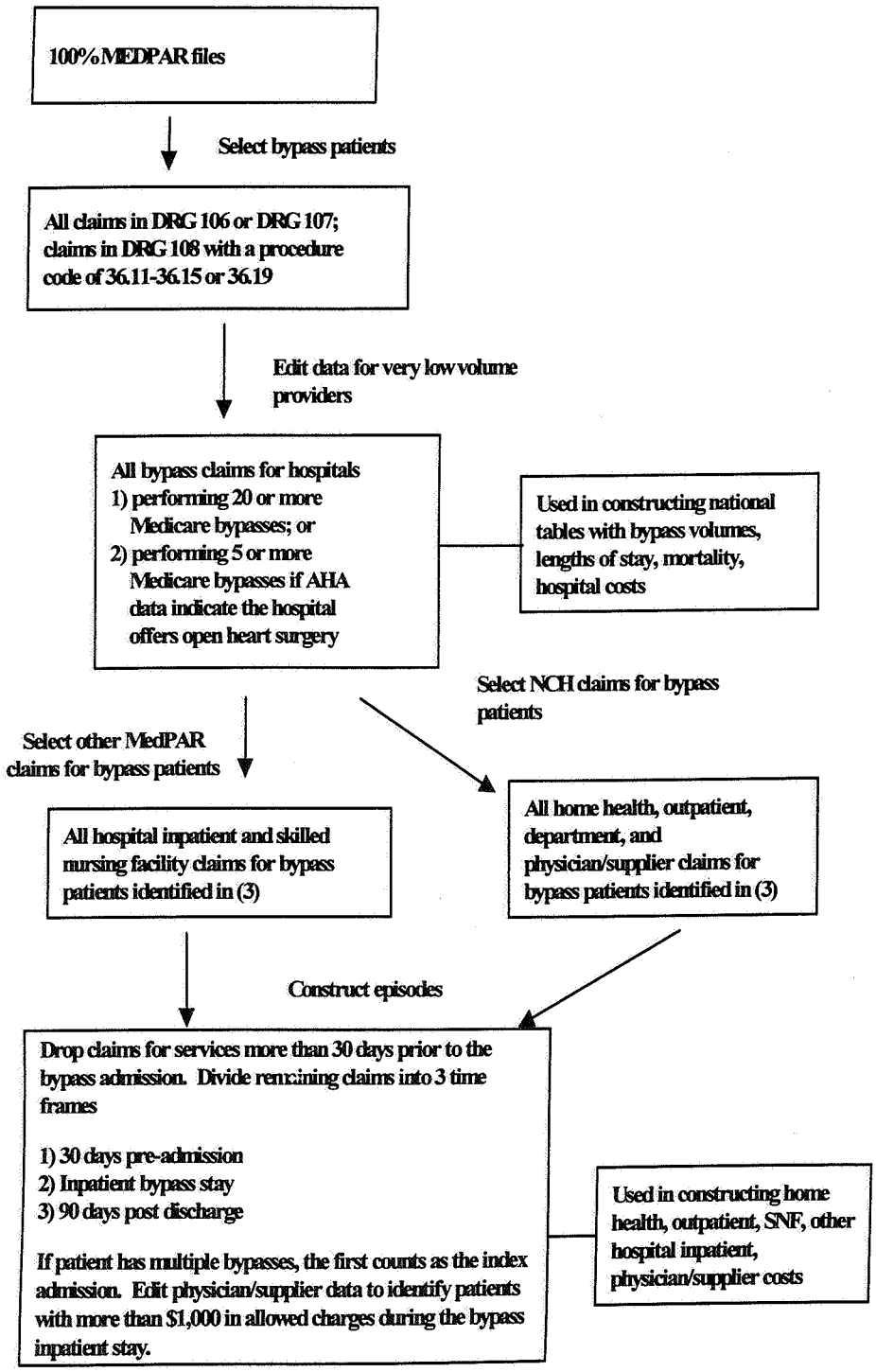
2.2.1 MedPAR Data

The data for inpatient hospital stays and skilled nursing facility (SNF) stays come from the Medicare MedPAR claims files for 1990-96. The MedPAR files contain a wealth of information on the inpatient stay including date of admission, date of discharge, length of stay, discharge status (alive/dead), DRG, diagnostic and procedure codes, and expenditures to the facility for the inpatient stay.

Selection Criteria. The first step in analytic file construction was to extract all Medicare CABG and angioplasty patients identified by the appropriate DRG and procedure codes for patients discharged from January 1990 through December 1996. Coronary Artery Bypass Graft (CABG) surgery is primarily found in two DRGs: DRG 106, Coronary bypass with cardiac catheterization; and DRG 107, Coronary bypass without cardiac catheterization. Patients who receive their angiographic examination on the same admission as their bypass surgery are classified into DRG 106, while those receiving angiography elsewhere prior to the bypass admission are classified into DRG 107.

During the study period a small number of CABG surgeries were also coded into DRG 108, which includes a variety of other cardiothoracic and vascular procedures. Although the same sets of procedure codes comprised DRG 106 and DRG 107 across all years of our study, DRG 108 underwent a major revision between 1990 and 1991. In 1990,

EXHIBIT 2-1 File Construction



DRG 108 was labeled "Other Cardiothoracic or Vascular Procedures With Pump" (St. Anthony Publications, 1990). This DRG was relabeled "Other Cardiothoracic Procedures" in the revised grouper effective October, 1990 (St. Anthony Publications, 1991), and the number of procedure codes in the DRG was reduced substantially. For all four years, CABG operations in DRG 108 were identified as observations having a CABG ICD-9 procedure code of 36.10, 36.11, 36.12, 36.13, 36.14, 36.15, or 36.19.

We should also note that bypasses occurring in conjunction with valve repair or replacement, such as those typically coded in DRGs 104 and 105 were excluded from the analysis, as were those found in any other DRG.

Angioplasty procedures coded in DRG 112 were also captured as part of the analytic file construction process. As was the case with DRG 108, DRG 112 underwent a major revision in the grouper effective October, 1990. To select only angioplasty cases coded into the DRG, in each of the seven years we kept only cases with an ICD-9 procedure code of 36.01, 36.02 or 36.05.

Data Editing. The data were checked and any duplicate or inconsistent cases were removed. In a few cases two claims appeared for the same beneficiary hospitalized in two different hospitals with the same admission and discharge dates. After examination of other fields on the record (primarily covered days and financial information), the erroneous case was identified and removed from the data. Next, hospital names and characteristics were merged onto the MedPAR records using data from the 1992 American Hospital Association file, or for later years, from HCFA's Provider Specific File. A small number of hospitals could not be identified on the AHA file or from other sources. For those hospitals we have

no information on location, teaching status, or bedsize. This problem is more acute in the later years. As a result, these hospitals are not included in tables presented by such stratifications.

Examination of the data indicated that a small number of hospitals appearing on the file were performing a very low number of cases. For example, the data included a psychiatric hospital performing six CABGs, and a 22-bed hospital performing only one. As a result, we removed from the file all observations for hospitals doing fewer than five Medicare CABGs per year, and those doing fewer than 20 if the AHA directory indicated that the hospital did not offer open heart surgery.

Other Inpatient Stays. Our goal was to construct a person level utilization history, beginning 30 days prior to the admission for bypass surgery, and extending for 90 days after surgery. After identifying all beneficiaries undergoing CABG surgery, we identified all other inpatient hospital and skilled nursing facility admissions for these individuals. Inpatient discharges occurring more than 30 days prior to or 90 days after the CABG admission were removed from the file.

2.2.2 National Claims History Data

The National Claims History (NCH) data contain a 100 percent sample of all Part B physician/supplier, outpatient department, home health, and hospice claims.

Selection Criteria. HCFA provided the evaluator with files containing all NCH claims for Medicare beneficiaries discharged from a hospital for CABG surgery during the

period January, 1990 through September, 1993 and January, 1994 through June, 1996. The data were acquired in three phases: 1990-92 data, 1993 data, and 1994-96 data. Our first round of data included all claims processed during 1990 through 1992 for bypass patients discharged during this three-year period. A second round of data included all claims for the last three months of 1992 and all of 1993 for patients discharged from the hospital for CABG surgery January through September 1993, as well as claims submitted in 1993 for patients having CABG during the last four months of 1992. The final round of data contained claims in 1994, 1995, and 1996 for patients undergoing surgery between January 1994 and June 30, 1996. Examination of the data indicated that claims appeared to be missing for patients discharged in May and June 1996; particularly claims for the post-surgery period. We assume the missing claims result from delays in processing the claims and adding them to the NCH files, from which our data were extracted. Given this data problem, we used only claims for patients undergoing surgery in January through April in constructing the 1996 estimates.

2.2.2.2 File Construction

For each type of data—physician/supplier, outpatient department, and home health—our goal was to create a person-level file containing summary information from all of the individual claims. (Data from the hospice file were not processed since bypass patients should not be candidates for hospice care.) Date of admission, date of discharge, and provider number for the inpatient CABG stay were first merged on to each NCH claim. All

claims for services provided more than thirty days before admission or 90 days after the CABG stay were discarded. The remaining claims were divided into three time frames:

(1) 30 days prior to admission;

(2) Inpatient CABG stay; and

(3) 90 days post-discharge;

Given the manner in which our data were extracted, data should be complete for all bypass recipients, except those undergoing surgery in January, 1990 or January 1994. For the January, 1990 and 1994 bypass recipients, the pre-admission data are truncated. The inpatient CABG stay and 90 days post-discharge periods should be complete for all patients.

2.2.3 Prevalence of "Incomplete Claims"

In the construction of our patient-level files, the MedPAR data were considered the "gold standard" for identifying bypass patients. The MedPAR files required a minimal amount of data editing to remove duplicate or miscoded claims and should be complete in that they represent a 100 percent sample of inpatient hospital stays, and each bypass patient must have an inpatient stay. All other data were then merged onto the MedPAR records to create episodes of care for each patient. Many bypass patients had no SNF, outpatient department, or home health claims, or claims for hospital inpatient stays other than the bypass admission. We assumed that these other files were complete, and people with no claims in fact did not receive these services. We also found that some of the bypass patients appearing in the MedPAR data had no physician/supplier claims. For example, in 1991, 10.6

percent of bypass patients on the MedPAR files had no physician/supplier claims. This degree of "incomplete" data can be attributed to patient membership in HMOs that do not submit Part B claims, to miscoded claims, and to claims that were erroneously not submitted. We also found that other patients had very few physician/supplier claims, and as a result, implausibly low allowed charges. In calculating average expenditures, we did not want to include these incomplete sets of claims in our analyses.

Thus, for all years, we restricted our physician/supplier analyses to patients with more than $1,000 in claims during the inpatient CABG stay. Again using 1991 as an example, this restriction eliminated another 2.4 percent of patients. Hence, our analysis of physician/supplier claims was based on 87 percent of the total bypass patients as reported in MedPAR.

2.2.4 Variable Construction

Data on national counts of Medicare bypass patients are based on the edited MedPAR files for 1990-96. We used full calendar year data for constructing national estimates for each of these years.

Mean values of three of our outcomes measures, in-hospital mortality, length of stay, and hospital inpatient payments, differ by DRG. Thus, unadjusted hospital averages will reflect differences in the proportion of patients by DRG across hospitals. To eliminate this source of variation in tables presenting stratifications by hospital characteristics, mean values

are adjusted for DRG mix. Mean values per hospital by DRG were calculated and weighted by the national proportion of cases in each DRG for each specific year.

The payments presented in this chapter are all Medicare allowed payments. Thus, they represent expenditures by the Medicare program and do not include deductibles or co-payments for which beneficiaries were responsible. Hospital inpatient payments include DRG base payments, outlier payments, disproportionate share payments, pass-throughs for capital related costs, bad debt, and direct medical education, and payments for indirect medical education. Medicare allowed payments for types of care (physician/supplier, home health, and outpatient department) were calculated as 80 percent of total payments.

2.3 Trends and Distribution in Number of Cases and Hospitals

2.3.1 National Totals

Table 2-1 presents the number of hospitals performing CABG surgery on Medicare beneficiaries and the number of CABGs performed, for each of the seven years in our study. In 1990, 833 hospitals, or roughly 15 percent of all short term acute care hospitals nationally, performed CABG surgery on Medicare beneficiaries. This number increased to 861 hospitals in 1991, to 880 hospitals in 1992, and to 905 hospitals in 1993, a nine percent increase across the four year period. This trend continued in 1994, 1995, and 1996, although the rate of growth slowed in later years.

The total number of Medicare CABGs grew 16 percent between 1990 and 1992, from 129,270 to 150,027 in 1992. The number of CABGs then decreased slightly in 1993, but

Table 2-1

Number of Hospitals Performing Medicare Bypasses, and Number of Medicare Bypasses Performed, 1990-96

	1990			1991			1992			1993			1994			1995			1996		
	Number of Hospitals	Number of Procedures	Percent of Procedures	Number of Hospitals	Number of Procedures	Percent of Procedures	Number of Hospitals	Number of Procedures	Percent of Procedures	Number of Hospitals	Number of Procedures	Percent of Procedures	Number of Hospitals	Number of Procedures	Percent of Procedures	Number of Hospitals	Number of Procedures	Percent of Procedures	Number of Hospitals	Number of Procedures	Percent of Procedures
NATIONAL	*833*	*129,270*		*861*	*139,448*		*880*	*150,027*		*905*	*149,409*		*922*	*159,525*		*935*	*170,777*		*943*	*181,573*	
DRG																					
106		62,892	49%		79,013	57%		85,443	57%		87,584	59%		94,775	59%		101,929	60%		107,773	59%
107		46,806	36		53,990	39		60,175	40		57,938	39		60,798	38		64,556	38		69,223	38
108		19,572	15		6,445	4		4,409	3		3,887	3		3,952	2		4,292	3		4,527	2
Location																					
Urban	769	121,049	96	792	130,928	96	813	140,848	96	834	141,285	96	850	150,882	96	879	161,331	96	861	170,667	96
Rural	35	4,405	4	38	4,777	4	41	5,317	4	43	5,603	4	44	5,940	4	53	6,857	4	52	7,897	4
Teaching Status																					
Major	223	47,335	38	223	49,558	37	225	52,734	36	218	50,844	35	218	53,653	34	222	56,061	33	220	58,674	33
Minor	223	37,601	30	231	40,542	30	236	43,512	30	254	46,290	32	263	49,622	32	270	54,015	32	264	57,263	32
None	358	40,518	32	376	45,605	33	393	49,919	34	405	49,754	33	413	53,547	34	440	58,112	35	429	62,627	35
Bedsize																					
1 - 199 beds	84	6,851	5	87	7,403	5	95	8,163	5	104	8,364	6	105	8,944	6	125	10,126	6	120	11,195	6
200 - 299 beds	177	19,452	16	191	21,473	16	198	23,870	16	208	24,449	17	219	26,444	17	224	29,049	17	224	31,461	18
300 - 399 beds	195	24,399	19	202	26,710	20	207	28,860	20	223	31,679	22	226	33,561	21	230	36,259	22	225	38,701	22
400 - 499 beds	132	21,074	17	134	23,457	17	136	25,182	17	128	22,950	16	130	24,486	16	135	26,028	15	128	27,437	15
500 - 599 beds	92	20,059	16	91	21,678	16	92	22,837	16	92	21,898	15	92	23,387	15	93	24,315	14	93	25,255	14
600 - 699 beds	48	12,308	10	48	13,036	10	48	13,922	10	47	13,881	9	47	15,110	10	48	16,068	10	48	17,120	10
700 or more beds	76	21,311	17	77	21,948	16	78	23,321	16	76	23,667	16	75	24,890	16	77	26,343	16	75	27,395	15

NOTES:
1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Categories may not sum to national total because hospitals could not be identified.
3. Calendar year data.
4. Calendar year 1995 data are missing two weeks in late March. 3.8% of sample.

SOURCES: 1990 through 1996 MedPAR files and American Hospital Association files.

continued its rise in 1994 and through 1996 when the number of Medicare bypasses reached 181,573. The total number of Medicare CABGs grew 40 percent between 1990 and 1996.

The number of CABGs coded into DRG 108—other cardiothoracic or vascular procedures—dropped substantially, reflecting the change in coding that occurred during 1991. Excluding 1990, the proportion of cases in DRG 106—CABG with cardiac catheterization—rose slightly from 57 percent of bypasses in 1991 to 59 percent in 1996. This indicates a slight increase in the proportion of patients undergoing angiography during the bypass stay, rather than prior to the bypass admission.

The vast majority of hospitals performing CABG surgery are found within urban (metropolitan statistical) areas. (Categories may not sum to the total number of hospitals because not all hospitals could be matched with AHA data.) While the number of rural (non-metropolitan) hospitals performing CABG surgery rose between 1990 and 1996, from 35 to 52 hospitals, they still constitute fewer than six percent of the hospitals doing CABGs. It appears as if diffusion is nearly complete among the major teaching hospitals, but continued among other hospitals during our time frame.

As expected, small hospitals are unlikely to offer CABG surgery. However, the number of bypass hospitals with fewer than 200 beds performing CABG surgery is on the rise, from only 84 hospitals in 1990 to 125 hospitals in 1995. Still, larger hospitals are more likely to offer CABG surgery, consistent with the service being offered in urban and teaching hospitals. Roughly 65 percent of hospitals with 500 or more beds provided CABG surgery to patients in 1993, a figure that stayed relatively constant in later years (AHA, 1993).

2.3.2 Volumes of Medicare CABGs Per Hospital

Table 2-2 presents the average number of Medicare CABGs (DRGs 106, 107, and 108) treated per hospital for 1990-96. The mean number rose from 155 in 1990 to 192 in 1996, an increase of 24 percent. Given that approximately one half of all CABGs are performed on those age 65 and over (NCHS, 1990), this would imply roughly that a total of 380 CABGs per year, or just over one each day, were performed in the average hospital doing bypass surgery in 1996.

The upward trend in average volumes holds for location, teaching status, and bedsize classification. No stratification shown in Table 2-2 experienced a decline in the average number of cases treated between 1990 and 1996. The average number of cases treated at urban facilities increased by roughly 25 percent, from an average of 157 Medicare bypasses in 1990 to 198 bypasses in 1996. Rural facilities experienced an increase of roughly 20 percent over the same period. The average number of bypasses performed increased similarly for each stratification of teaching status.

Although the temporal trends are generally similar, there are noticeable differences in the mean number of Medicare cases treated across stratifications. For example, in each year, the mean volume of cases treated in urban hospitals is roughly 30 percent larger than the mean volume in rural hospitals. Major teaching hospitals in 1996 have higher mean Medicare volumes (5.1 bypasses per week) than minor teaching hospitals (4.2 bypasses per week), and substantially higher mean Medicare volumes than non-teaching hospitals (2.8 bypasses per week). Among the bedsize categories, the mean number of Medicare cases

Table 2-2

Average Number of Medicare Bypasses Treated Per Hospital By Characteristic, 1990-96

	1990	1991	1992	1993	1994	1995	1996
NATIONAL	*155*	*162*	*170*	*165*	*173*	*183*	*192*
Location							
Urban	157	165	173	169	178	188	198
Rural	126	126	130	130	135	137	152
Teaching Status							
Major	212	222	234	233	246	254	267
Minor	169	176	184	182	149	204	217
None	113	121	127	122	130	138	146
Bedsize							
1-199 beds	82	83	86	81	85	87	90
200-299 beds	110	112	121	115	118	129	138
300-399 beds	125	132	139	141	147	159	168
400-499 beds	160	175	185	177	185	198	210
500-599 beds	218	238	248	240	177	263	277
600-699 beds	256	272	290	297	171	344	358
700 or more beds	280	285	299	310	327	336	361

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data.
3. Note missing data in 1995, see Table 2-1.

SOURCE: 1990 through 1996 MedPAR files, and American Hospital Association files.

treated increases substantially with bed size. The smallest hospitals treated 90 Medicare bypass patients on average in 1996 compared to 361 Medicare bypass patients for hospitals having 700 or more beds.

Table 2-3 presents percentile distributions for Medicare CABG volumes for each of the seven years. Ten percent of hospitals doing CABG surgery in 1996 (or roughly 90 hospitals) performed fewer than 40 Medicare CABGs annually, averaging less than one per week. Twenty-five percent (roughly 230 hospitals) performed fewer than 76 annually (about 1.4 per week), and half the hospitals treated fewer than 143 Medicare CABG patients annually. In contrast, the ten percent of hospitals with the highest Medicare volumes performed more than 406 CABGs on Medicare patients annually (7.6 per week), and the top five percent performed more than 535 annually. The average number of Medicare bypasses treated by hospitals in the 90th and 95th percentiles increased by 20 percent from 1990 to 1996.

Substantial recent literature (much of which is summarized in Luft *et al.*, 1990) indicates a significant inverse relationship between volumes and outcomes for CABG surgery. That is, hospitals performing higher volumes of CABGs tend to have better outcomes, ceteris paribus, than those with lower volumes. Thus, the substantial number of hospitals with low CABG volumes indicates that greater regionalization of the service would increase volumes per hospital and could reduce the frequency of poor outcomes nationally. Dayhoff and Cromwell (1994) estimated that mortality in the 90 days after bypass surgery could be reduced by roughly one percentage point (out of five) under greater regionalization.

Table 2-3

National Distribution Thresholds of Medicare Bypass Volumes Among Hospitals Performing Bypass Surgery, 1990-96

	Percentiles of Hospitals							
National	Mean	5%	10%	25%	50%	75%	90%	95%
1990	155	22	34	64	120	203	333	427
1991	162	20	32	67	124	217	335	452
1992	170	23	36	69	130	229	363	454
1993	165	23	33	67	126	220	352	458
1994	173	27	37	69	133	234	363	482
1995	183	25	38	71	137	243	395	506
1996	192	28	40	76	143	256	406	535

NOTES:
1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data.
3. Note missing data in 1995, see Table 2-1.

SOURCE: 1990 through 1996 MedPAR files.

2.4 Demographic Characteristics of Medicare Bypass Patients

Although the number of Medicare CABGs has changed between 1990 and 1996, the proportions of beneficiaries by gender and race have not varied substantially. The volumes of Medicare CABGs are shown in Table 2-4 by these demographic breakdowns.

Table 2-4

National Number of Medicare Bypass Operations By Age, Gender, and Race, 1990-96

	Bypass Procedures													
	1990		1991		1992		1993		1994		1995		1996	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Age														
Under 65 years	10,641	8 %	10,852	8 %	11,594	8 %	12,065	8 %	13,075	8 %	14,068	8 %	15,362	8 %
65 - 69 years	45,289	35	46,896	34	49,091	33	48,703	33	50,490	32	51,926	30	53,181	29
70 - 74 years	39,696	31	43,463	31	47,055	31	46,122	31	49,387	31	52,192	31	54,531	30
75 - 79 years	24,807	19	27,719	20	30,298	20	30,330	20	32,536	20	36,133	21	39,504	22
80 - 84 years	7,564	6	9,029	6	10,179	7	10,335	7	11,846	7	13,777	8	15,720	9
85 years and older	1,273	1	1,489	1	1,810	1	1,854	1	2,191	1	2,681	2	3,255	2
Gender														
Male	87,445	68	93,256	67	100,250	67	99,727	67	106,427	67	112,803	66	119,255	66
Female	41,825	32	46,192	33	49,750	33	49,682	33	53,098	33	57,974	34	62,318	34
Race														
Unknown	3,846	3	4,372	3	4,967	3	5,124	3	1,974	1	1,343	1	1,499	1
White	118,842	92	127,373	91	136,243	91	134,628	90	147,543	93	158,146	93	167,197	92
Black	4,112	3	4,534	3	5,070	3	5,293	4	6,273	4	6,921	4	7,638	4
Other	2,470	2	3,168	2	3,669	2	4,364	3	3,735	2	4,367	3	5,239	3

NOTES:
1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data.
3. Calendar year 1995 data are missing two weeks in late March. 3.8% of sample.

Twice as many men as women underwent CABG surgery in 1990, a ratio that changed only slightly over time. Greater prevalence of coronary artery disease among men no doubt plays a substantial role in this discrepancy, although females are poorer candidates for surgery due to their smaller arteries.

An overwhelming 92-93 percent of Medicare bypass procedures were performed on whites during the 1990-1996 period. Nationally, whites constitute slightly less than 90 percent of the population age 65 and older (Statistical Abstract, 1992). Conversely, only 3-4 percent of surgeries were on blacks, 2-3 percent on other known race/ethnicities, and another 3 percent on people whose race was unknown or not recorded. Ford *et al.* (1989) and Oberman and Cutter (1984) concluded that racial differences in CABG rates are unrelated to racial differences in the rates of coronary artery disease. Ayanian *et al.* (1993) found that rates of bypass and angioplasty following angiography were lower for blacks than whites, while Boutwell and Mitchell (1993) found that rural residents do not have significantly different bypass rates than urban residents. These studies cast doubts on the plausibility of differences being due solely by differences in geographic access to hospitals offering bypass surgery. Other explanations for the racial differences in CABG rates include less access to routine health care, a greater reluctance among blacks to undergo surgery, physician racial prejudice, or lack of Medicare supplemental insurance.

As might be expected among Medicare beneficiaries, fewer than 10 percent of the bypass recipients were under the age of 65. Patients between the ages of 65 and 74 received the majority of the Medicare CABGs performed. In 1990, 66 percent of Medicare bypass patients belonged to one of these two age groups, however, by 1996 the proportion had

decreased to 59 percent. In contrast, the proportion of bypass recipients in each of the three oldest age groupings (75 to 79, 80 to 84 and more than 84 years) increased from 1990 to 1996. The number of bypass recipients in each of the two oldest groups more than doubled from 1990 to 1996, although combined they still accounted for only 11 percent of all Medicare bypass patients in 1996.

2.5 Trends in National Mortality

The MedPAR files contain a field indicating whether each admission ended in a live discharge or death of the patient. Although in-hospital mortality rates measure only one aspect of the patient's outcome, they do provide a useful benchmark for cross-sectional and intertemporal comparisons of outcomes from surgery. Table 2-5 presents average in-hospital mortality rates for hospitals treating Medicare CABG patients. Mortality rates are adjusted to standardize the proportion of patients (to the national proportions) in each DRG. The average mortality rate decreased substantially from 6.5 percent in 1990, to 4.8 percent in 1995, before rising again in 1996. This trend in in-hospital mortality rates is also apparent by location, teaching status, and bedsize stratifications. As lengths of stay continue to decline as well, one might suspect that reductions in in-hospital mortality exaggerate any true improvements in the quality of care.

Within any year, mortality rates vary noticeably by hospital characteristic. The urban mortality rate is higher than the rural rate in each year, major teaching hospitals have a higher

Table 2-5

In-Hospital Mortality Rates For Hospitals Treating Medicare Bypass Patients, 1990-96

	1990	1991	1992	1993	1994	1995	1996
National	6.5 %	5.7 %	5.3 %	*5.1 %*	*5.0 %*	*4.8 %*	*5.4 %*
Location							
Urban	6.6	5.7	5.3	5.1	4.9	4.8	5.4
Rural	4.8	5.3	4.5	4.4	3.9	4.4	4.8
Teaching Status							
Major	6.8	5.8	5.8	5.1	4.8	4.9	5.8
Minor	6.0	5.6	5.0	4.7	5.1	4.4	5.4
None	6.6	5.5	5.1	5.3	4.9	4.9	5.2
Bedsize							
1-199 beds	8.0	6.8	5.5	5.9	5.7	5.9	6.0
200-299 beds	6.3	5.6	5.2	5.3	4.9	4.7	5.2
300-399 beds	6.4	5.9	5.4	5.1	4.7	4.7	5.6
400-499 beds	6.3	5.1	5.4	4.8	4.9	4.7	5.0
500-599 beds	6.0	5.3	5.2	5.0	4.8	4.2	5.5
600-699 beds	6.2	4.7	4.5	4.1	4.5	4.2	5.0
700 or more beds	6.5	5.8	5.0	4.4	4.6	4.7	5.4

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data.
3. Adjusted to standardize proportion of patients in each DRG within each year.
4. Calendar year 1995 data are missing two weeks in late March. 3.8% of sample.

SOURCES: 1990 through 1996 MedPAR files and American Hospital Association files.

mortality rate on average than minor teaching hospitals, and larger hospitals tend to have lower mortality rates than their smaller counterparts. However, with no further adjustments for case-mix severity, it is difficult to interpret these results. For example, higher mortality rates among major teaching hospitals could be caused by more severely ill patients being referred to these facilities. Lower mortality rates among larger hospitals could be due either to a less severe casemix, or more likely, from greater familiarity with the procedure.

The variation in hospital mortality rates is also apparent in Table 2-6. For example, in 1990, ten percent of hospitals doing CABG surgery had mortality rates for Medicare beneficiaries of 2.6 percent or less. Another ten percent had mortality rates of 11.1 percent or higher. By 1995 the mortality rate for hospitals in the lowest ten percent was 1.8 percent or less, a 30 percent reduction. Hospitals in the highest ten percent of in-hospital Medicare patient mortality saw a reduction to 8.1 percent or higher, again a substantial reduction. These variations are difficult to assess without information on casemix severity. Random variation may also plays a role, especially in smaller hospitals. The general downward trend in mortality across time is also seen in the percentile distributions between 1990 and 1995. At each percentile threshold, the mortality rate has decreased.

2.6 Trends in Bypass Lengths of Stay by DRG and Hospital Type

Average length of stay represents a second outcome measure that can be used to compare hospitals. Table 2-7 presents trends in average lengths of stay per hospital standardized to the national proportion of cases in each DRG. The national trend has been

Table 2-6

National Distribution Thresholds of Medicare Hospital Bypass Mortality Rates, 1990-96

		Percentiles of Hospitals						
	Mean	5%	10%	25%	50%	75%	90%	95%
National								
1990	6.5 %	1.8 %	2.6 %	4.0 %	5.9 %	8.2 %	11.1 %	13.3 %
1991	5.7	1.7	2.3	3.4	4.9	6.8	9.6	12.0
1992	5.3	1.6	2.2	3.2	4.6	6.6	9.0	10.6
1993	5.1	1.5	1.9	2.9	4.4	6.5	8.7	10.9
1994	5.0	1.3	1.8	2.9	4.3	6.2	8.3	10.8
1995	4.8	1.5	1.8	2.9	4.2	5.9	8.1	10.4
1996	5.4	1.3	1.9	3.1	4.6	6.7	10.1	12.6

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Adjusted to standardize proportion of patients in each DRG within each year.
3. Calendar year 1995 data are missing two weeks in late March. 3.8% of sample.

SOURCES: 1990 through 1996 MedPAR files.

Table 2-7

Average Length of Stay For Medicare Bypass Patients, 1990-96

	1990	1991	1992	1993	1994	1995	1996
NATIONAL	*15.0 Days*	*14.0 Days*	*13.5 Days*	*12.3 Days*	*11.3 Days*	*10.4 Days*	*9.9 Days*
DRG							
DRG 106	15.7	15.2	14.6	13.5	12.4	11.5	10.9
DRG 107	12.2	11.5	11.2	10.3	9.5	8.7	8.2
DRG 108	17.9	15.3	15.3	14.4	13.4	12.8	12.3
Location							
Urban	14.9	14.0	13.4	12.4	11.4	10.5	9.9
Rural	14.2	13.6	13.1	12.2	11.1	10.3	10.2
Teaching Status							
Major	16.5	15.3	14.6	13.6	12.6	11.5	10.4
Minor	14.5	13.7	13.2	12.2	11.2	10.3	9.7
None	14.1	13.3	12.8	11.8	10.8	10.0	9.7
Bedsize							
1-199 beds	14.1	13.2	13.0	11.9	10.7	10.1	9.6
200-299 beds	14.0	13.4	13.0	11.8	11.0	10.1	9.8
300-399 beds	14.7	13.6	13.0	12.0	11.1	10.3	9.7
400-499 beds	15.1	14.5	13.7	12.7	11.8	10.7	10.0
500-599 beds	15.7	14.3	13.7	12.9	11.8	10.7	10.1
600-699 beds	15.6	14.2	13.5	12.6	11.4	10.5	9.8
700 or more beds	16.6	15.8	14.8	13.4	12.3	11.7	10.4

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19
2. Calendar year data.
3. Adjusted to standardize proportion of patients in each DRG within each year.
4. Calendar year 1995 data are missing two weeks in late March. 3.8% of sample.

SOURCES: 1990 through 1996 MedPAR files and American Hospital Association files.

towards shorter stays, from an average of 15.0 days in 1990 to 9.9 days in 1996. This general downward trend is also apparent within each DRG and for location, teaching status, and bedsize stratifications shown in the table. The average length of stay for each of the three CABG DRGs decreased between 1990 and 1996, as did the average stay for each hospital grouping. Note that these stays represent only the acute care hospital stay. Increased use of sub-acute units or facilities may have contributed to the shorter acute care stays

Average lengths of stay differ noticeably across the three DRGs, as expected. DRG 108, including CABG patients who also underwent other thoracic or vascular procedures, had the longest average stay, ranging from 17.9 days in 1990 down to 12.3 days in 1996. CABG with cardiac catheterization on the same admission (DRG 106) required a stay roughly 3.5 days longer than CABG without cardiac catheterization (DRG 107) in 1990. By 1996 that difference had fallen to 2.7 days.

Like mortality rates, average lengths of stay remain unadjusted for casemix severity. Although we adjust for differences in the proportion of CABGs falling into each of the three DRGs, other differences in severity of illness may account for the longer stays at major teaching hospitals and at larger hospitals generally. Here again the differences are diminishing. In 1990 average lengths of stay were 16.5 days for major teaching hospitals compared to 14.1 for non-teaching hospitals. In 1996 average length of stay for major teaching hospitals was 10.4 days compared to just 9.7 days for non-teaching. The length of stay difference has declined from 2.4 days in 1990 to just 0.7 days in 1996. That this is the result of case-mix changes is unclear.

Table 2-8 presents distribution statistics for average lengths of stay per hospital. These percentile thresholds again indicate the decreasing lengths of stay over the study period. For instance, in 1990, five percent of hospitals had stays of 11.0 or fewer days even after controlling for DRG mix. By 1996, five percent had stays of 6.7 or fewer days. All seven years show substantial variation in length of stay across hospitals. The difference in average stays between the top and bottom ten percent of all hospitals was roughly seven days in 1990, narrowing to just five and a half days in 1996. Differences of this magnitude can add thousands of dollars to the average patient's cost.

2.7 Trends in Expenditures by Type and Locus of Service

By combining the MedPAR and NCH data, we can present data on expenditures by type of service, location of service, and timing of service relative to when the heart bypass surgery was performed. We first present summary data on trends in expenditures across three time frames: (1) 30 days prior to admission, (2) inpatient stay, and (3) 90 days after the bypass. We then present more detailed breakdowns on expenditures during the time frames.

2.7.1 Aggregate Trends in Payments

Table 2-9 presents average Medicare program allowed charges (or payments) per Medicare bypass patient by time period and type of service. Program charges during the 30 days prior to admission for the bypass ranged from $2,532 to $2,855 across the seven years, an increase of 13 percent. The majority of this amount was comprised of Part A expenditures

Table 2-8

National Distributions of Medicare Bypass Length of Stay Per Hospital, 1990-96

		Percentiles						
	Mean	5%	10%	25%	50%	75%	90%	95%
National								
1990	15.0	11.0	11.7	13.0	14.5	16.5	18.6	20.2
1991	14.0	10.5	11.1	12.1	13.7	15.4	17.0	18.3
1992	13.5	9.9	10.6	11.7	13.1	14.8	16.4	17.9
1993	12.3	9.3	9.9	10.8	12.3	13.5	15.2	16.2
1994	11.3	8.5	9.0	9.9	11.1	12.4	13.9	14.9
1995	10.4	7.8	8.3	9.2	10.2	11.5	12.7	13.6
1996	9.9	6.7	7.2	8.3	9.8	11.1	12.7	13.7

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data.
3. Calendar year 1995 data are missing two weeks in late March. 3.8% of sample.

SOURCES: 1990 through 1996 MedPAR files.

Table 2-9

Average Part A Payments and Part B Allowed Charges for Medicare Heart Bypass Patients, 1990-96

	1990		1991		1992		1993		1994		1995		1996	
	Average Allowed Charges	Proportion of Category	Average Allowed Charges	Proportion of Category	Average Allowed Charges	Proportion of Category	Average Allowed Charges	Proportion of Category	Average Allowed Charges	Proportion of Category	Average Allowed Charges	Proportion of Category	Average Allowed Charges	Proportion of Category
30 Days Prior to Bypass Admission														
Hospital Inpatient	$1,371	54.1%	$1,469	55.1%	$1,544	55.7%	$1,503	56.8%	$1,480	55.7%	$1,521	55.1%	$1,740	60.9%
Physician/Supplier	932	36.8	960	36.0	1,001	36.1	886	33.5	812	30.6	821	29.8	758	26.5
Outpatient Department	222	8.8	226	8.5	214	7.7	236	8.9	336	12.6	379	13.7	316	11.1
Home Health	7	0.3	10	0.4	11	0.4	16	0.6	25	0.9	32	1.2	35	1.2
Skilled Nursing Facility	1	0.0	1	0.0	1	0.1	3	0.1	4	0.1	5	0.2	7	0.2
TOTAL	**2,532**	**100.0**	**2,665**	**100.0**	**2,771**	**100.0**	**2,644**	**100.0**	**2,657**	**100.0**	**2,758**	**100.0**	**2,855**	**100.0**
Bypass Inpatient Stay														
Hospital Inpatient	23,258	79.0	23,463	77.8	24,928	79.8	24,754	81.7	25,078	80.9	25,516	80.9	25,832	81.8
Physician/Supplier	6,176	21.0	6,706	22.2	6,298	20.2	5,532	18.3	5,921	19.1	6,016	19.1	5,749	18.2
TOTAL	**29,434**	**100.0**	**30,169**	**100.0**	**31,226**	**100.0**	**30,286**	**100.0**	**30,999**	**100.0**	**31,532**	**100.0**	**31,581**	**100.0**
90 Days After Bypass Discharge														
Hospital Inpatient	1,698	58.4	1,838	55.8	1,976	60.0	2,170	56.5	2,441	51.9	3,381	55.8	7,915	51.3
Physician/Supplier	673	23.1	798	24.2	822	25.0	788	20.5	962	20.5	1,043	17.2	1,064	18.7
Outpatient Department	192	6.6	204	6.2	183	5.5	209	5.4	290	6.2	322	5.3	343	6.0
Home Health	287	9.9	375	11.4	367	11.1	518	13.5	730	15.5	815	13.5	873	15.3
Skilled Nursing Facility	60	2.1	78	2.4	118	3.6	159	4.1	277	5.9	494	8.2	492	8.7
TOTAL	**2,910**	**100.0**	**3,293**	**100.0**	**3,466**	**100.0**	**3,844**	**100.0**	**4,700**	**100.0**	**6,055**	**100.0**	**5,687**	**100.0**
BYPASS EPISODE TOTAL	**34,876**		**36,127**		**37,463**		**36,774**		**38,356**		**40,345**		**41,863**	

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are based on discharges through September 30th.
3. Hospital inpatient for the Bypass Inpatient stay includes the admission for bypass surgery. Hospital Inpatient for the other time frames includes other hospital stays.
4. Physician/supplier data are based on patients with more than $1,000 of physician/supplier allowed charges during the bypass inpatient stay.
5. Medicare program expenditures. Excludes patient liability.

SOURCE: 1990-1993 MedPAR and National Claims History files.

for hospital inpatient stays prior to the admission for bypass surgery. These could be previous admissions for heart problems, previous admissions for angiography (for patients in DRG 107), or unrelated admissions that occurred in the 30 days prior to the admission for bypass. Outpatient department spending accounted for 8 to 14 percent of the total, while home health and skilled nursing facility charges combined contributed less than 2 percent to total spending. Part B payments to physicians and suppliers constituted roughly one third of the total expenditures during the pre-bypass period, although this proportion fell in later years. Under the resource based relative value scale (RBRVS), Medicare payments to specialists for procedures were generally reduced, while payments to primary care physicians for management were generally increased. Thus, we would expect lower physician payments for care of bypass patients.

Part A payments plus Part B allowed charges during the bypass inpatient stay ranged from $29,434 in 1990 to $31,581 in 1996, a 7 percent increase. The proportion of charges accounted for by hospital Part A payments rose from 79 to 82 percent of the total, while physician/supplier payments decreased after 1991, concurrent with the introduction of the Medicare Fee Schedule.

Charges for the 90 days following discharge after bypass surgery more than doubled between 1990 and 1995, before decreasing slightly in 1996. In each year, the majority of the spending (50-60 percent) was for other hospital inpatient stays. These were patients readmitted to a hospital during the 90-day window. Physician/supplier expenditures increased by almost 60 percent during this period, while outpatient department expenditures increased by 78 percent. Average home health spending more than tripled between 1990 and

1996, while skilled nursing facility spending experienced an eight-fold increase. Despite this rapid growth, these two sources of expenditures still combined for only 24 percent of spending in 1996, up from 12 percent in 1990. The rise in home health and skilled nursing expenditures is consistent with shorter lengths of stay observed during the period, implying that patients require more care once they are discharged from the hospital. Medicare program expenditures on bypass surgery (in millions of dollars), calculated as the per-person expenditures multiplied by the number of Medicare bypass recipients. Total expenditures from 30 days pre-admission to 90 days post discharge grew 62 percent between 1990 and 1996, from $4.6 to $7.3 billion. This increase resulted from the 40 percent increase in bypasses performed coupled with the 20 percent increase in cost per bypass.

Expenditures during the inpatient stay accounted for the majority of the total costs in every year (roughly 80 percent). However, the fastest growing costs were for the period after discharge, which rose 175 percent, from $376 million in 1990 to $1.033 billion in 1996. This is consistent with the change in expenditures by locus of care, with home health costs more than quadrupling, from $38 to $165 million, and skilled nursing facility expenditures increasing 11-fold, from $8 to $91 million. Thus, wile prospective payment and the fee schedule were geared toward keeping hospital and physician costs in check, home health and SNF care costs exploded.

Tables 2-9 and 2-10 present highly aggregated summary data. More detailed expenditure breakdowns that follow shed light on trends. For example, what proportion of patients incur any SNF charges? How are physician/supplier inpatient expenditures spread across different physician specialties?

Table 2-10

Total Medicare Program Expenditures on Bypass Surgery, 1990-96 (in millions of dollars)

	1990	1991	1992	1993	1994	1995	1996	Percent Change 1990-96
By timing of expenditure								
30 Days Prior to Bypass Admission	$327	$372	$416	$395	$424	$471	$518	58 %
Bypass Inpatient Stay	3,805	4,207	4,685	4,525	4,945	5,385	5,734	51
90 Days after Bypass Discharge	376	459	520	574	750	1,034	1,033	175
Total Bypass Episode	4,509	5,038	5,621	5,494	6,119	6,890	7,285	62
By Locus of Care								
Hospital Inpatient	3,403	3,733	4,268	4,247	4,626	5,195	5,536	63
Physician/Suppliler	1,006	1,180	1,218	1,077	1,228	1,346	1,375	37
Outpatient Department	54	60	60	66	100	120	120	122
Home Health	38	54	57	80	120	145	165	334
Skilled Nursing Facility	8	11	18	24	45	85	91	1,038
Total Bypass Episode	4,509	5,038	5,621	5,494	6,119	6,890	7,285	62

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10 or 36.19
2. Calendar year data. 1993 values are annual estimates based on expenditure information on discharges through September 30. 1996 values are annual estimates based on expenditure information on discharges through April 30.
3. Medicare program expenditures. Exlcudes patient liability.

SOURCE: 1990 through 1996 MedPAR and NCH files.

2.7.2 Payments Incurred Prior to the Bypass

Table 2-11 presents a more detailed breakdown of charges incurred by heart bypass patients during the 30 days prior to admission for the bypass surgery. Roughly 37 percent of all bypass patients experienced another inpatient hospital stay within the 30 days prior to the bypass admission. This proportion will vary by DRG (not shown), as patients in DRG 107 will have had their angiography prior to the admission for bypass surgery. Inpatient stay costs calculated only for those with a prior admission averaged roughly $4,100 versus roughly $1,500 across all patients. In contrast, only 0.1 percent experienced a stay at a skilled nursing facility during the same period, accounting for the low average charges. The proportion of patients utilizing any prior home health care is also quite small, explaining the low average charges for this type of service.

Outpatient department allowed charges varied from $214 to $379 across the seven years, with roughly 30 percent of patients incurring outpatient costs. The hospital revenue center with the highest average allowed charges is cardiology, accounting for roughly 35 percent of the total charges, followed by radiology, supplies, lab, and pharmacy. These five revenue centers combine to account for roughly 75 percent of total charges in each year.

Part B physician/supplier charges reflect noticeable shifts in location of service across our time frame. Charges for hospital care prior to the CABG admission decreased by 45 percent, although they still constitute the majority of total physician/supplier charges. In contrast, both average office charges and outpatient department charges increased by more than 35 percent from 1990 to 1996. This shift would be consistent with a change in site of

Table 2-11

Average Part A Payments and Part B Allowed Charges for Medicare Heart Bypass Patients, 30 Days Prior to Admission, 1990-96

	Percent of Patients with claims	1990	1991	1992	1993	1994	1995	1996
Hospital Inpatient	36.6 %	$1,371	$1,469	$1,544	$1,503	$1,480	$1,521	$1,740
Skilled Nursing Facility	0.1	0.60	1.05	1.49	2.56	3.52	5.18	6.71
Home Health								
Skilled Nursing	1.4	4.70	6.52	7.45	10.73	16.40	20.95	23.30
Aides	0.5	1.31	1.91	2.25	3.59	5.59	6.92	7.55
Physical Therapy	0.2	0.43	0.59	0.50	1.03	1.57	2.24	2.34
Supplies	0.4	0.07	0.23	0.15	0.27	0.39	0.53	0.67
Other	0.2	0.23	0.33	0.38	0.51	0.83	1.33	1.34
Total	**1.5**	**6.73**	**9.58**	**10.73**	**16.12**	**24.79**	**31.98**	**35.20**
Outpatient Department								
Cardiology	12.6	78.62	82.14	80.66	86.83	115.42	138.28	134.75
Radiology	16.6	38.36	38.09	33.42	38.21	41.70	43.20	41.50
Supplies	12.7	22.95	24.64	23.19	23.71	30.01	30.76	26.22
Lab	19.0	16.02	15.84	15.64	18.07	21.56	24.13	21.68
Pharmacy	13.4	15.07	16.22	16.47	18.24	29.80	33.65	22.37
EKG	12.2	7.88	6.84	6.08	6.78	8.42	8.10	6.43
Clinic	6.4	4.85	4.85	3.92	4.48	7.55	8.80	6.38
Operating Room	1.0	3.70	2.95	2.75	3.49	3.89	4.27	4.22
Anesthesia	0.5	0.47	0.44	0.36	0.39	0.48	0.60	0.54
Therapy	0.3	0.50	0.40	0.50	0.71	0.86	1.18	1.14
Cardiac Rehabilitation	0.3	0.38	0.30	0.26	0.35	0.60	0.56	0.64
Dialysis	0.4	3.24	3.63	3.94	4.39	5.78	7.27	7.43
Other	13.5	29.63	29.27	26.43	30.81	69.60	78.30	42.34
Total	**30.3**	**221.67**	**225.63**	**213.61**	**236.45**	**335.68**	**379.09**	**315.64**
Physician/Supplier								
Office	71.8	130.99	149.65	174.41	159.75	179.02	198.84	195.33
Hospital	54.8	656.30	641.54	627.23	527.74	416.01	393.56	353.62
Outpatient Department	56.4	103.57	124.46	143.81	140.23	154.06	160.16	139.73
Lab	16.3	9.42	10.13	11.69	11.47	10.97	10.75	9.92
Skilled Nursing Facility	0.2	0.31	0.15	0.18	0.20	0.26	0.43	0.50
Other	14.0	31.62	33.97	43.99	46.87	51.78	56.84	58.76
Total	**89.8**	**932.20**	**959.90**	**1,001.32**	**886.25**	**812.12**	**820.58**	**757.86**
Total Pre-Bypass		**2,532**	**2,665**	**2,771**	**2,644**	**2,657**	**2,758**	**2,855**

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are based on discharges through September 30th. 1996 values are based on discharges through April 30th.
3. Hospital Inpatient includes allowed changes for stays prior to the admission for bypass surgery.
4. Physician/supplier data are based on patients with more than $1,000 of physician/supplier allowed charges during the bypass inpatient stay.
5. Medicare program expenditures. Excludes patient liability.

SOURCE: 1990 through 1996 MedPAR and National Claims History Data.

care; although the proportion of patients receiving services in these settings did not vary substantially across the seven years, the intensity of services received could have varied. Alternatively, introduction of the Medicare Fee Schedule in 1992 would tend to cause a shift in this direction, as payments for hospital-based procedures declined while those for office based management activities increased.

2.7.3 Payments During the Inpatient Stay

Table 2-12 presents detailed average payments during the inpatient stay. The first column again gives the average number of patients with claims for each classification. By design, all patients in our sample have Part A inpatient CABG claims. All patients should also have claims for both anesthesia during surgery and at least one surgeon's bill. Our data indicate that 96 percent of patients have an anesthesiologist's or nurse anesthetist's bill. The missing four percent could be attributed to miscoding of specialty on the claims, or missing data despite our data trims. Eighty four percent of patient had a cardiothoracic surgeon's bill. The bypass procedures codes were also coded by physicians identified with a specialty of general surgery or cardiology.

In addition to claims for anesthesia and surgery, bypass patients would be expected to have claims for other medical specialists. For example, patients in DRG 106, who are undergoing cardiac catheterization during the bypass stay, would have cardiology claims, as would many patients in DRG 107. Most patients would also be expected to have claims for radiology during the bypass stay. Patients would then have claims for other medical

Table 2-12

Average Part A Payments and Part B Allowed Inpatient Charges for Medicare Heart Bypass Patients, 1990-96

	Percent of Patients with Claims	1990	1991	1992	1993	1994	1995	1996
Hospital Inpatient Services	100.0 %	$23,258	$23,463	$24,928	$24,754	$25,078	$25,516	$25,832
Physician/Supplier Services								
Anesthesia	95.7	816	982	973	853	878	872	844
Cardiology	86.1	1,252	1,405	1,206	1,036	1,096	1,014	896
Cardiothoracic Surgery	83.8	2,739	2,869	2,847	2,560	2,820	2,985	2,915
Radiology	92.0	125	138	132	112	102	95	87
Pulmonology	20.0	78	86	85	83	83	84	85
Other Physicians	74.4	850	853	740	622	598	618	586
Non-Physicians	43.8	317	375	315	266	344	348	335
Total	100.0	6,176	6,706	6,298	5,532	5,921	6,016	5,749
TOTAL INPATIENT		29,434	30,169	31,226	30,286	30,999	31,532	31,582

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 physician/supplier values are based on discharges through September 30th. 1996 physician/supplier values are based on discharges through April 30th.
3. Physician/supplier data are based on patients with more than $1,000 of physician/supplier allowed charges during the bypass inpatient stay.
4. Anesthesia includes both anesthesiologists and certified registered nurse anesthetists.
5. Medicare program expenditures. Excludes patient liability.

SOURCE: 1990 through 1996 MedPAR and National Claims History Data.

specialists in accordance with treatment for co-morbid conditions or complications. For example, 20 percent of patients were treated by pulmonologists. Almost 75 percent of Medicare bypass recipients received treatment from other physician specialties, such as nephrology, internal medicine, or neurology. Additionally, 44 percent of bypass patients had claims from non-physician suppliers who are allowed to bill independently, such as physical or occupational therapists, psychologists, and clinical social workers.

Physician/supplier expenditures decreased from 21 percent of total inpatient expenditures in 1990 to 18 percent in 1996, as hospital spending increased while physician spending fell. Cardiothoracic surgeons received roughly 45-50 percent of the payments to physicians in each year, cardiologists roughly 21 percent, and anesthesiologists roughly 15 percent. The effects of physician payment reform are evident, as specialties experienced decreased allowed charges between 1991 and 1993. Different update rates in allowable fees under the Medicare Fee Schedule due to the volume performance standards imply higher surgery fees after 1993 relative to other specialties.

The MedPAR files include information on federal Part A reimbursement for each inpatient hospitalization. Under prospective payment, hospitals are reimbursed a fixed amount per case based on the DRG in which the patient is classified, regardless of the costs incurred. Thus, one source of variation in payments to the hospitals is the variation in the proportion of patients falling into each of the three CABG DRGs (106, 107, and 108). Payments to hospitals also vary because of pass-through amounts including capital related costs, direct medical education, and bad debts, as well as separate payment amounts for indirect medical education, and patients exceeding the outlier thresholds.

The average total expenditure per patient for each hospital performing Medicare CABGs is presented in Table 2-13, adjusted by the proportion of patients in each DRG, using the same stratifications presented earlier in the chapter. In each year, the average urban hospital received a Medicare payment roughly $5,000 more per CABG than its rural counterpart, a difference of roughly 25 percent. Minor teaching hospitals received slightly higher payments on average than non-teaching hospitals, and both received substantially less than the amount paid a major teaching hospital. Payments increase on average with bedsize, consistent with variations in pass-through amounts, as well as the urban, teaching orientation of larger hospitals.

2.7.4 Payments Following the Bypass

Table 2-14 presents data on allowed charges during the 90-day period following discharge from the hospital for bypass surgery. Total expenditures during this period more than doubled between 1990 and 1995, before decreasing for patients treated during the first 4 months of 1996.

The patient's post-discharge pattern of care can take several forms. Patients who do well after discharge may receive only routine outpatient and physician care. Patient who are in frailer condition may be discharged to a SNF or receive home health care, dependent on the level of care needed, with resulting higher incurred charges. Some patients will be

Table 2-13

Average Medicare Part A Expenditures For Bypass Hospitalization, 1990-96

	1990	1991	1992	1993	1994	1995	1996
National	*$23,258*	*$23,463*	*$24,928*	*$24,754*	*$25,078*	*$25,516*	*$25,832*
Location							
Urban	23,589	23,748	25,213	24,843	25,197	25,683	26,027
Rural	18,014	18,877	20,491	21,590	21,626	22,089	22,425
Teaching Status							
Major	29,818	30,016	32,916	30,713	31,601	32,311	32,690
Minor	21,252	21,724	22,670	22,260	22,322	22,843	23,212
None	20,620	20,781	21,837	20,887	21,065	21,520	21,921
Bedsize							
1-199 beds	21,549	21,476	22,929	22,731	22,543	23,225	23,588
200-299 beds	21,049	21,506	22,624	21,886	21,970	22,358	22,849
300-399 beds	23,098	22,992	24,156	23,593	23,776	24,182	24,360
400-499 beds	23,406	23,838	25,440	24,032	24,455	24,871	25,389
500-599 beds	24,679	24,949	27,153	26,299	26,729	27,316	27,813
600-699 beds	24,182	24,244	23,814	25,338	25,620	26,225	26,811
700 or more beds	29,078	29,565	31,831	28,756	29,778	30,515	30,647

NOTES:
1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data.
3. Adjusted to standardize proportion of cases in each DRG.
4. Medicare program expenditures. Excludes patient liability.

SOURCES: 1990 through 1996 MedPAR files.

Table 2-14

Average Part A Payments and Part B Allowed Charges for Medicare Heart Bypass Patients During the 90 Days After Bypass Surgery, 1990-96

	Percent of Patients with Claims	1990	1991	1992	1993	1994	1995	1996
Hospital Inpatient	25.1 %	$1,698	$1,838	$1,976	$2,170	$2,441	$3,381	$2,915
Skilled Nursing Facility	6.4	60	78	118	159	277	494	492
Home Health								
Skilled Nursing	26.1	204	261	254	355	496	552	595
Aides	9.6	51	70	68	97	134	144	145
Physical Therapy	4.9	16	23	24	37	59	72	81
Supplies	9.8	7	8	8	12	17	19	20
Other	4.2	9	12	12	17	24	28	32
Total	**26.3**	**287**	**375**	**367**	**518**	**730**	**815**	**873**
Outpatient Department								
Cardiology	7.6	14	12	10	12	15	16	17
Radiology	23.5	35	33	28	31	37	39	42
Supplies	10.4	6	7	6	8	11	12	13
Lab	30.3	26	27	25	29	35	38	40
Pharmacy	9.2	5	5	5	6	7	8	8
EKG	13.1	11	9	7	9	9	9	9
Operating Room	1.4	4	4	4	4	6	7	8
Anesthesia	0.6	1	1	1	1	1	1	1
Therapy	1.7	10	10	9	9	15	17	19
Cardiac Rehabilitation	10.0	29	45	37	44	71	76	84
Clinic	13.6	10	10	10	11	14	16	19
Dialysis	0.6	19	21	20	22	32	38	37
Other	9.9	22	20	19	24	35	12	47
Total	**46.6**	**192**	**204**	**183**	**209**	**290**	**322**	**343**
Physician/Supplier								
Office	88.0	213	263	278	262	295	314	314
Hospital	29.9	333	379	371	353	439	468	477
Outpatient Department	47.9	55	66	68	65	83	91	92
Lab	35.7	21	28	21	29	30	29	27
Skilled Nursing Facility	3.1	3	3	4	5	10	15	19
Other	21.2	49	59	70	74	105	126	135
Total	**94.9**	**674**	**798**	**822**	**788**	**962**	**1,043**	**1,064**
Total Post Bypass		**2,910**	**3,293**	**3,466**	**3,844**	**4,700**	**6,055**	**5,687**

NOTES:
1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data. 1993 values are based on discharges through September 30th. 1996 values are based on discharges through April 30th.
3. Hospital inpatient includes allowed charges for stays after the discharge for bypass surgery.
4. Physician/supplier data are based on patients with more than $1,000 of physician/supplier allowed charges during the bypass inpatient stay.
5. Medicare program expenditures. Excludes patient liability.

SOURCE: 1990 through 1996 MedPAR and National Claims History files.

discharged, only to require readmission for a complication such as post-surgical infection. These patients will incur Part A charges for the additional hospital stay as well as Part B charges for their physician care.

Roughly one quarter of all bypass patients had another inpatient stay within 90 days of the bypass stay. This total would include a small number of patients readmitted for more bypass surgery, patients with continuing heart problems, or any other admission within this time frame. Inpatient hospital stays accounted for over half the expenditures during the post-surgery period. Spending on post-bypass inpatient hospital stays rose by 72 percent from 1990 to 1996 ($1,698 to $2,915); in contrast the cost of the CABG inpatient stay rose by only 11 percent. The proportion of patients re-admitted within 90 days after the bypass rose only slightly (23.5 percent to 26.7 percent, not shown) during the seven year period, so an increase in patients requiring further hospitalization did not account for the large increase in spending. Higher readmission costs could imply that shortened lengths of stay are resulting in readmissions for more serious conditions, although we can draw no definitive conclusion from our data.

The average amount spent on skilled nursing facility stays rose more than 8-fold during this period, from $60 to $592. The increase in average charges resulted from increased utilization of SNFs after discharge (from 2.1 percent of patients in 1990 to 8.2 percent in 1995, not shown). Again, this increase may result from shorter inpatient hospital stays, necessitating continued treatment at a SNF.

Average home health charges rose from $287 to $873 (tripling) between 1990 and 1996, although the proportion of patients with home health claims increased only slightly.

This implies a greater intensity of care, i.e., more skilled nursing visits per patient, among those receiving home health care. As in the pre-surgery period, the bulk of spending was on skilled nursing care.

Average outpatient department charges rose from $192 in 1990 to $343 in 1996. The department experiencing the most rapid growth in expenditures was cardiac rehabilitation, which increased from $29 in 1990 to $84 in 1996, making it the single largest hospital-based expenditure category for the years 1991-96. The increase was accompanied by a relatively small increase in the fraction of patients receiving cardiac rehabilitation, again implying more intensive care for those receiving the service.

Part B expenditures increased 58 percent (from $674 to $1,064) between 1990 and 1996. The largest amount in each year was for hospital treatment after the bypass admission, followed by office visits.

2.7.5 Multivariate Analysis of Expenditures

Table 2-13 indicated that payments to hospitals for the bypass stay varied considerably according to hospital characteristic. To further explore reasons for variation in costs per bypass, Table 2-15 presents three sets of multivariate linear regression results. The dependent variables for the three regressions are: (1) hospital Part A inpatient reimbursement for the bypass stay; (2) hospital and physician/supplier reimbursement for the bypass stay; and (3) total reimbursement for the bypass episode, from 30 days pre-admission to 90 days post-discharge. Each regression uses the same set of independent variables:

Table 2-15

Expenditure Regressions for Medicare Bypass Patients, 1990-96

	Hospital Inpatient Reimbursement	Hospital and Physician/Supplier Inpatient Reimbursement	Total Bypass Episode Reimbursement
Intercept	45,101 *	54,815 *	112,431 *
Rural	-1,900 *	-3,041 *	-6,635 *
(urban)			
Non-Teaching	-10,269 *	-10,091 *	-21,810 *
Minor Teaching	-8,698 *	-9,017 *	-19,615 *
(major teaching)			
< 100 beds	2,557 *	1,721 *	5,417 *
100 - 199 beds	1,887 *	2,105 *	5,510 *
200 - 299 beds	538 *	353 *	1,763 *
300 - 399 beds	951 *	1,020 *	2,840 *
400 - 499 beds	204 *	172 *	1,020 *
500 - 599 beds	-302 *	-331 *	-284
600 - 699 beds	-1,308 *	-1,788 *	-3,622 *
700 - 799 beds	1,398 *	1,375 *	3,483 *
(> 799 beds)			
age < 65	-2,942 *	-2,743 *	-8,052 *
age 65 - 69	-2,223 *	-2,259 *	-8,127 *
age 70 - 74	-1,498 *	-1,696 *	-6,494 *
age 75 - 79	-985 *	-1,154 *	-4,645 *
age 80 - 84	-617 *	-722 *	-2,816 *
(age > 84)			
male	-456 *	-188 *	-1,932 *
(female)			
unknown race	-970 *	-2,504 *	-5,791 *
white	-850 *	-2,274 *	-5,182 *
black	443 *	-976 *	-1,169 *
(other race)			
DRG 106	-2,839 *	-3,086 *	-7,944 *
DRG 107	-8,299 *	-9,559 *	-17,381 *
(DRG 108)			
1990 Discharge	-4,146 *	-3,794 *	-11,890 *
1991 Discharge	-3,412 *	-2,678 *	-9,797 *
1992 Discharge	-1,503 *	-1,156 *	-5,935 *
1993 Discharge	-1,130 *	-1,604 *	-6,606 *
1994 Discharge	-881 *	-860 *	-3,064 *
1995 Discharge	-394 *	-225 *	-419 *
(1996 Discharge)			
Discharged Alive	-5,940 *	-7,020 *	-8,386 *
(died in-hospital)			
R-squared	0.23	0.25	0.18
N. of observations	936,453	668,011	668,011

NOTE:
1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data.
3. Hospital inpatient reimbursement includes Medicare Pare A expenditures for the bypass stay.
4. Hospital and physician/supplier inpatient reimbursement includes Medicare Part A and Part B expenditures for the bypass stay.
5. Bypass episode reimbursed includes all hospital, SNF, physician/supplier, home health and outpatient department expenditures from 30 days pre-bypass admission to 90 days post-discharge.
6. Hospital and physician/supplier and total bypass episode regressions include only patients with inpatient physician/supplier expenditures >$1,000.

SOURCE: 1990-96 MedPAR and NCH files.

characteristics of the bypass hospital (urban/rural location, teaching status, bedsize); characteristics of the patient (age, gender, race); the patient's DRG; year of discharge; and patient discharge status. Left-out referent groups that are reflected in the intercept are listed in parentheses.

The variables with the largest coefficients in all three regressions are the teaching status dummies. Payments for inpatient hospital stay to non-teaching hospitals and minor teaching hospitals are roughly $10,269 and 48,698 lower than to major teaching hospitals, ceteris paribus, because of Medicare payments for indirect medical education (IME) and direct medical education (DME). Teaching status has an even larger effect on payments during the entire bypass episode, (column 3) accounting for$21,810 and $19,615 of the variation in charges, respectively. This result is explained if patients with readmissions return to the hospital in which the bypass was performed. Each stay in the teaching hospital would be more expensive than in the non-teaching hospital, so additional stays would increase the overall teaching differential for the episode.

The variables with the next largest coefficients are the DRG dummies, with both DRG 106 and DRG 107 receiving lower payments than DRG 108. It is surprising that the differential costs for DRG 106 and DRG 107 are not much affected when considering the entire bypass episode (rather than just the bypass stay). Since patients in DRG 107 undergo catheterization before the bypass admission, the additional costs during the 30 days prior to bypass for 107 patients was expected to reduce the payment differential. However, it may that DRG 106 patients are on average sicker (including for example, emergent AMI patients) which would help account for the difference in costs over the episode.

While the hospital bedsize coefficients are generally significant (compared to the largest hospitals) no relationship is obvious, and several of the coefficients are relatively small. This indicates that much of the variation in payment by hospital size (seen in Table 2-13) is caused by the correlation between size and other factors such as teaching status.

All the patient characteristic variables are significant. This is somewhat surprising for PPS hospital inpatient reimbursement, given that bypass DRG payments do not vary with patient demographic factors or patient discharge status. However, payments are increased for outliers, and differences in the proportion of patients who meet outlier threshold by characteristic could explain the significance of these variables. This may also explain the lower costs of patients discharged alive, if patients who die in the hospital tend to exceed outlier thresholds. The coefficients on the patient characteristic variables are larger in the total bypass episode regression, reflecting varying utilization of care associated with, say, age.

Controlling for other factors, a strong trend is found in inpatient expenditures across the years. Payments become progressively higher each year, with the 1990 payment $4,146 less than the 1996 payment. When inpatient physician services are included, the trend is generally the same, although payments in 1992 were found to be higher than those in 1993. Finally, once other variables are controlled for, patients discharged in 1996 were $11,890 more expensive on a total episode basis compared with 1990.

2.8 Angioplasty Trends and Utilization

2.8.1 National Totals

In this section, trends in the utilization of angioplasty are discussed. These trends are important in that some candidates for single and double vessel bypass may now be choosing treatment via less invasive angioplasty.

Table 2-16 presents the number of hospitals performing angioplasty on Medicare beneficiaries and the number of angioplasties performed between 1990 and 1996. In 1990, 803 hospitals, or roughly 15 percent of all short term acute care hospitals nationally, performed angioplasty on Medicare beneficiaries. This number increased to 965 hospitals in 1996, a 20 percent increase across the seven year period. Not surprisingly, growth in the number of hospitals performing angioplasty roughly parallels that of the number performing bypass surgery. The total number of Medicare angioplasties performed more than doubled 1990 and 1996, from just under 100,000 to 207,064. In Exhibit 2-2, trends in CABG volumes are compared to trends in angioplasty volumes for 1990-1996. In 1990, the number of Medicare CABGs exceeded the number of PTCAs by roughly 30 percent. The number of Medicare angioplasties performed first exceeded the number of CABGs in 1993; by 1996 the volume of angioplasties was 15 percent higher than the CABG volume. That both angioplasty and CABG are increasing in frequency may come as a surprise to those who believe, and perhaps rightly so, that angioplasty is a substitute for CABG surgery.

Table 2-16

Number of Hospitals Performing Medicare Angioplasty, and Number of Medicare Angioplasties Performed, 1990-96

	1990			1991			1992			1993			1994			1995			1996		
	Number of Hospitals	Number of Procedures	Percent of Procedures	Number of Hospitals	Number of Procedures	Percent of Procedures	Number of Hospitals	Number of Procedures	Percent of Procedures	Number of Hospitals	Number of Procedures	Percent of Procedures	Number of Hospitals	Number of Procedures	Percent of Procedures	Number of Hospitals	Number of Procedures	Percent of Procedures	Number of Hospitals	Number of Procedures	Percent of Procedures
NATIONAL	*803*	*99,744*		*806*	*123,084*		*849*	*145,126*		*908*	*155,768*		*938*	*172,402*		*932*	*186,722*		*965*	*207,064*	
Location																					
Urban	737	93,050	96	742	114,922	96	782	135,600	96	837	145,562	96	864	161,002	96	872	174,226	95	878	191,805	95
Rural	39	3,615	4	38	4,482	4	40	5,604	4	43	6,270	4	46	7,241	4	52	8,416	5	57	10,294	5
Teaching Status																					
Major	204	33,840	35	204	40,987	34	208	47,558	34	218	49,811	33	218	55,168	33	222	59,257	32	221	64,070	32
Minor	226	28,637	30	229	35,434	30	240	41,888	30	256	45,715	30	266	49,615	29	266	54,820	30	268	61,176	30
None	346	34,188	35	347	42,983	36	374	51,758	37	406	56,306	37	426	63,460	38	436	68,565	38	446	76,853	38
Bedsize																					
1 - 199 beds	75	5,385	6	74	6,294	5	87	7,865	6	106	8,955	6	113	10,372	6	124	11,421	6	130	13,413	7
200 - 299 beds	174	16,654	17	181	21,249	18	192	25,956	18	207	27,960	18	221	31,103	18	223	33,949	19	229	38,891	19
300 - 399 beds	196	20,821	22	196	25,547	21	208	30,205	21	223	32,623	21	228	35,993	21	228	39,494	22	228	43,606	22
400 - 499 beds	122	14,164	15	121	17,945	15	125	21,349	15	129	23,295	15	133	25,628	15	132	27,743	15	132	30,206	15
500 - 599 beds	90	15,295	16	90	17,896	15	91	20,677	15	93	21,638	14	93	24,264	14	93	26,208	14	93	28,837	14
600 - 699 beds	47	8,072	8	46	10,441	9	47	11,701	8	47	12,465	8	47	13,833	8	47	15,707	9	48	17,158	8
700 or more beds	72	16,274	17	72	20,032	17	72	23,451	17	75	24,896	16	75	27,050	16	77	28,120	15	75	29,998	15

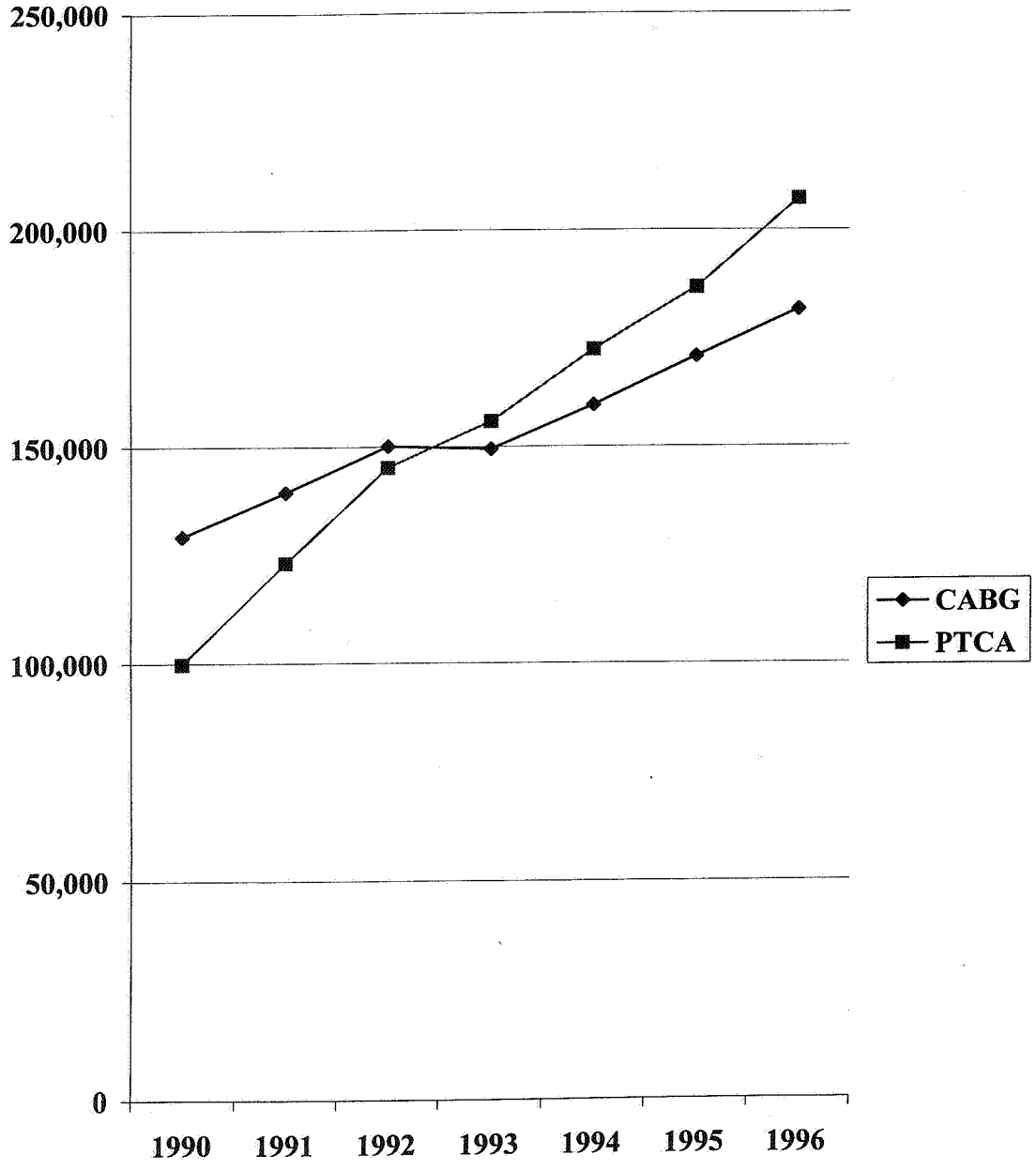
NOTES:

1. Includes all angioplasty procedures defined as cases in DRG 112 with a procedure code of 36.01, 36.02, or 36.05.
2. Categories may not sum to national total because hospitals could not be identified.
3. Calendar year data.
4. Calendar year 1995 data are missing two weeks in late March. 3.8% of sample.

SOURCES: 1990 through 1996 MedPAR files and American Hospital Association files.

Exhibit 2-2

Trends in Medicare Bypass and Angioplasty Volumes, 1990-96



What supports the large growth in both angioplasty and bypass volumes? Medicare enrollment figures have risen, with the number of Medicare hospital insurance and/or supplemental insurance enrollees increasing from 34.2 million in 1990 to 37.3 million in 1995, a 9 percent increase (HCFA, 1996). Demographic changes within the Medicare population may also provide part of the explanation as the median age of the Medicare population is increasing. However, a more likely explanation may simply be that with innovations in CABG and angioplasty treatments more and more physicians (and their patients) are seeing the benefits of intervention as outweighing the risks.

Since hospitals offering angioplasty generally must offer bypass surgery as well (in the event of a failed angioplasty), it is not surprising the breakdowns of hospitals by location, teaching status and bedsize mirror those presented earlier for bypass. The fast majority of hospitals are in urban areas, diffusion was fairly complete among major teaching hospitals, but continued during this period among minor and non-teaching hospitals, and larger hospitals were more likely to perform the procedure than smaller ones.

2.8.2 Medicare Angioplasty Volumes Per Hospital

In Table 2-17 we see that the growth in the number of angioplasty volumes is due to an expansion in the average number of procedures performed as well as the number of hospitals performing angioplasty. The average number of Medicare angioplasties increased by over 70 percent from 1990-96. In 1990 the average hospital treated 124 Medicare patients using angioplasty. By 1996 at number had risen to 215. Similar growth is experienced for

Table 2-17

Average Number of Medicare Angioplasty Treated Per Hospital By Characteristic, 1990-96

	1990	1991	1992	1993	1994	1995	1996
NATIONAL	*124*	*153*	*171*	*172*	*184*	*196*	*215*
Location							
Urban	126	155	173	174	186	200	218
Rural	93	118	140	146	157	162	181
Teaching Status							
Major	166	201	229	228	253	267	290
Minor	127	155	175	179	187	206	228
None	99	124	138	139	149	157	172
Bedsize							
1-199 beds	72	88	92	88	96	94	104
200-299 beds	96	117	135	133	138	150	168
300-399 beds	106	130	144	145	157	172	189
400-499 beds	116	148	170	179	191	207	226
500-599 beds	170	200	228	233	260	282	311
600-699 beds	172	229	251	265	295	335	358
700 or more beds	226	280	326	333	363	366	402

NOTES:

1. Includes all angioplasty procedures defined as cases in DRG 112 with a procedure code of 36.01, 36.02, or 36.05.
2. Calendar year data.
3. Calendar year 1995 data are missing two weeks in late March.

SOURCE: 1990 through 1996 MedPAR files and American Hospital Association files.

urban hospitals, but rural hospitals almost double the average number of cases treated over the same time period. The rates of increase were all similar when comparing major, minor, and non-teaching hospitals. All bedsize categories experienced increases in average number of cases, although the growth did vary somewhat. Average volumes in the smallest hospitals (1-199 beds) increased 44 percent during the 7 year period, compared to 78 percent growth for hospitals with more than 700 beds and more than 100 percent growth for those with 600-699 beds.

Table 2-18 presents distributional statistics for Medicare PTCA volumes for each year. Not surprisingly, given the increase in average volumes, most percentile thresholds experienced considerable growth between 1990 and 1996. For example, in 1990, 10 percent of hospitals were treating 253 or more cases, while in 1996, 10 percent were treating 466 or more cases. However, the lowest thresholds did not experience a comparable increase. In 1990, 5 percent of hospitals performing PTCA treated 21 or fewer cases, by 1996, the comparable figure was only 27 cases. Similarly, the 10th percentile volume rose from 25 cases in 1990 to 39 cases in 1996. Thus, in all years we find a fairly constant proportion of hospitals treating fewer than one Medicare PTCA case per week.

2.8.3 Demographic Characteristics of Medicare Angioplasty Patients

Table 2-19 presents trends in the age, gender, and racial breakdowns of Medicare PTCA patients for 1990-96. The gender differences between angioplasty and CABG patients

Table 2-18

National Distribution Thresholds of Medicare Volumes Among Hospitals Performing Angioplasty, 1990-96

	Percentiles of Hospitals							
National	Mean	5%	10%	25%	50%	75%	90%	95%
1990	125	21	25	48	92	162	253	340
1991	153	27	39	64	114	190	307	416
1992	171	28	37	67	130	224	340	477
1993	172	21	32	66	126	228	360	465
1994	184	23	35	70	135	242	394	496
1995	196	24	37	76	141	257	421	539
1996	215	27	39	84	154	280	466	627

NOTES:

1. Includes all angioplasty procedures defined as cases in DRG 112 with a procedure code of 36.01, 36.02, or 36.05.
2. Calendar year data.
3. Calendar year 1995 data are missing two weeks in late March.

SOURCE: 1990 through 1996 MedPAR files and American Hospital Association files.

Table 2-19

National Number of Medicare Angioplasties By Age, Gender, and Race, 1990-96

	Angioplasty Procedures													
	1990		1991		1992		1993		1994		1995		1996	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Age														
Under 65 years	9,468	9 %	11,275	9 %	13,530	9 %	15,212	10 %	17,839	10 %	19,663	11 %	22,703	11 %
65 - 69 years	35,763	36	41,991	34	47,468	33	49,804	32	53,246	31	55,352	30	58,179	28
70 - 74 years	28,582	29	35,629	29	41,996	29	44,419	29	48,854	28	52,720	28	57,110	28
75 - 79 years	17,850	18	22,528	18	27,183	19	29,205	19	32,487	19	35,747	19	41,296	20
80 - 84 years	6,597	7	9,200	7	11,643	8	13,361	9	15,455	9	17,758	9	20,921	10
85 years and older	1,714	2	2,461	2	3,306	2	3,757	2	4,521	3	5,482	3	6,855	3
Gender														
Male	59,222	59	73,037	59	85,481	59	92,319	59	101,893	59	109,852	59	121,532	59
Female	40,752	41	50,047	41	59,618	41	63,449	41	70,509	41	76,870	41	85,532	41
Race														
Unknown	3,014	3	3,718	3	4,754	3	5,282	3	2,288	1	1,607	1	1,823	1
White	91,261	91	111,836	91	130,816	90	139,325	89	158,175	92	171,503	92	189,136	91
Black	3,606	4	4,699	4	5,773	4	6,488	4	7,912	5	8,869	5	10,149	5
Other	2,093	2	2,831	2	3,745	3	4,672	3	4,027	2	4,743	3	5,956	3

NOTES:
1. Includes all angioplasty procedures, defined as cases in DRG 112 with a procedure code of 36.01, 36.02 or 36.05.
2. Calendar year data.
3. Calendar year 1995 data are missing two weeks in late March. 3.8% of sample.

SOURCE: 1990 through 1996 MedPAR files.

are striking. Typically, only 33 percent of Medicare bypass patients were women, compared to 41 percent of angioplasty patients. (Neither of these values changed substantially during our time frame.) This may reflect differences in severity of disease (number and nature of vessels involved) between men and women, or may reflect the higher risk of surgery for women, resulting from their smaller body size.

Trends in the age distribution of angioplasty patients are also interesting. In 1990, 65 percent of angioplasties were performed on those in the age 65-69 groups. By 1996, this proportion had fallen to 56 percent, as the number of angioplasties performed on Medicare beneficiaries under 65 years and in the 75-79 age groups more than doubled, the number performed on those 80 and older more than tripled.

How does the age distribution of angioplasty patients compare with that of CABG patients? In each year, a sightly higher percentage of angioplasty patients fall into the youngest (under age 65) and oldest (80 and older) categories than is the case for bypass. However, the overall age distributions between bypass and angioplasty patients are quite similar.

As was the case with bypass, roughly 90 percent of angioplasty patients in each year are classified as white, a statistic that does not change noticeably across the 7 years.

2.8.4 Mortality

Table 2-20 indicates that mean mortality rates per hospital did not vary substantially across the 1990-96 period, ranging from 1.3 to 1.6 percent. Mean rates within hospital category (location, teaching status, and bedsize) also do not vary by more than a few tenths of one percent (not shown). However, mortality rates do vary noticeably across all hospitals in each year. For example, in 1990, 25 percent of hospitals performing angioplasty had no deaths, while 5 percent of hospitals had a mortality rate of 5 percent or higher. In later years, the 95th percentile value decreased slightly, although five percent of all hospitals still had mortality rates of 4.1 percent or higher in 1996.

2.8.5 Length of Stay

Lengths of stay for angioplasty patients have fallen dramatically during the 1990-96 period, as shown in Table 2-21. The mean length of stay in 1990 was 6.4 days--by 1996 it had fallen over 30 percent to 4.3 days. Each of the percentile thresholds also experienced a continuous decrease in length of stay. For example, in 1990 five percent of hospitals had stays averaging 9.7 days or longer, but by 1996 the top five percent of hospitals had stays of only 6.2 days.

Lengths of stay for PTCA patients are typically less than half as long as for bypass patients. Both experienced very similar reductions (of roughly one third) in the average length of stay between 1990 and 1996.

Table 2-20

National Distribution Thresholds of Medicare Hospital Angioplasty Mortality Rates, 1990-96

	Percentiles of Hospitals							
	Mean	5%	10%	25%	50%	75%	90%	95%
National								
1990	1.5 %	0.0 %	0.0 %	0.0 %	0.8 %	1.9 %	3.3 %	5.0 %
1991	1.4	0.0	0.0	0.0	0.9	2.0	3.2	4.2
1992	1.3	0.0	0.0	0.0	1.0	1.8	3.0	3.9
1993	1.3	0.0	0.0	0.0	1.0	1.9	3.1	3.9
1994	1.6	0.0	0.0	0.4	1.1	2.1	3.2	4.3
1995	1.4	0.0	0.2	0.3	1.1	2.0	3.0	3.9
1996	1.3	0.0	0.0	0.3	0.9	1.8	2.9	4.1

NOTES:

1. Includes all angioplasty procedures defined as cases in DRG 112 with a procedure code of 36.01, 36.02, or 36.05.
2. Calendar year data.
3. Calendar year 1995 data are missing two weeks in late March. 3.8% of sample.

SOURCE: 1990 through 1996 MedPAR files.

Table 2-21

National Distributions of Medicare Angioplasty Length of Stay Per Hospital, 1990-96 (in Days)

		Percentiles						
National	Mean	5%	10%	25%	50%	75%	90%	95%
1990	6.4	3.8	4.3	5.2	6.2	7.3	8.6	9.7
1991	5.9	3.7	4.2	4.9	5.8	6.8	7.8	8.6
1992	5.6	3.6	3.9	4.6	5.5	6.5	7.5	8.2
1993	5.3	3.3	3.6	4.4	5.3	6.1	7.0	7.9
1994	5.0	3.2	3.5	4.1	5.0	5.7	6.6	7.4
1995	4.8	3.1	3.5	4.0	4.7	5.4	6.2	6.7
1996	4.3	2.8	3.0	3.5	4.1	4.9	5.6	6.2

NOTES:

1. Includes all angioplasty procedures defined as cases in DRG 112 with a procedure code of 36.01, 36.02, or 36.05.
2. Calendar year data.
3. Calendar year 1995 data are missing two weeks in late March. 3.8% of sample.

SOURCE: 1990 through 1996 MedPAR files.

3 Selection of Demonstration Participants

Because the negotiated bundled hospital and physician price for CABG surgery is such a departure from existing reimbursement methods, involving major changes in internal coordination and payment controls within the sites, it is key to explain the basic decision to participate. At bottom is the question of selection bias, not at the patient level as it is ordinarily understood, but at the site level. While not necessarily a problem, bias could severely limit the generalizability of the findings to future applicants. For instance, demonstration applicants may be more financially vulnerable and permit HCFA to negotiate larger discounts than future, more financially secure, applicants.

The basic decision to participate (or apply) can be decomposed into a set of static, current, considerations as well as a set of dynamic, future, expectations. Current considerations are summarized in the question each applicant must answer, "What is in it for us right away?" If an applicant felt that it could negotiate an all-inclusive price that exceeded current total payments, it might apply. A rate set below current payments, on the other hand, does not mean below current costs. Where CABG surgery is already profitable, other factors may be given more weight in the decision to participate; thereby encouraging participation even at a rate lower than currently paid.

Most of the dynamic reasons for participating can be summed up in the phrase, "it will be good for business," or, in a word, volume. If the hospital has high fixed costs and underutilized capacity, then marginal costs may be below any price it might negotiate with HCFA.

Theory suggests several interesting hypotheses. For example, hospitals with unused capacity and higher fixed costs should be more likely to apply. Spillover effects on other patient demand will be important. Hospitals with several local CABG competitors should be more likely to apply, ceteris paribus. Because of higher bad debts, hospitals in areas with less supplemental coverage should be more likely to apply. And, finally, hospitals with the majority of their physicians on salary should be more likely to apply.

3.1 Application Process

Over 700 hospitals performed CABGs on Medicare patients in 1986. All were sent a solicitation by HCFA; yet only 206 submitted letters of interest and a pre-application. Certainly, the majority who didn't apply realized that they lacked the requisite volume, but some potential applicants may not even have submitted letters of intent. Of the 206 submitting letters, only 42 were invited by HCFA to apply of which 27 actually submitted full applications. Lewin/VHI and HER staff reviewed all 27 applications.

The wide range of bids among the 27 hospitals was surprising. Although most were competitive, and some offered substantial discounts on current payments, several hospitals appeared to be bidding premium, rather than discounted, prices. These cannot be considered

serious bids, in spite of the fact that they were well-qualified institutions that worked hard in preparing their bids. Of the 42 hospitals invited to participate, only a small handful (less than 15) were prepared to offer meaningful discounts for the privilege of being called Medicare Participating Heart Bypass Centers. Without the threat of exclusive contracting, HCFA's ability to negotiate substantial reductions for a significant number of high cost, prestigious, institutions is severely limited.

3.2 Evaluation of Bids and Negotiations

HCFA established an outside panel of experts to review the quality of each institution and evaluate the competitiveness of each bid. This process narrowed down the candidates from 27 to ten.

At this point, the evaluation contractor was asked to conduct an in-depth review of each proposal and rank the ten finalists along a number of dimensions.

3.2.1 Ranking the Ten Finalists

Applicants were ranked according to 11 criteria. Four related to price: (1) relative prices; (2) discount rates; (3) financial risk; and (4) volume discounts. Relative prices involved comparisons with other local bypass hospitals. Financial risk involved a subjective evaluation of the risk accepted by the bidder for high cost cases. Applicants were also ranked on their breadth of service coverage, including: (5) coverage of unrelated procedures; and

(6) coverage of readmissions. They were also ranked on their quality of care measured in two ways: (7) severity-adjusted mortality rates; and (8) appropriateness of care. The latter depended primarily on average lengths of stay. The final three criteria were: (9) financial incentives offered patients and referring physicians; (10) the quality of the bypass information systems; and (11) total Medicare and non-Medicare bypass volume.

Applicants were given a score of 0-100 on each criterion using the full range of the scale. An aggregate score was derived using subjective weights reflecting the importance of each criterion. In the basic ranking, the four price elements together were given a weight of 50 percent. The two quality measures together were weighted 25 percent; the two service characteristics, 10 percent total; beneficiary incentives, information systems, and total volume were weighted 5 percent each. Based on these weighted scores, the ten finalists were then ranked from 1 to 10. Because the weighting process was necessarily subjective, sensitivity analysis was used to test the robustness of the rankings by varying the weights. Changing the weights had little effect on the ranking of the top 4-5 hospitals.

3.2.2 Evaluating Price Discounts

The next stage involved extensive negotiations with the top applicants, including face-to-face meetings at HCFA/ORD (Office of Research and Demonstrations) near Baltimore, Maryland. The most challenging aspect of these negotiations was verifying the price discount being offered by the applicants. This required linking Part B physician bills with the corresponding Part A hospital bills. While the addition of pass-throughs

complicates the issue, the Part A calculations are still relatively straightforward. Armen Thoumaian, the Project Officer at HCFA/ORD, with the assistance of Edward Berends, used MDRS data to derive estimates of the average Part B expenditures paid to physicians treating bypass patients in the applicant hospitals. This is a challenging task given the hundreds of hospitals performing CABG surgery in the U.S. and the voluminous bills that must be aggregated and linked by patient ID to Part A bills.

Many problems arose in deriving the benchmark cost estimates used to evaluate each applicant's bid. First, there was the problem of erroneous or missing data. Some Part A bills, for example, had no Part B surgeon's bill, resulting in very low overall costs. Second, there was the question of the scope of included physician bills, given that most applicants did not cover all physicians in their global bid. Outlier trims were used as a rough approach to incomplete data.

In the end, this cost-finding process added considerably to the time and effort in negotiating final bids. The process was extended further in order to complete the OMB waiver cost estimates designed to show the expected savings from the demonstration. If HCFA decided to implement this approach nationwide, it would first have to undertake a major data processing effort using the National Claims History Files.

The size of the average proposed discount across the two DRGs covered under the demonstration varied considerable across the 10 finalists. Four hospitals submitted bids that actually implied premiums, rather than discounts, as their proposed rates were higher than the expenditures projected by HCFA. Two of these four hospitals offered discounts on the

Part A hospital expenditures but proposed Part B physician payments that were more than 40 percent greater than the HCFA Part B estimates. The other two hospitals submitted proposals calling for premium payments to the hospital for participating. A fifth hospital submitted a proposal with rates identical to HCFA's projected expenditures, implying no premium or discount. The remaining five hospitals proposed rates that were discounted relative to projected expenditures.

3.2.3 Negotiations

To focus the negotiations on the ambiguous points in the applicants' proposals, the evaluation staff then produced a negotiation protocol to be used by HCFA/ODE staff in face-to-face meetings with the applicant. (Evaluation staff were not included in these negotiations.) The protocol was based on an in-depth review of each proposal. Questions were developed relating to price, beneficiary incentives, quality assurance, and information systems. HCFA/ODE staff then arranged and completed the negotiation phase.

After negotiations were completed and the original four hospitals were selected, HCFA/ODE sent out a letter asking the six excluded applicants if they would like to reconsider their initial bid. In response, three of the six resubmitted new bids, and the government successfully negotiated rates with these hospitals. As a result, St. Vincent's Hospital in Portland, Oregon, St. Luke's Hospital in Houston and Methodist Hospital in Indianapolis were added to the demonstration in mid-1993, two years after the start of the original demonstration.

3.2.4 Updating the Negotiated Prices

The negotiated prices went into effect for the four original demonstration hospitals in May and June 1991. The negotiated prices have been updated annually for three of the demonstration sites, with the new prices effective January first of each year. The fourth site, Ohio State University Hospital, agreed during the negotiation process to forego updates. The reader is referred to Volume II, Appendix 3, for HCFA's detailed update methodology. Below, we give a brief summary of the method.

The annual Part A update amount is the difference between the DRG operating amounts for the two years under the prospective payment system. The DRG operating amount consists of the DRG base payment, plus any disproportionate share, and indirect medical education adjustments. The DRG base payment is constructed using the DRG relative weight, the hospital wage index, and national and regional adjusted standardized amounts for labor and nonlabor inputs. Thus, the DRG base payment can vary over time as HCFA updates each of these components. For example, the national relative weight for DRG 107 was reduced from 4.7899 in 1991 to 4.2348 in 1993 (St. Anthony Publications, 1991, 1993), leading to a reduction the DRG base payment to demonstration hospitals, ceteris paribus. The disproportionate share factor is based upon the number of inpatient admission days for disabled Social Security recipients receiving Supplemental Security Income and for Medicaid patients as a proportion of total inpatient days. The figure used for the indirect medical education factor is based on interns and residents information used by the Fiscal Intermediary for each hospital.

The annual Part B update is derived by estimating the change in payment for a typical package of physician/supplier services provided during the bypass hospitalization. A typical bundle of services was constructed using CPT-4 codes of the most essential physician services for DRG 106 and 107 combined with estimates of other consulting services typically occurring during the bypass surgical episode. The bundle was based on over 100 bypasses performed at St. Joseph's Hospital in Atlanta. See Appendix 3 for more detail. The change in allowable payments for this bundle was then estimated to construct the update.

Calculation of payment for this bundle was complicated by the introduction of the Medicare Fee Schedule in January, 1992. The annual updates have been adjusted to reflect the transition of payments used to phase in the fee schedule.

3.2.5 Success of Negotiation Process

One of the most important criteria in determining the success of the demonstration is the size of the price discount achieved through selective contracting. The government's negotiating leverage is limited by the Congressional proscription against exclusive contracting. Medicare beneficiaries can still use any hospital they choose for bypass surgery and the government will pay the appropriate DRG rate for Part A and the allowable fees for all Part B physician services. What the government is offering, then, is an imprimatur: the Medicare Participating Heart Bypass Center. This presumably confers status and quality and can be used by the applicant in its marketing efforts. Each hospital-physician team in the country had to evaluate the worth of this imprimatur relative to their own costs, the likely

competitive responses of other local hospitals, and any advantages of being in a demonstration that might become national policy.

In spite of its limited bargaining position, HCFA/ODE staff were able to negotiate sizable discounts of 10 percent or more in the four original participating hospitals (see Table 3-1). Some of the discounts were modest only because Medicare payments were already quite low. For example, the discount rates for St. Joseph's in Atlanta were much lower than for University Hospital in Boston. However, the regular payments to St. Joseph's are $14 - $17 thousand lower than to University Hospital, making it impossible for them to offer as large a discount. Disappointing were the bids of some of the more costly teaching hospitals. These institutions were not willing to offer significant discounts, presumably feeling secure in their competitive position and not fearing substantial loss of volume. How these hospitals would respond to a national program with voluntary participation is unclear. Even less clear would be their response if Congress permitted HCFA to negotiate exclusive contracts in various cities. Given the very high marginal profits hospitals appear to enjoy from bypass surgery (see Chapter 6), many would likely be willing to offer substantial discounts rather than forego Medicare bypass patients altogether.

3.3 Demonstration Hospital Reasons for Participating

As part of an initial 2-day site visit, the evaluation team asked several questions about the hospital's decision to participate. What follows is an analytic synopsis of responses by hospital administrators and physicians.

Table 3-1

Negotiated Discounts at the Demonstration Hospitals

	1991		1992		1993	
	DRG 106	DRG 107	DRG 106	DRG 107	DRG 106	DRG 107
Original Demonstration Sites						
St. Joseph's Hospital - Atlanta						
Payment in Lieu of Demonstration	$29,305	$26,249	$30,550	$27,995	$30,928	$24,731
Negotiated Payment	26,393	23,303	26,434	23,923	27,532	21,693
Discount (Dollars)	2,912	2,946	4,116	4,072	3,396	3,038
Discount Rate	9.9 %	11.2 %	13.5 %	14.5 %	11.0 %	12.3 %
University Hospital - Boston						
Payment in Lieu of Demonstration	46,330	42,970	46,706	44,310	46,795	38,751
Negotiated Payment	35,181	33,671	35,185	34,569	36,566	30,566
Discount (Dollars)	11,149	9,299	11,521	9,741	10,229	8,185
Discount Rate	24.1 %	21.6 %	24.7 %	22.0 %	21.9 %	21.1 %
Ohio State University Hospital						
Payment in Lieu of Demonstration	37,341	33,296	37,446	34,228	39,864	31,382
Negotiated Payment	26,952	21,092	26,952	21,092	26,952	21,092
Discount (Dollars)	10,389	12,204	10,494	13,136	12,912	10,290
Discount Rate	27.8 %	36.7 %	28.0 %	38.4 %	32.4 %	32.8 %
St. Joseph Mercy - Ann Arbor						
Payment in Lieu of Demonstration	35,762	31,782	35,359	32,143	37,783	29,788
Negotiated Payment	32,282	25,578	32,629	26,537	35,470	24,683
Discount (Dollars)	3,480	6,204	2,730	5,606	2,313	5,105
Discount Rate	9.7 %	19.5 %	7.7 %	17.4 %	6.1 %	17.1 %
Expansion Demonstration Sites						
St. Vincent's Hospital - Portland, OR						
Payment in Lieu of Demonstration	-	-	-	-	34,613	27,655
Negotiated Payment	-	-	-	-	30,386	26,100
Discount (Dollars)	-	-	-	-	4,227	1,555
Discount Rate	-	-	-	-	12.2 %	5.6 %
Methodist Hospital - Indianapolis						
Payment in Lieu of Demonstration	-	-	-	-	36,140	28,490
Negotiated Payment	-	-	-	-	33,982	25,934
Discount (Dollars)	-	-	-	-	2,158	2,556
Discount Rate	-	-	-	-	6.0 %	9.0 %
St. Luke's Hospital - Houston						
Payment in Lieu of Demonstration	-	-	-	-	36,491	28,993
Negotiated Payment	-	-	-	-	34,078	27,040
Discount (Dollars)	-	-	-	-	2,413	1,953
Discount Rate	-	-	-	-	6.6 %	6.7 %

NOTE: The four original demonstration hospitals began receiving bundled payment in May-June 1991. The three expansion hospitals began receiving bundled payment in June 1993.

SOURCE: Health Care Financing Administration, Office of Research and Demonstration.

3.3.1 Competitive Pressures

A major reason to participate in the demonstration was competitive pressures, both currently in local markets as well as expected competition in the future. All four original participating institutions are in highly competitive markets: Atlanta, Boston, Columbus, and Ann Arbor. All face at least one serious local competitor in open heart surgery, and most face several competitors. Interestingly, possibly because of who they were, only two of the four were concerned about their national reputation. All had concrete reasons for wanting to protect or expand their current market.

Competition encouraged them to apply in three ways. First, they were concerned about HCFA's future contracting intentions. If the Agency was going to "go national" with the program, they wanted to be on the included list of providers, particularly if HCFA was allowed to engage in selective contracting. Second, they were very concerned about the interest other payers had in bundled CABG payments. Several managed care and regular private insurers had already contacted them about a packaged CABG product with a single, guaranteed rate. A failure to be on HCFA's preferred provider list could also cut into their private market. And third, they were generally concerned about the possibility of not applying and having a local competitor be named a Medicare Participating Heart Bypass Center. Uncertainty about who was bidding, reinforced by local rumors, "forced" some hospitals to bid even if unsure of the cost consequences.

How important was local or national market position in deciding whether to bid? Although none of the four selected demonstration hospitals were nationally recognized open

heart centers, many prestigious centers did apply but were not selected initially. Within their local markets, it is also true that three of the four demonstration hospitals were either the largest bypass provider or, in the case of Ohio State University, a financially secure institution that could afford the risk of not participating. Thus, while competitive concerns were prominent in the decision to apply, they were not the only ones.

All participants recognized the spillover effects on other business and wanted to protect their open heart market share and reputation. Bypass surgery, more than most procedures, relies on a far-flung referral network to generate enough cases to support the surgical team and intensive care services. Marketing the hospital as a Medicare Participating Heart Bypass Center was felt to strengthen its referral network as well as protect it against encroachments from established or new competitors. How effective HCFA's imprimatur is in gaining market share is open to question, however. Some surgeons felt that because they were already doing heart transplants, being designated a Medicare Bypass Center would add little to the hospital's prestige.

3.3.2 Bypasses and Profits

From the hospital's perspective, bypass surgery is generally considered a profitable procedure. All four participating hospitals were seeking to expand volume, even if average costs remained constant, because it more than covered variable costs.

Interestingly, the hospital's desire to increase volume in order to drive down average costs was not an important reason for applying. It is true that administrators in St. Joseph's

Mercy in Ann Arbor and at Ohio State University Hospital were concerned about their high costs, but in general they did not expect the large volume growth necessary to produce significant scale economies. Other participants were low-cost hospitals already.

What was emphasized in these hospitals was the need to put physicians under the same capitated payment incentives that the hospital was under. In order to compete on price for private business and to keep costs below DRG rates, some administrators felt that physicians had to join the hospital team to better manage the whole course of care. Specifically, managers were concerned about lengths of stay in the ICU and routine accommodations and the expensive testing and drugs patients received.

A striking impression one had in visiting the four sites was the economic advantages of concentrating on a few services. St. Joseph's Hospital in Atlanta is the pre-eminent example of the economies to be realized by narrowing the scope of services. It is one of the lowest cost bypass hospitals in the nation. Of the 42 hospitals invited to submit final applications, it ranked fourth (behind The Cleveland Clinic, the Texas Heart Institute, and the University of Alabama) in total bypasses in 1987. St. Joseph's was by far the smallest hospital (346 beds) to be considered in the final ten. Nevertheless, it performed 5.1 bypass surgeries per bed compared to only 2.2 per bed at The Cleveland Clinic or St. Luke's (THI). According to its administrators, roughly 70% of its casemix is cardiac related. It has 50 cardiologists on staff, one for every 6 beds. Its Medicare casemix in 1991 was roughly 2.1, even though it is a nonteaching institution. Its surgeons perform 30-50 heart transplants annually. It has a burgeoning angioplasty service performing several thousand PTCAs a

year. Despite its size and limited national recognition at the start of the demonstration, this hospital knows how to treat heart cases.

Contrast this focus with other major university settings who applied to the demonstration. None performed more than 0.5 bypasses per bed; one-tenth the concentration rate of St. Joseph's. Certainly, these institutions knew how to perform successful open heart surgery as well, but their diversified casemix undoubtedly strains their clinical and management resources which adds to costs.

3.3.3 The Physician's Role in the Participation Decision

Two physician specialties are key in the participation decision: thoracic surgeons and cardiologists. Without doubt, cooperation of the thoracic surgeons is critical to participation. Hospitals appear to have little control over these specialists, who have numerous opportunities to practice elsewhere. Among the demonstration hospitals, the surgeons were interested in expanding their practices, although to varying degrees. But because they are already well paid, the notion of a single bundled payment presents unnecessary financial risk to some.

Surgeon support for participation can go either way in spite of the extra risk. In one site, for example, the thoracic surgeons felt that the hospital was not giving them the attention and support (i.e., operating room time) they deserved. By becoming a Bypass Center, they hoped that open heart surgery would receive more attention. This argument was

less explicit in the other sites, but the surgeons' interest in hospital marketing of bypass surgery was closely related to the desire for "institutional support."

Cardiologists generally viewed bypass surgery as complementary to their activities. Only recently with the introduction of cardiac angioplasty has the cardiologist invaded the surgeon's territory as a direct competitor. Nevertheless, cardiologists still appeared supportive of the Bypass Center concept and felt it would strengthen their referral network as well.

3.3.4 Teaching Hospital Participation

A disproportionate number of bypass hospitals train interns and residents, and 37 of the 42 institutions invited to submit full proposals were teaching hospitals. (St. Joseph's in Atlanta was a notable exception.) This does not mean that they are more likely to apply, however. Of the four demonstration hospitals, Ohio State and Boston University Hospitals are directly linked to a medical school. There was no indication, though, that surgeons were coerced into participating. Many faculty surgeons were interested in expanding their practices and saw the advantages of being involved in a Medicare Heart Bypass Center as a marketing tool.

What was most striking about major teaching hospitals was not their greater likelihood of participating but rather the opposite. Hospitals affiliated with medical schools were less likely to offer substantial discounts and, hence, be selected for two reasons. First, and most important, they are the flagship institutions in their communities. They enjoy high

occupancy rates and extra Medicare reimbursements for teaching. Most presume that they will be part of a selective contracting system if Medicare goes national with bypass packaging. And second, they generally have severe constraints on operating room access and ICU beds. Very few are willing to focus more on bypass surgery, particularly as it becomes more routinized. Consequently, even if thoracic surgeons and cardiologists desired expansion, the hospital often cannot accommodate them to any great extent; this, in spite of the fact that bypass surgery is perceived as a profitable activity that cross-subsidizes other teaching and research. This may also explain why the bids of many well-known teaching hospitals were uncompetitive. Ohio State University is an exception in this regard and may be explained by a desire to rebuild a surgical program that languished in the early 1980s. It is also facing exceptionally vigorous local and regional competition.

4 Comparative Analyses of Demonstration Versus Competitor Hospital Volumes

4.1 Evaluation Questions

This chapter presents findings on Medicare bypass volumes and market shares for the seven hospitals funded under the Medicare Participating Heart Bypass Center Demonstration. The issues addressed in the chapter can be summarized by the following questions:

- Did participation in the demonstration lead to changes in hospital Medicare bypass volumes?
- Did participation in the demonstration lead to changes in hospital Medicare bypass market shares?
- What was the distribution of Medicare bypass cases by DRG in the demonstration hospitals? Did this distribution change after the start of the demonstration?
- Did demonstration hospitals treat a demographic mix of patients that differs from their competitors? Did the demographic mix of patients change after the start of the demonstration?
- Did average length of stay for Medicare bypass patients change after the start of the demonstration?

All of the demonstration sites hoped that the prestige of being named a "Medicare Participating Heart Bypass Center" would lead to growth in the number of bypasses performed at the hospital. Thus, we are interested in knowing whether designation as a demonstration site did in fact lead to volume gains and whether such gains were due to (a) the general growth in CABG surgery, or (b) a shift in existing demand away from local (and

outside) competitors. If all of the demonstration sites' volume increases were due to the growth in CABG surgery generally, then there are no competitive advantages to being a Center. Thus, in Section 4.3 we present the volumes and market shares for bypass surgery of both demonstration and competitor hospitals. We also examine changes in demonstration hospital catchment areas, to determine whether changes in patient volumes result from the hospital drawing from a larger geographic area, or drawing more patients from the catchment area that existed prior to the demonstration.

In Section 4.4 we present volumes and market shares for angioplasty for the demonstration and competitor hospitals. Angioplasty volumes are of interest for two reasons. First, if the demonstration imprimatur increased the volumes of bypass cases, we might find spillover effects, with the increased prestige also leading to an increase in angioplasty cases. This would be particularly likely for hospitals with a large percentage of cases in DRG 106, who have their angiography done during the bypass stay. (As opposed to hospitals who have patients referred specifically for bypass after the results of angiography are known.) Second, for a subset of coronary artery disease patients, both angioplasty and bypass are options for relieving the obstruction. Shifts in the number of patients undergoing bypass versus angioplasty could result from the desire to move patients into or out of the demonstration, since angioplasty patients continued to be paid on a PPS/Medicare Fee Schedule basis.

Bypass patients are classified primarily into two DRGs: DRG 106 for bypass with catheterization; and DRG 107 for patients who have undergone angiography prior to the

bypass admission. Thus, a high proportion of patients in DRG 107 is indicative of a referral center for bypass surgery. In Section 4.5 we examine changes in the proportion of patients by DRG to determine whether shifts in bypass volumes have been accompanied by changes in the proportion of patients who were referred to the hospital after their angiography was completed.

Hospitals can increase profits, even with lower per case payments, if they can reduce resource utilization sufficiently to offset the lower reimbursement. One method by which the hospital could achieve this is by changing its casemix, admitting patients who are less severely ill who require fewer resources. Our claims data do not provide detailed information on patients' medical conditions, such as degree of stenosis or ejection fraction, with which to measure severity. However, they do provide us with data on the patient's age and gender that can be compared across time to see if there have been shifts in the type of patients the hospital treats since the implementation of the demonstration. These issues are discussed in Section 4.6.

Another method of increasing productivity is through shorter lengths of stay. National figures presented in Chapter 2 indicate that the average length of stay has fallen by several days since 1990. In Section 4.7 we compare lengths of stay for the demonstration hospitals and their competitors to determine whether the demonstration sites have been successful in shortening stays more than other hospitals.

4.2 Methods and Data

4.2.1 Pre/Post Study/Control Quasi-Experimental Design

This study uses a quasi-experimental design with seven demonstration hospitals matched to seven control groups. A simpler experimental design would have tested for changes using pre- and post-demonstration data only from the demonstration sites themselves. Some of the research questions can be answered in an absolute sense using only data from the demonstration sites (e.g., did Medicare bypass volumes change in the demonstration hospitals?). However, absolute changes by themselves are not particularly meaningful, given the secular trends in bypass surgery. For example, we know (from Chapter 2) that the number of bypasses performed nationally grew by 40 percent between 1990 and 1996. At a minimum, the trend for the demonstration sites should be compared with the national trend.

Many other research questions demand additional information from non-demonstration sites, calling for a quasi-experimental design. For example, the question "Did market shares change for the demonstration hospitals?" cannot be addressed without information on competitor volumes. Thus, the competitor hospitals naturally form the "control" group for addressing this question. Use of these controls adjusts for growth or shrinkage in local bypass markets that may differ from the national trend towards higher volumes. The comparison groups control for idiosyncratic local factors that may account for changes in Medicare bypass volumes independent of participation in the demonstration.

They also serve as controls for examining bypass casemix and length of stay changes during the demonstration.

4.2.2 Original vs. New Participants

The Medicare bypass demonstration involved seven hospitals around the country. Four original sites started receiving bundled payments in June, 1991. Three "expansion" sites joined the demonstration in June, 1993. Although we generally present similar data for both the original and expansion sites, care must be taken in interpreting the results. For the original sites, we have five years of demonstration data. For the expansion sites, we present much more extensive background material and have three years worth of post implementation data.

4.2.3 Definitions of Demonstration Hospital Markets

Since bypass surgery is often non-urgent, yet a costly, technologically complex procedure, patients may be willing to travel much further for treatment than would be the case for many other conditions. In addition, patient triaging is sensitive to the local physician networks. Cardiologists tend to refer patients to surgeons and facilities that they know and that have treated prior patients successfully. The results of our referring physician survey (discussed in Chapter 9) indicate that the relationship with the hospital staff and superiority of surgical outcomes are the two most important factors influencing the referral decision.

Thus, markets for bypass surgery do not conform to geographic designations such as cities or counties.

Construction of markets for the seven demonstration hospitals was a two-step process. First, all hospitals located within the same metropolitan statistical areas (MSAs) as the demonstration sites were identified. Second, demonstration sites were asked who they viewed as competitors for patients, and were allowed to list hospitals outside of their immediate metropolitan areas. While some hospitals added no competitors outside their MSAs, several, particularly those in smaller metropolitan areas, listed additional hospitals whom they considered competitors. While this method of constructing markets introduces an element of discretion, it results in a more meaningful set of competitors than a simple geographic definition.

Table 4-1 lists the hospitals in each of the seven demonstration markets along with their location, bedsize, teaching status, and ownership.[1] Within each market, the demonstration hospital is listed first and bolded. St. Joseph's Hospital in Atlanta, at 346 beds, is smaller than all five of its competitors. It is the only non-teaching hospital in the market, and the only non-teaching demonstration site. University Hospital in Boston is in competition with eight other major teaching hospitals in the Boston MSA, and also considers Catholic Medical Center in Manchester, New Hampshire, roughly 60 miles from Boston, a competitor, as shown in Exhibit 4-1. With 341 beds, University Hospital is the smallest demonstration hospital. Ohio State University Hospital considers itself competitive for

[1] Major teaching hospitals are those affiliated with medical schools; minor teaching hospitals have residence programs but are not affiliated with a medical school; and non-teaching hospitals have no residency programs.

Table 4-1

Medicare Participating Heart Bypass Center Demonstration Hospitals and Their Competitors

Original Demonstration Sites	Metropolitan Area	Hospital Beds	Percentage of Beds in Market	Teaching Status	Ownership
Atlanta					
Saint Joseph's	**Atlanta**	**346**	**11%**	**Non**	**Not-for-profit**
Emory University	Atlanta	532	17	Major	Not-for-profit
Crawford Long	Atlanta	461	15	Major	Not-for-profit
Grady Memorial	Atlanta	927	30	Major	Public
Piedmont	Atlanta	474	15	Minor	Not-for-profit
Georgia Baptist	Atlanta	374	12	Major	Not-for-profit
Boston					
University Hospital	**Boston**	**341**	**7**	**Major**	**Not-for-profit**
Mount Auburn	Boston	290	6	Major	Not-for-profit
St. Elizabeth's	Boston	350	8	Major	Not-for-profit
Massachusetts General	Boston	1,014	22	Major	Not-for-profit
Beth Israel	Boston	504	11	Major	Not-for-profit
Brigham & Women's	Boston	726	16	Major	Not-for-profit
New England Medical Center	Boston	461	10	Major	Not-for-profit
New England Deaconess	Boston	365	8	Major	Not-for-profit
Lahey Clinic	Boston	272	6	Major	Not-for-profit
Catholic Memorial	Manchester	292	6	Non	Not-for-profit
Columbus					
Ohio State	**Columbus**	**657**	**10**	**Major**	**Public**
University of Cincinnati	Cincinnati	707	11	Major	Public
Riverside Methodist	Columbus	856	13	Major	Not-for-profit
Grant Medical Center	Columbus	423	6	Major	Not-for-profit
Mount Carmel Health	Columbus	764	12	Minor	Not-for-profit
Medical College of Ohio	Toledo	291	4	Major	Public
Miami Valley	Dayton	757	12	Major	Not-for-profit
University Hospital	Cleveland	749	11	Major	Not-for-profit
Doctors Hospital	Columbus	417	6	Non	Not-for-profit
Cleveland Clinic	Cleveland	897	14	Major	Not-for-profit
Ann Arbor					
St. Joseph Mercy - Ann Arbor	**Ann Arbor**	**618**	**9**	**Major**	**Not-for-profit**
Sinai Hospital	Detroit	498	8	Major	Not-for-profit
St. Joseph Mercy	Detroit	450	7	Minor	Not-for-profit
University of Michigan	Ann Arbor	875	13	Major	Not-for-profit
Henry Ford	Detroit	778	12	Major	Not-for-profit
St. Joseph	Flint	423	6	Minor	Not-for-profit
Harper	Detroit	580	9	Major	Not-for-profit
Ingham Medical Center	Lansing	258	4	Major	Public
William Beaumont	Detroit	874	13	Major	Not-for-profit
Mclaren Regional Medical Center	Flint	436	7	Minor	Not-for-profit
Detroit Osteopathic	Detroit	150	2	Non	Not-for-profit
St. John's	Detroit	575	9	Major	Not-for-profit

Table 4-1 (continued)

Medicare Participating Heart Bypass Center Demonstration Hospitals and Their Competitors

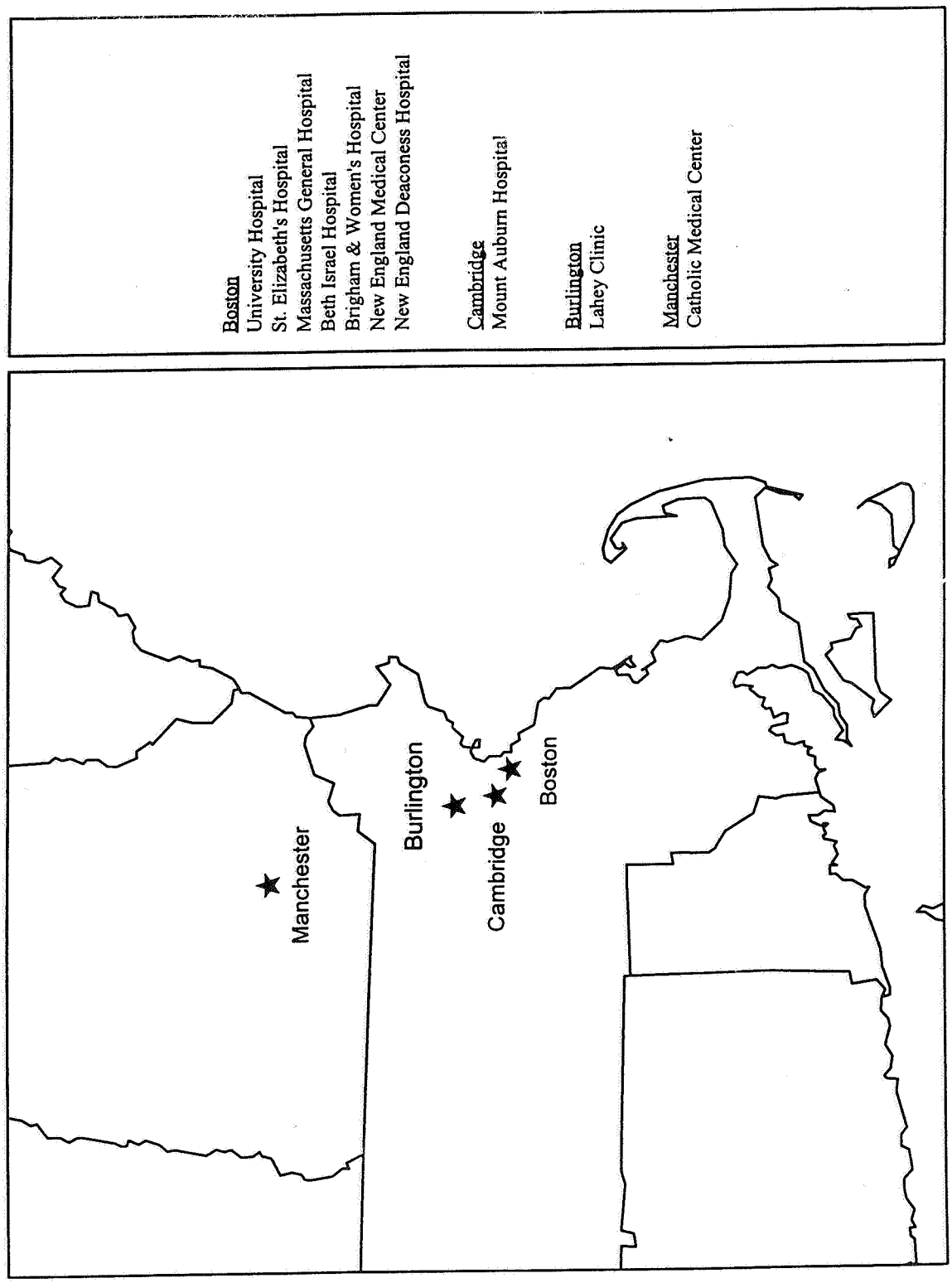
Original Demonstration Sites	Metropolitan Area	Hospital Beds	Percentage of Beds in Market	Teaching Status	Ownership
Portland					
St. Vincent	**Portland**	**451**	**24%**	**Minor**	**Not-for-profit**
Emanuel Hospital	Portland	349	18	Minor	Not-for-profit
University Hospital	Portland	348	18	Major	Public
Good Samaritan	Portland	319	17	Minor	Not-for-profit
Providence Medical Center	Portland	439	23	Minor	Not-for-profit
Indianapolis					
Methodist	**Indianapolis**	**1,051**	**28**	**Major**	**Not-for-profit**
St. Vincent	Indianapolis	857	23	Minor	Not-for-profit
Indiana University	Indianapolis	591	16	Major	Public
St. Francis	Indianapolis	434	12	Minor	Not-for-profit
Community Hospital	Indianapolis	822	22	Non	Not-for-profit
Houston					
St. Luke's	**Houston**	**696**	**9**	**Major**	**Not-for-profit**
St. Joseph	Houston	606	8	Minor	Not-for-profit
Hermann	Houston	575	7	Major	Not-for-profit
Bayshore	Houston	347	4	Non	For Profit
Memorial	Houston	830	10	Minor	Not-for-profit
Medical Center Hospital	Houston	169	2	Non	Public
Methodist	Houston	1,197	15	Major	For Profit
Memorial City	Houston	129	2	Non	For Profit
Humana	Houston	467	6	Non	For Profit
HCA Spring Branch	Houston	298	4	Non	For Profit
Houston Northwest	Houston	390	5	Non	For Profit
Harris County Hospital District	Houston	984	12	Major	Public
Sam Houston Memorial	Houston	181	2	Non	For Profit
HCA West Houston Medical Ctr.	Houston	131	2	Non	For Profit
HCA Medical Center Hospital	Houston	144	2	Non	For Profit
University of Texas	Galveston	785	10	Major	Public

NOTES: 1) Within each market, the demonstration hospital is listed first and bolded.
2) The original demonstration sites began the demonstration June 1991.
The expansion demonstration sites began the demonstration June 1993.
3) Major teaching hospitals are affiliated with Medical Schools; minor teaching hospitals have residency programs but are not affiliated with a medical school; and non-teaching hospitals have no residency programs.

SOURCE: American Hospital Association.

Exhibit 4-1

Massachusetts and New Hampshire



bypass cases with nine hospitals located across Ohio, shown in Exhibit 4-2. Four competitors are located in Columbus (with OSU Hospital), two are in Cleveland, and one each are in Cincinnati, Dayton, and Toledo. Like seven of its competitors, Ohio State University Hospital is a major teaching facility. St. Joseph Mercy Hospital in Ann Arbor considers eleven hospitals located in central and eastern Michigan as competitors, shown in Exhibit 4-3. At 618 beds, St. Joseph Mercy is larger than all but three of its competitors, and is a major teaching facility. St. Joseph Mercy considers the Detroit hospitals, located roughly 35-40 miles to the east as competitors. It did not, however, identify any of the Toledo, Ohio hospitals, located roughly 50 miles from Ann Arbor, as competitors.

Among the three expansion sites, St. Vincent's Hospital is the largest of the five hospitals doing CABG surgery in Portland, Oregon and is a minor teaching hospital. Methodist Hospital in Indianapolis, with 1,051 beds is the largest of the seven demonstration hospitals. It faces competition from four other hospitals in the MSA. St. Luke's is one of fifteen hospitals performing bypass surgery in the Houston MSA. A major teaching facility with 696 beds, it is the only demonstration hospital facing competition from for-profit hospitals.

4.2.4 Data Sources

Data for this analysis come from the Medicare MedPAR Part A claims files. After the files containing all Medicare bypasses in the nation were cleaned and edited as described in Chapter 2, claims for patients treated in the demonstration hospitals and their competitors

Exhibit 4-2

Ohio

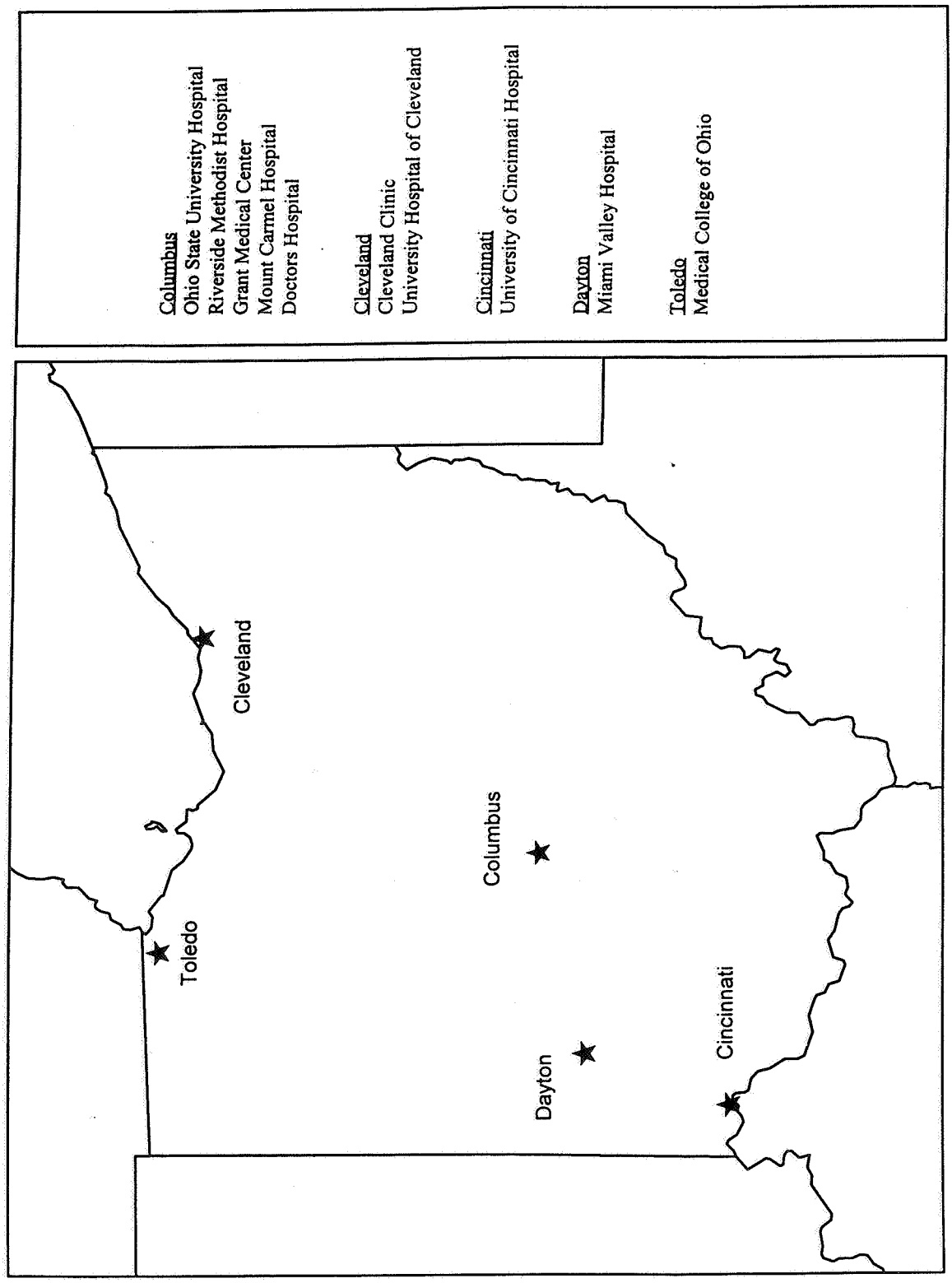
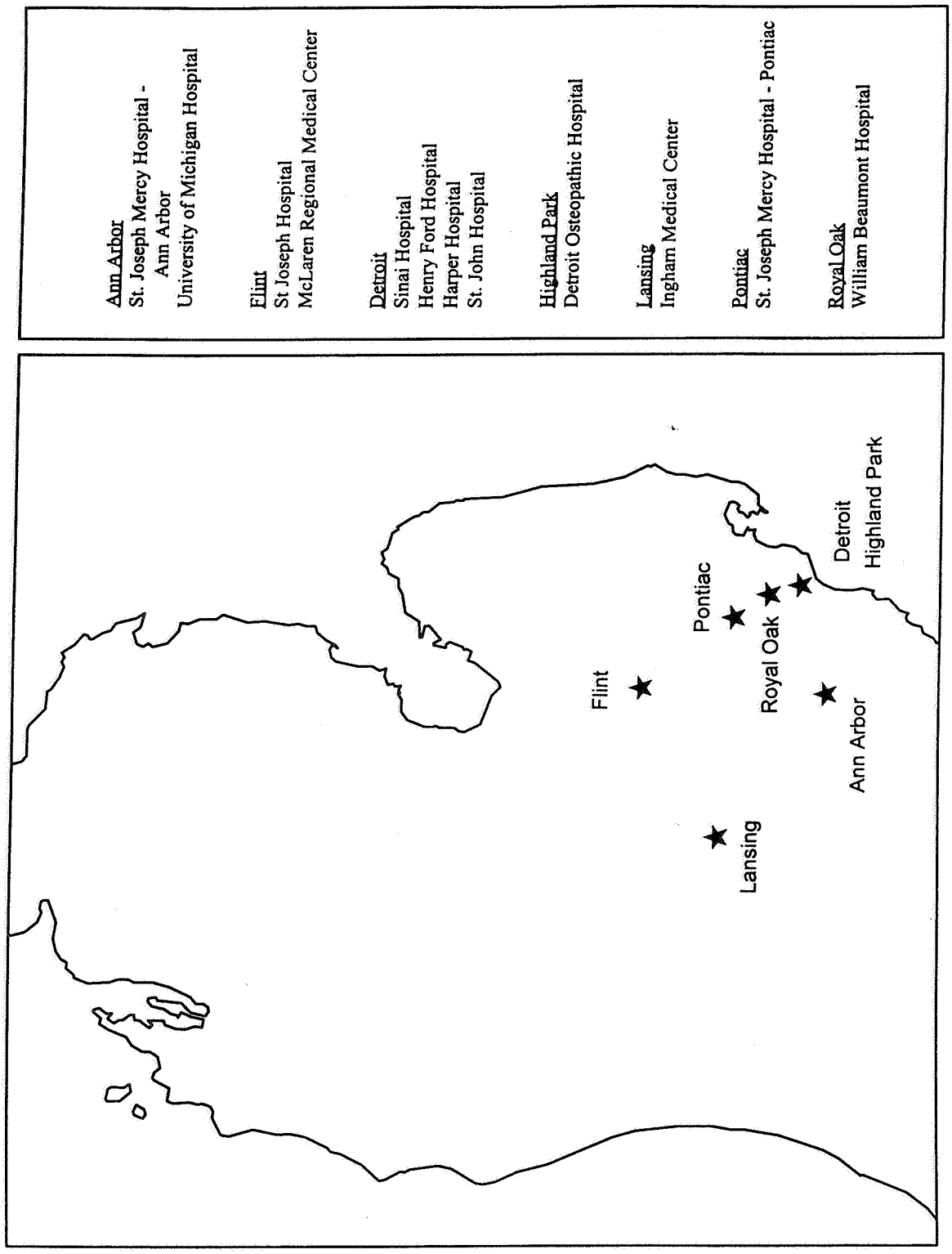


Exhibit 4-3
Michigan



were identified. Volumes and market shares were then constructed for each hospital. Other variables, such as demographic characteristics of patients, mortality, and length of stay are separate fields on the MedPAR file. Examination of the data revealed extremely short average stays in the Portland market, resulting from HMO patients who were transferred to another acute care facility shortly after the bypass surgery. To prevent these patients from biasing the stay estimates downward, HMO enrollees were excluded from all length of stay analyses.

4.3 Medicare Bypass Volume and Market Shares by Site

Table 4-2 shows the number of CABGs performed in each of the demonstration markets for 1990 through 1996. Figures 4-1 and 4-2 shows the demonstration sites' market shares. Again, the reader is reminded that the market is not defined strictly based on geography; a few distant competitors are sometimes included as well.

4.3.1 Original Sites

The demonstration began in May or June, 1991 for the four original sites. Thus, 1990 represents a baseline period for these hospitals, and 1991 is a transition period. Baseline volumes differed substantially among the four sites. In 1990, more than 600 Medicare bypass operations were performed in St. Joseph's Hospital in Atlanta, more than twice as many as at University Hospital in Boston and at St. Joseph Mercy Hospital in Ann

Table 4-2

Medicare Bypass Volumes and Market Shares for Demonstration Hospitals and Their Competitors, 1990-96

Original Demonstration Sites	1990 Medicare CABGs	1990 Market Share	1991 Medicare CABGs	1991 Market Share	1992 Medicare CABGs	1992 Market Share	1993 Medicare CABGs	1993 Market Share	1994 Medicare CABGs	1994 Market Share	1995 Medicare CABGs	1995 Market Share	1996 Medicare CABGs	1996 Market Share
Atlanta														
St. Joseph's	**604**	**37.6 %**	**692**	**38.6 %**	**703**	**39.2 %**	**771**	**41.9 %**	**746**	**39.1 %**	**756**	**37.6 %**	**803**	**37.0 % #**
Emory University	501	31.2	533	29.7	478	26.6	363	19.7	355	18.6	396	19.7	467	21.5
Crawford Long	184	11.5	199	11.1	225	12.5	260	14.1	330	17.3	340	16.9	398	18.3
Grady Memorial	10	0.6	19	1.1	18	1.0	18	1.0	13	0.7	20	1.0	11	0.5
Piedmont	137	8.5	172	9.6	200	11.1	273	14.9	313	16.4	369	18.3	414	19.1
Georgia Baptist	170	10.6	179	10.0	171	9.5	153	8.3	150	7.9	132	6.6	80	3.7
Total	1,606	100.0	1,794	100.0	1,795	100.0	1,838	100.0	1,907	100.0	2,013	100.0	2,173	100.0
Boston														
University Hospital	**249**	**9.8 %**	**242**	**8.9 %**	**211**	**7.5 %**	**225**	**7.9 %**	**250**	**8.0 %**	**285**	**8.7 %**	**295**	**8.6 % #***
Mount Auburn	114	4.5	130	4.8	138	4.9	140	4.9	187	6.0	171	5.2	173	5.1
St. Elizabeth's	233	9.2	205	7.6	154	5.4	190	6.7	141	4.5	183	5.6	149	4.4
Massachusetts General	397	15.6	395	14.6	415	14.7	436	15.4	498	15.9	497	15.1	522	15.3
Beth Israel	254	10.0	277	10.2	261	9.2	226	8.0	233	7.4	217	6.6	347	10.2
Brigham & Women's	344	13.5	348	12.9	330	11.7	367	12.9	391	12.5	409	12.4	492	14.4
New England Medical Center	265	10.4	285	10.5	293	10.4	261	9.2	311	9.9	288	8.8	278	8.1
New England Deaconess	294	11.6	325	12.0	407	14.4	400	14.1	361	11.5	401	12.2	275	8.1
Lahey Clinic	75	2.9	144	5.3	188	6.6	210	7.4	300	9.6	327	9.9	268	7.8
Catholic Medical Center	319	12.5	356	13.2	431	15.2	383	13.5	456	14.6	509	15.5	617	18.1
Total	2,544	100.0	2,707	100.0	2,828	100.0	2,838	100.0	3,128	100.0	3,287	100.0	3,416	100.0
Columbus														
Ohio State University	**131**	**5.1 %**	**125**	**4.6 %**	**131**	**4.7 %**	**153**	**5.5 %**	**143**	**5.2 %**	**184**	**5.9 %**	**208**	**6.3 % #***
University of Cincinnati	118	4.6	190	7.1	180	6.5	150	5.4	140	5.1	152	4.9	151	4.5
Riverside Methodist	582	22.8	650	24.2	674	24.2	639	22.9	612	22.1	663	21.4	729	22.0
Grant Medical Center	148	5.8	156	5.8	166	5.9	193	6.9	226	8.2	218	7.0	245	7.4
Mount Carmel	207	8.1	238	8.8	247	8.9	303	10.8	336	12.2	415	13.4	456	13.7
Medical College of Ohio	75	2.9	62	2.3	69	2.5	75	2.7	61	2.2	92	3.0	106	3.2
Miami Valley	165	6.5	156	5.8	190	6.8	192	6.9	173	6.3	208	6.7	168	5.1
University Hospital of Cleveland	138	5.4	108	4.0	134	4.8	160	5.7	187	6.8	204	6.6	209	6.3
Doctors Hospital	78	3.1	72	2.7	72	2.6	86	3.1	79	2.9	100	3.2	130	3.9
Cleveland Clinic	915	35.8	933	34.7	927	33.2	844	30.2	807	29.2	865	27.9	917	27.6
Total	2,557	100.0	2,690	100.0	2,790	100.0	2,795	100.0	2,764	100.0	3,101	100.0	3,319	100.0

Table 4-2 (continued)

Medicare Bypass Volumes and Market Shares for Demonstration Hospitals and Their Competitors, 1990-96

	1990		1991		1992		1993		1994		1995		1996	
	Medicare CABGs	Market Share	Medicare CABGs	Market Share	Medicare CABGs	Market Share	Medicare CABGs	Market Share	Medicare CABGs	Market Share	Medicare CABGs	Market Share	Medicare CABGs	Market Share
Ann Arbor														
St. Joseph Mercy - Ann Arbor	**284**	**10.2 %**	**306**	**10.8 %**	**325**	**11.0 %**	**455**	**15.2 %**	**421**	**13.7 %**	**423**	**13.4 %**	**451**	**14.6 % #***
Sinai Hospital	198	7.1	186	6.6	128	4.3	141	4.7	129	4.2	129	4.1	148	4.8
St. Joseph Mercy	106	3.8	118	4.2	172	5.8	155	5.2	152	4.9	200	6.3	210	6.8
University of Michigan	207	7.5	219	7.7	209	7.1	172	5.7	198	6.4	183	5.8	177	5.7
Henry Ford	179	6.5	143	5.1	162	5.5	159	5.3	167	5.4	174	5.5	168	5.5
St. Joseph	112	4.0	118	4.2	127	4.3	113	3.8	140	4.6	125	4.0	78	2.5
Harper Hospital	220	7.9	258	9.1	267	9.1	232	7.7	208	6.8	217	6.9	197	6.4
Ingham Medical Center	275	9.9	316	11.2	352	11.9	325	10.8	307	10.0	271	8.6	103	3.3
William Beaumont	437	15.8	394	13.9	428	14.5	458	15.3	453	14.7	491	15.6	542	17.6
McLaren Regional	193	7.0	243	8.6	237	8.0	248	8.3	334	10.9	350	11.1	397	12.9
Detroit Osteopathic	86	3.1	39	1.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
St. John's	477	17.2	489	17.3	541	18.4	544	18.1	566	18.4	589	18.7	609	19.8
Total	2,774	100.0	2,829	100.0	2,948	100.0	3,002	100.0	3,075	100.0	3,152	100.0	3,080	100.0
Expansion Demonstration Sites														
Portland														
St. Vincent	**393**	**43.6 %**	**563**	**50.0 %**	**562**	**48.8 %**	**517**	**52.1 %**	**490**	**53.6 %**	**404**	**49.2 %**	**373**	**43.6 % #**
Emanuel Hospital	60	6.7	37	3.3	72	6.3	33	3.3	48	5.2	34	4.1	28	3.3
University Hospital	26	2.9	48	4.3	20	1.7	31	3.3	15	1.6	23	2.8	24	2.8
Good Samaritan	279	30.9	282	25.1	316	27.4	264	26.6	229	25.0	210	25.6	231	27.0
Providence Medical Center	144	16.0	195	17.3	182	15.8	147	14.8	133	14.5	150	18.3	199	23.3
Total	902	100.0	1,125	100.0	1,152	100.0	992	100.0	915	100.0	821	100.0	855	100.0
Indianapolis														
Methodist	**352**	**28.4 %**	**335**	**26.8 %**	**372**	**28.0 %**	**328**	**22.6 %**	**334**	**22.9 %**	**306**	**20.6 %**	**320**	**21.6 % #***
Indiana University	94	7.6	97	7.8	115	8.7	106	7.3	118	8.1	100	6.7	106	7.2
St. Francis	170	13.7	199	15.9	181	13.6	225	15.5	211	14.5	260	17.5	259	17.5
Community Hospital	110	8.9	115	9.2	111	8.4	102	7.0	85	5.8	59	4.0	52	3.5
St. Vincent	512	41.3	502	40.2	548	41.3	693	47.7	710	48.7	764	51.3	743	50.2
Total	1,238	100.0	1,248	100.0	1,327	100.0	1,454	100.0	1,458	100.0	1,489	100.0	1480	100.0

Table 4-2 (continued)

Medicare Bypass Volumes and Market Shares for Demonstration Hospitals and Their Competitors, 1990-96

	1990		1991		1992		1993		1994		1995		1996	
	Medicare CABGs	Market Share	Medicare CABGs	Market Share	Medicare CABGs	Market Share	Medicare CABGs	Market Share	Medicare CABGs	Market Share	Medicare CABGs	Market Share	Medicare CABGs	Market Share
Houston														
St. Luke's	**686**	**33.5 %**	**680**	**34.3 %**	**622**	**32.0 %**	**643**	**33.9 %**	**610**	**34.9 %**	**516**	**30.1 %**	**524**	**29.8 % #***
St. Joseph	185	9.0	69	3.5	82	4.2	48	2.5	39	2.2	32	1.9	29	1.6
Hermann	33	1.6	82	4.1	93	4.8	83	4.4	70	4.0	103	6.0	104	5.9
Bayshore	44	2.1	43	2.2	42	2.2	51	2.7	50	2.9	40	2.3	19	1.1
Memorial	156	7.6	157	7.9	167	8.6	165	8.7	136	7.8	169	9.9	168	9.5
Medical Center Hospital	70	3.4	91	4.6	92	4.7	63	3.3	75	4.3	69	4.0	88	5.0
Methodist	504	24.6	467	23.5	470	24.2	500	26.4	407	23.3	451	26.3	490	27.8
Memorial City	58	2.8	66	3.3	74	3.8	62	3.3	68	3.9	92	5.4	86	4.9
Humana	42	2.1	50	2.5	43	2.2	26	1.4	15	0.9	5	0.3	6	0.3
HCA Spring Branch	82	4.0	60	3.0	55	2.8	51	2.7	72	4.1	54	3.2	53	3.0
Houston Northwest	46	2.2	57	2.9	54	2.8	66	3.5	51	2.9	52	3.0	72	4.1
U. Texas - Galveston	62	3.0	62	3.1	60	3.1	61	3.2	82	4.7	66	3.9	61	3.5
Other	80	3.9	101	5.1	90	4.6	80	4.2	74	4.2	64	3.7	60	3.4
Total	2,048	100.0	1,985	100.0	1,944	100.0	1,899	100.0	1,749	100.0	1,713	100.0	1760	100.0

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Within each market, the demonstration hospital is listed first and bolded.
3. Calendar year data.
4. The original demonstration sites began the demonstration June 1991. The expansion demonstration sites began the demonstration June 1993.
5. # indicates domonstration market shares varied significanly across the seven years. * indicates the 1996 market share differed significantly from the 1990 market share ($p < .05$).

SOURCE: 1990 through 1996 MedPAR files.

Figure 4-1

Market Shares for Original Demonstraton Hospitals

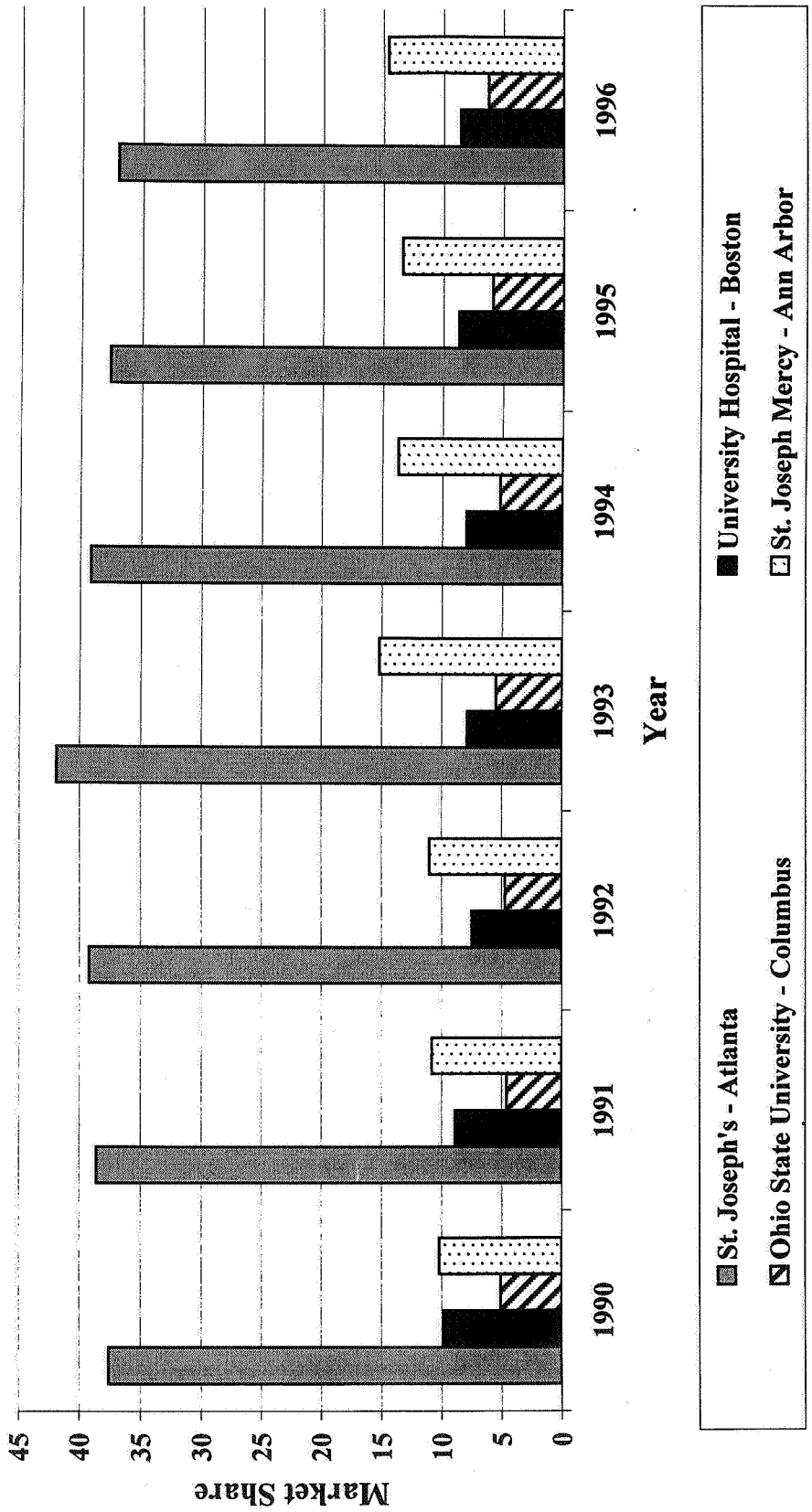
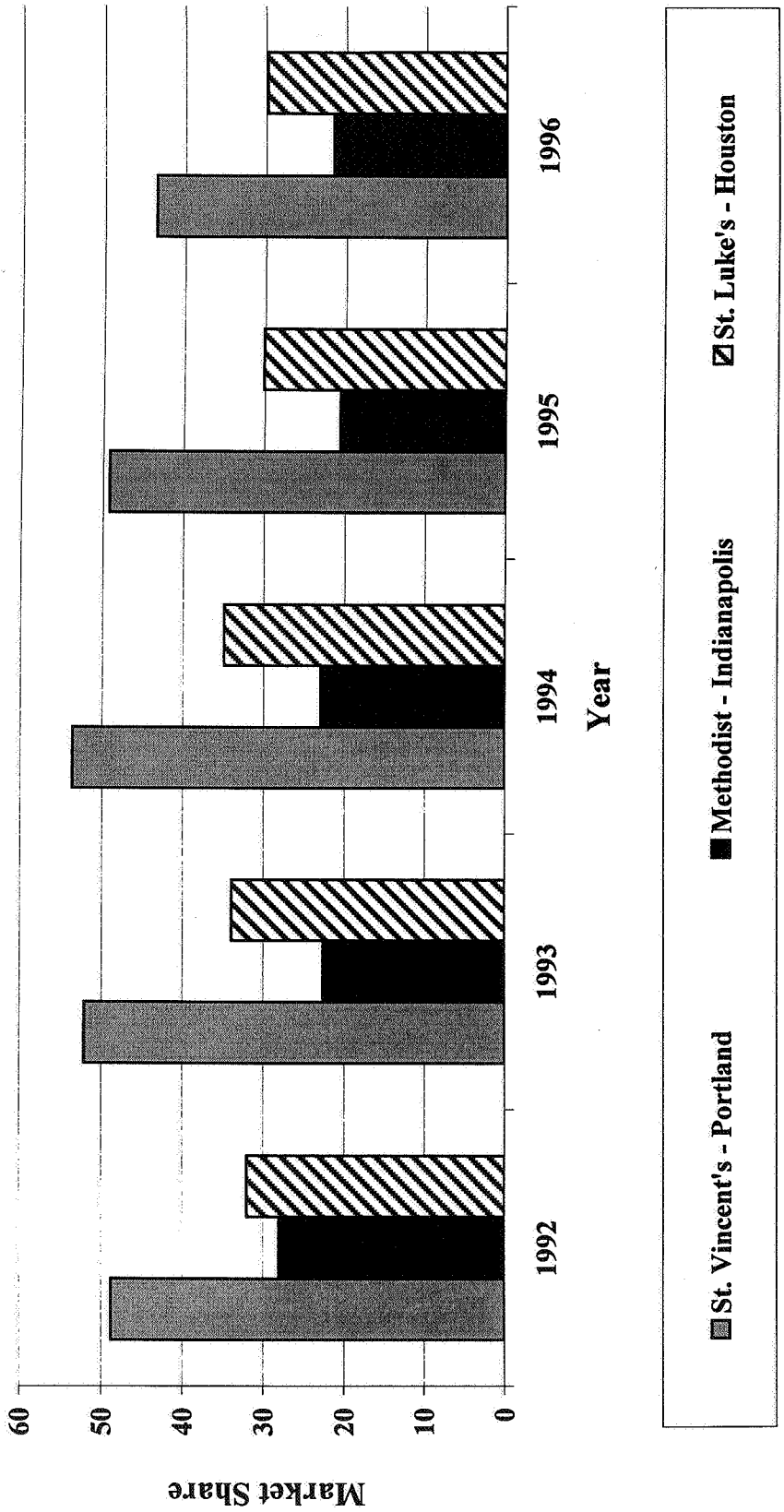


Figure 4-2

Market Shares for Expansion Demonstraton Hospitals



Arbor. Only 131 Medicare operations were performed in Ohio State University Hospital, the lowest Medicare volume of any of the seven demonstration sites.

St. Joseph's Hospital in Atlanta experienced a 28 percent increase in the number of Medicare bypasses performed between 1990 and 1993, from 604 to 771 cases. The total number of Medicare CABGs done in the Atlanta market rose 13 percent during this period, from 1,606 to 1,838. As a result, the large increase in CABGs for St. Joseph's, Atlanta, translated to a more modest increase in market share, from 38 to 42 percent. A chi-square test indicated that this change in market share was statistically significant ($p < 0.05$). The number of bypasses performed decreased slightly in 1994 before reaching a seven-year high of 803 in 1996. The hospital's market share fell from 42 percent to 37 percent during the 1993-96 period, however, as the number of bypasses performed in the market continued to increase at an even faster rate. Hence, the hospital's Medicare market shares prior to the demonstration and at its completion were not significantly different.

For all seven years, St. Joseph's Hospital in Atlanta had the highest volume of Medicare CABGs in the Atlanta market. Their major competitor was Emory University Hospital, which saw its Medicare bypass volume decrease from 501 cases in 1990 to 355 cases in 1994, before experiencing volume increases in 1995 and 1996. Thus, the market share of St. Joseph's major competitor fell from 31.2% to 21.5% during the course of the demonstration, leaving St. Joseph's in a much more dominant market position by 1996. The increase in Emory Hospital's volumes during 1995 and 1996 may result from a competitive response to St. Joseph's growing market share. However, we have very little information on

competitor sites' reactions to the demonstration hospitals. In contrast, two of the competitors with smaller volumes in 1990, Crawford Long and Piedmont Hospital, experienced substantial volume increases by 1996. Physicians belonging to the major cardiothoracic surgery group treating patients at St. Joseph's also have privileges at Piedmont Hospital. Thus, the shifts in market share may to some extent reflect changes in surgeon referral patterns to hospitals. The two remaining hospitals experienced decreasing or constant volumes between 1990 and 1996.

A second demonstration hospital, St. Joseph Mercy, Ann Arbor, also experienced a large increase in volume between 1990 and 1993, from 284 to 455 cases. This 56 percent increase in volume translated into a significant increase in market share from 10 to 15 percent. However, as was the case with St. Joseph's Atlanta, volumes and market shares fell in 1994 and 1995. Unlike St. Joseph's in Atlanta, the 1996 market share for St. Joseph Mercy remained significantly higher than in 1990 prior to the demonstration.

St. Joseph Mercy's competitors include the University of Michigan Hospital, also in Ann Arbor, as well as four hospitals in Detroit, two in Flint, and one each in Lansing, Pontiac, and Royal Oak (see Exhibit 4-3). While St. Joseph's was experiencing an increase in volumes and market share, the University of Michigan Hospital experienced a decrease in market share from 7.5% to 5.7%. As a result, in each of the years 1993-96, St. Joseph's Medicare CABG volume was more than twice as great as that of its nearest direct competitor. The demonstration site's two highest volume competitors were William Beaumont and St. John's hospitals, both of which had experienced slight market share increases between 1990

and 1996. St. John's Hospital is in downtown Detroit and is not competing directly with St. Joseph's for a large number of urban patients, who would be unlikely to travel to Ann Arbor for surgery. However, William Beaumont, in suburban Royal Oak is likely to compete more directly with St. Joseph Mercy for patients residing west of downtown Detroit.

University Hospital in Boston experienced decreases in cases in 1991 and 1992, followed by an increase for 1993 through 1996. This corresponded to a significant decrease in its market share between 1990 and 1992. Although the market share increased between 1992 and 1996, the 1996 level was still significantly lower than the 1990 pre-demonstration share because of the strong growth in overall market volume (up 34 percent). University Hospital competes with other major teaching hospitals in Boston for CABG patients, especially Massachusetts General Hospital and Brigham and Women's Hospital that together control nearly 30 percent of the Boston Medicare market. Catholic Medical Center in Manchester, New Hampshire, also has a large share of the market. Although University Hospital considers Catholic Medical Center to be a competitor, it seems likely that Catholic Medical Center draws patients primarily from New Hampshire, rather than from the Boston metropolitan area. (Excluding Catholic Medical Center from the market, University Hospital's market share would have fallen slightly from 11.2 to 10.5 percent between 1990 and 1996. The two hospitals experiencing the largest growth in market shares were Catholic Medical Center, increasing from 12.5 to 18.1 percent of the market, and the Lahey Clinic, with Medicare bypass volumes increasing from only 75 in 1990 to 268 in 1996. Several

hospitals experienced small declines in market share, while St. Elizabeth's experienced a noticeable decrease.

The fourth original demonstration site, Ohio State University Hospital, experienced virtually constant bypass volumes across the first three years, before volumes grew 14 percent in 1993. This was followed by a slight decrease in volumes in 1994 (to 143 Medicare cases), and then 45 percent growth in volumes between 1994 and 1996. This translated into an eventual increase in market share from 5.1 percent in 1990 to 6.3 percent in 1996, which was statistically significant, despite a 30 percent growth in total market volume. Ohio State listed competitor hospitals in Cincinnati, Cleveland, Dayton, and Toledo, as well as Columbus. Excluding the Cleveland Clinic, which has one of the largest Medicare bypass volumes in the country, OSU's market share would be in the 8-9% range. Among the hospitals in Columbus, OSU's market share rose from 11.4 to 11.8% from 1990 to 1996. The local market is dominated by Riverside Methodist, with volumes rising from 582 cases in 1990 to 729 cases in 1996. The hospital experiencing the largest growth in local market share from 1990-96 was Mount Carmel whose Medicare bypass volume rose from 207 to 456.

4.3.2 Expansion Demonstration Sites

For the demonstration sites, 1990 to mid-1993 represents the pre-demonstration period. St. Luke's of Houston had the largest pre-demonstration volumes, with more than

600 Medicare cases in each of the years 1990-92, followed by St. Vincent in Portland and Methodist of Indianapolis.

St. Vincent's Hospital experienced a 43 percent increase in Medicare CABG volume between 1990 and 1991, from 393 to 563 patients (Table 4-2). Much of this increase resulted from an influx of Medicare Kaiser HMO patients, whose insurer contracted with St. Vincent's to provide bypass surgery. These patients typically have a very short stay at St. Vincent's and are then transferred to another short-term hospital. St. Vincent's Medicare CABG volume then remained virtually unchanged between 1991 and 1992, before declining over 10 percent in 1993, although its market share actually rose in a shrinking bypass market. Volumes continued to decline in 1994, 1995 and 1996, with market share in 1996 being identical to market share in 1990, but well below its 1992 pre-demonstration share. St. Vincent's Hospital had the largest market share in Portland for all seven years. Among its competitors, only Providence Medical Center experienced any substantial growth in volumes across the seven year period. Providence Medical Center belongs to the same system as St. Vincent's, so some of the volume shifts may result from triaging between the two hospitals in the system. Good Samaritan, considered the only serious bypass competitor by St. Vincent's within the Portland market, saw a 3-point decline in market share.

Methodist Hospital in Indianapolis experienced an unusual pattern of increasing and decreasing volumes across each of the years between 1990 and 1996. Volumes for the seven years ranged from 328 to 372 Medicare bypasses. The market share for Methodist Hospital in Indianapolis fell during the seven year period, from 28.4 percent to 21.6 percent

(a statistically significant decrease), even though 1996 was an "up" year for volume. Between 1992 (the last pre-demonstration year) and 1996, market share fell from 28.0 to 21.6 percent. In all seven years, Methodist had the second largest market share among the five hospitals in Indianapolis offering CABG surgery. However, fluctuations in volumes at Methodist, coupled with strong volume increases at St. Francis and St. Vincent Hospitals, led to a lower market share for Methodist. This decrease is particularly noticeable for 1993, the first year of the demonstration at this site. In contrast, St. Vincent's domination of the market grew from a 41.3% market share in 1990 to a 50.2% market share in 1996.

St. Luke's Hospital in Houston experienced a 24 percent decrease in Medicare CABG volumes between 1990 and 1996; 18 percent since 1993. Even with the decrease, more than 500 Medicare CABGs were performed in St. Luke's in 1996. St. Luke's in Houston also experienced a small decline in market share during the seven-year period, although it maintained the largest market share for all seven years. St. Luke's and Methodist Hospital dominated the Houston market, with a combined market share of roughly 60 percent in each year. However, Methodist's share of the market rose from 24.2 percent in 1992 to 27.8 percent in 1996, while St. Luke's was declining. Thus, while St. Luke's and Methodist continue to dominate the market, St. Luke's has failed to maintain its volume during the demonstration. St. Luke's did not market the demonstration, citing their existing national prestige. Five hospitals in Houston had market shares of less than 2 percent, and another seven had market shares of less than 5 percent in each of the seven years. Although each of these hospitals has a small volume individually (fewer than 90 Medicare bypasses), as a

group they diminish St. Luke's market share, and provide managed care organizations with an alternative for contracting.

Did Medicare bypass volumes become more regionalized in large hospitals during the course of the demonstration? To examine the concentration of cases, we constructed a Herfindahl index for each market in the year prior to the start of the demonstration and in 1996 (see Figure 4-3).[2] In three markets, Atlanta, Columbus, and Portland, the Herfindahl decreased between 1990 and 1996, indicating a lower level of concentration of cases. Each of these markets had a large volume hospital (Emory, Cleveland Clinic, and St. Vincent's, respectively) that lost substantial market share during the demonstration. Ann Arbor and Indianapolis experienced increases in concentration (indicated by the higher Herfindahl) while Boston and Houston remained virtually unchanged. Thus, the evidence regarding regionalization is quite mixed for these sites.

4.3.3 Volume Trends by Quarter

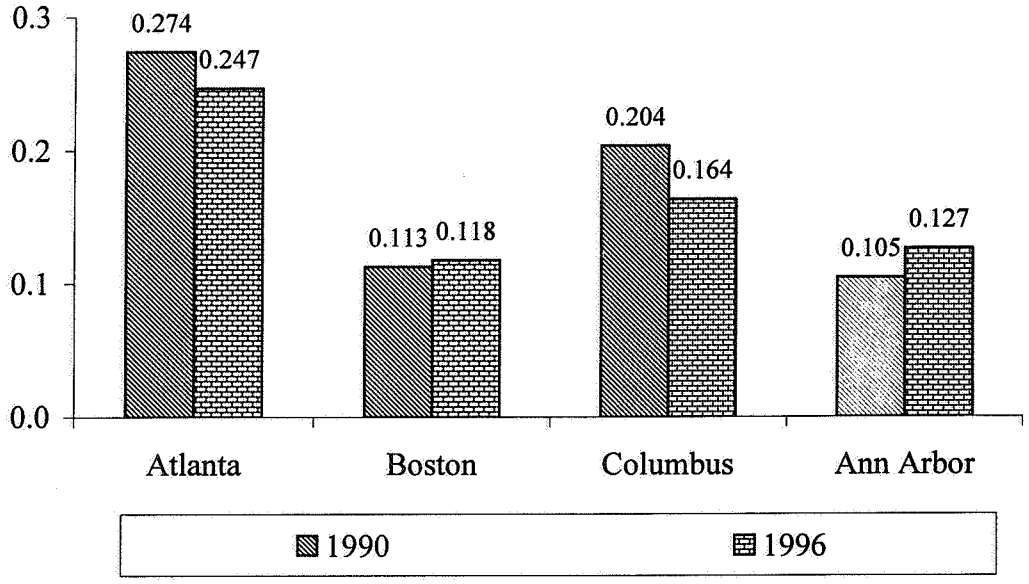
To gain a better understanding of how the demonstration affected volumes, Figure 4-4 presents Medicare discharges per quarter during the seven-year period. For the original demonstration sites, the first six quarters are pre-demonstration while the last 22 quarters are post-demonstration. (Although the demo was scheduled to end June 30, 1996, demo sites were given the option to maintain the negotiated bundled payment while HCFA selected sites

[2] The Herfindahl index is constructed by squaring each individual hospital's market share, and then summing the squared values. Thus, if all cases were concentrated in one hospital, the Herfindahl index would equal one. As cases become dispersed across more hospitals, the Herfindahl index decreases, with its lower boundary being zero.

Figure 4-3

Pre- and Post-Demonstration Herfindahl Indexes for the Demonstration Markets

Original Sites



Expansion Sites

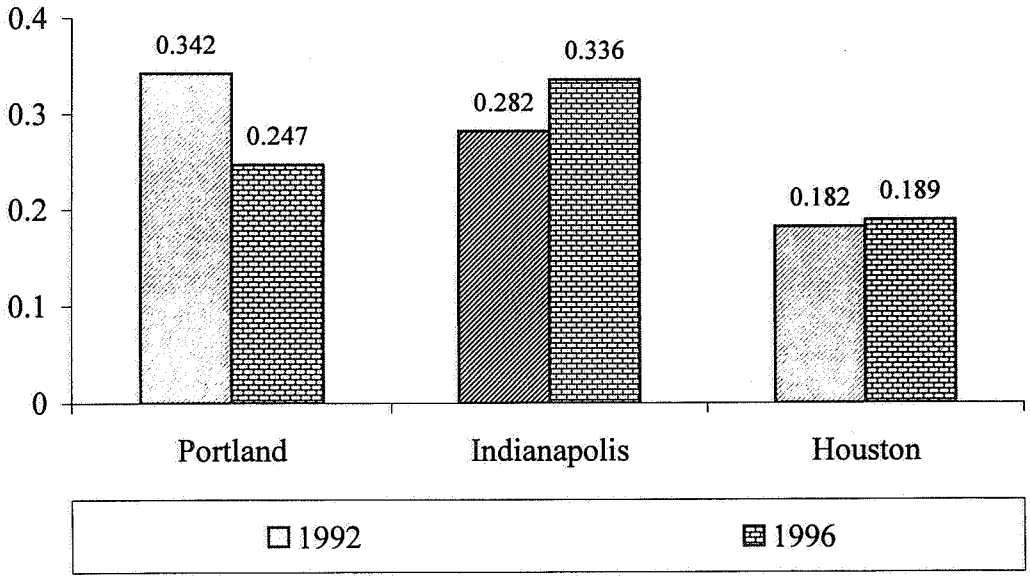
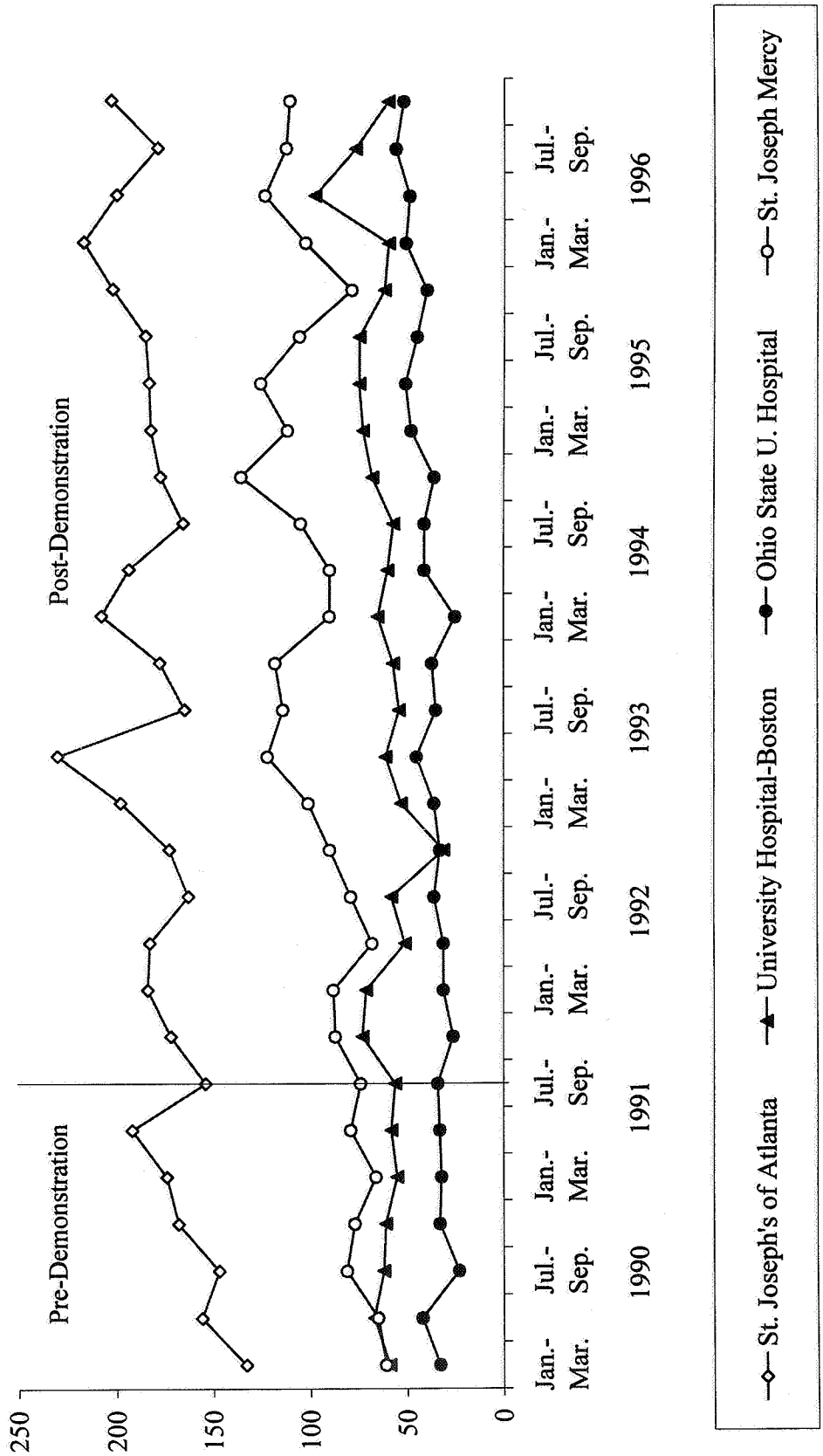


Figure 4-4

Medicare Bypass Volumes at Demonstration Hospitals, by Quarter, 1990-96



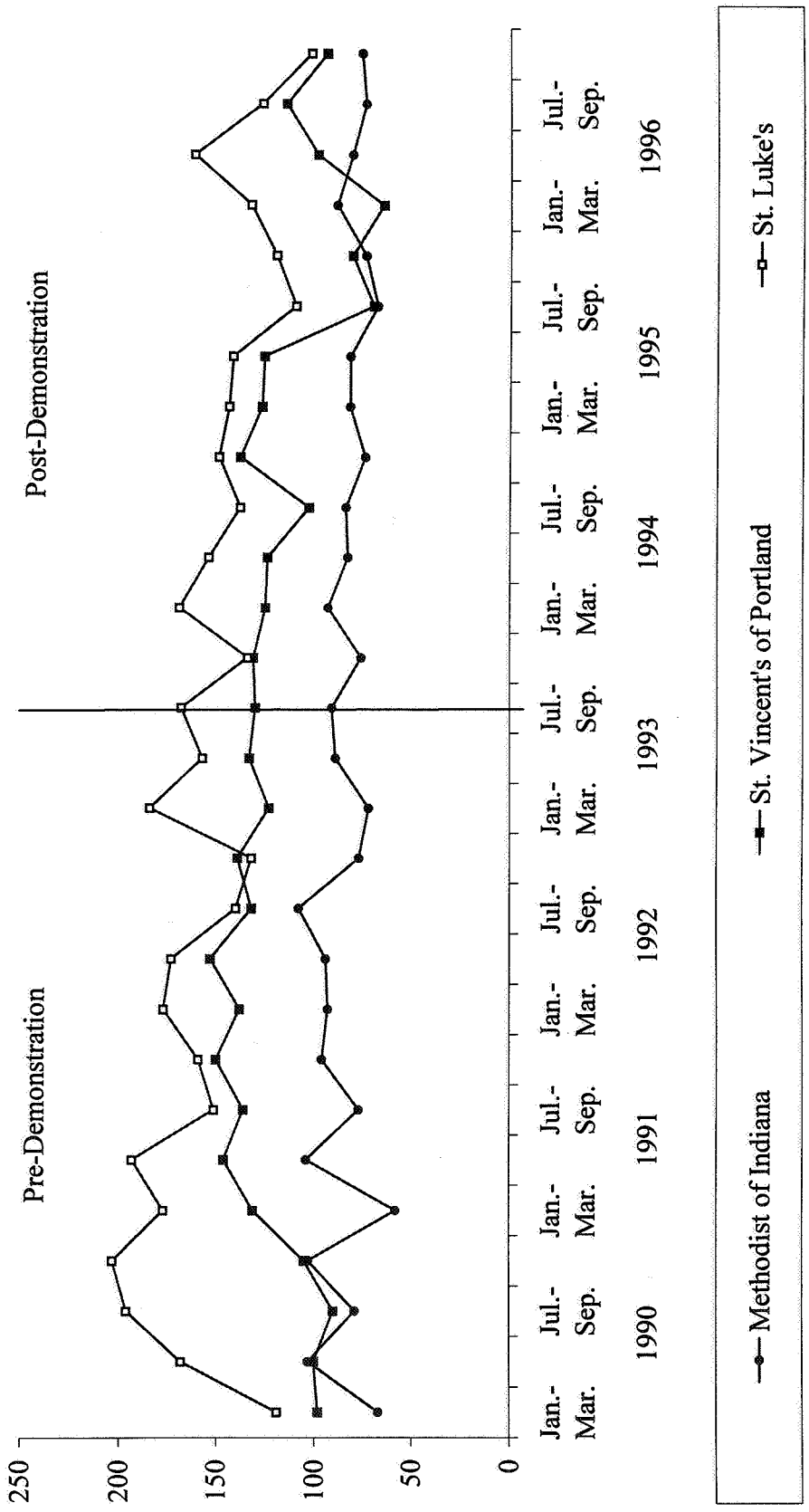
for its Participating Centers of Excellence Demonstration if they applied for the new demonstration. All but one of the sites elected to stay on the demonstration payment system and apply for the Participating Centers of Excellence Demo. Hence, on this table we also present data for the last two quarters of 1996.)

No immediate effect of the demonstration on volumes is apparent. There is substantial variation in volumes by quarter across all sites, with no readily apparent trend in the two quarters after the demonstration began versus the earlier quarters. Comparing total volumes for the four quarters before and after the demonstration began, two sites (St. Joseph's Hospital in Atlanta and Ohio State) experienced volume increases of less than two percent, while the other two sites experienced volume increases of 5-7 percent. It is not until 1993 that a trend becomes more readily apparent. The second quarter in 1993 was the first quarter during which St. Joseph's Hospital in Atlanta performed more than 200 Medicare bypasses, although the hospital did do 192 in the quarter just prior to the demonstration. St. Joseph Mercy increased its volume to more than 100 bypasses during each quarter of 1993, compared with 79 in the quarter prior to the demonstration. In contrast, the 1993 quarterly volumes for Ohio State University Hospital and University Hospital in Boston look quite similar to those in pre-demonstration quarters.

For the expansion demonstration sites (see Figure 4-5), volumes in the four quarters after the demonstration began all look very similar to those in the preceding four quarters. It is difficult to discern trends across quarters because of large swings in volumes across quarters both before and after the demonstration. For instance, Methodist Hospital in

Figure 4-5

Medicare Bypass Volumes at Demonstration Hospitals, by Quarter, 1990-96



Indianapolis performed 103 surgeries the fourth quarter of 1990, followed by 58 and 104 cases in the first two quarters of 1991. Similarly, in 1992 the highest quarter volume at University Hospital was more than twice as large as the smallest volume, and quarterly volumes at Methodist, St. Joseph Mercy and St. Luke's all varied by more than 30 percent.

4.3.4 Where do Medicare Bypass Patients Come From?

Each of the demonstration sites hoped to increase volumes and market shares during the course of the demonstration. Increases in volumes could be accomplished two ways: by drawing more patients from their existing market areas, or by expanding the market to draw patients from different geographic areas. Hence, we can classify the hospitals as engaging in intensive and extensive competition. Intensive competition would result in an increase in local market share as the imprimatur was used as a signal of high quality. Extensive competition would result in an increase in use of the demo site as a referral center with an increase in the number of patients travelling a longer distance to the hospital.

We used the beneficiary county of residence variable on the MedPAR files to examine where Medicare bypass patients treated in each of the demonstration hospitals live. Exhibits 4-4 through 4-10 map the number of beneficiaries living in each county who underwent bypass surgery in a demonstration site in the year prior to the start of the demonstration (1990 for the original sites; 1992 for the expansion sites) and in 1995, the last full year of the demonstration.[3]

[3] Counties in which only one Medicare beneficiary resided were dropped from the analysis.

Exhibit 4-4
St. Joseph's Hospital - Atlanta
Counties of Residence for Medicare Bypass Patients

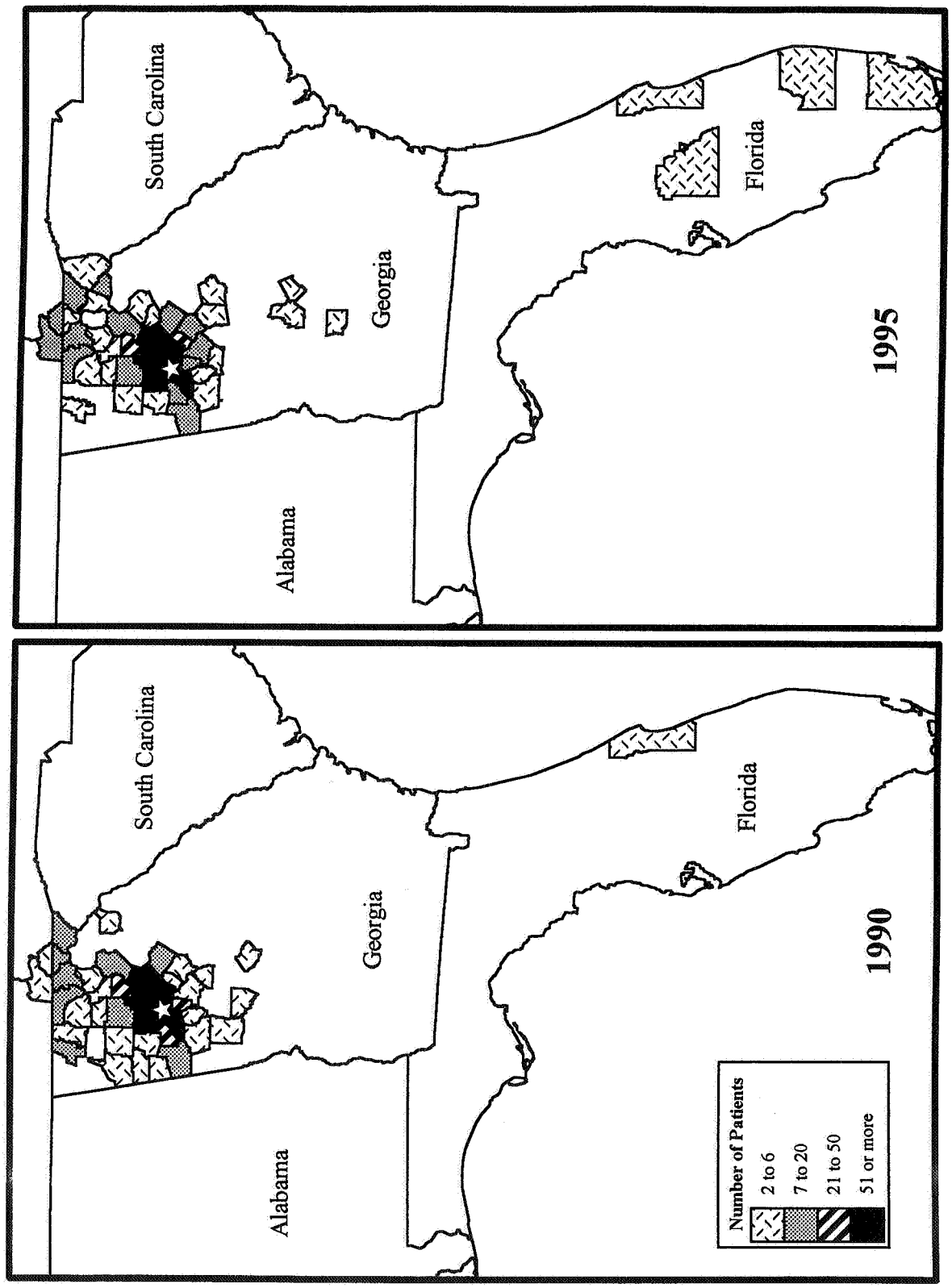


Exhibit 4-5
St. Joseph Mercy Hospital - Ann Arbor
Counties of Residence for Medicare Bypass Patients

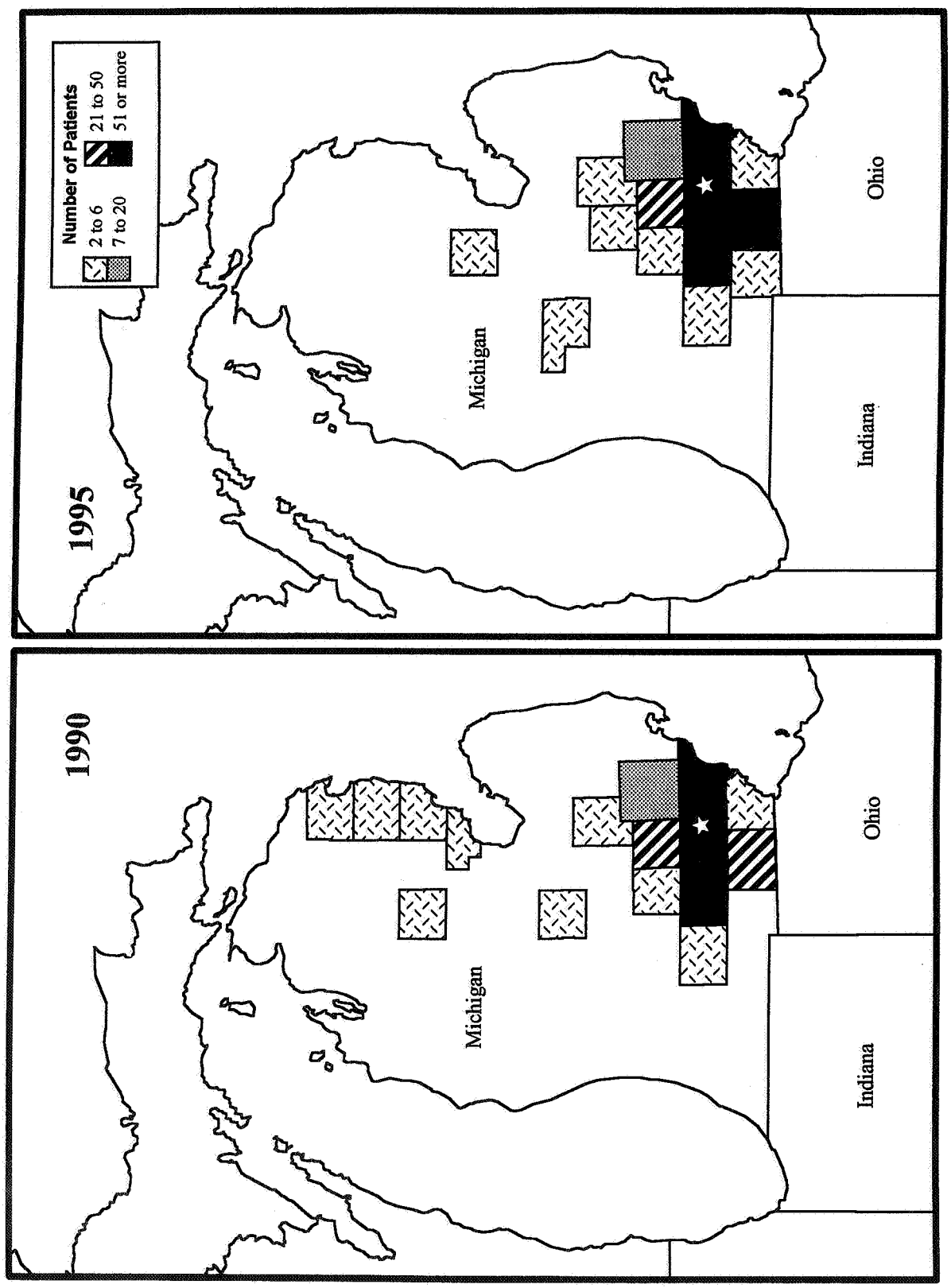


Exhibit 4-6
University Hospital - Boston
Counties of Residence for Medicare Bypass Patients

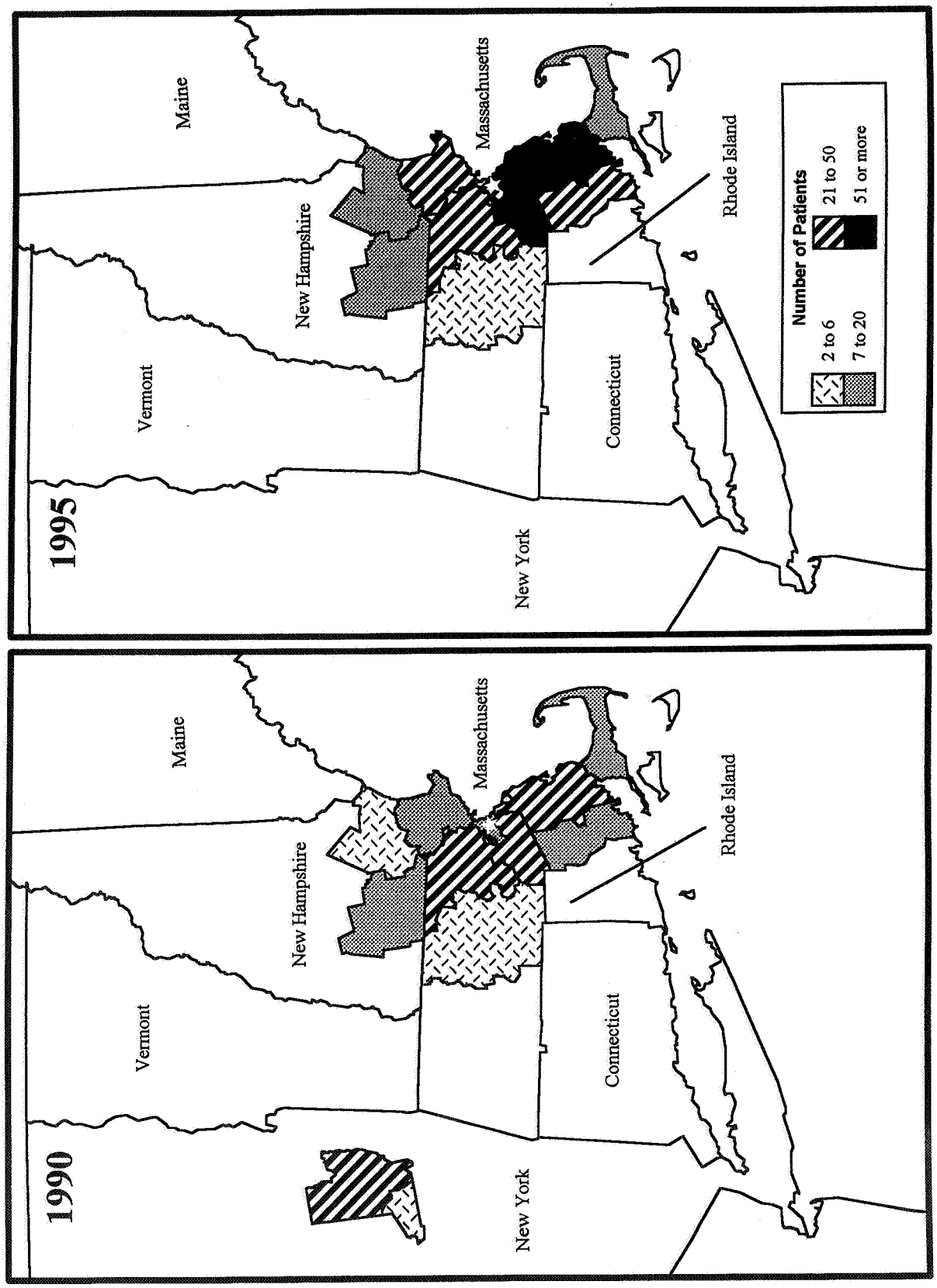


Exhibit 4-7
Ohio State University Hospital - Columbus
Counties of Residence for Medicare Bypass Patients

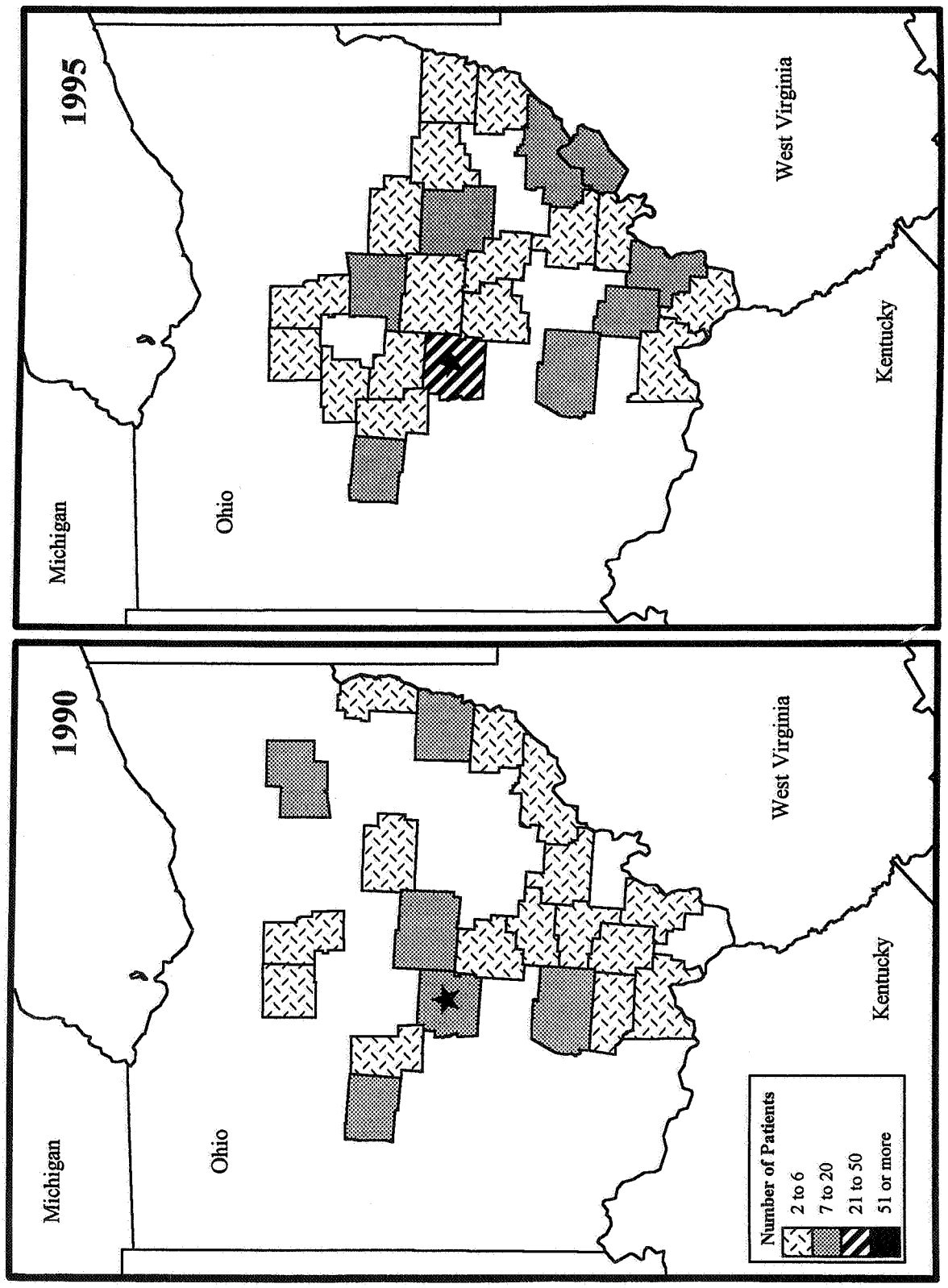


Exhibit 4-8
St. Vincent's Hospital - Portland
Counties of Residence for Medicare Bypass Patients

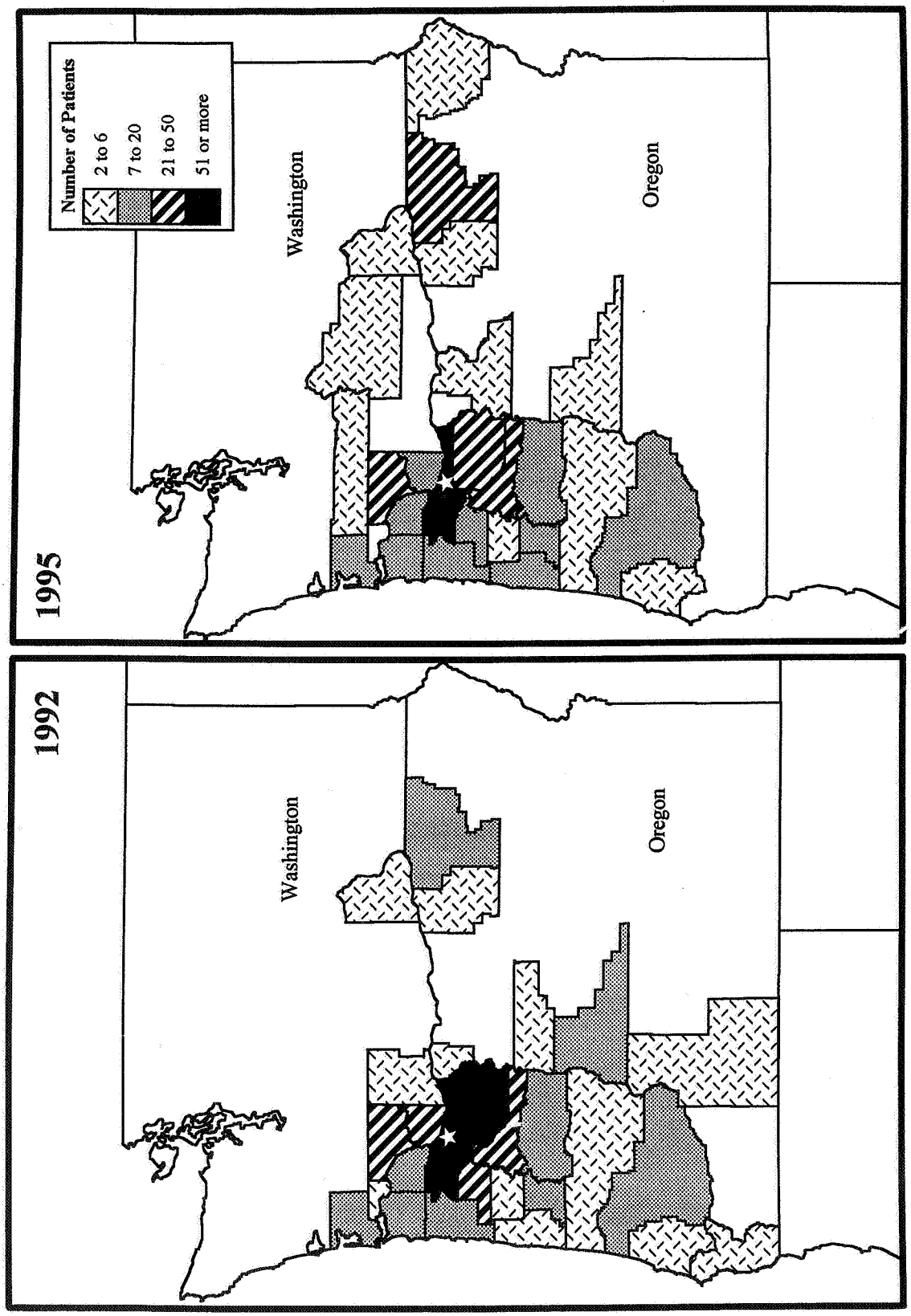


Exhibit 4-9
Methodist Hospital - Indianapolis
Counties of Residence for Medicare Bypass Patients

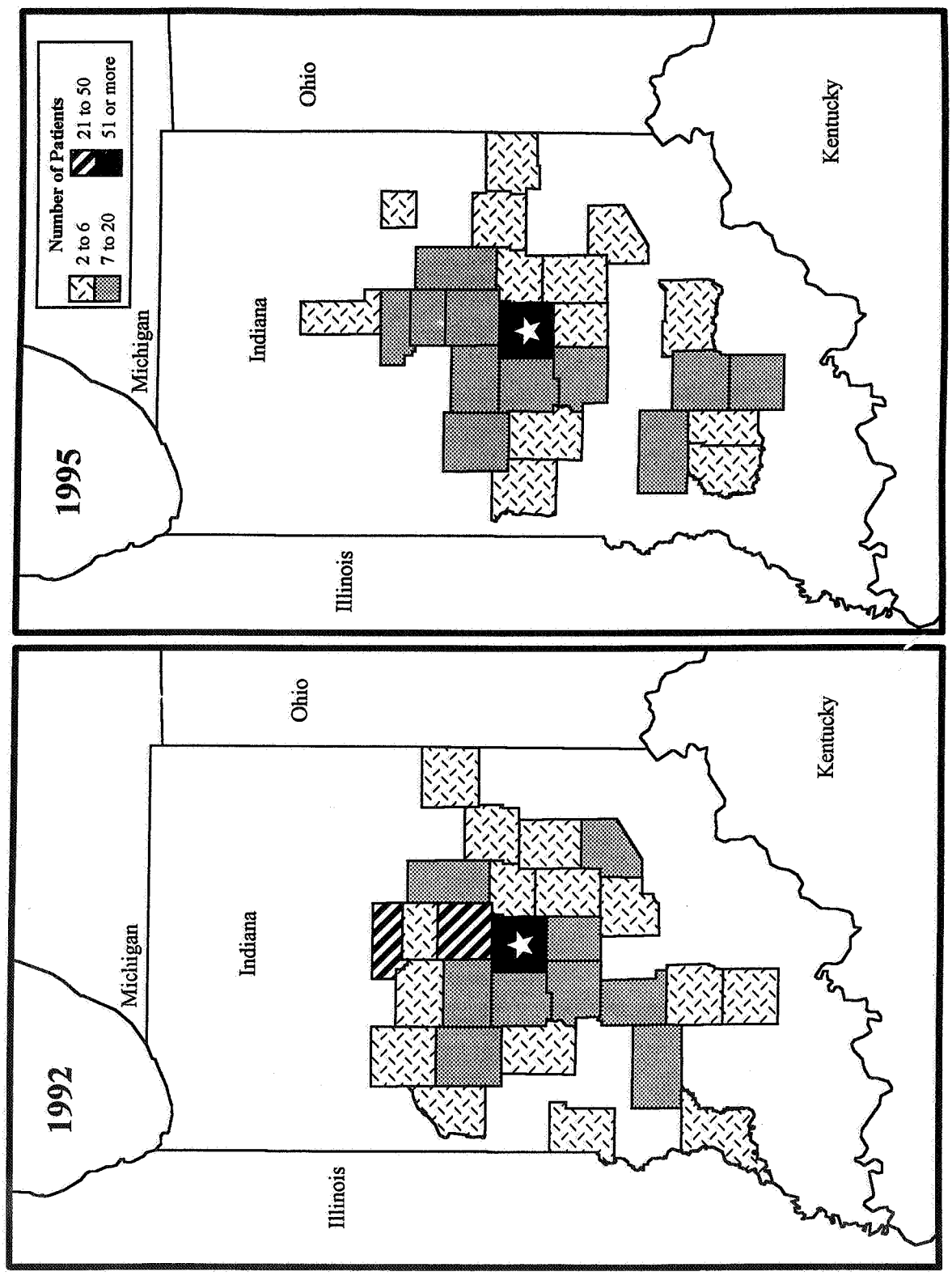
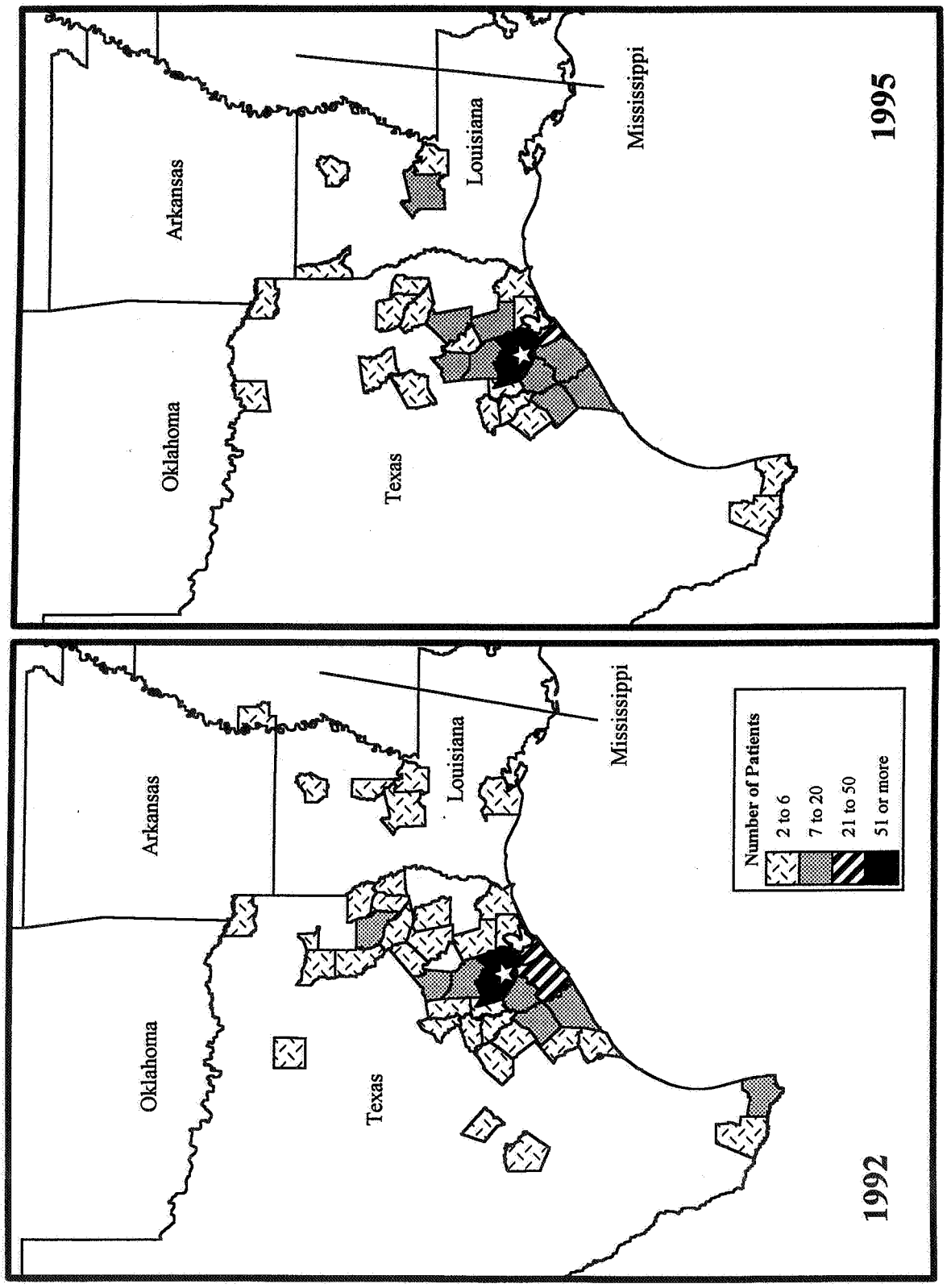


Exhibit 4-10
St. Luke's Hospital - Houston
Counties of Residence for Medicare Bypass Patients



St. Joseph's in Atlanta experienced a 25 percent increase in Medicare bypass volumes between 1990 and 1995. St. Joseph's drew more than 50 patients from each of four counties in 1990 (the solid black area on Exhibit 4-4). The number of patients drawn from these four counties increased by 26 percent between 1990 and 1995, so that in each year they accounted for roughly half of St. Joseph's total Medicare bypass patients. St. Joseph's also increased volumes by attracting more patients from counties to the southeast of Atlanta and from the north along the Georgia-North Carolina border. However, St. Joseph lost 3 counties along the Georgia-Alabama border from which patients had come in 1990.

St. Joseph Mercy in Ann Arbor had an experience similar to St. Joseph's in Atlanta in terms of overall volume growth. However, St. Joseph Mercy draws bypass patients from a relatively small number of counties, primarily in southeastern Michigan. Three counties (shaded black in the left-hand panel of Exhibit 4-5) account for roughly 65 percent of St. Joseph Mercy's Medicare bypass patients in both years. Between 1990 and 1995, the volume of patients from counties that border northern Ohio increased, but those travelling from northern Michigan decreased.

In contrast, the market area for University Hospital (Exhibit 4-6) has changed noticeably between 1990 and 1995 with the loss of the entire Albany market area. Case study work confirmed that the opening of a new heart surgery unit in the Albany area dramatically reduced referrals to University Hospital. (No hospitals in Albany were mentioned by University as competitors, given that the two cities are roughly 150 miles from each other.) However, the hospital increased the number of patients it drew from the

counties south of Boston and those along the Massachusetts north shore. This increase in local patients supported the overall increase in volume, from 249 cases in 1990 to 285 in 1995.

Ohio State University Hospital increased its market area between 1990 and 1995, with patients coming from several additional counties in central and southeastern Ohio, and along the West Virginia and Kentucky borders. (Medicare bypass volumes rose by 40 percent during this period.) OSU also increased the number of patients coming from the Columbus area slightly, however, only about 12 percent of OSU's bypass patients come from Franklin County in which Columbus is located. OSU was unable to make inroads in the highly competitive Toledo, Cleveland and Cincinnati areas; no patients traveled from these sections of the state to OSU for surgery in either year. (These cities are located in the northwest, northeast, and southwest corners of the state, respectively. See Exhibit 4-2.)

All three of the expansion demonstration sites experienced declining Medicare bypass volumes during the 1992-1995 period, which are reflected in Exhibits 4-8 through 4-10. At St. Vincent's Hospital, volumes fell 28 percent between 1992 and 1995. The decline in volumes was even greater in the Portland metropolitan area. Three counties (shaded black in the left-hand panel of Exhibit 4-8) accounted for almost half of St. Vincent's volume in 1990; volumes from these counties decreased by 37 percent in 1995. St. Vincent's was able to offset this loss, to some extent, by increasing volumes in several counties to the east along the Oregon-Washington border.

Methodist Hospital's Medicare bypass volumes fell 18 percent during the 1992-95 period. The number of patients drawn from Marion County (in which Indianapolis is located) decreased even more dramatically, by 34 percent (from 146 to 96). The market seems to have diminished, most noticeably, immediately north of the hospital. St. Vincent's of Indianapolis is located on the northern edge of the city; its volumes increased substantially during this time period. The one area where Methodist seems to have increased its market is the area well south of the city, around Bloomington. Several counties in this area (see the southernmost shaded counties in the right-hand panel of Exhibit 4-9) provided more patients to Methodist in 1995 than in 1992.

The reduction in geographic market area is even clearer for St. Luke's Hospital in Houston. Medicare bypass volumes decreased by 16 percent between 1992 and 1995. In 1992, the hospital had patients coming from many counties in eastern Texas and Louisiana; by 1995, far fewer counties in this area provided patients. St. Luke's also seems to have lost some market area in the counties west and south of Houston. Although the number of patients from the Houston-Galveston-Brazoria metropolitan area fell during this period, the decrease was not as great as for the outlying counties.

Table 4-3 summarizes the change in Medicare bypass volumes from "core counties" and "extended counties" for each of the demonstration sites. Core counties are those in which the hospital had a well-established market pre-demonstration, and from which volume increases would result from intensive competition. Extended counties are those further geographically from the demonstration site, in which the pre-demonstration market was less

Table 4-3

Changes in Medicare Bypass Volumes at Demonstration Sites by Patient Residence

	"Core Counties"			"Extended Counties"		
	Medicare Bypass Volume			Medicare Bypass Volume		
Original Sites	**1990**	**1995**	**Percent Change**	**1990**	**1995**	**Percent Change**
St. Joseph - Atlanta	314	395	26 %	290	361	24 %
University Hospital - Boston	53	93	75	196	202	3
Ohio State University - Columbus	31	39	26	100	145	45
St. Joseph Mercy - Ann Arbor	179	279	56	105	144	37
Expansion Sites	**1992**	**1995**	**Percent Change**	**1992**	**1995**	**Percent Change**
St. Vincent's - Portland	249	156	-37	313	248	-21
Methodist - Indianapolis	146	96	-34	226	210	-7
St. Luke's - Houston	318	274	-14	304	242	-20

Notes: Core Counties are defined as: Atlanta - Cobb, DeKalb, Fulton, Gwinnett; Boston - Norfolk, Suffolk; Columbus - Fairfield, Franklin, Licking, Union; Ann Arbor - Jackson, Washtenaw, Wayne; Portland - Clackamas, Multnomah, Washington; Indianapolis - Martion; Houston - Brazoria, Galveston, Harris.

Source: 1990, 1992, 1995 MedPAR files.

its patients from its own county (Marion), while no other county contributed more than 25 strongly established. Defining the core counties is problematic, given the pre-demonstration markets for the seven sites. For example, in 1992, Methodist Hospital drew 40 percent of patients. Thus Marion county seems the logical "core" to Methodist's market. In contrast, University Hospital drew only 6 percent of its patients from its home county (Suffolk) making it desirable to include neighboring Norfolk county, which provided 16 percent of University's patients, as part of the core.

Using these definitions of core counties, St. Joseph's in Atlanta increased volumes from the core and extended counties almost equally, 26 percent and 24 percent, between 1990 and 1995. In contrast, University Hospital increased volumes from core counties by 75 percent, while volumes from extended counties increased by only 3 percent. Thus, increases in University's volumes from the north and south shore areas just offset losses from the Albany area, while many more patients were attracted from Boston and its immediate suburbs. Ohio State University increased volumes more dramatically from the extended counties, with its inroads into southeastern Ohio, while St. Joseph Mercy's volume increase was predominantly from its core counties.

In contrast to the four original sites, each of the expansion sites lost volume between 1992 (the year prior to their entry into the demo) and 1995. Two of the sites, St. Vincent's and Methodist, lost a greater percentage of volume from the core counties than the extended counties. Methodist's losses from decreasing volumes north of the Indianapolis were almost offset by gains in southern Indiana area. However, Methodist is heavily

dependent on patients from its home county, and these patients seem to be increasingly travelling to St. Vincent's (also in Indianapolis) for treatment. St. Luke's in Houston, in contrast, lost more volume from the extended counties than from its core market area. This loss was evidenced on Exhibit 4-10 by the large decrease in market area in the eastern Texas, Louisiana border area.

4.3.5 Implications

All of the sites had hoped that their participation in the demonstration would lead to increased volumes. However, only two of the sites, St. Joseph Mercy in Ann Arbor and OSU Hospital, experienced significant growth in market share during the course of the demonstration. (St. Joseph in Atlanta had increasing volumes and market share relative to its main competitor, Emory Hospital.) Competition for bypass cases is very intense in many markets, and the ability to increase volumes under the demonstration may have been limited by several factors.

First, with the exception of emergency cases, most patients are referred to a hospital, either by a primary care physician (for cardiology care and an angiography study) or by a cardiologist (for bypass surgery). Referral patterns tend to be dependent on factors such as reputation of the hospital, previous good outcomes for referrals, and personal knowledge of surgeons and other staff. (See Chapter 9 for a discussion of factors affecting referrals in the demonstration markets.) Thus, we might expect to see changes in referral patterns if a new bypass surgery unit opened (as happened to University Hospital when a

hospital in Albany began performing surgery), or if surgeons move from one hospital to another. We do not, however, expect a major change in referrals because one hospital in the market enters the demonstration, ceteris paribus. Unless dramatic marketing and government promotion occurs, we don't know how an inferred "Center of Excellence" imprimatur may affect volumes.

Second, while hospitals were allowed to promote the demonstration in their marketing materials (subject to approval from HCFA), most did not promote it heavily. Several reasons were given for this decision. First, there was the feeling in several sites that they were located in a "conservative" marketplace where advertising for medical care was still viewed suspiciously. They did not feel it would be appropriate to do anything that might be construed as "slick advertising." Additionally, some sites had previously decided to abandon marketing of specific programs or specialties and to concentrate on advertising the overall image of the hospital. Thus, any advertising that was specific to cardiology or cardiac surgery would run counter to the theme of their advertising campaign. (Our survey of patients found that overall reputation for quality was the most important factor influencing choice of hospital. However, reputation of the heart surgery program ranked a close second. See Chapter 9.) Another reason not to heavily promote the demonstration was the limited manner in which beneficiaries benefitted directly from the demonstration. Since the vast majority of beneficiaries in these markets have supplemental insurance, the primary advantage of the demonstration was simpler billing, rather than reduced out of pocket expense.

A third limitation to the growth in demonstration market shares was the limited promotion of the demonstration by HCFA. There was never any intention by the government to restrict beneficiaries in local markets to using the demonstration sites or even towards steering them towards particular hospitals. In addition, HCFA engaged in very limited promotion of the demonstration. For example, it did not identify the demonstration sites as "Centers of Excellence," as is done in private managed care plans, and had no major press conferences to kick off the demonstration or with the addition of the expansion sites.[4]

What does the limited ability of the demonstration sites to expand their markets imply for quality of care? Analysis described in Chapter 9 of this report implies that quality in the demonstration sites did not suffer during the duration of the demonstration and likely improved in certain respects. However, one of the original motivations for the demonstration was to regionalize cases in a few high volume hospitals that had demonstrated high quality care. Numerous studies (see for example, Luft, *et al.*, 1990) have found an inverse relationship between outcomes and volumes for CABG surgery. That is, hospitals performing higher volumes of CABGs tend to have better outcomes, ceteris paribus, than those with lower volumes. Dayhoff and Cromwell (1994) estimated that mortality in the 90 days after bypass surgery could be reduced by roughly one percentage point (average mortality is five percent) under greater regionalization. Thus, if cases were regionalized in a demonstration site, particularly in a market like Houston that has a large number of hospitals performing low volumes of bypass surgery, the overall bypass mortality rate in the

[4] In the newly planned demonstration, HCFA intends to use the " Participating Centers of Excellence" designation.

market would decrease. However, under the current demonstration, we saw very limited evidence of regionalization in the demonstration sites.

More promising is the reduction in the number of hospitals performing very low volumes of bypass surgeries in these markets. Across the seven markets, in 1990, there were 23 hospitals performing bypass that treated fewer than 100 Medicare cases annually. By 1996, that number had fallen to 9 hospitals. While this reduction is generally attributable to the overall growth in bypass volumes, it is reassuring that most small volume hospitals were able to either increase their volumes or, in a few cases, quit performing bypass surgery rather than continue to operate on very low volumes annually. However, this effect would appear to be unrelated to the presence of a demonstration hospital in the market.

4.4 Medicare Angioplasty Volumes and Market Shares by Site

Angioplasty volumes and market shares are of interest because angioplasty and bypass surgery are closely related procedures that are both alternatives for coronary revascularization. We can posit two hypotheses for the relationship between bypass and angioplasty volumes. Under one, bypass and angioplasty are demand complements, and a hospital experiencing growth in volumes for one would be expected to experience growth in the other, as a result of an increased reputation as a "heart" hospital. Under the second, bypass and angioplasty are substitutes in production, with improvements in angioplasty decreasing the number of coronary artery disease patients undergoing bypass.

To see how designation as a bypass center might affect volumes of bypass and angioplasty, consider the following model (Figure 4-6). The market contains three hospitals: Hospital A which performs cardiac catheterization but has no open heart facilities, Hospital B which is the bypass center, and Hospital C which has open heart facilities but is not designated a bypass center. For simplicity, assume that no patients undergoing catheterization at Hospital B or C travel to the other site for revascularization.

The number of patients in Hospital B undergoing CABG in DRG 106 (B_{106}) can be expressed as:

$B_{106} = B_{cath}/M * B_{106}/B_{cath} * M$

where B_{cath} = the number of patients receiving catheterization in Hospital B, and M = the number of catheterization patients in the market. Thus, the term B_{cath}/M represents the portion of patients undergoing catheterization in the market who have the procedure performed in Hospital B, and the term B_{106}/B_{cath} represents the proportion of patients undergoing catheterization in Hospital B who have bypass performed in that hospital.

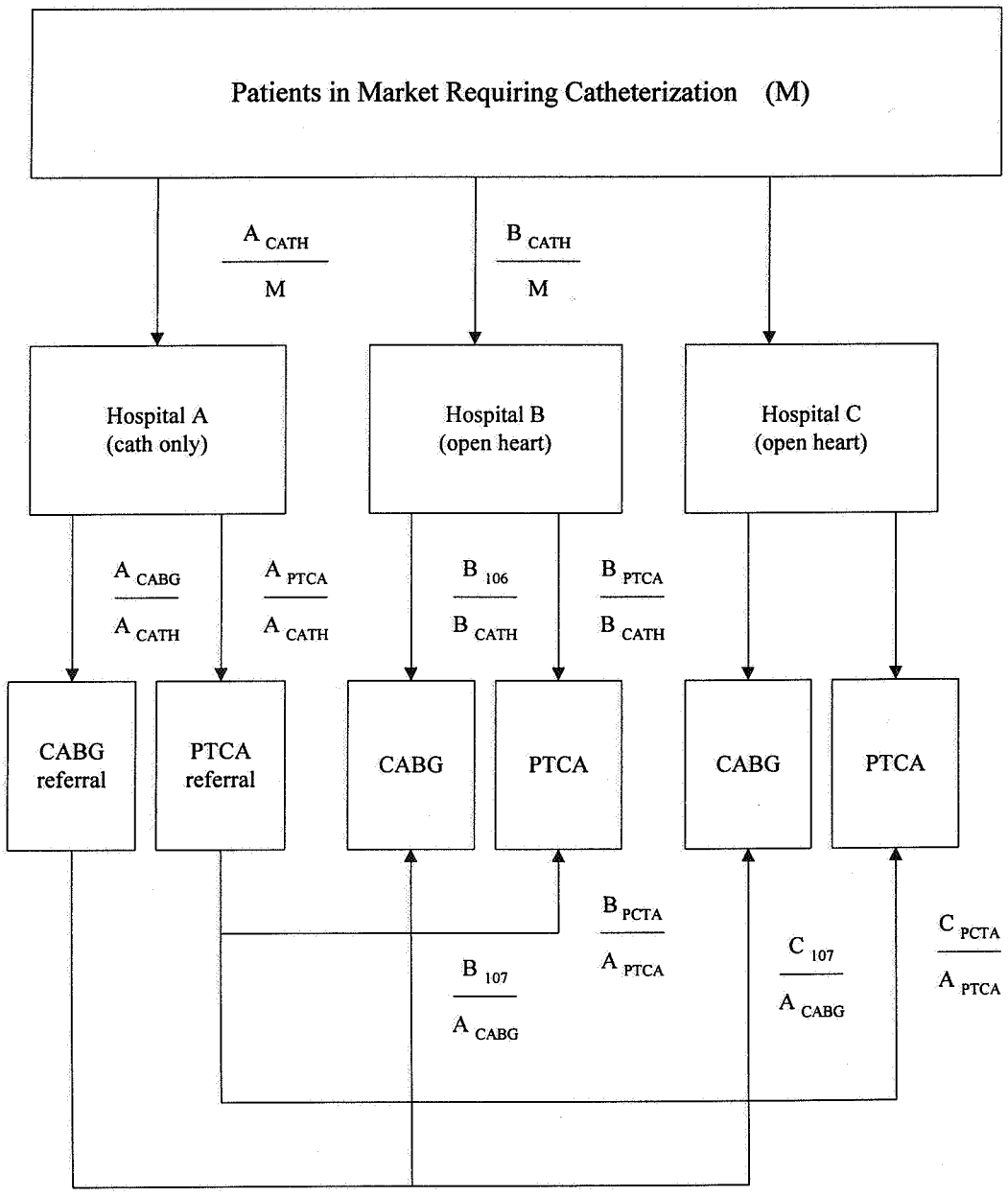
The number of patients undergoing bypass in Hospital B as patients in DRG 107 (who had their catheterization elsewhere) can then be written:

$B_{107} = A_{cath}/M * A_{cabg}/A_{cath} * B_{107}/A_{cabg} * M,$

where A_{cath} = the number of patients having catheterization in hospital A, and A_{cabg} = the number of patients having catheterization in hospital A who are bypass candidates. Thus, A_{cath}/M equals the proportion of patients undergoing catheterization who have the procedure performed in hospital A, A_{cabg}/A_{cath} = the proportion of Hospital A's catheterization patients

Figure 4-6

Model of Bypass and Angioplasty Volumes



who are referred for bypass, and B_{107}/A_{cabg} is the proportion of Hospital A's bypass referrals who go to Hospital B for the bypass.

Combining the two equations, we have the total number of bypasses in Hospital B expressed as:

Hospital B CABG = $(B_{cath}/M * B_{106}/B_{cath} + A_{cath}/M * A_{cabg}/A_{cath} * B_{107}/A_{cabg}) * M.$

Analogously, the total number of angioplasties in Hospital B can be expressed as:

Hospital B PTCA = $(B_{cath}/M * B_{ptca}/B_{cath} + A_{cath}/M * A_{ptca}/A_{cath} * B_{ptca}/A_{ptca}) * M,$

the sum of patients undergoing catheterization in hospital B and those referred from hospital A.

How would designation of Hospital B as a "Bypass Center" be expected to affect the volumes of CABG and PTCA in that hospital? First, we would expect to see the ratio B_{cath}/M increase, as Hospital B developed more of a reputation as a Heart Center. More patients undergoing catheterization, who might be found candidates for bypass, would choose to have the diagnostic study performed in Hospital B. This would increase volumes in both bypass and angioplasty. We would also expect to see the ratio B_{107}/A_{cabg} increase; as Hospital B developed more of a reputation for bypass surgery, Hospital A would refer more bypass candidates to that site. Referrals to Hospital B for angioplasty (B_{ptca}/A_{ptca}) might also increase, although we would expect the effect to be weaker than the referral effect for bypass.

Ceteris paribus, the designation of Hospital B as a bypass center would thus lead to an expected increase in volumes for both bypass and angioplasty, although the effect on bypass would be greater. However, technology has changed over time, affecting which

patients are considered candidates for bypass and angioplasty. As PTCA becomes a viable alternative for a wider range of revascularization candidates, the proportion of patients considered as candidates for CABG (the B_{106}/B_{cath}, and A_{cabg}/A_{cath} terms) decreases and the proportion considered as candidates for PTCA (the B_{ptca}/B_{cath} and A_{ptca}/A_{cath} terms) increases.

Combining the demand and substitution effects, the total CABG cases in the bypass center could rise or fall, depending on the relative strengths of the effects. However, the change in the number of bypasses relative to the number of angioplasties should be relatively higher in hospitals that are more referral oriented (with a higher proportion of cases in DRG 107), because of the stronger referral effect on bypass cases from Hospital A.

How did bypass and angioplasty market shares change in our demonstration hospitals? Table 4-4 presents Medicare angioplasty and bypass market shares for each demonstration hospital for 1990-96. Saint Joseph's in Atlanta and University Hospital both had very high proportions of cases in DRG 107 in 1990 (discussed more fully below in Section 4.5). From our model, we would have predicted relative growth in bypass volumes, compared to angioplasty volumes for these sites. However, St. Joseph's experienced strong growth in angioplasty market shares while bypass shares fell slightly by 1996. At University Hospital the decrease in bypass share was somewhat less than the decrease in angioplasty share, consistent with the model. The hospital with by far the lowest fraction of DRG 107 patients was Methodist in Indianapolis. Its market shares for both bypass and angioplasty fell at a nearly identical rate.

Table 4-4

Comparison of Medicare Bypass and Angiography Market Shares for Demonstration Sites, 1990-96

	1990	1991	1992	1993	1994	1995	1996
Atlanta							
Saint Joseph's							
CABG	37.6 %	38.6 %*	39.2 %*	41.9 %*	39.1 %*	37.6 %*	37.0 %*
PTCA	35.2	41.4	44.3	45.1	42.7	40.7	42.1
Boston							
University Hospital							
CABG	9.8 *	8.9	7.5 *	7.9 *	8.0 *	8.7 *	8.6 *
PTCA	12.4	9.1	9.7	10.8	10.6	11.0	9.7
Columbus							
Ohio State University							
CABG	5.1 *	4.6 *	4.7 *	5.5 *	5.2 *	5.9	6.3 *
PTCA	9.3	9.1	7.6	7.6	6.4	5.5	4.0
Ann Arbor							
St. Joseph Mercy							
CABG	10.2 *	10.8 *	11.0 *	15.2 *	13.7 *	13.4 *	14.6 *
PTCA	16.5	18.5	16.4	11.9	9.8	8.1	7.3
Portland							
St. Vincent's							
CABG	43.6	50.0	48.8 *	52.1	53.6	49.2	43.6 *
PTCA	46.5	50.7	53.1	49.8	51.3	49.4	51.4
Indianapolis							
Methodist							
CABG	28.4	26.8	28.0 *	22.6	22.9	20.6	21.6
PTCA	26.1	27.9	24.7	22.1	23.7	18.6	21.0
Houston							
St. Luke's							
CABG	33.5	34.3	32.0	33.9 *	34.9 *	30.1 *	29.8 *
PTCA	32.8	33.9	30.5	29.2	29.1	27.4	26.4

NOTES:
1. Includes all angioplasty procedures defined as cases in DRG112 with a procedure code of 36.01, 36.02 or 36.05.
2. Calendar year data.
3. The original demonstration sites began the demonstration in June 1991.
   The expansion demonstration sites began the demonstration June 1993.
4. * indicates significant difference between CABG and PTCA market shares ($p < .05$).

SOURCE: 1990 through 1996 MedPar files.

Given the difficulty interpreting changes in market shares, we also present Medicare volumes for bypass and angioplasty in Figure 4-7. At each of the four original sites, the number of Medicare CABG procedures performed increased between 1990 and 1996. However, two of the sites, St. Joseph's (Atlanta) and University Hospital (Boston), also experienced an increase in the number of PTCAs performed, while Ohio State and St. Joseph Mercy (Ann Arbor) experienced declines in PTCA volumes. Both OSU and St. Joseph Mercy also share a pattern in which the volume of angioplasties exceeds bypasses in early years, but in later years more bypasses than PTCAs are performed. Given the much stronger referral orientation of St. Joseph's in Atlanta and University Hospital, we would have expected the opposite result.

Among the three expansion sites, St. Vincent's in Portland had very similar trends for both CABG and PTCA volumes. Volumes rose dramatically between 1990 and 1991, and then experienced a generally slow decline through 1996. Here, volume changes can be explained by changing contracts with managed care organizations that result in either an influx or a reduction of cardiac patients from the hospital. At Methodist Hospital, volumes of bypasses decrease slightly while angioplasties increase in 1991 and 1992 before decreasing in the later years. Of all the sites, only St. Luke's in Houston shows a pattern consistent with the substitution story: bypass volumes decrease over time while angioplasty volumes increase.

Figure 4-7

Comparison of Medicare Bypass and Angiography Market Shares and Volumes for Demonstration Sites, 1990-96

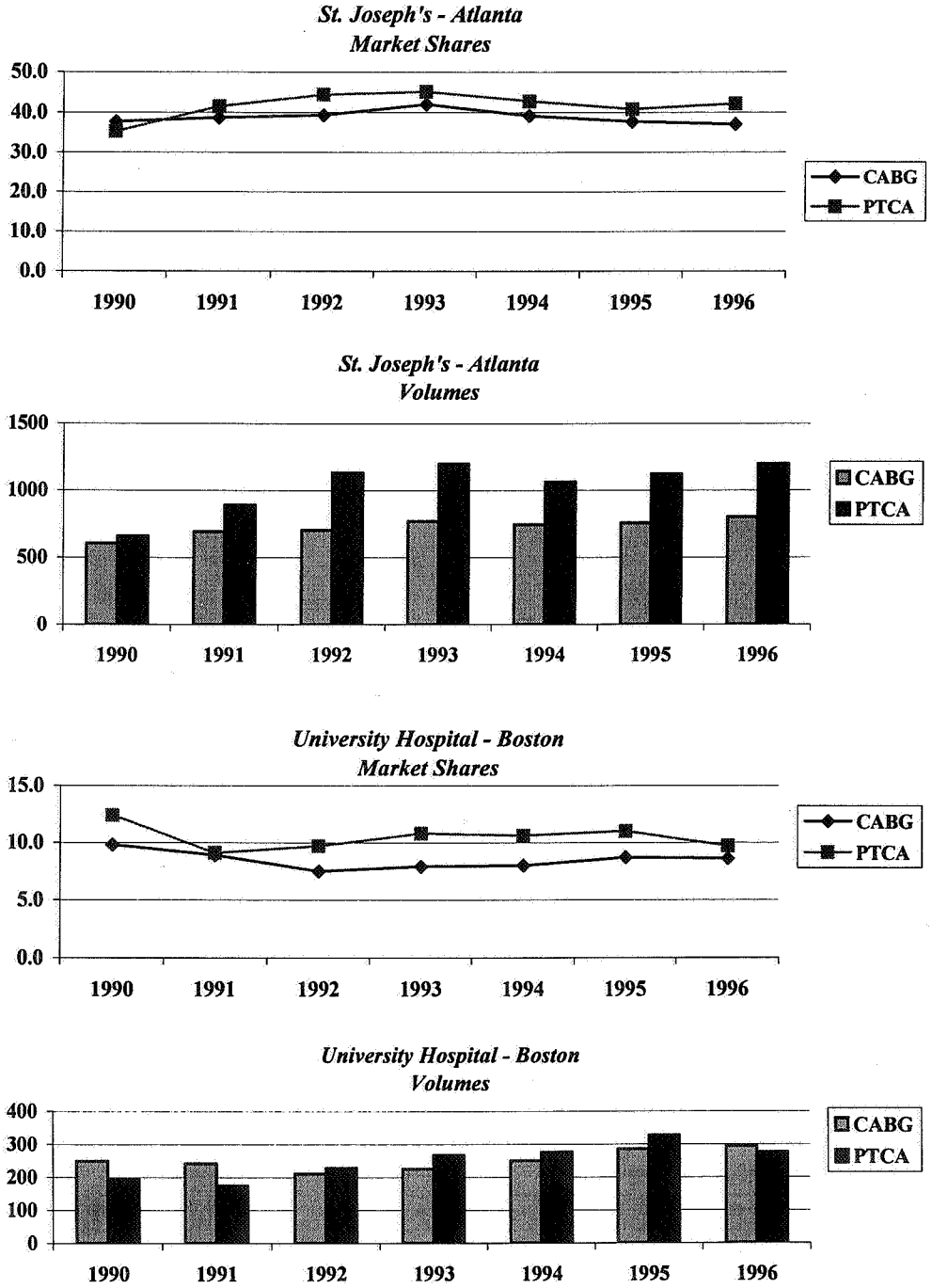
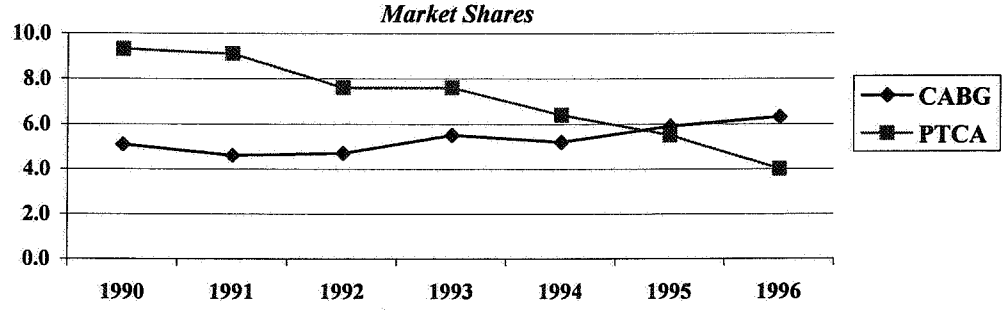


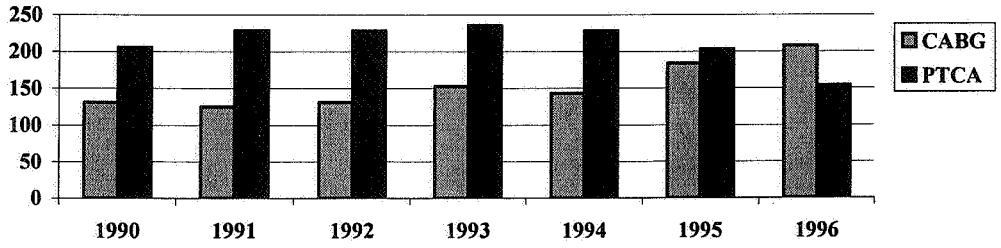
Figure 4-7 (continued)

Comparison of Medicare Bypass and Angiography Market Shares and Volumes for Demonstration Sites, 1990-96

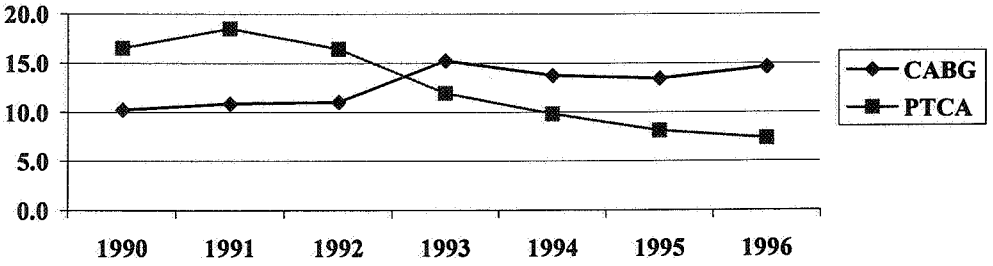
Ohio State University - Columbus
Market Shares



Ohio State University - Columbus
Volumes



St. Joseph Mercy - Ann Arbor
Market Shares



St. Joseph Mercy - Ann Arbor
Volumes

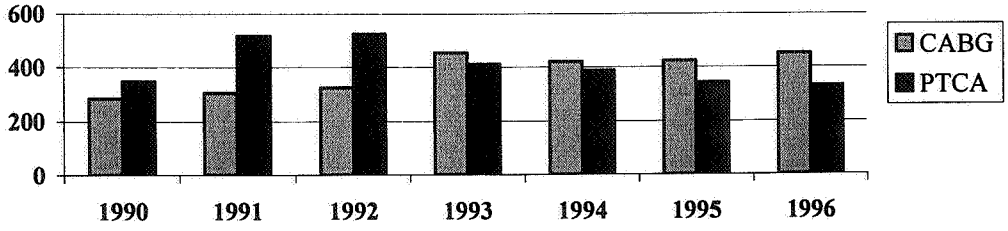
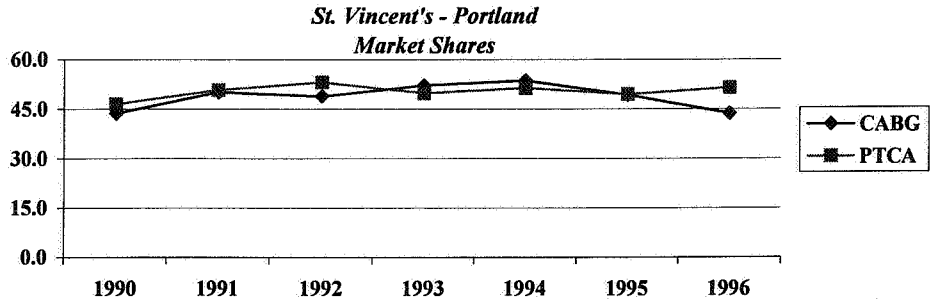
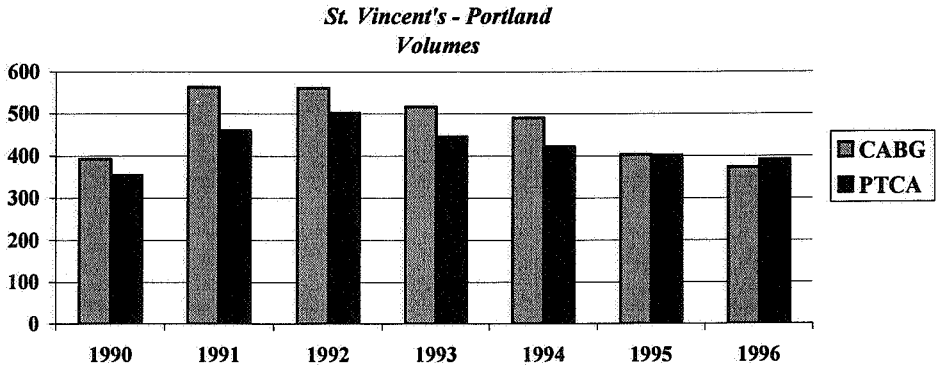
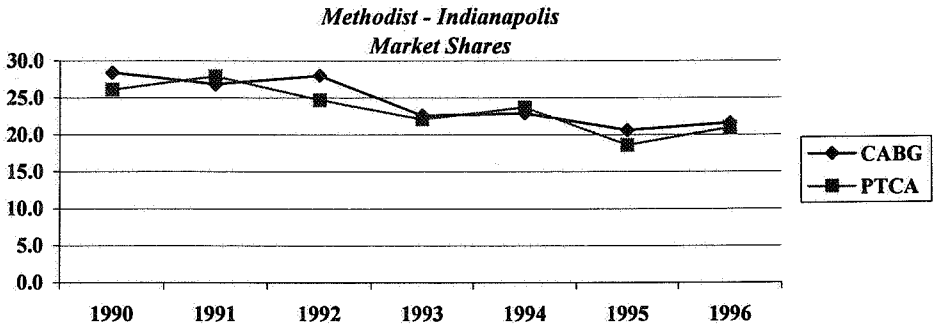


Figure 4-7 (continued)

Comparison of Medicare Bypass and Angiography Market Shares and Volumes for Demonstration Sites, 1990-96







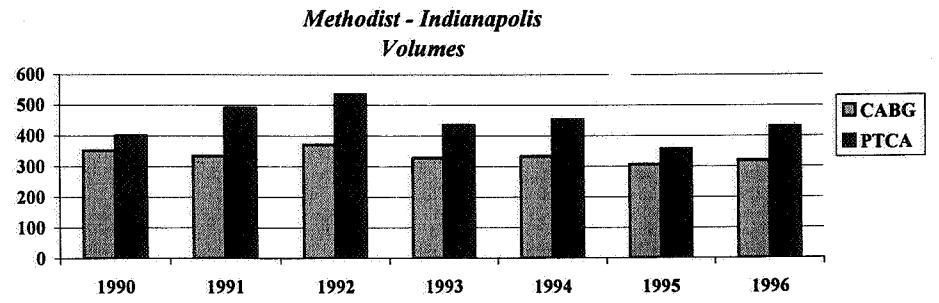
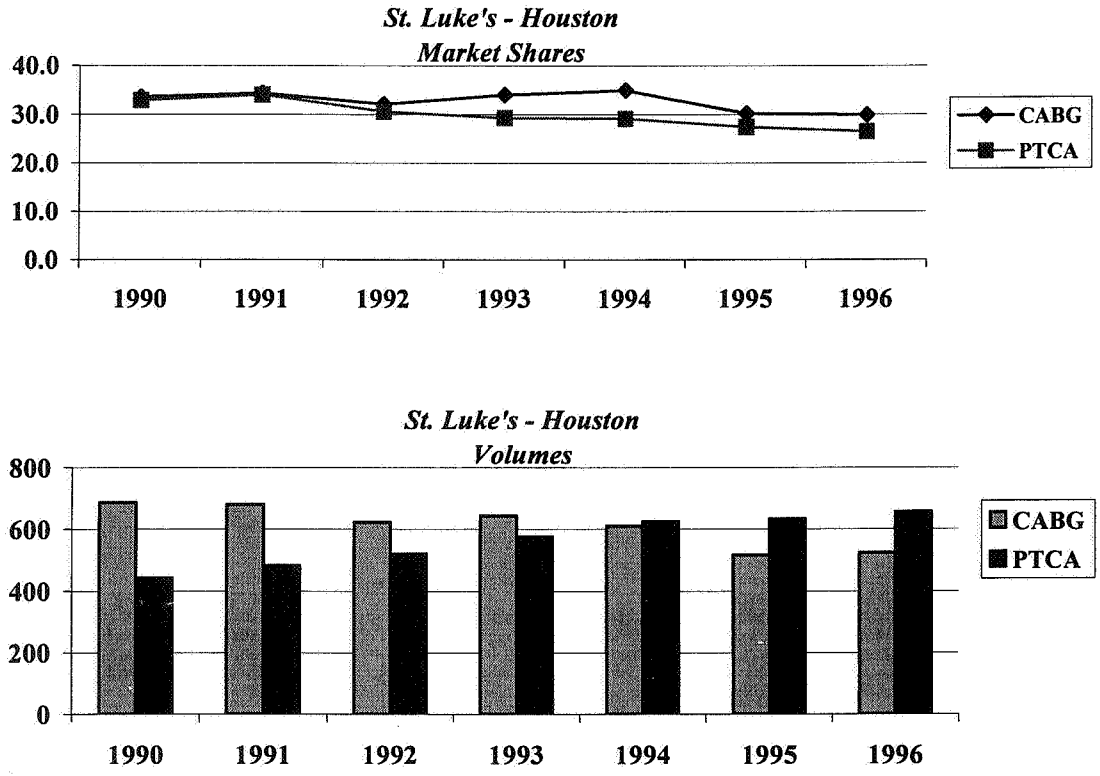


Figure 4-7 (continued)

Comparison of Medicare Bypass and Angiography Market Shares and Volumes for Demonstration Sites, 1990-96



SOURCE: 1990-96 MedPAR files.

Given these mixed results, it is difficult to make a strong case for the substitution and the complement hypotheses. However, we have a very small sample, and many factors that we are not able to hold constant may also affect changes in volumes. These can be hospital-specific forces, such as changes in Medicare managed care contracts, or changes in staffing with surgeons or cardiologists leaving or joining the staff. Additionally, market forces, such as the opening of new catheterization labs and the overall diffusion of PTCA will affect the flow of patients to the hospital for cardiac revascularization and the eventual decision to perform CABG vs. PTCA.

4.5 Distribution of Patients by DRG

Table 4-5 presents the distribution of cases by DRG for 1990-96 at each of the demonstration sites and their competitors. The national average proportions for DRGs 106, 107, and 108 are presented in the top row for comparison. Recall that DRG 106 is bypass with catheterization while DRG 107 is bypass without catheterization. A high percentage of patients in DRG 107 would be indicative of a referral hospital for patients who have already had their angiography performed elsewhere.

Three sets of chi-square tests for homogeneity of proportions (SAS Institute, 1990) were conducted to test statistically for differences in proportions. The ability of the chi-square test to detect significant differences in proportions depends on two factors: the difference in the proportions and the sample sizes. It is important to bear this in mind given that we only report the proportions and not DRG frequencies (to reduce the size of the

Table 4-5

Distribution of Medicare Bypass Patients in Demonstration Hospitals and Their Competitors by DRG, 1990-1996

	1990			1991			1992			1993			1994			1995			1996		
	DRG 106	DRG 107	DRG 108	DRG 106	DRG 107	DRG 108	DRG 106	DRG 107	DRG 108	DRG 106	DRG 107	DRG 108	DRG 106	DRG 107	DRG 108	DRG 106	DRG 107	DRG 108	DRG 106	DRG 107	DRG 108
National Proportions	49 %	36 %	15 %	57 %	39 %	4 %	57 %	40 %	3 %	59 %	39 %	3 %	59 %	38 %	2 %	60 %	38 %	3 %	59 %	38 %	2 %
Atlanta																					
St. Joseph's	26	59	16	31	63	6	30	63	7	26	70	3	45	53	2	49	50	2	49	49	2 #
Competitors	43	51	6 *	44	54	2 *	46	52	2 *	47	52	1 *	44	54	2	48	50	2	42	56	2 *
Boston																					
University Hospital	35	53	12	47	48	5	36	59	5	37	62	1	42	56	2	39	58	4	47	51	2 #
Competitors	38	46	15	49	48	4	47	50	3 *	47	50	3 *	44	52	4	46	50	3 *	46	50	4
Columbus																					
Ohio State U.	45	45	10	57	39	4	56	41	3	64	35	1	64	35	1	58	40	2	50	49	1 #
Competitors	40	46	14	44	51	5 *	44	53	3 *	47	50	3 *	48	48	4 *	47	50	3 *	48	48	3
Ann Arbor																					
St. Joseph Mercy	44	39	18	49	45	5	45	53	2	59	38	3	48	49	3	53	44	3	52	47	1 #
Competitors	32	56	12 *	39	58	3 *	39	58	3 *	42	53	5 *	48	49	4	47	50	3	49	48	3 *
Portland, OR																					
St. Vincent's	42	40	18	38	56	6	38	58	3	34	64	2	29	63	8	36	56	7	43	50	6 #
Competitors	31	48	21 *	42	51	6	42	53	5	49	46	5 *	49	47	4 *	51	47	2 *	50	47	3 *
Indianapolis																					
Methodist	49	32	19	62	31	7	55	39	6	56	37	6	62	34	4	53	44	3	57	40	3 #
Competitors	54	32	14	60	35	5	55	42	3 *	53	44	3 *	53	45	3 *	51	44	5	42	51	7 *
Houston																					
St. Luke's	42	42	16	48	37	15	47	49	4	49	48	2	46	50	3	45	52	3	45	52	3 #
Competitors	48	35	17 *	61	33	5 *	67	30	3 *	58	38	4 *	62	33	5 *	57	38	4 *	60	36	4 *

NOTES:
1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data.
3. Competitors is an average of all hospitals doing bypasses in market excluding the demonstration hospital.
4. * Sets of demonstration site/competition proportions that are significantly different ($p<0.05$).
5. # Demonstration site proportions that are significantly different across the seven years ($p<0.05$).

SOURCE: 1990 through 1996 MedPAR files.

tables). The natural tendency is to assume that a larger difference in proportions is more likely to be significant than a smaller difference, but greater variability in proportions due to small samples may produce statistically insignificant results even for large differences.

First, for each of the demonstration hospitals, we tested whether the distribution of patients had changed significantly across the 1991-96 period. (The 1991-96 period was chosen to eliminate the effect of the coding change that occurred between 1990 and 1991). The proportion of patients by DRG varied significantly ($p < 0.01$) across time in each of the seven demonstration sites (noted by the # symbol at far right) except Ohio State University (which had the smallest volumes of any demo site).

Second, we tested for homogeneity of proportions across the seven demonstration sites for each of the four study years. The proportion of patients by DRG also varied significantly within each year across the seven demonstration hospitals (no symbol on table). For example, in 1993, 70 percent of the CABG patients in St. Joseph's Hospital in Atlanta were in DRG 107, indicating a very high percentage who had been referred to the hospital after their angiography was completed. University Hospital in Boston also has a very high percentage of patients in DRG 107. In contrast, in 1993, fewer than 40 percent of bypass patients were in DRG 107 for Ohio State University Hospital, St. Joseph Mercy, and Methodist of Indianapolis. The distributions of cases by DRG in these three hospitals are similar to the national proportions, indicating less of a referral-based practice than is found in the other demonstration sites.

Third, we tested for homogeneity of proportions between each demonstration hospital and its competitors. Given local variations in practice patterns and population demographics, this comparison is likely to be more meaningful than the comparison across demonstration sites. Five of the seven sites had statistically different DRG proportions than their competitors in at least five study years (as noted by the * symbol and the box around sets of proportions). St. Luke's, Houston, had a higher percentage of referral patients in DRG 107 than their competitors, while Ohio State University and St. Joseph Mercy Ann Arbor had a higher proportion of patients in DRG 106. St. Joseph's Atlanta and St. Vincent's show interesting patterns, with the proportion of cases in DRG 106 reversing during the course of the demonstration. St. Joseph's Atlanta had a very high proportion of cases in DRG 107 in 1990-93, but by 1996 it was treating proportionately more DRG 106 cases than its competitors. St. Joseph's DRG mix changed drastically between 1993 and 1994, with the proportion of cases in DRG 106 rising 26 to 45 percent of total Medicare bypasses. St. Vincent's evinced the opposite pattern, beginning with a higher percentage of DRG 106 cases and then becoming more of a referral hospital with a higher percentage in DRG 107.

In 1996, 38 percent of patients nationally were in DRG 107. Among the demonstration sites, 40 percent of patients in Methodist of Indianapolis were in this DRG; in each of the remaining sites treated 47 percent or more of the patients were classified as DRG 107. This indicates that all hospitals, with the exception of Methodist, are receiving a much higher proportion of patients as referrals (after undergoing catheterization) than the national average. However, this is also the case for most sets of competitor hospitals, so the

proportion of cases in each DRG may be driven more by market factors (number of outlying hospitals with catheterization labs but no open heart facilities) than by some feature of the demonstration sites.

4.6 Demographic Characteristics of Demonstration vs. Competitor Cases

Hospital payments for bypass surgery under the demonstration do not vary within DRG; however, the severity of patient illness can vary within DRG. Thus, hospitals have an incentive to "cream skim" by treating only the less seriously ill patients who require fewer resources and have a greater likelihood of a short stay and good outcomes. The MedPAR claims files contain two demographic variables, age and gender, that serve as rough indicators of whether a hospital is treating patients that vary systematically from those treated by its competitors. (In Chapter 8, we compare patient severity using much more detailed clinical risk factors.) The risk of death increases with increasing age, ceteris paribus, as shown below in Chapter 7. Within the Medicare population, a hospital treating a higher proportion of "younger" patients would generally be treating patients who were less severely ill than a hospital treating a high proportion of "older" patients. To test for differences in the age distribution of patients, we classified Medicare bypass recipients into three categories: under age 65, age 65-74, and age 75 and over, and conducted chi-square tests on the proportion of patients by category.

Female patients are generally poorer surgical candidates due to their smaller blood vessels. For this reason, we tested for differences in the proportion of patients by gender to determine if any hospital is treating a disproportionately larger fraction of males.

Table 4-6 presents the distribution of Medicare CABG recipients by age in the seven demonstration hospitals and their competitors. Chi-square tests reveal that the proportions of patients in the three age categories vary significantly across the demonstration hospitals in all years except 1990 and 1994. It appears from the table that the differences in age distributions across the seven demonstration sites may reflect differences across the seven markets (demonstration hospitals and competitors combined).

To determine whether the demonstration hospitals were treating a different age mix of patients than the local competition, we performed chi-square tests on each demonstration/competitor pair in each year. Of the 49 pairs of proportions, only 10 were significantly different. The only hospital treating significantly different age distributions in 3 years was St. Joseph's Atlanta which had fewer young (under 65) patients than its competitors. Thus, for the most part, this would indicate that differences in proportions by age group are a function of geographic differences in demographic patterns across the country rather than demonstration hospitals attracting a unique age mix within their own markets.

Tests for homogeneity of proportions for each demonstration site across the seven years showed significant changes for University Hospital in Boston, St. Joseph Mercy in Ann Arbor and Methodist Hospital in Indianapolis. St. Joseph Mercy and Methodist experienced

Table 4-6

Distribution of Medicare Bypass Procedures in Demonstration Hospitals and Their Competitors, by Age, 1990-96

	1990			1991			1992			1993			1994			1995			1996			
	Under 65 Years	65-74 Years	Over 74 Years	Under 65 Years	65-74 Years	Over 74 Years	Under 65 Years	65-74 Years	Over 74 Years	Under 65 Years	65-74 Years	Over 74 Years	Under 65 Years	65-74 Years	Over 74 Years	Under 65 Years	65-74 Years	Over 74 Years	Under 65 Years	65-74 Years	Over 74 Years	
National Proportions	8 %	66 %	26 %	8 %	65 %	27 %	8 %	64 %	28 %	8 %	64 %	28 %	8 %	63 %	29 %	8 %	61 %	31 %	8 %	59 %	33 %	
Atlanta																						
St. Joseph's	8	67	25	11	64	25	10	63	27	11	67	22	10	63	28	7	66	27	8	61	31	
Competitors	11	66	23 *	12	64	24	9	61	30	14	63	23	11	63	26	14	60	26 *	14	57	29 *	
Boston																						
University Hospital	7	65	29	5	62	33	6	58	36	8	66	26	9	67	24	7	57	36	11	56	34	#
Competitors	6	66	29	6	62	32	5	63	32	7	62	31	5	61	34 *	6	58	36	6	57	37	*
Columbus																						
Ohio State University	13	67	20	14	60	26	15	66	19	12	62	26	12	66	22	13	58	29	18	62	20	
Competitors	11	69	20	9	66	27	8	65	26 *	10	65	25	10	66	24	9	65	26	9	62	29	*
Ann Arbor																						
St. Joseph Mercy	10	68	22	6	69	25	4	69	26	5	65	30	10	61	29	6	62	31	6	61	32	#
Competitors	8	66	26	7	65	28	7	65	28	6	65	29	8	64	28	6	63	31	7	60	33	
Portland, OR																						
St. Vincent	6	66	29	6	64	30	5	65	30	5	63	32	6	63	31	7	66	27	7	57	36	
Competitors	9	64	26 *	8	64	28	7	66	27	5	65	30	7	60	34	8	62	30	7	57	35	
Indianapolis																						
Methodist	11	66	23	8	62	30	13	63	24	5	69	26	10	63	27	8	58	34	10	57	33	#
Competitors	9	69	22	9	67	24	9	64	27	8	68	24	8	64	28	8	65	27 *	9	63	28	
Houston																						
St. Luke's	9	67	24	9	67	24	8	68	25	8	66	26	9	65	25	10	62	28	8	62	30	
Competitors	9	65	26	8	70	22 *	7	66	27	9	69	22	10	63	27	10	63	27	9	62	29	

NOTES:
1. Includes all heart bypass operations, defined as DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data.
3. Competitors is an average of all hospitals doing CABGs in markets excluding demonstration hospital.
4. * Sets of demonstration site/competition proportions that are significantly different ($p<0.05$).
5. # Demonstration site proportions that are significantly different across the four years ($p<0.05$).

SOURCE: 1990 through 1996 MedPAR files.

an increase in patients over age 74 while Boston University experienced up-and-down fluctuations in this percentage (before reaching higher levels in 1995 and 1996). However, none of the hospitals treated an age distribution that was different from its market for more than three years, indicating that the hospital may merely be following a more general market trend.

Table 4-7 presents the proportion of bypasses performed on males in the demonstration hospitals and markets. As is the case nationally, roughly two-thirds of bypass recipients are male. This proportion varies significantly among the seven demonstration hospitals (at the 5 percent level) for 1990 and 1991, but not for any of the later years. The proportion of male patients ranges from a high of 72 percent in St. Luke's in 1990 and 1993 to a low of 59 percent in Ohio State University Hospital in 1995.

The proportion of males treated in St. Joseph's Hospital in Atlanta and St. Vincent's are never statistically different than the proportions for their competitors. The only hospital that differs from its competitors for more than two years in terms of the gender distribution is St. Luke's (treating more males), and the number of hospitals differing from their competitors decreased after the demonstration started.

4.7 Length of Stay Trends

Table 4-8 presents the average length of stay for each of the original demonstration hospitals versus their competitors. Nationally, the average length of stay for patients in DRG 107 (CABG without cardiac catheterization) is roughly three days shorter than for those

Table 4-7

Proportion of Medicare Bypass Procedures on Males in Demonstration Hospitals, 1990-96 and Their Competitors

	1990	1991	1992	1993	1994	1995	1996
National Proportions	68 %	67 %	67 %	67 %	67 %	66 %	66 %
Atlanta							
St. Joseph's	65	65	69	65	64	64	64
Competitors	67	67	67	66	68	67	67
Boston							
University Hospital	65	60	60	63	63	65	68
Competitors	66	66 *	67 *	65	65	66	63
Columbus							
Ohio State Univ.	70	63	65	66	69	59	65
Competitors	68	66	67	66	66	69 *	66
Ann Arbor							
St. Joseph Mercy	69	70	71	65	65	66	68
Competitors	65	73 *	65 *	65	64	64	66
Portland, OR							
St. Vincent	69	70	70	69	69	69	72
Competitors	69	72	70	64	73	66	72
Indianapolis							
Methodist	60	60	66	70	65	64	64
Competitors	64	68 *	65	67	65	64	66
Houston							
St. Luke's	72	71	68	72	70	67	68
Competitors	67 *	68	68	64 *	65 *	63	62 *

NOTES:
1. Includes all heart bypass operations, defined as DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data.
3. Competitors is an average of all hospitals doing bypasses in markets excluding demonstration hospital.
4. * Sets of demonstration site/competition proportions that are significantly different ($p<0.05$).
5. # Demonstration site proportions that are significantly different across the four years ($p<0.05$).

SOURCE: 1990 through 1996 MedPAR files.

Table 4-8

Average Adjusted Length of Stay for Medicare Bypass Patients in Demonstration Markets

	1990	1991	1992	1993	1994	1995	1996
National Average	15.0	14.0	13.5	12.3	11.3	10.4	9.9
Atlanta							
Saint Joseph's	12.3	11.3	10.2	9.0	8.2	7.6	7.2
Competitors	13.6	12.5	12.1	11.2	9.8	9.0	8.3
Boston							
University Hospital	17.6	13.8	12.9	11.9	10.7	10.1	9.2
Competitors	16.7	15.8	14.9	14.3	12.6	11.3	10.4
Columbus							
Ohio State U. Hospital	15.4	15.9	14.3	13.2	9.4	9.4	10.4
Competitors	14.6	13.6	12.9	12.4	11.3	10.2	9.6
Ann Arbor							
St. Joseph Mercy	14.2	12.1	11.4	10.7	9.9	9.9	9.0
Competitors	15.5	14.6	13.3	12.5	11.8	11.2	10.5
Portland, OR							
St. Vincent's	12.4	11.0	10.1	9.1	9.4	8.8	8.8
Competitors	9.9	10.6	10.1	9.9	9.3	8.5	8.7
Indianapolis							
Methodist	14.4	12.4	11.5	10.5	8.7	8.3	8.4
Competitors	15.4	13.5	12.7	12.2	11.1	10.1	10.0
Houston							
St. Luke's	14.7	13.7	12.7	11.5	11.4	11.5	10.5
Competitors	16.9	15.5	16.1	14.2	12.8	12.0	11.3

NOTES:
1. Includes all heart bypass operations, defined as DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data.
3. Adjusted to standardize for proportion of patients in each DRG.
4. Competitors is an average of all hospitals doing bypasses in markets excluding demonstration hospital.
5. Data for St. Vincent's exclude HMO enrollees.

SOURCE: 1990 through 1996 MedPAR files.

undergoing CABG with catheterization in DRG 106. To standardize for differences in the number of patients in each DRG, each hospital's average length of stay by DRG was weighted by the national proportion of cases in each DRG.

As was seen nationally, the general trend in demonstration hospitals is towards shorter stays. For example, in Atlanta, the average length of stay at Saint Joseph's Hospital decreased 27 percent, from 12.3 to 9.0 days from 1990 to 1993, and then decreased another 20 percent to 7.2 days in 1996. The average length of stay for the Atlanta competitors decreased 18 percent, from 13.6 to 11.2 days in 1993 and another 25 percent, to 8.3 days by 1996. The average stay at University Hospital in Boston decreased by 8.4 days from 1990 to 1996, from 17.6 to 9.2 days, the largest decrease for any of our sites.

Using regression analysis, we tested whether the average length of stay differed significantly across the seven demonstration sites, adjusting for DRG mix. In each of the seven years the F-value indicated significant differences ($p < 0.01$). We also used pooled regression analysis to test whether length of stay in each of the seven demonstration sites was significantly different from the set of all competitors (aggregated across all seven sites) in each of the four years. The results of these regressions are presented in Table 4-9. Stays in St. Joseph's Hospital in Atlanta and in St. Vincent's in Portland were significantly shorter than in the competitors for all seven years, holding the DRG mix constant, with the differences ranging from 1.24 (St. Vincent's, 1996) to 3.30 (St. Vincent's, 1991) days. Stays in Methodist were roughly 2 days shorter (and statistically different) than in the competitors for 1991-96, while stays in St. Joseph Mercy were roughly two days shorter during the

Table 4-9

Results of Medicare Bypass Length of Stay Regressions for Demonstration Hospitals and Competitors, 1990-96

	1990	1991	1992	1993	1994	1995	1996
Intercept	18.72 **	15.27 **	15.09 **	13.88 **	13.89 **	12.22 **	11.92 **
DRG 106	-2.46 **	0.58	-0.21	-0.03	-1.16 **	-0.53	-0.90 **
DRG 107	-6.21 **	-3.60 **	-3.77 **	-3.42 **	-4.16 **	-3.34 **	-3.66 **
St. Joseph's	-2.52 **	-2.74 **	-2.94 **	-2.88 **	-3.21 **	-2.85 **	-2.64 **
University-Boston	1.42	-0.67	-1.20	-1.36 **	-1.15	-0.74	-0.86 **
Ohio State	0.23	1.69 **	0.86	1.05	-2.13 **	-1.17	0.28
St. Joseph Mercy	-1.14	-1.96 **	-1.90 **	-1.81 **	-1.76 **	-0.75	-0.95 **
St. Vincent's	-2.87 **	-3.30 **	-3.30 **	-2.82 **	-1.36 **	-1.68 **	-1.24 **
St. Luke's	-0.49	-0.20	-0.65	-0.80 **	-0.09	1.07 **	0.61
Methodist	-0.87	-2.03 **	-2.01 **	-2.13 **	-2.91 **	-2.36 **	-1.56 **
R^2	0.03	0.05	0.03	0.06	0.06	0.06	0.07
F-test	49.38	85.54	49.28	103.75	101.96	103.98	127.77
No. of Observations	13,446	14,061	14,361	14,473	14,735	15,372	15,868

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data.
3. DRG 108 is the omitted category. All competitors for the seven demonstration hospitals is the omitted category.
4. ** Statistically significant ($p<0.01$).
5. Data for St. Vincent's excludes HMO enrollees.

SOURCE: 1990 through 1996 MedPAR files.

1991-94 period, before the difference was reduced to roughly one day. Only Ohio State and St. Luke's Hospital failed to show a statistically shorter length of stay holding DRG mix constant.

We also used regression analysis to test whether the start of the demonstration had affected the trend in length of stay at the demonstration sites. Each regression was performed using patient level data for each demonstration hospital and its own set of market competitors. For this analysis, we constructed a variable "month" defined as one for January 1990, two for February 1990, and so forth, through 78 for June 1996. Length of stay was regressed on DRG (to adjust for casemix differences), demo (equal to one for the demonstration hospital during the demonstration), and demo interacted with month. A negative coefficient on the interaction term would indicate that during the demonstration, length of stay decreased more rapidly in the demonstration hospital than its competitors.

The coefficient on the month variable is negative and significant in all regressions, as expected, see Table 4-10, indicating that lengths of stay have grown shorter in all seven sites. The coefficient on the interaction of month and demo is statistically significant for Methodist Hospital (Indianapolis) and St. Luke's (Houston). The coefficient is negative for Methodist, indicating a greater reduction in stays than in its market competitors, while the coefficient is positive for St. Luke's, indicating a lesser reduction than other Houston hospitals. For the other demonstration hospitals, the coefficient is not significant, indicating that the trend in length of stay was not significantly different between demonstration and

Table 4-10

Regression Results on Trends in Medicare Bypass Length of Stay at Demonstration Hospitals, 1990-96

	Atlanta	Boston	Columbus	Ann Arbor	Portland	Indianapolis	Houston
Intercept	13.782 **	18.875 **	19.163 **	15.378 **	12.593 **	16.620 **	18.220 **
DRG106	-0.579	-0.978 **	-1.595 **	0.275	-0.435	-1.339 **	-3.037 **
DRG107	-2.633 **	-5.844 **	-4.813 **	-3.860 **	-2.271 **	-4.619 **	-4.139 **
Demo	-1.534 **	-1.219 **	1.487 **	-1.417 **	0.848 **	-1.259 **	-2.393 **
Month	-0.072 **	-0.094 **	-0.091 **	0.020 **	-0.033 **	-0.091 **	-0.059
Month*Demo	0.002	-0.011	-0.023	-0.003	-0.006	-0.013 *	0.017 *
R^2	0.08	0.11	0.08	0.08	0.05	0.10	0.02
F-test	200.26	455.16	297.75	332.33	47.55	190.33	54.06
No. of Observations	12,024	19,028	18,285	19,406	4,579	8,944	12,287

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data.
3. DRG 108 is the omitted category.
4. ** Statistically significant ($p<0.01$).
5. * Statistically significant ($p<0.05$).

SOURCE: 1990 through 1996 MedPAR files.

competitor hospitals. However, note that we control only for DRG mix and not for any other risk factors that may affect length of stay.

To further examine how lengths of stay have changed over time, Table 4-11 presents data on the distributions of lengths of stay in demonstration hospitals and their competitors, relative to national percentile thresholds. For each DRG in 1990, 1993 and 1996, we calculated the national thresholds of length of stay (in days) for which 25 percent of cases, 50 percent of cases, and 75 percent of cases which had shorter stays.[5] We then calculated for each demonstration site the proportion of cases with equal or shorter lengths of stay and weighted by national DRG percentages to standardize casemixes. Using these percentage thresholds, we can examine whether hospitals are achieving shorter lengths of stay by eliminating patients with very long stays or by shortening stays across the entire range of patients.

The national percentile columns illustrate the dramatic secular decrease in lengths of stay for Medicare bypass patients. In 1990, 25 percent of patients were discharged with a length of stay of 11 days or less; by 1996, 25 percent of patients were discharged after only 7 days. In 1990, one quarter of all patients had stays of 18 or more days; by 1996 the comparable figure was 13 or more days.

Demonstration and competitor hospitals differed considerably in how they compared to these national benchmarks. For example, in 1990, the 50th percentile (median) threshold for DRG-adjusted Medicare bypass length of stay was 14 days. Among the

[5] Appendix L presents more detailed distributional statistics for 1990-96.

Table 4-11

Percent of Cases with Medicare Bypass Lengths of Stay Equator Less Than Natural Percentile Threshold, Demonstration Hospitals and Competitors, 1990-96

National Threshold		Atlanta		Boston		Columbus		Ann Arbor		Portland, OR		Houston		Indianapolis	
Percentile	Days	Demo	Control	Demo	Control	Demo	Control	Demo	Control	Demo	Control	Demo	Control	Demo	Control
1990															
25%	11	56.2	44.0	28.6	27.0	23.1	38.4	33.6	30.4	48.7	69.4	32.4	24.9	43.1	33.6
50%	14	75.1	67.3	47.4	50.2	58.0	63.3	58.0	54.2	77.9	87.0	62.4	47.5	61.4	56.7
75%	18	87.8	82.2	67.2	69.5	80.5	80.0	80.5	76.0	89.8	95.8	79.9	68.9	79.3	75.1
1993															
25%	9	64.0	50.9	37.4	21.7	21.6	35.0	39.6	33.8	48.9	50.5	34.9	24.5	50.7	38.9
50%	12	82.5	71.3	64.5	47.4	48.6	60.2	68.4	58.0	80.1	78.1	62.9	47.5	75.9	63.9
75%	15	91.1	85.1	82.0	68.3	70.7	78.4	85.5	76.7	94.3	87.8	79.8	68.1	86.3	79.8
1996															
25%	7	59.5	48.8	35.5	22.6	30.1	30.7	33.8	26.1	27.2	33.4	17.4	23.1	45.1	29.9
50%	9	81.9	69.2	59.6	52.1	57.6	56.2	61.9	49.5	61.7	66.7	46.2	44.1	72.3	53.3
75%	13	92.5	84.1	82.6	76.4	71.9	79.7	84.8	73.9	86.8	87.4	75.1	66.5	87.7	77.4

NOTES:

1. Includes all heart bypass operations, defined as cases in DRG 106 or DRG 107 and cases in DRG 108 with a procedure code of 36.10-36.15 or 36.19.
2. Calendar year data.
3. Competitors is an average of all hospitals doing bypasses in market excluding the demonstration hospital.
4. Lengths of stay are adjusted to standardize the proportion of patients in each DRG.
5. Data for St. Vincent's Hospital excludes HMO enrollees.

SOURCE: 1990-96 MedPAR and National Claims History files.

demonstration and competitor hospitals, the proportion of cases with stays this length or shorter ranged from 47.4 percent in University Hospital, which had the longest average length of stay (17.6 days), to 87.0 percent in the Portland set of competitor hospitals, which had the shortest average length of stay (9.9 days). A similar comparison at the 75th percentile (18 days) indicates that only 67.2 percent of patients at University Hospital had been discharged within this period, while 95.8 percent of those in the Portland competitor hospitals had stays this length or shorter.

Three demonstration hospitals, in Atlanta, Portland, and Indianapolis, consistently outperformed the national benchmarks, in terms of patients having shorter lengths of stay. For example, in Atlanta, St. Joseph Mercy had more than 50 percent of its patients discharged by the national 25 percentile standard in each of the three years. University Hospital had the most dramatic improvement, relative to the national standards, with the proportion of patients discharged by the 50^{th} percentile standard increasing from 47.4% in 1990 to 64.5 percent in 1993 and 59.6 percent in 1996.

Comparing across pairs of demonstration and control hospitals, the demo sites in Atlanta, Ann Arbor, and Indianapolis generally have shorter stays than their competitors in all three years. The Boston and Columbus hospitals shorten stays most, relative to their competitors.

5 Impact of Bundled Payments on the Net Program Costs to Medicare and Beneficiaries

5.1 Introduction

In this chapter, we present estimates of the savings to the Medicare program and to beneficiaries resulting from the demonstration. To calculate savings from the demonstration, two basic evaluation questions are addressed. First, what did the program pay under the demonstration at each site? Second, what would the program have paid out in lieu of the negotiated bundled inpatient payment at each site?

Savings are estimated using three spending definitions. The first, and narrowest, definition involves a direct comparison of demonstration global inpatient payments and the PPS and Part B payments that would have been made if there were no evaluation at each demonstration site. Total savings are calculated as the amount of the negotiated per case discount multiplied by the number of cases under the demonstration.

The second savings calculation considers outpatient and other institutional costs post-discharge in addition to the global payment for the bypass surgery. If demonstration hospitals shift care from the inpatient setting so that it can be billed separately from the bundled demonstration rate, inpatient savings will overestimate true savings for the bypass episode.

The third, and broadest, measurement of savings addresses the question "Did the program save money after considering volume shifts from non-demo to demo hospitals?" During the selection process, all candidates' bids were screened against the costs of other local hospitals performing CABGs. It is our understanding that the demonstration hospitals are among the low-cost providers in their own market area. Hence, any bias due to changing market shares may, in fact, overstate the gains HCFA could expect from a national program that might select more expensive hospitals in some cities. Alternatively, a national program taking low cost hospitals would save through volume shifts.

The remainder of the chapter is organized in the following manner. Section 5.2 discusses the analytic approach taken to estimate savings. First, it discusses the quasi-experimental design of the evaluation, and then it describes the three measures of savings that are estimated. Section 5.3 describes the data and the methods used in constructing the savings estimates. Section 5.4 provides results of the analysis.

5.2 Methods and Data Sources

5.2.1 Quasi-experimental Design

This study uses a quasi-experimental design with each demonstration hospital matched to a control group. A simpler experimental design would have tested for changes using pre- and post-demonstration data only from the demonstration sites themselves. However, many research questions demand additional information from non-demo sites, calling for a quasi-experimental design. For example, the question, "How did changes in

market shares for the demonstration hospital affect the estimates of savings?" cannot be addressed without information on competitor volumes. Thus, the competitor hospitals naturally form the "control" group for addressing this question. Competitor hospitals were defined as all hospitals located within the same metropolitan statistical areas (MSAs) as the demonstration sites, plus any additional hospitals that the demonstration sites viewed as competitors. (See Chapter 4 for a detailed discussion of the competitor hospitals.)

The Medicare bypass demonstration consisted of seven hospitals around the country. Four original sites started receiving bundled payments in May and June, 1991. Three "expansion" sites joined the demonstration in June 1993. For all sites, we have data from the demonstration's start through its conclusion in June, 1996.

To calculate savings under the demonstration, both the actual payments made and the payments that would have been made in lieu of the demonstration must be estimated. Calculating the actual payments received under the demonstration is the more straightforward of the two, given that data on payments are available from HCFA. The issues that arise from calculating the payments that would have been made if the hospitals had not participated in the demonstration are discussed in Section 5.2.4 which describes the methodology for calculating savings.

5.2.2 Measures of Savings

Total Inpatient Savings. The first, and narrowest, measure of savings simply involves net inpatient program savings at the demonstration hospitals. It is defined as:

$$NS^1_{dt} = [NIPC_{dt} - P_{dt}]*D_{dt}$$

where NS^1_{dt} = net program savings in demonstration hospital, d, in year t due to just inpatient services only; $NIPC_{dt}$ = expected net inpatient program outlays per discharge in lieu of the demonstration; P_{dt} = the HCFA negotiated price in year t; D_{dt} = the total number of demonstration CABG patients in the demo hospital in year t.

Inpatient program outlays in lieu of the demonstration are defined as

$$NIPC_{dt} = DRG_{dt} + OUT_{dt} + PT_{dt} + P_{dmt}MD_{dmt}$$

where DRG_{dt} = expected DRG 106 or 107 payment to the demo in lieu of the bundled payment; OUT_{dt} = average CABG outlier payments; PT_{dt} = average Part A passthroughs; P_{dmt} = average physician allowables for the m-th service; and MD_{dmt} = average quantity of inpatient physician services per CABG discharge in the demonstration hospital if the hospital had not participated.

Only Part A DRG, outlier, IME, and pass-through costs plus Part B inpatient physician costs would be counted.

This version of savings focuses strictly on government obligations. A second version includes beneficiary liability by adding to NIPC the beneficiary component of the demonstration payment to the negotiated rate, P*, including the beneficiary inpatient deductible and copayment amounts for the bypass stay.

Under the narrowest definition, estimated program gain or loss would depend strictly on whether the bundled negotiated price was below or above expected inpatient outlays under prospective payment. The figures in brackets would be on a per discharge

basis so as not to confound gains with any volume changes. Total savings requires multiplying per case savings by total demonstration Medicare CABG volume. Any productivity and other efficiency gains due to volume increases would accrue to providers rather than to the program unless HCFA negotiated a sliding volume rate. Inflation would not be a problem because expected outlays in lieu of the demonstration (NIPC) are evaluated over the same period covered by the negotiated rate. Also note the NIPC is not actual hospital costs per case but an estimate of yearly Medicare payments under the existing DRG system.

Total Inpatient Plus Ambulatory Savings. A broader definition of net Medicare savings (or costs) would consider outpatient and other institutional costs as well. Hospitals, and particularly physicians, will have greater incentives to discharge demonstration patients earlier with attendant follow-up care at home or in another facility, with additional bills submitted outside the demonstration. Hence, a broader measure of savings is defined as:

$$NS^2_{dt} = NS^1_{dt} + (NOPC_{do} - NOPC_{dt})*D_{dt}$$

$$NOPC_{dt} = NIPC_{dot} + OPD_{dt} + SNF_{dt} + P_{dot}MD_{dot} + DME_{dt} + HHA_{dt}$$

where NS^2_{dt} = net savings including the change in post-demonstration costs not covered by the negotiated price (i.e., $NOPC_{do}$ minus $NOPC_{dt}$); $NIPC_{dot}$ = net inpatient program outlays for CABG patients treated in other hospitals after discharge from the demonstration hospital; OPD_{dt} = total Part A outpatient costs per CABG discharge; SNF_{dt} = total SNF costs per CABG discharge ; $P_{dot}MD_{dot}$ = total outpatient physician costs per CABG discharge; DME_{dt}

= total durable medical equipment costs per CABG discharge; and HHA_{dt} = total home health costs.

If hospitals shift the site of care by discharging patients earlier, the term in parentheses will be negative and inpatient savings alone will overestimate total savings for the bypass episode.

Cost Impacts of Changes in Market Shares. The broadest measure of cost savings would include the first two measures plus any additional savings or losses that result from changes in the locus of surgery between demonstration and other competitor hospitals. It is calculated as:

$$NS^3_{dt} = NS^2_{dt} + [\Delta (1 - MS_{dt})*NIPC^*_{ot} + \Delta Ms_{dt}*P^*_{dt}]*D_{dt}$$

where

NS^3_{dt} = net total savings beginning with project inpatient discounts and including adjustments for both ambulatory cost differences and any differences due to shifts to a more or less expensive demonstration hospital; ΔMS_{dt} = change in the demonstration's hospital's market share; and $NIPC^*_{ot}$ = average net inpatient Medicare CABG outlays in local non-demonstration hospitals. Since $\Delta(1 - MS) = - \Delta MS$, $NS^3_{dt} = NS^2_{dt} + [\Delta Ms_{dt} (P^*_{dt} - NIPC^*_{ot})]*D_{mt}$. Thus, $(NIPC_{dt} - P_{dt})$ can be interpreted as the savings per case shifted. The product of MS_{dt} and D_{mt} (number of cases in the market) provides the number of cases shifted, and the entire right-hand term is the change in costs after accounting for shifts away from competitor hospitals towards the demonstration hospital.

5.2.3 Data Sources

Negotiated Hospital Rates. HCFA provided the contractor with the negotiated demonstration rates for each hospital for 1991-93. These are presented in Table 5-1. The program liability is divided into two components, Part A and Part B. These correspond to the charges to each trust fund for demonstration patients. They do not indicate the split of the bundled payment between the hospital and the physicians, as this is determined within each hospital. Beneficiary liability is the amount paid by the patient in lieu of the normal (variable) physician/supplier copayments.

Claims Data. Claims data for this part of the evaluation come from two sources: HCFA's MedPAR and National Claims History data files. The goal of the file construction was to identify all claims for patients undergoing coronary bypass surgery, in DRG 106 or DRG 107 in the demonstration hospitals and their competitors. Patients included those discharged from January 1, 1990 through June 30, 1996. Since the demonstration began in mid-1991, the 1990 data provide a full year of baseline utilization for the original sites. Analogously, we use 1992 as a baseline year for the expansion sites.

The data for inpatient hospital stays and skilled nursing facility (SNF) stays come from the Medicare MedPAR claims files for 1990-96. File construction began with the national file containing all bypass patients, described in Chapter 2, that had been edited to remove duplicate or inconsistent cases. The first step in the file construction was to identify the demonstration hospitals and their competitors. Lists of competitor hospitals were constructed with the help of representatives of the demonstration hospitals, as described in

Table 5-1

Negotiated Payment Rates to Original Bypass Demonstration Hospitals, 1991-96

	DRG 106				DRG 107			
	Part A Payment	Part B Payment	Beneficiary Liability	Total	Part A Payment	Part B Payment	Beneficiary Liability	Total
St. Joseph's - Atlanta								
1991	$21,432	$3,969	$992	$26,393	$18,457	$3,877	$969	$23,303
1992	21,465	3,975	994	26,434	20,877	2,437	609	23,923
1993	22,302	4,184	1,046	27,532	18,983	2,710	542	21,693
1994	22,658	4,252	1,063	27,973	19,063	2,179	545	21,787
1995	24,158	4,533	1,133	29,824	20,435	2,335	584	23,354
1996	23,918	4,488	1,122	29,529	20,370	2,328	582	23,280
University Hospital - Boston								
1991	30,801	3,504	876	35,181	29,938	2,986	747	33,671
1992	30,804	3,505	876	35,185	30,737	3,066	766	34,569
1993	31,996	3,656	914	36,566	27,206	2,688	672	30,566
1994	32,300	3,691	923	36,914	27,182	2,688	672	30,542
1995	35,478	4,055	1,014	40,547	29,635	2,930	733	33,298
1996	35,849	4,097	1,024	40,970	30,147	2,981	745	33,873
Ohio State University Hospital								
1991	23,972	2,384	596	26,952	18,697	1,916	479	21,092
1992	23,972	2,384	596	26,952	18,697	1,916	479	21,092
1993	23,972	2,384	596	26,952	18,697	1,916	479	21,092
1994	28,905	2,858	715	32,478	22,977	2,366	591	25,934
1995	30,873	3,053	763	34,689	24,632	2,535	634	27,801
1996	31,138	3,079	770	34,987	24,922	2,565	641	28,128

Table 5-1

Negotiated Payment Rates to Originial Bypass Demonstration Hospitals, 1991-93 (continued)

	DRG 106				DRG 107			
	Part A Payment	Part B Payment	Beneficiary Liability	Total	Part A Payment	Part B Payment	Beneficiary Liability	Total
St. Joseph Mercy - Ann Arbor								
1991	27,265	4,014	1,003	32,282	21,544	3,227	807	25,578
1992	27,558	4,057	1,014	32,629	22,352	3,348	837	26,537
1993	29,972	4,400	1,100	35,470	20,733	3,160	790	24,683
1994	31,904	4,682	1,171	37,760	21,972	3,348	837	26,157
1995	33,057	4,851	1,213	39,121	22,959	3,498	875	27,332
1996	32,663	4,793	1,198	38,654	22,889	3,488	872	27,249
Methodist - Indianapolis								
1993	29,057	3,940	935	33,982	22,689	2,596	649	25,934
1994	30,581	4,149	1,037	35,767	23,639	2,702	675	27,016
1995	31,412	4,262	1,065	36,739	24,365	2,785	696	27,846
1996	30,174	4,094	1,023	35,291	24,224	2,768	692	27,684
St. Vincent - Portland								
1993	25,981	3,524	881	30,386	22,835	2,612	653	26,100
1994	26,125	3,544	886	30,555	22,718	2,596	649	25,963
1995	26,945	3,656	914	31,515	23,465	2,682	670	26,817
1996	26,842	3,642	910	31,394	23,486	2,684	671	26,841
St. Luke's - Houston								
1993	29,138	3,952	988	34,078	23,660	2,704	676	27,040
1994	29,438	3,994	998	34,430	23,743	2,713	678	27,134
1995	30,070	4,080	1,020	35,170	24,357	2,784	696	27,837
1996	30,788	4,177	1,044	36,009	23,486	2,684	671	26,841

SOURCE: HCFA, Office of Research and Demonstrations.

Chapter 4. American Hospital Association data, which provides hospital name, was merged onto the MedPAR files using the Medicare Hospital Provider Number to identify these hospitals. Demonstration sites were identified by the same method. In addition, one of the original demonstration hospitals and all of the expansion sites had been given special provider numbers by HCFA to aid in the processing of bypass demonstration claims. HCFA provided the contractor with these special provider numbers, and these claims were also identified. After identifying all beneficiaries undergoing CABG surgery in the demonstration hospitals and their competitors, all of the other inpatient hospital and skilled nursing facility admissions for these individuals were extracted from the relevant files.

HCFA also provided the evaluator with files containing all NCH claims for Medicare beneficiaries discharged from any hospital for CABG surgery during the period same January, 1990 through June, 1996 period. These raw files contained millions of claims. These were first processed to remove duplicate or denied claims. Claims for patients in the demonstration and the competitor hospitals were identified using the patient Health Insurance Claims Numbers (HICNOs) identified from the MedPAR file. Thus, physician/supplier, outpatient department, and home health claims were added to the file containing institutional claims. Our original 1996 values, calculated using the January-June data, yielded very low mean values. After calculating means on a monthly basis, it became apparent that the data for May and June 1996 seemed incomplete. We assume that processing delays resulted in these claims not appearing in the files we received from HCFA.

As a result, although discharge volumes are based on all cases through June, 1996, non-institutional costs per discharge are based only on discharges through April of that year.

5.2.4 Construction of Cost Measures

This section describes the construction of the cost measures used in calculating the three measures of cost savings.

Inpatient-Only Savings. Construction of inpatient-only savings requires comparison of hospital and physician/supplier payments made under the demonstration with payments that would have been made for inpatient bypasses in lieu of the demonstration. Demonstration payments per case were constructed using the negotiated rates (described in Table 5-1), weighted by the proportion of cases in each DRG in the demonstration hospital, and updated annually by HCFA. Beneficiary liability was calculated as the negotiated Part B copayment plus the inpatient deductible (if owed) from the MedPAR files.

The hospital Part A charges for the inpatient stay constitute roughly 70 percent of the cost of the bypass episode (inpatient stay and 90 days post-discharge). Fortunately, estimation of corresponding PPS expenditures per case in lieu of the demonstration is straightforward since hospitals receive a fixed amount per DRG that does not vary with changes in length of stay, type of treatment, or costs.[1] Thus, this amount is insensitive to changes in physician practice patterns that might result from the demonstration.

[1]Hospitals can receive more for outlier cases. These amounts are also captured in PPS payments.

There are two possible ways to compute the PPS payments to the demonstration sites for the inpatient stay in lieu of the demonstration negotiated rate. One approach is to use the relevant fields on the MedPAR files. A second approach is to calculate what the two DRG payments would have been using the DRG cost weights, PPS wage index, pass through amounts, etc., just as if there were no demonstration. In theory, both methods should produce the same results. However, given the millions of claims that are processed, there are likely to be some miscoded fields in the data, making the construction of values from the claims less accurate than the calculated rates. Hence, we used the second approach.

Estimating what would have been paid to physicians for the inpatient stay in lieu of the demonstration is more problematic. Physician/supplier outlays could be constructed using submitted claims. Outlier amounts from erroneous data (or missing claims) could be handled using data trims. A drawback of this approach is the potential for the demonstration to affect physician/supplier practice patterns of inpatient care. Thus, using the actual bills submitted may underestimate what would have been paid in lieu of the demonstration if physicians under the demonstration conserved on inpatient services under the bundled payment.

An alternative method for estimating physician/supplier outlays is to calculate what would have been paid for a standard "package" of inpatient services, using the RBRVS payment amounts, adjusted appropriately to account for changes in payments across time and over geographic areas. This approach eliminates the problem of endogeneity that results from using actual bills submitted under the demonstration. The drawback of this approach

is that it assumes all patients receive a standard set of services and does not allow care to vary based on patient severity or physician practice styles. For example, if a demonstration hospitals' patients were sicker on average than patients receiving the standard services, the estimate of physician/supplier spending in lieu of the demonstration will be biased downwards. However, this approach still seems preferable to using actual physician/supplier charges that partially reflect cost-saving behaviors.

Beneficiary inpatient liability per case in lieu of the demonstration is calculated as the sum of the inpatient deductible plus 20 percent of physician/supplier charges for the inpatient stay. The inpatient deductible is a separate variable on the MedPAR file; the physician/supplier copayment was calculated directly as a percentage of the estimated Part B liability.

The components of expenditures and savings were calculated separately for DRG 106 and DRG 107. Total expenditures and savings were then computed as a weighted average of the two, where the hospital proportion of cases in each DRG served as the weights.

Inpatient Plus Outpatient Savings. Calculation of outpatient savings requires calculation of two additional estimates: (1) actual Medicare expenditures, and (2) expenditures in lieu of the demonstration after the bypass discharge. We use a 90-day post-discharge cutoff which, although relatively short, should capture most of the care that was shifted from the inpatient stay to post-discharge. Use of a shorter post-discharge period also helps filter out care for conditions unrelated to the bypass.

Actual Medicare expenditures in the post-discharge period were calculated using Medicare claims. Outpatient department, physician/supplier services, and home health charges were aggregated for each individual. All beneficiaries with less than $1,000 in inpatient physician/supplier claims were dropped assuming these cases had incomplete claims (see Chapter 2). It is also likely that their post-discharge claims are incomplete. SNF and inpatient hospital (for re-admissions following the bypass discharge) payments were calculated from the MedPAR files as the sum of the "amount reimbursed" variable, including the base amount for the DRG, the PPS portion of capital payments, outlier payments, disproportionate share payments, and indirect medical education, and the "bill total per diem" variable that includes the pass-through portion of capital payments, bad debt, and other pass-throughs such as direct medical education from the MedPAR files.

Post-discharge costs in lieu of the demonstration were calculated using 1990 baseline outpatient data for each demonstration hospital. These costs were constructed in a manner identical to the construction of the actual post-discharge costs during the demonstration period. To estimate the trend in outpatient expenditures in lieu of the demonstration, we calculated the percentage change in post-discharge expenditures between the base period and each of the demonstration years for the sets of competitor hospitals. Base-period average post-discharge expenditures for the demonstration hospitals were then adjusted by these inflation factors to estimate expenditures over the demonstration period if there had been no demonstration.

The competitor hospitals are a natural control group for this analysis and should reflect changes in local post-discharge practice patterns. However, growth in outpatient costs at the competitor hospitals may be particularly sensitive to outlier cases, given the small number of patients treated in any one market. Hence, update factors may be subject to unreasonable random variation. To test the sensitivity of the results to the choice of update factors, we also estimated the post-discharge trend in lieu of the demonstration using national update factors based on outpatient data for all hospitals performing bypass surgery, as described in Chapter 2. These growth rates were 9 percent from 1990 to 1991, 21 percent from 1990 to 1992, 25 percent from 1990 to 1993, 61 percent from 1990 to 1994, 100 percent from 1990 to 1995, and 95 percent from 1990 to 1996.

Estimates of post-discharge spending were calculated separately for DRG 106 and 107 then averaged with the demonstration hospital's proportion of cases in the two DRGs serving as weights. This was done for ease of presentation.

This approach to calculating outpatient savings implicitly assumes that differences in actual versus estimated spending in lieu of the demonstration are caused by the demonstration. Another source of variation in actual spending, mentioned above, is random variation in patient post-discharge needs. Given the relatively small number of patients in some of the demonstration hospitals, a few seriously ill patients could increase average spending in any given year. Even assuming no change in patient severity, these hospitals may not have followed local or national trends in post-discharge spending if they had not participated in the demonstration. The fact that the hospitals applied to be in the

demonstration indicates that they were interested in making their bypass surgery units more profitable. These hospitals may have been more aggressive in shortening stays and shifting care to the outpatient setting or to other facilities than the average hospital, even without the demonstration, but we cannot estimate what this shift would have been.

Savings Including Market Share Shifts. Calculation of savings from the demonstration including additional savings from changes in market shares requires calculation of inpatient payments to competitor hospitals and overall market shares. Actual market shares were calculated as the demonstration hospital's fraction of total Medicare bypass cases in the market, as identified using the MedPAR files.

Net inpatient CABG outlays in non-demonstration hospitals were calculated as the sum of the "amount reimbursed" and "bill total per diem" variables from the MedPAR files, discussed above. Inpatient physician/supplier charges in non-demonstration hospitals were calculated from the NCH files. As before, patients with less than $1,000 in inpatient charges were dropped from computation of the means.

The demonstration hospital's market share in 1990 was assumed to be the market share it would have had throughout 1991-96 in lieu of the demonstration for the four original demonstration sites. The hospital's market share in 1992 was assumed to be its (constant) market share in lieu of the demonstration for the three expansion sites. Again, this is a strong assumption in that all the demonstration hospitals have indicated (by applying for the demonstration and during case study interviews) that they were interested in actively trying to increase their volumes and market shares. They may have accomplished this goal without

being chosen as a demonstration hospital, but we have no way of evaluating how successful they might have been.

5.3 Comparative Costs of Demo Vs. Non-Demo Patients by Market Area

5.3.1 Bypass Inpatient Stay

Original Sites. Table 5-2 presents savings arising during the inpatient portion of the stay at the four demonstration sites. For each hospital, the payment that would have been made in lieu of the demonstration is divided into three components: the PPS hospital payment, the part B physician/supplier payment, and the beneficiary liability. Payment under the demonstration is divided into program liability and beneficiary liability. Savings per case are then calculated by subtracting the negotiated demonstration payment from the payment in lieu of the demonstration. Total savings per hospital are the product of savings per case and the number of demonstration CABGs performed.

Total inpatient savings in the four original sites from the start of the demonstration through its completion in June 1996, totaled $34.4 million. Medicare program savings totaled $29.2 million and beneficiary savings totaled $5.2 million. Demonstration savings in 1991 (the demonstration covered roughly the last seven months of this year) totaled $4.0 million, and savings in 1992 totaled $7.2 million. Savings for 1993 totaled $7.1 million, in 1994 $6.4 million, in and 1995 $6.0 million. Savings through June 1996, totaled $3.6 million.

Table 5-2

Inpatient Savings at the Four Original Heart Bypass Demonstration Hospitals: 1991-1996

	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
Four Original Demonstration Sites						
Total Program Savings	$3,556,472	$6,317,988	$5,962,287	$5,392,023	$5,029,582	$2,986,469
Total Beneficiary Savings	512,737	905,949	1,128,191	1,046,637	995,398	577,124
Total Savings	4,069,209	7,223,937	7,090,478	6,438,660	6,024,980	3,563,593
St. Joseph's - Atlanta						
Payment in Lieu of Demonstration						
PPS Payment	19,367	21,218	18,915	19,732	20,754	20,642
Part B Payment	6,141	5,778	5,792	5,988	6,194	6,182
Beneficiary Liability	1,749	1,816	1,697	1,809	1,860	1,934
Total	**27,257**	**28,812**	**26,404**	**27,529**	**28,808**	**28,758**
Demonstration Payment						
Program Liability	23,132	23,622	22,750	23,514	25,395	25,263
Beneficiary Liability	1,191	1,104	928	1,092	1,168	1,250
Total	**24,323**	**24,727**	**23,678**	**24,606**	**26,563**	**26,513**
Program Savings per case	2,376	3,374	1,957	2,206	1,553	1,561
Beneficiary Savings per case	558	712	769	717	692	684
Total Savings per case	**2,934**	**4,086**	**2,726**	**2,923**	**2,245**	**2,245**
Number of cases	383	654	745	733	744	429
Total Savings	**1,123,722**	**2,672,244**	**2,030,870**	**2,142,559**	**1,670,280**	**963,105**

Table 5-2 (continued)

Inpatient Savings at the Four Original Heart Bypass Demonstration Hospitals: 1991-1996

	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
University Hospital- Boston						
Payment in Lieu of Demonstration						
PPS Payment	36,338	37,448	34,003	33,983	36,064	37,370
Part B Payment	6,526	6,129	6,071	6,138	6,395	6,485
Beneficiary Liability	1,753	1,644	1,653	1,702	1,747	1,810
Total	**44,617**	**45,221**	**41,727**	**41,823**	**44,206**	**45,665**
Demonstration Payment						
Program Liability	33,480	33,883	31,902	32,336	35,229	36,436
Beneficiary Liability	931	920	897	948	995	1,072
Total	**34,411**	**34,803**	**32,799**	**33,284**	**36,224**	**37,508**
Program Savings per case	9,384	9,694	8,172	7,785	7,230	7,419
Beneficiary Savings per case	822	724	756	754	750	738
Total Savings per case	**10,206**	**10,418**	**8,928**	**8,539**	**7,980**	**8,157**
Number of cases	123	165	223	244	275	164
Total Savings	**1,255,338**	**1,718,970**	**1,990,944**	**2,083,516**	**2,194,500**	**1,337,748**

Table 5-2 (continued)

Inpatient Savings at the Four Original Heart Bypass Demonstration Hospitals: 1991-1996

	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
Ohio State U. Hospital						
Payment in Lieu of Demonstration						
PPS Payment	27,581	28,486	27,194	28,119	32,969	32,641
Part B Payment	6,316	5,893	6,223	5,992	3,560	3,525
Beneficiary Liability	1,786	1,683	1,778	1,731	1,252	1,222
Total	**35,683**	**36,062**	**35,195**	**35,842**	**37,781**	**37,388**
Demonstration Payment						
Program Liability	23,711	23,573	24,028	29,190	30,785	30,512
Beneficiary Liability	838	860	842	967	1,072	1,046
Total	**24,549**	**24,433**	**24,870**	**30,157**	**31,857**	**31,558**
Program Savings per case	10,186	10,806	9,389	4,921	5,744	5,474
Beneficiary Savings per case	948	823	936	764	180	176
Savings per case	**11,134**	**11,629**	**10,325**	**5,685**	**5,924**	**5,650**
Number of cases	80	127	152	145	180	106
Total Savings	**890,720**	**1,476,883**	**1,569,400**	**824,325**	**1,066,320**	**598,900**

Table 5-2 (continued)

Inpatient Savings at the Four Original Heart Bypass Demonstration Hospitals: 1991-1996

	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
St. Joseph Mercy - Ann Arbor						
Payment in Lieu of Demonstration						
PPS Payment	25,775	25,809	26,624	27,099	27,752	27,225
Part B Payment	6,229	5,963	6,129	6,212	6,597	6,555
Beneficiary Liability	1,847	1,804	1,913	1,947	2,063	2,080
Total	**33,851**	**33,576**	**34,666**	**35,258**	**36,412**	**35,860**
Demonstration Payment						
Program Liability	27,948	28,211	29,914	30,477	32,271	31,614
Beneficiary Liability	1,116	1,128	1,360	1,395	1,473	1,480
Total	**29,064**	**29,339**	**31,274**	**31,872**	**33,744**	**33,094**
Program Savings per case	4,056	3,561	2,839	2,834	2,078	2,166
Beneficiary Savings per case	731	676	553	552	590	600
Total Savings per case	**4,787**	**4,237**	**3,392**	**3,386**	**2,668**	**2,766**
Number of cases	167	320	442	410	410	240
Total Savings	**799,429**	**1,355,840**	**1,499,264**	**1,388,260**	**1,093,880**	**663,840**

NOTE:
1. Includes all heart bypass operations in DRG 106 or DRG 107.
2. The demonstration began in May-June 1991 at the four original demonstration sites. The 1991 data include only cases covered under the demonstration.
3. 1996 savings are based on discharges through June 30th.

SOURCE: 1991-96 MedPAR and NCH files. Negotiated Demonstration Rates reported in Table 5-1.

In each of the first three years of the demonstration, Ohio State University Hospital generated the largest per case savings of the demonstration hospitals. Program savings ranged from $9,389 to $10,806 per case, while beneficiary savings per case ranged from $823 to $948. These were slightly larger than the per case savings at University Hospital, Boston and more than twice as large as those at St. Joseph's Hospital in Atlanta or St. Joseph Mercy. Although OSU had the smallest volumes of the four demo sites, its large discount per case resulted in extraordinary savings. Total Medicare savings at OSU were $890,000 in 1991, $1.5 million in 1992, and $1.6 million for 1993. Although OSU negotiated a rate with no updates through 1993, beginning in 1994, the DRG 106 and 107 rates were updated annually as part of an agreement to continue beyone the original three years of the demonstration. As a result, the per case discount decreased substantially, but remained over $5,600 for each year. The lower discount resulted in lower annual savings, $824,000 in 1994, $1.1 million in 1995 and roughly $600,000 for the first six months of 1996.

University Hospital in Boston is similar to OSU Hospital in that it offered relatively large per case savings but treated a relatively small number of patients. Inpatient program savings per case ranged from $7,230 to $9,694 across the seven years. (For 1994-96, University Hospital offered the highest inpatient discounts of any demonstration site). University Hospital would have had the highest payments in lieu of the demonstration among the four hospitals, as well as the highest demonstration payments. This is not surprising for a teaching hospital located in the high cost Boston metropolitan area.

In contrast, St. Joseph's Hospital in Atlanta had the smallest per case savings among the demonstration hospitals. St. Joseph's Hospital in Atlanta is a non-teaching hospital, located in a low-cost area of the country. As a result, its PPS inpatient payment in lieu of the demonstration is substantially lower than for the other three sites, e.g., more than $7,000 lower than that for OSU Hospital which provided the greatest per case savings. As a result of its low PPS payment, St. Joseph could not offer as large a discount as the teaching hospitals with higher PPS payments. Nevertheless, despite its low per case savings, St. Joseph contributed the greatest total inpatient savings over the course of the demonstration (over $10.6 million) because of its very high volumes.

Total savings at St. Joseph Mercy, Ann Arbor, totaled $6.8 million across the seven demonstration years. St. Joseph Mercy had the second largest volume among the four demonstration hospitals in each year, but much lower per case savings than OSU and University Hospital.

Expansion Sites. Table 5-3 presents analogous inpatient savings information for each of the three expansion demonstration sites. Recall that for these sites, the demonstration began in mid-1993 and ended in June 1996. Total inpatient savings across all three new sites equaled $10.1 million, of which $7.4 million accrued to the Medicare program and $2.7 million accrued to beneficiaries.

Among the expansion sites, St. Luke's Hospital in Houston accounted for the largest inpatient savings in each year. Total savings per case at St. Luke's were roughly

Table 5-3

Inpatient Savings at the Three Expansion Heart Bypass Demonstration Hospitals: 1993-1996

	Jun-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Dec 1996
Three Original Demonstration Sites				
Total Program Savings	$1,049,441	$2,649,308	$2,115,422	$1,626,871
Total Beneficiary Savings	463,541	941,049	853,529	424,489
Total Savings	1,512,982	3,590,357	2,968,951	2,051,360
Methodist - Indianapolis				
Payment in Lieu of Demonstration				
PPS Payment	25,638	27,162	27,099	27,671
Part B Payment	5,760	5,977	6,078	6,024
Beneficiary Liability	1,758	1,886	1,915	1,922
Total	**33,157**	**35,025**	**35,090**	**35,617**
Demonstration Payment				
Program Liability	29,655	31,376	31,405	31,232
Beneficiary Liability	1,141	1,301	1,292	1,320
Total	**30,796**	**32,677**	**32,697**	**32,552**
Program Savings per case	1,743	1,763	1,772	2,463
Beneficiary Savings per case	617	585	623	602
Total Savings per case	**2,361**	**2,348**	**2,395**	**3,065**
Number of cases	153	320	297	175
Total Savings	**361,233**	**751,360**	**711,315**	**536,375**
St. Vincent's - Portland				
Payment in Lieu of Demonstration				
PPS Payment	21,763	21,928	22,973	23,616
Part B Payment	5,884	6,013	6,194	6,224
Beneficiary Liability	1,886	1,955	2,034	1,901
Total	**29,534**	**29,896**	**31,202**	**31,740**
Demonstration Payment				
Program Liability	26,129	26,241	27,407	27,737
Beneficiary Liability	1,130	1,175	1,252	1,248
Total	**27,259**	**27,416**	**28,659**	**28,985**
Program Savings per case	1,518	1,700	1,760	2,101
Beneficiary Savings per case	756	780	782	653
Total Savings per case	**2,275**	**2,480**	**2,543**	**2,754**
Number of cases	244	452	375	155
Total Savings	**555,100**	**1,120,960**	**953,625**	**426,870**

Table 5-3 (continued)

Inpatient Savings at the Three Expansion Heart Bypass Demonstration Hospitals: 1993-1996

	Jun-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Dec 1996
St. Luke's - Houston				
Payment in Lieu of Demonstration				
PPS Payment	25,024	25,613	25,685	26,528
Part B Payment	6,052	6,038	6,278	6,269
Beneficiary Liability	1,816	1,884	1,897	1,892
Total	**32,892**	**33,535**	**33,859**	**34,689**
Demonstration Payment				
Program Liability	29,571	29,423	30,101	29,906
Beneficiary Liability	1,142	1,205	1,145	1,168
Total	**30,713**	**30,628**	**31,246**	**31,074**
Program Savings per case	1,505	2,228	1,862	2,891
Beneficiary Savings per case	674	679	752	724
Savings per case	**2,179**	**2,907**	**2,614**	**3,615**
Number of cases	274	591	499	301
Total Savings	**597,046**	**1,718,037**	**1,304,386**	**1,088,115**

NOTE:
1. Includes all heart bypass operations in DRG 106 or DRG 107.
2. The demonstration began in May-June 1993 at the three expansion demonstration sites. The 1993 data include only cases covered under the demonstration.
3. 1996 savings are based on discharges through June 30th.

SOURCE: 1992-96 MedPAR and NCH files. Negotiated Demonstration Rates reported in Table 5-1.

equal to those in the other expansion sites, but the much larger volume in St. Luke's led to savings of over $1 million in 1994, 1995, and 1996.

Medicare inpatient program savings at St. Vincent's in Portland totaled $2.1 million across the three years of the demonstration. Savings at Methodist Hospital of Indianapolis were somewhat lower, $1.8 million because of the smaller volumes at this site.

5.3.2 Post-Discharge Expenditures

Original Sites. Table 5-4 presents Medicare program savings (or losses) during the 90 days following discharge from the bypass hospitalization. Savings per case were calculated as the projected expenditures in lieu of the demonstration less the actual expenditures for each of the demo hospitals. This number was multiplied by the volume of demonstration cases to give an estimate of total savings arising from changes in locus of service. For example, St. Joseph's in Atlanta averaged $2,653 per patient in post discharge expenditures in 1991. Updating their 1990 actual expenditures ($3,353) by the national growth rate yielded a projected 1991 expenditure per patient of $3,600. Thus, St. Joseph's averaged of a savings of $947 per patient in 1991, or $362,701 across all demonstration cases.

Total post-discharge savings across the four sites were $409,905 in 1991, $387,450 in 1992 and $517,981 in 1993, $1.2 million in 1994, and $992,078 in 1995. In 1996, savings through June 30 equaled $598,916. Thus, although changes in post-discharge spending were

Table 5-4

Ninety Day Post Discharge Savings at the Four Original Heart Bypass Demonstration Hospitals

	Jan-Dec 1990	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
FOUR DEMONSTRATION SITES							
Total Post Discharge Savings		**$409,905**	**$387,450**	**$517,754**	**$1,170,368**	**$992,078**	**$598,916**
St. Joseph's - Atlanta							
Projected Post Discharge Expenditures in Lieu of Demonstration							
Skilled Nursing Facility		$93	$141	$198	$293	$523	$521
Hospital		2,279	2,495	2,685	3,009	4,168	3,594
Physician/Supplier		852	941	867	1,197	1,298	1,324
Home Health		272	254	303	650	725	777
Outpatient Department		103	125	93	156	173	186
Total		**3,600**	**3,956**	**4,146**	**5,305**	**6,888**	**6,400**
Actual Post Discharge Expenditures							
Skilled Nursing Facility	64	14	87	69	218	358	677
Hospital	2,093	1,380	2,156	1,940	2,115	3,289	2,468
Physician/Supplier	837	844	862	820	980	1,082	1,042
Home Health	255	281	351	402	434	439	361
Outpatient Department	103	120	103	105	149	178	264
Total	**3,353**	**2,653**	**3,560**	**3,337**	**3,896**	**5,346**	**4,812**
Post Discharge Savings/Loss per case		**947**	**396**	**809**	**1,409**	**1,542**	**1,588**
Number of cases		383	654	745	733	744	429
Total Savings		**362,701**	**259,168**	**602,344**	**1,032,797**	**1,147,248**	**681,252**
University Hospital - Boston							
Projected Post Discharge Expenditures in Lieu of Demonstration							
Skilled Nursing Facility		0	0	0	0	0	0
Hospital		3,291	3,569	3,872	4,306	5,964	5,142
Physician/Supplier		985	1,074	1,006	1,394	1,511	1,542
Home Health		699	636	801	1,587	1,772	1,898
Outpatient Department		253	302	230	372	413	439
Total		**5,227**	**5,581**	**5,909**	**7,659**	**9,660**	**9,022**

Table 5-4 (continued)

Ninety Day Post Discharge Savings at the Four Original Heart Bypass Demonstration Hospitals

	Jan-Dec 1990	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
		Actual Post Discharge Expenditures					
Skilled Nursing Facility	0	24	95	312	400	877	932
Hospital	2,995	3,205	4,443	4,521	4,789	8,027	5,952
Physician/Supplier	975	925	879	968	1,392	1,553	1,617
Home Health	624	735	634	596	1,159	1,180	1,618
Outpatient Department	246	258	216	207	430	441	652
Total	**4,841**	**5,146**	**6,267**	**6,605**	**8,170**	**12,078**	**10,771**
Post Discharge Savings/Loss per case		81	-686	-696	-511	-2,418	-1,749
Number of cases		123	165	223	244	275	164
Total Savings		**9,967**	**-113,243**	**-155,133**	**-124,684**	**-664,950**	**-286,836**
Ohio State University Hospital							
		Projected Post Discharge Expenditures in Lieu of Demonstration					
Skilled Nursing Facility		131	200	270	425	758	755
Hospital		1,776	1,913	2,113	2,311	3,200	2,759
Physician/Supplier		646	660	658	919	996	1,017
Home Health		81	77	104	179	200	214
Outpatient Department		166	203	158	240	267	284
Total		**2,801**	**3,053**	**3,304**	**4,074**	**5,422**	**5,029**
		Actual Post Discharge Expenditures					
Skilled Nursing Facility	92	0	100	102	178	275	308
Hospital	1,607	3,533	2,003	3,351	2,866	2,872	2,110
Physician/Supplier	643	570	654	581	661	779	704
Home Health	70	118	79	422	304	756	428
Outpatient Department	159	284	316	193	230	336	469
Total	2,572	**4,504**	**3,153**	**4,648**	**4,239**	**5,018**	**4,019**
Post Discharge Savings/Loss per case		-1,703	-100	-1,345	-165	404	1,010
Number of cases		80	127	152	145	180	106
Total Savings		**-136,279**	**-12,674**	**-204,394**	**-23,925**	**72,720**	**107,060**

Table 5-4 (continued)

Ninety Day Post Discharge Savings at the Four Original Heart Bypass Demonstration Hospitals

	Jan-Dec 1990	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
St. Joseph Mercy - Ann Arbor							
Projected Post Discharge Expenditures in Lieu of Demonstration							
Skilled Nursing Facility		0	0	0	0	0	0
Hospital		1,963	2,125	2,343	2,565	3,553	3,063
Physician/Supplier		660	701	670	935	1,014	1,035
Home Health		234	218	307	527	588	630
Outpatient Department		230	277	221	336	373	397
Total		**3,088**	**3,321**	**3,541**	**4,363**	**5,528**	**5,125**
Actual Post Discharge Expenditures							
Skilled Nursing Facility	0	39	42	71	85	43	49
Hospital	1,784	867	1,507	1,646	1,863	2,670	2,710
Physician/Supplier	654	581	628	632	876	915	876
Home Health	207	375	221	401	577	592	710
Outpatient Department	222	187	127	169	264	242	374
Total	2,868	**2,049**	**2,527**	**2,919**	**3,665**	**4,462**	**4,719**
Post Discharge Savings/Loss per case		**1,039**	**794**	**622**	**698**	**1,066**	**406**
Number of cases		167	320	442	410	410	240
Total Savings		**173,516**	**254,198**	**274,936**	**286,180**	**437,060**	**97,440**

NOTE:

1. Includes all heart bypass operations in DRG 106 or 107.
2. The demonstration began in May-June 1991 at the four original demonstration sites.
3. 1996 values are based on discharges through June 30th.
4. Projected expenditures were calculated by multiplying the demonstration hospital's 1990 expenditures by the national growth rate in post discharge spending for each year.
5. Savings estimates do not include beneficiary savings.

SOURCE: 1990-96 MedPAR and NCH files.

expected to decrease the estimates of total savings, they actually increased savings estimates by $4.1 million over the seven years.

For two of the hospitals, St. Joseph in Atlanta and St. Joseph Mercy, Ann Arbor, actual expenditures in the period post discharge are always less than the projected expenditures, resulting in larger savings per case than implied by the inpatient savings. These savings result primarily from lower-than-expected costs for re-hospitalization following discharge from the bypass stay. The post-discharge savings at St. Joseph Mercy ranged from a low of $406 per case in 1996 to a high of $1,066 per case in 1995. Savings per case in St. Joseph's, Atlanta ranged from a low of $396 in 1992 to a high of $1,588 in 1996.

University Hospital in Boston also has slightly lower actual than projected expenditures in 1991; however, the difference of $81 is inconsequential. In 1992 and 1993, actual expenditures exceeded projected expenditures by nearly $700. Losses per case grew even larger during the later years of the demonstration, reaching $2,418 in 1995 and $1,749 in 1996. This difference results primarily from higher-than-projected costs for re-hospitalizations.

In the early years of the demonstration, only Ohio State University Hospital, with losses in post-discharge expenditures each year, showed evidence of a shift of care outside the hospital. However, despite showing large estimated losses in 1991 and 1993, in the later years, OSU was estimated as having small losses per case (less than $200) and even a savings in 1995 and 1996.

These results are surprising, since it was expected that inclusion of changes in post-discharge care would decrease the savings estimates from the demonstration. There are two reasons to question the accuracy of these estimates. First, our projected expenditures are based on applying national trend rates to 1990 baseline per case outpatient spending on demonstration hospital bypass patients. If these baseline rates are unusually high because of random variation, regression to the mean is likely, and our projected expenditures will be high, biasing our savings estimates upward. Calculating an average expenditure for multiple baseline years would have reduced this problem, but our data did not include any years prior to 1990. Second, payments during the demonstration are subject to a random component, and the differences across years may not be significant. If there is wide variation in post-discharge costs across patients, the presence (or lack) of a few outlier cases may affect average costs but not indicate meaningful differences. The effects of outlier cases are magnified since most of the savings (or loss) comes from rehospitalizations--a few cases with high expenses could drive the entire estimate.

Statistical tests were conducted on pooled 1991-96 data to determine whether actual post-discharge expenditures were significantly different than the projected expenditures by site. The mean and variance for actual expenditures was calculated directly, while the mean and variance of projected expenditures was calculated based on the 1990 actual spending, updated to account for national trends. T-tests of pooled data for 1991-96 indicated that projected expenditures were not significantly different than actual expenditures for any of the demonstration sites. Thus, we cannot conclude that the demonstration resulted in slower

growth in post-discharge costs (despite the estimated savings) compared to what we would have observed in lieu of the demonstration.

Expansion Sites. Table 5-5 presents similar post-discharge savings estimates for the three expansion sites. The results from the expansion sites are quite different than for the original sites. Across the three sites, actual post discharge expenditures were found to exceed projected sites in each year, with losses ranging from $191,234 in 1995 to $925,527 in 1996.

Both St. Luke's in Houston and St. Vincent's in Portland experienced additional costs per case in each year. At St. Luke's, the additional cost per case ranged from $203 in 1995 to $1,872 for the first 6 months of 1996. In 1996, the bulk of the costs arose from higher than predicted rehospitalization costs, although physician charges were also much higher than expected. In 1994 and 1995, actual rehospitalization costs were near (or even lower than) projected costs. However, skilled nursing facility and home health costs exceeded the projected values. At St. Vincent's, additional costs per case were generally fairly small, but rose to $701 in 1996 as a result of higher than projected rehospitalization costs.

The pattern at Methodist resembles that found in the original expansion sites more than its cohort of expansion sites. Although Methodist experienced additional costs per case of $1,061 in 1993, in 1994 actual expenditures were $372 lower than projected, and in 1995 actual and projected expenditures were almost equal. Methodist experienced its largest additional costs per case in 1996, as did both the other expansion sites. Note that 1996

Table 5-5

Ninety Day Post Discharge Savings at the Three Expansion Heart Bypass Demonstration Hospitals

	Jan-Dec 1992	Jun-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
THREE DEMONSTRATION SITES					
Total Post Discharge Savings		**-$547,693**	**-$466,106**	**-$191,234**	**-$925,527**
Methodist - Indianapolis					
Projected Post Discharge Expenditures in Lieu of Demonstration					
Skilled Nursing Facility		$136	$237	$422	$421
Hospital		1,999	2,248	3,114	2,685
Physician/Supplier		625	763	827	844
Home Health		203	286	320	343
Outpatient Department		164	228	253	270
Total		**3,128**	**3,763**	**4,937**	**4,562**
Actual Post Discharge Expenditures					
Skilled Nursing Facility	101	205	126	534	411
Hospital	1,820	2,937	1,943	2,829	3,759
Physician/Supplier	652	739	726	845	1,015
Home Health	144	134	310	371	440
Outpatient Department	144	174	286	354	385
Total	**2,861**	**4,189**	**3,391**	**4,933**	**6,010**
Post Discharge Savings/Loss per case		**-1,061**	**372**	**4**	**-1,448**
Number of cases		153	320	297	175
Total Savings		**-162,333**	**119,040**	**1,188**	**-253,400**
St. Vincents - Portland					
Projected Post Discharge Expenditures in Lieu of Demonstration					
Skilled Nursing Facility		65	113	201	200
Hospital		720	810	1,122	968
Physician/Supplier		455	556	603	615
Home Health		126	177	198	212
Outpatient Department		128	177	197	210
Total		**1,494**	**1,833**	**2,321**	**2,204**
Actual Post Discharge Expenditures					
Skilled Nursing Facility	48	69	212	152	336
Hospital	656	798	960	1,444	1,406
Physician/Supplier	475	482	672	570	665
Home Health	89	165	200	170	239
Outpatient Department	112	104	150	228	259
Total	**1,380**	**1,618**	**2,194**	**2,564**	**2,905**
Post Discharge Savings/Loss per case		-124	-361	-243	-701
Number of cases		244	452	375	155
Total Savings		**-30,256**	**-163,172**	**-91,125**	**-108,655**

Table 5-5 (continued)

Ninety Day Post Discharge Savings at the Three Expansion Heart Bypass Demonstration Hospitals

	Jan-Dec 1992	Jun-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
St. Luke's - Houston					
Projected Post Discharge Expenditures in Lieu of Demonstration					
Skilled Nursing Facility		70	122	218	217
Hospital		2,192	2,466	3,415	2,995
Physician/Supplier		640	782	848	865
Home Health		231	326	364	390
Outpatient Department		185	257	285	304
Total		**3,319**	**3,953**	**5,130**	**4,720**
Actual Post Discharge Expenditures					
Skilled Nursing Facility	52	53	220	534	406
Hospital	1,996	3,208	2,571	2,829	3,781
Physician/Supplier	668	892	939	1,245	1,556
Home Health	164	275	682	371	378
Outpatient Department	162	187	255	354	471
Total	**3,042**	**4,615**	**4,667**	**5,333**	**6,592**
Post Discharge Savings/Loss per case		-1,296	-714	-203	-1,872
Number of cases		274	591	499	301
Total Savings		**-355,104**	**-421,974**	**-101,297**	**-563,472**

NOTE:

1. Includes all heart bypass operations in DRG 106 or 107.
2. The demonstration began in May-June 1993 at the three expansion demonstration sites.
3. 1996 values are based on discharges through June 30th.
4. Projected expenditures were calculated by multiplying the demonstration hospital's 1990 expenditures by the national growth rate in post discharge spending for each year.
5. Savings estimates do not include beneficiary savings.

SOURCE: 1992-96 MedPAR and NCH files.

estimates are based on only four months of data, so the random element is larger than for earlier years.

Statistical tests were conducted to determine if the pooled 1993-96 data were meaningfully different than the 1992 data, updated to account for inflation. As was the case with the original sites, the actual post-discharge expenditures were not found to differ from the expected expenditures. Thus, we can reject the hypothesis that the demonstration led to more rapid growth in post-discharge expenditures.

Use of National vs. Market Updates. To test the sensitivity of these results to the use of national inflation factors for updating post-discharge expenditures, post-discharge savings were also estimated using inflation factors based on trends in competitor hospitals to update the demonstration hospital baseline values.

These results are summarized in Table 5-6 and 5-7. The use of market-specific update factors results in substantially higher savings estimates for St. Joseph's Hospital in Atlanta. For example, in 1992, post-discharge savings per case were $2,150 using Atlanta market trend factors compared to $947 per case using national trend updates. This difference results from a very large increase in post-discharge costs for the Atlanta competitors between 1990 and 1991. Since the national average increase was much smaller (and St. Joseph's had an even smaller increase) the demonstration hospital experienced larger savings using the market trend. Post-bypass savings estimates are also smaller for University Hospital-Boston using the national estimates, although the difference is not as great as for St. Joseph's. The pairs of estimates for OSU Hospital and St. Joseph Mercy Hospital, Ann Arbor, are generally

Table 5-6

Comparison of 90 Day Post-Discharge Savings Estimates Calculated Using Market Area Growth Rates in Expenditures with Those Calculated Using National Growth Rates

	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
FOUR DEMONSTRATION SITES						
Total Post Discharge Savings						
Using Market Area Trends	$1,032,110	$1,287,553	$2,694,999	$2,818,712	$2,330,818	$1,652,050
Using National Trends	409,937	387,174	517,981	1,170,368	992,078	598,916
St. Joseph's - Atlanta						
Post Discharge Savings per Case						
Using Market Area Trends	$2,150	$1,828	$2,761	$3,249	$3,392	$3,368
Using National Trends	947	396	809	1,409	1,542	1,588
Total Post Discharge Savings						
Using Market Area Trends	823,450	1,195,512	2,056,945	2,381,517	2,523,648	1,444,759
Using National Trends	362,701	258,984	602,705	1,032,797	1,147,248	681,252
University Hospital - Boston						
Post Discharge Savings per Case						
Using Market Area Trends	968	-263	360	700	-731	530
Using National Trends	81	-686	-696	-511	-2,418	-1,749
Total Post Discharge Savings						
Using Market Area Trends	119,064	-43,395	80,280	170,800	-201,150	86,841
Using National Trends	9,963	-113,190	-155,208	-124,684	-664,950	-286,836

Table 5-6 (continued)

Comparison of 90 Day Post-Discharge Savings Estimates Calculated Using Market Area Growth Rates in Expenditures with Those Calculated Using National Growth Rates

	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Dec 1996
Ohio State University Hospital						
Post Discharge Savings per Case						
Using Market Area Trends	-1,775	-312	-1,288	791	-39	844
Using National Trends	-1,703	-100	-1,345	-165	404	1,010
Total Post Discharge Savings						
Using Market Area Trends	-142,000	-39,624	-195,776	114,695	-7,020	89,515
Using National Trends	-136,240	-12,700	-204,440	-23,925	72,720	107,060
St. Joseph Mercy - Ann Arbor						
Post Discharge Savings per Case						
Using Market Area Trends	788	547	819	370	679	129
Using National Trends	1,039	794	622	698	1,066	406
Total Post Discharge Savings						
Using Market Area Trends	131,596	175,040	361,998	151,700	278,390	30,935
Using National Trends	173,513	254,080	274,924	286,180	437,060	97,440

NOTE:

1. Includes all heart bypass operations in DRG 106 or 107.
2. The demonstration began in May-June at the four original demonstration sites. The 1991 data include only cases covered under the demonstration.
3. 1996 values are based on discharges through June 30th.
4. Post discharge savings are calculated as the difference between projected expenditures in lieu of the demonstration and actual expenditures during the 90 days after discharge.

SOURCE: 1990-96 MedPAR and NCH files.

Table 5-7

Comparison of 90 Day Post-Discharge Savings Estimates Calculated Using Market Area Growth Rates in Expenditures with Those Calculated Using National Growth Rates

	Jun-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
THREE EXPANSION SITES				
Total Post Discharge Savings				
Using Market Area Trends	-$592,934	-$843,410	-$617,295	-$1,062,077
Using National Trends	-547,693	-466,106	-191,234	-925,527
Methodist - Indianapolis				
Post Discharge Savings per Case				
Using Market Area Trends	-$1,180	$154	-$623	-$1,985
Using National Trends	-1,061	372	4	-1,448
Total Post Discharge Savings				
Using Market Area Trends	-180,540	49,280	-185,031	-347,375
Using National Trends	-162,333	119,040	1,188	-253,400
St. Vincents - Portland				
Post Discharge Savings per Case				
Using Market Area Trends	-328	-623	-506	-898
Using National Trends	-124	-361	-243	-701
Total Post Discharge Savings				
Using Market Area Trends	-80,032	-281,596	-189,750	-139,190
Using National Trends	-30,256	-163,172	-91,125	-108,655
St. Luke's - Houston				
Post Discharge Savings per Case				
Using Market Area Trends	-1,213	-1,034	-486	-1,912
Using National Trends	-1,296	-714	-203	-1,872
Total Post Discharge Savings				
Using Market Area Trends	-332,362	-611,094	-242,514	-575,512
Using National Trends	-355,104	-421,974	-101,297	-563,472

NOTE:
1. Includes all heart bypass operations in DRG 106 or 107.
2. The demonstration began in May-June at the three expansion demonstration sites. The 1993 data include only cases covered under the demonstration.
3. 1996 values are based on discharges through June 30th.
4. Post discharge savings are calculated as the difference between projected expenditures in lieu of the demonstration and actual expenditures during the 90 days after discharge.

SOURCE: 1992-96 MedPAR and NCH files.

similar, as the market spending updates are more similar to the national updates in these areas.

Clearly, total program estimates are significantly lower using national trend update factors, almost all of which results from the lower savings estimates in the Atlanta demonstration site. For example, in 1991 the total post-discharge savings across the four demonstration sites is $409,937 using the national updates and $1 million using the market area updates. The difference in the savings estimates for St. Joseph's Hospital in Atlanta under the two sets of updates is roughly $450,000 in 1991, and $750,000 to more than $1 million in all later years.

The large differences in estimated savings per case across the demonstration sites were the result of large differences in post-discharge expenditure growth among the four sets of competitors. For example, post-discharge spending for competitors of St. Joseph's Hospital in Atlanta grew 50 percent between 1990 and 1991, while post-discharge spending for OSU Hospital's competitors grew by only 7 percent (not shown).

The differences between the national and market area savings for the expansion hospitals (shown in Table 5-7) are generally not as large as for the original sites. Additional costs are larger each year calculated using the market area trends, but these differences are not nearly as dramatic as those seen for the original sites.

Given the degree of randomness in the data, our estimates of total savings rely on the post discharge savings based on national trends that provide lower, more conservative estimates.

5.3.3 Savings From Shifts in Market Shares

Original Sites. The third measure of savings presented includes savings resulting from shifts in market shares from competitor to demonstration hospitals. Market share shifts are calculated as the difference between the each demonstration hospital's annual market share and the pre-demo share (1990 for the original sties, 1992 for the expansion sites). Table 5-8 presents program savings resulting from market share shifts. Since total savings depends on both the market share shift and the shift in DRG proportions within hospital, there is no intuitive method of aggregating the per case savings by DRG. Instead, savings are presented by DRG and then totaled for each site.

St. Joseph's in Atlanta was estimated to have a demonstration payment in 1991 for DRG106 that was $5,794 lower than the average of its competitors. St. Joseph's market share was 3.4 percentage points greater for DRG 106 in 1991 than in 1990, corresponding to an increase in volume of 14.52 cases. Multiplying the number of cases shifted by the savings per case (14.52 x $5,794) yields an estimated savings of $84,129 from the increase in market share.

St. Joseph's Hospital in Atlanta experienced a market share increase for DRG 106 for all six years relative to the 1990 market share. Although market share for DRG 107 decreases in every year except 1992 and 1993, the large increases in market share for DRG 106 coupled with a demonstration payment $5,000-$8,000 less than the payment received by competitor hospitals, led to additional savings of $39,525 in 1991, $262,641 in 1992, and more than $450,000 for each of 1994, 1995, and 1996.

Table 5-8

Savings From Shifts in Market Shares at the Four Original Demonstration Hospitals

	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
FOUR ORIGINAL DEMONSTRATION SITES						
Total Savings from Market Share Shifts	**$57,137**	**$74,948**	**$1,113,532**	**$958,587**	**$1,049,421**	**$865,269**
St. Joseph's - Atlanta						
DRG 106						
Payment to Competitors	31,195	33,401	34,755	36,564	38,678	38,109
Demonstration Payment	25,401	25,440	26,486	27,973	29,824	29,529
Savings per Case Shifted	5,794	7,961	8,269	8,591	8,854	8,580
Change from 1990 Market Share	0.034	0.028	0.025	0.132	0.114	0.173
Estimated Number of Cases Shifted	14.52	19.91	17.60	111.54	111.49	88.06
Savings from Market share shift	84,129	158,504	145,534	958,240	987,132	755,555
DRG 107						
Payment to Competitors	21,441	23,734	22,286	27,414	29,197	30,379
Demonstration Payment	18,457	20,877	18,983	21,787	23,354	23,280
Savings per Case Shifted	5,310	5,821	5,166	5,627	5,843	7,099
Change from 1990 Market Share	-0.013	0.018	0.079	-0.030	-0.042	-0.065
Estimated Number of Cases Shifted	-8.40	17.89	86.34	-30.93	-42.00	-38.22
Savings from Market share shift	-44,604	104,138	446,032	-174,043	-245,406	-271,324
Total Savings from Market share shift	**$39,525**	**$262,641**	**$591,567**	**$784,197**	**$741,726**	**$484,231**
University Hospital - Boston						
DRG 106						
Payment to Competitors	37,540	42,418	46,513	47,681	47,579	48,274
Demonstration Payment	34,305	34,309	35,652	36,914	40,547	40,970
Savings per Case Shifted	3,235	8,109	10,861	10,767	7,032	7,304
Change from 1990 Market Share	0.001	-0.033	-0.025	-0.013	-0.015	0.011
Estimated Number of Cases Shifted	0.64	-42.67	-32.62	-17.85	-22.57	9.22
Savings from Market share shift	2,070	-346,011	-354,286	-192,191	-158,712	67,343

Table 5-8 (continued)

Savings From Shifts in Market Shares at the Four Original Demonstration Hospitals

	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
DRG 107						
Payment to Competitors	31,640	34,310	33,773	34,278	35,283	36,705
Demonstration Payment	32,924	33,823	29,894	30,542	33,298	33,873
Savings per Case Shifted	-1,284	487	3,879	3,736	1,985	2,832
Change from 1990 Market Share	-0.017	-0.025	-0.015	-0.027	-0.014	-0.025
Estimated Number of Cases Shifted	-11.58	-35.60	-21.64	-44.17	-23.48	-22.82
Savings from Market share shift	14,869	-17,337	-83,942	-165,019	-46,608	-64,626
Total Savings from Market share shift	**$16,939**	**($363,348)**	**($438,227)**	**($357,210)**	**($205,320)**	**$2,717**
Ohio State University Hospital						
DRG 106						
Payment to Competitors	34,253	35,256	36,438	38,293	39,113	39,050
Demonstration Payment	26,356	26,356	26,356	32,478	34,689	34,987
Savings per Case Shifted	7,897	8,900	10,082	5,815	4,424	4,063
Change from 1990 Market Share	0.005	0.001	0.015	0.009	0.013	-0.007
Estimated Number of Cases Shifted	3.74	1.24	20.20	12.19	19.29	-5.90
Savings from Market share shift	29,535	11,036	203,656	70,885	85,339	-23,972
DRG 107						
Payment to Competitors	33,185	33,354	30,988	31,368	31,940	32,330
Demonstration Payment	20,613	20,613	20,613	25,934	27,801	28,128
Savings per Case Shifted	12,572	12,741	10,375	5,434	4,139	4,202
Change from 1990 Market Share	-0.015	-0.014	-0.012	-0.013	-0.003	0.013
Estimated Number of Cases Shifted	-13.74	-20.48	-16.44	-17.09	-4.58	10.70
Savings from Market share shift	-172,739	-260,936	-170,565	-92,867	-18,957	44,961
Total Savings from Market share shift	**($143,205)**	**($249,900)**	**$33,091**	**($21,982)**	**$66,382**	**$20,990**

Table 5-8 (continued)

Savings From Shifts in Market Shares at the Four Original Demonstration Hospitals

	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
St. Joseph Mercy - Ann Arbor						
DRG 106						
Payment to Competitors	37,385	37,848	39,370	39,882	40,820	41,416
Demonstration Payment	31,279	31,615	34,372	37,760	39,121	38,654
Savings per Case Shifted	6,106	6,233	4,998	2,122	1,699	2,762
Change from 1990 Market Share	0.013	0.008	0.066	0.004	0.014	-0.007
Estimated Number of Cases Shifted	7.77	9.69	89.10	5.85	21.15	-6.79
Savings from Market share shift	47,444	60,398	445,322	12,414	35,934	-18,754
DRG 107						
Payment to Competitors	33,412	33,137	31,817	31,678	32,870	33,657
Demonstration Payment	24,771	25,700	23,893	26,157	27,332	27,249
Savings per Case Shifted	8,641	7,437	7,924	5,521	5,538	6,408
Change from 1990 Market Share	0.012	0.029	0.040	0.065	0.048	0.073
Estimated Number of Cases Shifted	11.16	49.10	60.80	98.02	74.16	58.69
Savings from Market share shift	96,434	365,157	481,779	541,168	410,698	376,086
Total Savings from Market share shift	**$143,877**	**$425,554**	**$927,101**	**$553,582**	**$446,632**	**$357,332**

NOTE:

1. Includes all heart bypass operations in DRG 106 or 107.
2. The demonstration began in May-June 1991 at the four original demonstration sites. The 1991 data include only cases covered under the demonstration.
3. 1996 values are based on discharges through June 30th.
4. Savings estimates do not include beneficiary savings.

SOURCE: 1990-96 MedPAR and NCH files.

St. Joseph Mercy, Ann Arbor, also increased its market share in each year, relative to the baseline. As a result, additional total savings accrue to the program from this shift, ranging from $143,877 in 1991 to $927,101 in 1993.

Ohio State University Hospital experienced overall decreases in market share during 1991, 1992 and 1994 as the result of a small increases in market share for DRG 106 and larger decreases in market share for DRG 107. Consequently, the program experienced a small additional cost each year (-$143,205, -$249,900 and -$21,982) as the result of patient shifts to higher cost hospitals. In 1993, 1995, and 1996, OSU increased its market share relative to the 1990 share, and the program experienced a savings ranging from $20,990 to $66,382.

University Hospital in Boston experienced overall decreases in its market share in all years relative to 1990. This produced program losses ranging from $205,320 in 1995 to $438,227 in 1993 as patients were shifted to more expensive non-demonstration hospitals. In 1996, overall market share decreased, but the increase in market share for DRG 106 coupled with the high savings per case shifted led to a small savings of $2,717. In 1990, the decrease in market share led to a savings of $16,939 in DRG 107, as University Hospital was slightly more expensive than the average of its competitors. This perverse effect was unexpected, and it is not clear that savings as a result of shifts from the demonstration hospital to lower cost competitors should be considered as savings to the program.

Expansion Sites. Table 5-9 presents similar results on savings from shifts in market shares for the three expansion sites. Methodist Hospital in Indianapolis had estimated

Table 5-9

Savings From Shifts in Market Shares at the Three Expansion Demonstration Hospitals

	Jun-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
THREE EXPANSION DEMONSTRATION SITES				
Total Savings from Market Share Shifts	**($9,154)**	**$51,784**	**($191,902)**	**($259,785)**
Methodist - Indianapolis				
DRG 106				
Payment to Competitors	34,217	34,211	34,797	35,749
Demonstration Payment	33,982	35,767	36,739	35,291
Savings per Case Shifted	235	-1,556	-1,942	458
Change from 1992 Market Share	-0.045	-0.023	-0.071	0.011
Estimated Number of Cases Shifted	-16.02	-18.40	-54.39	4.20
Savings from Market share shift	-3,765	28,630	105,625	1,924
DRG 107				
Payment to Competitors	25,396	26,461	26,718	26,932
Demonstration Payment	25,934	27,016	27,846	27,684
Savings per Case Shifted	-538	-555	-1,128	-752
Change from 1992 Market Share	-0.064	-0.019	-0.057	-0.086
Estimated Number of Cases Shifted	-20.93	-11.67	-37.33	-30.53
Savings from Market share shift	11,260	6,477	42,108	22,959
Total Savings from Market share shift	**$7,496**	**$35,107**	**$147,734**	**$24,882**
St. Vincent's - Portland				
DRG 106				
Payment to Competitors	36,688	37,239	39,129	38,613
Demonstration Payment	30,386	30,555	31,515	31,394
Savings per Case Shifted	6,302	6,684	7,614	7,219
Change from 1992 Market Share	-0.044	-0.062	-0.061	-0.102
Estimated Number of Cases Shifted	-8.01	-21.76	-21.96	-20.30
Savings from Market share shift	-50,479	-145,444	-167,203	-146,546
DRG 107				
Payment to Competitors	28,093	28,066	28,956	29,381
Demonstration Payment	26,100	25,963	26,817	26,841
Savings per Case Shifted	1,993	2,103	2,139	2,540
Change from 1992 Market Share	0.090	0.097	0.025	-0.128
Estimated Number of Cases Shifted	24.30	42.28	10.62	-27.39
Savings from Market share shift	48,430	88,915	22,716	-69,571
Total Savings from Market share shift	**($2,049)**	**($56,529)**	**($144,487)**	**($216,116)**

Table 5-9

Savings From Shifts in Market Shares at the Three Expansion Demonstration Hospitals

	Jun-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996
St. Luke's - Houston				
DRG 106				
Payment to Competitors	34,794	36,054	37,069	38,067
Demonstration Payment	34,078	34,430	35,170	36,009
Savings per Case Shifted	716	1,624	1,899	2,058
Change from 1992 Market Share	0.054	0.034	0.000	-0.016
Estimated Number of Cases Shifted	25.54	34.17	0.00	-9.58
Savings from Market share shift	18,287	55,492	0	-19,716
DRG 107				
Payment to Competitors	29,343	29,289	31,677	31,622
Demonstration Payment	27,040	27,134	27,837	28,703
Savings per Case Shifted	2,303	2,155	3,840	2,919
Change from 1992 Market Share	-0.043	0.012	-0.070	-0.041
Estimated Number of Cases Shifted	-14.28	8.22	-50.82	-16.73
Savings from Market share shift	-32,887	17,714	-195,149	-48,835
Total Savings from Market share shift	**($14,600)**	**$73,206**	**($195,149)**	**($68,551)**

NOTE:

1. Includes all heart bypass operations in DRG 106 or 107.
2. The demonstration began in May-June 1993 at the three expansion demonstration sites. The 1993 data include only cases covered under the demonstration.
3. 1996 values are based on discharges through June 30th.
4. Savings estimates do not include beneficiary savings.

SOURCE: 1992-96 MedPAR and NCH files.

savings from market share changes in each demonstration year. However, most of these are the result of a declining market share, coupled with savings as patients were shifted to hospitals that were slightly less expensive than Methodist. This is the same perverse effect that was observed for University Hospital in 1990. Again, it is not clear whether shifts to less expensive sites should be considered as savings resulting from the demonstration. However, the amounts are small in each year, so "zeroing out" the savings would have little effect on total savings estimates.

St. Vincent's in Portland experienced decreases in its market share for DRG 106 in each of the demonstration years. In 1993, 1994 and 1995, increases in the market share for DRG 107 rose, helping to offset the losses from 106, although the net effect was an additional cost in each year. In 1996, St. Vincent's also experienced decreases in market share for DRG 107, leading to an overall loss of $216,116.

At St. Luke's in Houston an increase in market shares led to a savings of $73,206 in 1994. In the other demonstration years, market share decreases led to costs ranging from $14,600 in 1993 to $195,149 in 1995.

5.4 Summary of Cost Savings

We present summary savings tables in the following order. First, we present programmatic savings from the original sites, the expansion sites, and all sites combined. Next, we present estimates of beneficiary savings from the original and the expansion sites. Finally, we summarize all savings during the entire course of the demonstration.

Original Sites. Table 5-10 presents cumulative Medicare program savings from the inpatient stay, post-discharge savings, and savings resulting from shifts in market shares. Total savings at the four original demonstration hospitals, from the inception of the demonstration through its completion in June, 1996 total $37.4 million. This corresponds to an 12.7 percent discount on the projected expenditures of $294 million in lieu of the demonstration (not shown). The bulk of the savings, 78 percent, arises from the negotiated inpatient discounts, eleven percent results from lower outlays in the 90 days after discharge, and eleven percent results from increases in market shares for the demonstration sites.

Total savings for the seven months of 1991 during which the demonstration was in operation totaled $4.0 million, and total savings for 1992 totaled $6.8 million. Savings grew slightly in 1993 and 1994, to roughly $7.5 million in each year. Savings fell slightly in 1995, to $7.1 million, and for the first six months of 1996, savings equaled $4.5 million. Inpatient savings ranged from 67 percent of total savings in 1996 to 93 percent of total savings in 1992. Post-discharge savings constituted 6-16 percent of the total savings in each year, an unexpected result. The only component to grow as a proportion of total spending across the seven years is the savings attributable to market share shifts, which is encouraging. This accounted for two percent of total savings in 1991 and 1992, and nineteen percent in 1996.

St. Joseph's Hospital in Atlanta had the largest cumulative savings across the demonstration. It had both the largest post-discharge savings and the largest savings from increases in market share. Its level of inpatient savings was lower than University Hospital,

Table 5-10

Total Medicare Program Savings for Four Original Demonstration Hospitals, 1991-1996

	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Jun 1995	Jan-Jun 1996	Total
Four Demonstration Sites							
Inpatient Savings	$3,556,472	$6,317,988	$5,962,287	$5,392,023	$5,029,582	$2,986,469	$29,244,821
Post Discharge Savings	409,905	387,449	517,981	1,170,368	992,078	598,916	4,076,697
Market Share Shift Savings	57,137	74,948	1,113,532	958,587	1,049,421	865,269	4,118,894
Total Savings	4,023,514	6,780,385	7,593,800	7,520,978	7,071,081	4,450,654	37,440,412
St. Joseph's - Atlanta							
Inpatient Savings	910,008	2,206,596	1,457,965	1,616,998	1,155,432	669,669	8,016,668
Post Discharge Savings	362,701	259,168	602,705	1,032,797	1,147,248	681,252	4,085,871
Market Share Shift Savings	39,525	262,641	591,567	784,197	741,726	484,231	2,903,887
Total Savings	1,312,234	2,728,405	2,652,237	3,433,992	3,044,406	1,835,152	15,006,426
University Hospital - Boston							
Inpatient Savings	1,154,232	1,599,510	1,822,356	1,899,540	1,988,250	1,216,716	9,680,604
Post Discharge Savings	9,967	-113,243	-155,208	-124,684	-664,950	-286,836	-1,334,954
Market Share Shift Savings	16,939	-363,348	-438,227	-357,210	-205,320	2,717	-1,344,449
Total Savings	1,181,138	1,122,919	1,228,921	1,417,646	1,117,980	932,597	7,001,201
Ohio State University Hospital							
Inpatient Savings	814,880	1,372,362	1,427,128	713,545	1,033,920	580,244	5,942,079
Post Discharge Savings	-136,279	-12,674	-204,440	-23,925	72,720	107,060	-197,538
Market Share Shift Savings	-143,205	-249,900	33,091	-21,982	66,382	20,990	-294,624
Total Savings	535,396	1,109,788	1,255,779	667,638	1,173,022	708,294	5,449,917

Table 5-10 (continued)

Total Medicare Program Savings for Four Original Demonstration Hospitals, 1991-1996

	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996	Total
St. Joseph Mercy - Ann Arbor							
Inpatient Savings	677,352	1,139,520	1,254,838	1,161,940	851,980	519,840	5,605,470
Post Discharge Savings	173,516	254,198	274,924	286,180	437,060	97,440	1,523,318
Market Share Shift Savings	143,877	425,554	927,101	553,582	446,632	357,332	2,854,078
Total Savings	994,745	1,819,272	2,456,863	2,001,702	1,735,672	974,612	9,982,866

NOTES:

1. Includes all heart bypass operations in DRG 106 or 107.
2. The demonstration began in May-June 1991 at the four original demonstration sites. The 1991 data include only cases covered under the demonstration.
3. 1996 values are based on discharges through June 30th.
4. Savings estimates do not include beneficiary savings.

SOURCE: Savings estimates in Tables 5-2 through 5-9.

which offered a much larger discount per case. The large inpatient savings and savings from growth in market share were not surprising, given St. Joseph's high volume of cases and increase in market share shown in Chapter 4. The level of post-discharge savings is surprising, given that shifts in post-discharge care were expected to create a loss to the program.

St. Joseph Mercy of Ann Arbor is similar to St. Joseph's Hospital in Atlanta in its positive post-discharge savings and savings resulting from market share increases.

University Hospital in Boston and Ohio State University Hospital have similar patterns of savings. Both show the expected cumulative additional costs in the post-discharge period from shifts to other facilities or to outpatient locations that can be billed separately outside the demonstration. Both also had net losses from a decrease in market share.

Expansion Sites. Table 5-11 presents similar summary data for the expansion sites. Total program savings for these three sites equaled $4.9 million, or a 4 percent discount on the projected expenditures of $144 million in lieu of the demonstration (not shown). Inpatient savings totaled $7.4 million, but reductions in savings were incurred for both the post discharge period ($2.1 million) and as a result of market share losses ($409,057). Thus, total savings equaled 66 percent of the savings estimated to result from negotiated inpatient rates. Losses resulting from shifts to care in the period after discharge were expected. (However, recall that none of the hospitals showed a statistically significant departure from anticipated post-discharge spending). We had expected that the program

Table 5-11

Total Medicare Program Savings for Three Expansion Demonstration Hospitals, 1993-96

	Jun-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996	Total
Expansion Demonstration Sites					
Inpatient Savings	$1,049,441	$2,649,308	$2,115,422	$1,626,871	$7,441,042
Post Discharge Savings	-547,693	-466,106	-191,234	-925,527	-2,130,560
Market Share Shift Savings	-9,154	51,784	-191,902	-259,785	-409,057
Total Savings	492,594	2,234,986	1,732,286	441,559	4,901,425
Methodist - Indianapolis					
Inpatient Savings	266,679	564,160	526,284	431,025	1,788,148
Post Discharge Savings	-162,333	119,040	1,188	-253,400	-295,505
Market Share Shift Savings	7,496	35,107	147,734	24,882	215,219
Total Savings	111,842	718,307	675,206	202,507	1,707,862
St. Vincent's - Portland					
Inpatient Savings	370,392	768,400	660,000	325,655	2,124,447
Post Discharge Savings	-30,256	-163,172	-91,125	-108,655	-393,208
Market Share Shift Savings	-2,049	-56,529	-144,487	-216,116	-419,181
Total Savings	338,087	548,699	424,388	884	1,312,058
St. Luke's - Houston					
Inpatient Savings	412,370	1,316,748	929,138	870,191	3,528,447
Post Discharge Savings	-355,104	-421,974	-101,297	-563,472	-1,441,847
Market Share Shift Savings	-14,600	73,206	-195,149	-68,551	-205,094
Total Savings	42,666	967,980	632,692	238,168	1,881,506

NOTES:

1. Includes all heart bypass operations in DRG 106 or 107.
2. The demonstration began in May-June 1993 at the three expansion sites. The 1993 data include only cases covered under the demonstration.
3. 1996 values are based on discharges through June 30th.
4. Savings estimates do not include beneficiary savings.

SOURCE: Savings estimates in Tables 5-2 through 5-9.

would benefit from savings resulting from increases in market shares for the demonstration sites, but none of the expansion sites achieved any market share growth.

The three hospitals show fairly similar patterns of savings. Total inpatient savings range from $1.8 million at Methodist Hospital to $3.5 million at St. Luke's, as a result of St. Luke's large volume. All hospitals experienced an overall reduction in savings resulting from shifts to care after discharge, ranging from roughly 17 percent of inpatient savings for both Methodist and St. Vincent's to 40 percent of the inpatient savings for St. Luke's.

Table 5-12 summarizes savings across all seven sites for all years of the demonstration. Total Medicare program savings, excluding beneficiary savings, equals $42 million, of which $36.7 million results from inpatient savings, $1.9 million from post-discharge savings, and $3.7 million from shifts in market shares. Market share savings are positive in each year (as savings from the original sites offset losses from the expansion sites). Post-discharge savings are negative in two years, 1993 and 1996, although the large savings from the original sites in 1994 and 1995 result in positive savings for those years. Estimates of post-discharge savings and savings arising from market share shifts may reflect some random variation, given the difficulties inherent in the quasi-experimental design. However, given that these components comprise only ten percent of the total savings estimates, the totals should be relatively insensitive to these problems.

Beneficiary Savings. Beneficiary savings are summarized in Table 5-13 and 5-14. Ninety-three percent of the $5.6 million in estimated savings at the original sites results from the lower negotiated payment for the bypass hospitalization. Savings to beneficiaries from

Table 5-12

Total Medicare Program Savings Across all Demonstration Sites, 1991-96

	1991	1992	1993	1994	1995	1996	Total
Inpatient Savings	$3,556,472	$6,317,988	$7,011,728	$8,041,331	$7,145,004	$4,613,340	$36,685,863
Post Discharge Savings	409,905	387,449	-29,712	704,262	800,844	-326,611	1,946,137
Market Share Shift Savings	57,137	74,948	1,104,378	1,010,371	857,519	605,484	3,709,837
Total Savings	4,023,514	6,780,385	8,086,394	9,755,964	8,803,367	4,892,213	42,341,837

NOTES:

1. Includes all heart bypass operations in DRG 106 or DRG 107.
2. The demonstration began in May-June 1991 at the four original sites. It began in May-June 1993 at the three expansion sites.
3. 1996 savings are based on discharges through June 30th.

SOURCE: Savings estimates presented in Table 5-10 and 5-11.

Table 5-13

Total Medicare Beneficiary Savings for Four Original Demonstration Hospitals, 1991-96

	Jun-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996	Total
Four Demonstration Sites							
Inpatient Savings	$512,737	$905,949	$1,128,191	$1,046,637	$995,398	$577,124	$5,166,036
Post Discharge Savings	6,041	42,384	21,572	60,774	64,668	24,383	219,822
Market Share Shift Savings	6,973 #	-2,123	93,560	27,421	35,066	22,565	181,339
Total Savings	525,751	946,210	1,243,323	1,134,832	1,095,132	624,072	5,569,320

NOTE:

1. Includes all heart bypass operations in DRG 106 or DRG 107.
2. The demonstration began in May-June 1991 at the four original demonstration sites. The 1991 data include only cases covered under the demonstration.
3. 1996 savings are based on discharges through June 30th.

SOURCE: 1991-96 MedPAR and NCH files.

Table 5-14

Total Medicare Beneficiary Savings for Three Expansion Demonstration Hospitals, 1993-96

	Jun-Dec 1993	Jan-Dec 1994	Jan-Dec 1995	Jan-Jun 1996	Total
Three Demonstration Sites					
Inpatient Savings	$463,541	$941,049	$853,529	$424,489	$2,682,608
Post Discharge Savings	-22,325	-34,638	-66,782	-80,913	-204,658
Market Share Shift Savings	-6,106	27,252	-83,400	-54,162	-116,416
Total Savings	435,110	933,663	703,347	289,414	2,361,534

NOTE:
1. Includes all heart bypass operations in DRG 106 or DRG 107.
2. The demonstration began in May-June 1993 at the three expansion demonstration sites. The 1993 data include only cases covered under the demonstration.
3. 1996 savings are based on discharges through June 30th.

SOURCE: 1993-96 MedPAR and NCH files.

reductions in post-discharge utilization are quite small. This is not surprising since patients have already paid the Part A deductible, and would only accrue savings from reductions in Part B expenditures. The reduced inpatient demonstration liability also generates small savings as market shares increase for the demonstration sites.

For the expansion sites, inpatient savings total $2.7 million. Higher post-discharge expenditures lead to a small reduction in savings, as patients face a higher liability. The market share loss to more expensive hospitals also leads to a loss of $116,416 in increased beneficiary liability.

Summary. Table 5-15 summarizes total savings across all sites all years. The demonstration resulted in total savings of $50.3 million, of which $47.3 million accrued to the Medicare program and $7.9 million accrued to beneficiaries. The largest total savings, $17.8 million came from St. Joseph's hospital, more than 50 percent greater than the $11.5 million from St. Joseph Mercy. Each of the original demonstration sites had higher annual savings than the expansion sites; average annual savings at Ohio State University (lowest of the original sites) were $1.2 million, compared to an average savings of $1.0 million for St. Vincent's, the highest of the expansion sites.

Table 5-15

Summary of Total Demonstration Savings

	1991	1992	1993	1994	1995	1996	Total
All Demonstration Sites							
Program Savings	$4,023,514	$6,780,385	$8,086,394	$9,755,964	$8,803,367	$4,892,213	$42,341,837
Beneficiary Savings	525,751	946,210	1,678,433	2,068,495	1,798,479	913,486	7,930,854
Total Savings	4,549,265	7,726,595	9,764,827	11,824,459	10,601,846	5,805,699	50,272,691
St. Joseph's - Atlanta							
Program Savings	1,312,234	2,728,405	2,652,237	3,433,992	3,044,406	1,835,152	15,006,426
Beneficiary Savings	221,422	510,891	636,611	591,057	563,290	315,435	2,838,706
Total Savings	1,533,656	3,239,296	3,288,848	4,025,049	3,607,696	2,150,587	17,845,132
University Hospital - Boston							
Program Savings	1,181,138	1,122,919	1,228,921	1,417,646	1,117,980	932,597	7,001,201
Beneficiary Savings	96,645	88,255	141,720	140,327	170,092	100,531	737,570
Total Savings	1,277,783	1,211,174	1,370,641	1,557,973	1,288,072	1,033,128	7,738,771
Ohio State University - Columbus							
Program Savings	535,396	1,109,788	1,255,779	667,638	1,173,022	708,294	5,449,917
Beneficiary Savings	66,132	87,758	148,404	118,829	50,932	24,557	496,612
Total Savings	601,528	1,197,546	1,404,183	786,467	1,223,954	732,851	5,946,529
St. Joseph Mercy - Ann Arbor							
Program Savings	994,745	1,819,272	2,456,863	2,001,702	1,735,672	974,612	9,982,866
Beneficiary Savings	140,552	259,305	316,587	284,619	310,817	183,549	1,495,429
Total Savings	1,135,297	2,078,577	2,773,450	2,286,321	2,046,489	1,158,161	11,478,295

Table 5-15 (continued)

Summary of Total Demonstration Savings

	1991	1992	1993	1994	1995	1996	Total
Methodist - Indianapolis							
Program Savings			111,842	718,307	675,206	202,507	1,707,862
Beneficiary Savings			107,712	172,090	133,960	79,249	493,011
Total Savings			219,554	890,397	809,166	281,756	2,200,873
St. Vincent's - Portland							
Program Savings			370,392	768,400	660,000	325,655	2,124,447
Beneficiary Savings			190,706	358,106	286,093	64,022	898,927
Total Savings			561,098	1,126,506	946,093	389,677	3,023,374
St. Luke's - Houston							
Program Savings			42,666	967,980	632,692	238,168	1,881,506
Beneficiary Savings			170,596	378,431	282,241	140,999	972,267
Total Savings			213,262	1,346,411	914,933	379,167	2,853,773

NOTES:

1) Includes all heart bypass operations in DRG106 or DRG107.
2) The demonstration began May-June 1991 at the three original demonstration sites and May-June 1993 at the three expansion sites. Only cases covered under the demonstration are included in the savings estimates.
3) 1996 savings are based on discharges through June 30th.

SOURCE: Savings estimates on tables 5-2 through 5-14.

6 Impact of Bundled Payments on Hospital Costs

6.1 Introduction

By negotiating fixed discounts on average payments for DRG's 106 and 107, the Medicare program and its beneficiaries are assured of savings unless outpatient expenses associated with demonstration bypass patients rise faster than expected. Lower average payments, on the other hand, mean lower, or even negative, margins for the participating hospitals. Unless participants can reduce their costs of treating bypass patients, they may incur losses that may be unsustainable in the long run.

Participants can reduce the costs of treating bypass patients in several ways. First, they can change the patterns of inpatient care, such as shortening ICU stays, that reduce the need for variable hospital resources and supplies, including ICU nursing time and drugs. Second, if they are successful in increasing volumes, they can spread fixed costs across more cases and reduce average fixed costs per bypass patient. Third, by discharging earlier, they could shift more of the post-operative treatment to an outpatient setting, reducing the costs they personally incur by raising the costs to other providers, e.g., home health agencies, referring family physicians. The third possibility has already been addressed in the previous chapter. In the current chapter, attention is focused on the costs incurred by participants.

Whether any of the demonstration hospitals achieved cost savings is immaterial to the government in the sense that HCFA pays no more or less if the hospitals' own costs rise or fall. Yet, the government is very interested in whether participants achieved meaningful cost savings as part of the demonstration. If they did conserve resources, not only will they be more likely to continue under negotiated global rates, but other hospitals will have a stronger interest in global budgeting as well. The key question is:

> Will hospital costs fall when physician incentives to reduce spending are aligned with hospital incentives under DRG prospective payment?

Many physicians might argue that their inpatient practice patterns are unaffected by financial incentives: they give each patient what they need--especially very ill coronary artery disease patients requiring bypass surgery. Others, however, might argue that more cost-effective practice patterns can be implemented even for bypass surgery so long as physicians are willing to cooperate with hospital administration.

The economic literature (Pauly and Redisch, 1973; Pauly, 1980; Harris, 1977) supports the hypothesis that physicians tend to treat the hospital as their workshop. To them, the inputs to patient care are practically free, including nurse time, radiological supplies, drugs, ICU telemetry, scanners, echocardiography, EKGs, and cardiac catheter devices. Surgeons and cardiologists pay nothing for this equipment and support in the inpatient setting; these costs are external to their own practices. Once physicians are under a single global rate, however, all of these costs are internalized. (How hospitals and physicians divide the global payment is relevant to how much of the hospital cost burden or savings

physicians bear. See Chapter 13 on the split of the global payment under the demonstration.) Realizing that more cost-effective practice patterns could save the hospital money may encourage surgeons, in particular, to conserve on scarce resources. They might do so either out of a concern for the financial solvency of the hospital under the demonstration or in response to incentives to share in any cost savings by receiving a larger share of the global payment.

In evaluating the cost impacts of the demonstration, it is important to distinguish cost savings that might have accrued from greater volumes from those realized by more cost-effective practice patterns and/or better hospital management. Volume gains affect costs by lowering average fixed costs on all cases. Overall average costs per bypass patient could be lower, in this case, without any improvements in practice patterns or hospital management. Evaluating changes in average fixed (or indirect) costs should speak to the volume effects. Changes in practice patterns and hospital management, by contrast, should affect variable costs for the most part. Unfortunately, not all of the hospital micro-cost systems are equally detailed in distinguishing fixed from variable costs.

Key evaluation questions addressed in this chapter include:

- Did the costs incurred by demonstration hospitals rise more slowly under fixed global payments than they would have under DRG prospective payment?
- Did the average total and variable profit margins on bypass patients rise or fall under the demonstration?
- What proportion of the costs of bypass surgery do hospitals consider fixed vs. variable? Did average fixed or variable costs per case change more?

- What is the level of costs by department for bypass patients? Did the costs of some departments rise or fall faster than others? If so, might this be indicative of changes in practice patterns or management efficiencies?

To answer these questions, Section 6.2, first, provides a brief summary of the micro-cost systems in the four participating hospitals. The next four sections present trends in hospital costs and margins by hospital. Section 6.7 then compares the key findings across institutions.

6.2 Data Sources and Methods

As a first step in analyzing trends in costs, each participating hospital submitted detailed cost information on every Medicare patient undergoing bypass surgery beginning in 1990, before the demonstration began, through 1993. (Cost data were not collected in the last six months of the demonstration in order to complete the evaluation within the five-year time/frame.) The data pertained only to the facility and did not include any physician inputs or charges unless they were paid for directly by the hospital.

6.2.1 Micro-Cost Systems

Only Ohio State University Hospital among the four institutions continued to use the traditional method of cost-to-charge ratios by department to determine patient costs. This system was used by all hospitals in the United States during the era of cost reimbursement.

It involves distinguishing between overhead support, nursing, and ancillary services and then stepping down support costs into the nursing and ancillary departments. Next, patient days in routine and ICU nursing are divided into direct department plus stepdown costs to produce a per diem cost for all patients. Billing information on lengths of stay are then multiplied by these two average daily cost figures to produce estimates of total nursing costs for each bypass patient. Overhead costs are also stepped down into ancillary departments (e.g., operating room, laboratory) and an overall department cost-to-charge ratio calculated. Again, billing information is then used to determine each patient's "share" of department costs by multiplying charges by the cost-to-charge ratio.

Once Medicare prospective payment was introduced in late 1983, hospitals began replacing this old method of cost finding with more detailed, accurate methods. The principal problem with the old system arose from the use of very aggregate department-wide per diems and cost-to-charge ratios to isolate costs for individual patients. Two patients with equal radiology charges, for example, may generate different costs because their mix of procedures may be different. Ten chest x-rays may result in the same total charges as a single magnetic resonance scan, but may require more or less labor and supplies.

Both St. Joseph's Hospital in Atlanta and Boston University Hospital had implemented state-of-the-art micro-costing systems before the demonstration began. St. Joseph Mercy Hospital in Ann Arbor converted to a very similar system late in the demonstration. In the process, the staff recalibrated their 1991-93 costs using the new system. Costing is done in these systems from the bottom up. First, department heads

identify the procedures and services that comprise 80% of department charges. Then, applying management engineering techniques, they identify the labor, supplies, and equipment inputs associated with each procedure. The average technician time required to perform an echocardiographic exam is determined, for instance, along with the feet of film, other supplies, and machine time. Next, a unit cost is determined for each input in each department, e.g., a technician's hourly wage. When unit costs are multiplied by the number of units of a service or procedure, a patient's total cost for a given procedure is generated. Summing across all the different procedure costs gives total costs incurred on behalf of the patient for the department. Finally, summing across all departments gives an estimate of the patient's total cost. Overhead costs are allocated to procedures on a fixed/variable basis. Because of the vast number of procedures performed every day in the inpatient setting, cost-to-charge ratios are used to identify costs for the residual 20% of services.

This approach to costing has many strengths. First, specific inputs are linked up with specific intermediate outputs at the department level. Calibrating the system gives department managers a much clearer understanding of the underlying costs associated with the procedures performed in their department. It also puts management on firm ground with clinical staff in explaining why certain procedures cost much more than others. A second advantage is the emphasis placed on categorizing inputs into fixed and variable, direct and indirect. Managers need to know what will happen to costs if volumes of patients or procedures rise. To do this, inputs must be classified as fixed and variable. This is where the art (and arbitrariness) of micro-costing comes in. As will be seen, hospitals using very

similar micro-costing systems produce very different estimates of fixed and variable costs. As bypass patients are likely very similar in their procedure requirements when averaged over all admissions during a year, it is clear that large differences in fixed/variable proportions are the result of the costing system and not patient mix.

The micro-cost analysis naturally only considers hospital Part A payments and costs. This is because no Part B cost system exists for physician practices. It should also be emphasized that the estimated Part A component of the demonstration payment may not be what the hospital actually retained if physicians negotiated a larger share of the global payment. The purpose of estimating hospital-only margins, however, is to predict how much profit or loss the hospital could enjoy under the original Part A and B components before any transfers to physicians.

6.2.2 Financial Variables

By classifying costs into fixed and variable, financial managers are able to calculate two variants of patient margins, or profits. Net income is simply the difference between net revenue and estimated patient costs and is sometimes referred to as average profit margin. In the demonstration, net revenue is the amount being paid under the negotiated rates amounting to two fixed amounts for all Medicare patients in DRG 106 or 107, respectively. For purposes of the analysis, the estimated Part B physician portion of the global rate is excluded as is any patient copay so as not to overstate the revenues available to the hospital to cover its own institutional costs.

What the hospital actually pays physicians generally is different from the estimates used by HCFA to determine the beneficiary copay and the trust fund split (see Chapter 13). It is also true that it would be entitled to a portion of the patient liability representing the Part A deductible. Because the Part A deductible is a small portion of the beneficiary liability coinsurance, on average, only what HCFA stated its Part A liability to be was used in defining the hospital's net revenue.

The second measure of financial performance is the variable profit margin, calculated as the difference between net revenue and total variable costs. Positive variable margins imply that bypass patients are more than covering the extra costs that are incurred during their admission. Fixed costs are excluded. Variable margins are always greater than net income or average margins because of positive fixed costs. In the short run, financial managers should be willing to accept any patients that more than cover their own variable costs and help pay for some of the fixed costs. It is also possible for a hospital simultaneously to experience positive variable margins and negative average net income on bypass patients if they are not "covering their share" of allocated fixed costs.

Are demonstration patients "losers" from the hospital's perspective if net income is negative. The answer, most likely, is no. Some hospital administrators and physicians may think so, however. All hospitals offered discounts on their DRG rates and are taking losses in the sense that they could have received more revenue from HCFA, all other things constant if they had continued to receive prospective DRG payments. But things are not constant. Consider the financial implications of having fewer or no bypass patients during

a given year. Large fixed costs would go uncovered, not to mention the staff that would have to be laid off and costly inventories that would be stockpiled and not used, tying up cash flow. Then there are the spillover effects of the demonstration to be considered as well. If participating in the demonstration generates other bypass or medical-surgical admissions, then the net income associated with demonstration patients is underestimated. Furthermore, if aligning physician and hospital incentives results in lower costs for non-Medicare bypass patients, then profitability on private patients is increased.

6.2.3 Data Sources

Data were submitted in different computerized files by each of the participants covering the 1990-93 period. Each hospital was asked to submit a set of baseline files on Medicare bypass patients prior to the start of the demonstration, followed by annual submissions of micro-cost data. One file contained background information on the patient, including age, sex, admission and discharge date. Another file usually summarized each patient's cost information at the department level in 6-9 variables, e.g., direct variable, direct nonsalary, indirect administration. Finally, in the three hospitals using detailed micro-cost systems, a patient-procedure-service file was provided. This file contained thousands of observations listing all of the individual drugs, lab tests, operating room supplies, etc., each patient received.

Often, these files were submitted in a different variable layout. Department codes changed, necessitating the use of inter-year crosswalks to align services with departments.

Hospitals differed in their breakdown of departments; thus, it was not possible to present a uniform set of departmental data for comparison purposes--although all important cost centers are available. More detrimental to interhospital comparisons was the lack of uniform definitions of indirect vs. direct costs or variable vs. fixed costs. Some hospitals, for example, allocated most of central supplies to ancillary services while others kept it as a separate indirect overhead department. Some hospitals broke out the blood bank or rehabilitation cost centers from the lab and physical therapy, respectively, while others simply merged them. Even over time within the same hospital, systems changed. Blood bank may be reported for three years but not the last year.

Estimating the volume effects on costs proved impossible with the data provided. The key variable, average fixed costs, is influenced by more than just bypass volume. Average fixed costs per surgery in the operating room, for example, not only depends upon the growth in bypass surgery but other surgery as well. Not enough detail was available on non-demonstration hospital volumes to meaningfully isolate demonstration specific volume effects on costs.

Another problem with the cost data is the fact that they are always in current dollars. Costs rise over time because of rising wage rates, drug prices, more costly equipment, etc., not to mention changes in practice patterns. Hence, the results presented below make no adjustments for general inflation in the hospital sector. This is not a problem in determining the profitability of demonstration cases because net revenues have been updated using HCFA methods under the demonstration. However, cost trends alone will overstate the trend in real

resources, procedures, and services used to treat bypass patients. Given that somewhat over half the annual rise in hospital costs can be traced to input price inflation outside the industry's control (Cromwell and Butrica, 1994), the bias probably amounts to roughly 5% a year over the three years of the demonstration. That is, one would have expected the costs of bypass patients to rise nearly 16% due to higher input prices alone, ignoring the trend towards more intensive care (Mitchell, *et al.*, 1993; Adamache, *et al.*, 1994).

No independent assessment has been made of the accuracy of the cost figures. Direct variable costs attributed to a patient can be considered fairly accurate as they relate to specific services received. Indirect fixed costs are more problematic because they can be allocated to patients in different ways. For the three hospitals using state-of-the-art costing systems, at least the total costs should be within the acceptable range as well as for many of the key departments. It is in each hospital's best interest to make the cost allocation as accurate as possible. None of the micro-cost systems are used to maximize reimbursement; only to inform managers of real costs by type of patient. Significant costing problems were encountered at the department level for Ohio State University Hospital.

6.3 Cost and Margin Trends in St. Joseph's Hospital, Atlanta

6.3.1 Overall Costs and Margins

Tables 6-1 and 6-2 summarize trends in cost, charge, revenue and profit trends for St. Joseph's Hospital in Atlanta beginning a year before the demonstration started and

Table 6-1

DRG 106 Average Costs, Revenues, and Margins Per Demonstration Patient, 1990-1993: St. Joseph's Hospital, Atlanta

Category	July-Dec 1990	May-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	90	140	221	246	-
Total Charges	$34,867	$37,794	$40,856	$37,539	+7.7 %
Variable Cost	14,951	13,261	13,349	12,039	-19.2
Fixed Cost	7,167	8,950	9,239	8,169	+14.0
Total Direct Cost	**16,155**	**16,236**	**16,097**	**14,007**	**-13.3**
-Variable Salary	6,366	5,797	5,799	5,203	-18.3
-Variable Non-Salary	7,170	6,514	6,786	6,136	-14.4
-Fixed Salary	795	1,746	1,692	1,117	+40.5
-Fixed Non-Salary	1,029	1,049	1,206	1,012	-1.7
-Fixed Capital	796	1,130	614	540	-32.2
Total Indirect Cost	**5,962**	**5,975**	**6,491**	**6,201**	**+4.0**
-Variable Salary	464	656	543	474	+2.2
-Variable Non-Salary	951	294	221	226	-75.1
-Fixed Salary	738	1,797	1,470	1,336	+81.0
-Fixed Non-Salary	2,054	2,704	4,038	3,975	+93.5
-Fixed Capital	1,756	524	219	190	-89.2
Total Cost	**22,118**	**22,211**	**22,588**	**20,208**	**-8.6**
Net Revenue	20,636	21,432	21,465	22,334	+8.2
Net Income	-1,482	-779	-1,123	2,126	-
Variable Margin	5,685	8,171	8,116	10,295	+81.1

NOTES:
1. Variable Margin = Net Revenue - Variable Cost;
2. Net Income = Net Revenue - Total Cost.
3. Net revenue for 1991 slightly different than $20,362 reported by hospital.
4. Net revenues for 1991-93 = Part A amount estimated by HCFA/ORD.

SOURCE: St. Joseph Hospital Micro-Cost Accounting System.

Table 6-2

DRG 107 Average Costs, Revenues, and Margins Per Demonstration Patient, 1990-1993: St. Joseph Hospital, Atlanta

Category	July-Dec 1990	May-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	216	261	424	419	-
Total Charges	$28,774	$29,714	$30,540	$28,283	-1.7 %
Variable Cost	12,255	10,347	10,101	9,232	-24.7
Fixed Cost	5,500	6,974	6,842	6,228	+13.2
Total Direct Cost	**13,086**	**12,650**	**12,098**	**10,702**	-18.2
-Variable Salary	5,205	4,783	4,484	4,139	-20.5
-Variable Non-Salary	5,293	4,795	5,034	4,545	-14.3
-Fixed Salary	670	1,383	1,290	869	+29.7
-Fixed Non-Salary	728	785	878	772	+6.0
-Fixed Capital	560	904	412	377	-32.7
Total Indirect Cost	**4,670**	**4,671**	**4,845**	**4,758**	**+1.9**
-Variable Salary	359	525	410	368	2.5
-Variable Non-Salary	768	244	173	180	-76.6
-Fixed Salary	359	1,446	1,105	1,039	+189.4
-Fixed Non-Salary	1,582	2,034	2,993	3,024	+91.2
-Fixed Capital	1,373	423	165	147	-89.3
Total Cost	**17,756**	**17,321**	**16,943**	**15,460**	**-12.9**
Net Revenue	16,865	18,457	20,878	18,973	+12.5
Net Income	-891	1,136	3,935	3,513	-
Variable Margin	4,610	8,110	10,777	9,741	+111.1

NOTES:
1. Variable Margin = Net Revenue - Variable Cost;
2. Net Income = Net Revenue - Total Cost.

SOURCE: St. Joseph Hospital Micro-Cost Accounting System.

extending through December, 1993. During the baseline 1990 period, the average total cost of DRG 106, bypass with catheterization, was $22,118, excluding any physician costs. Three years later, costs averaged $20,208, a reduction $1,910, or 8.6%. Variable costs, which were estimated to be over twice as much as fixed costs in the baseline period, fell 19.2%. Fixed costs rose 14%.

Average total costs per case fell even more in DRG 107: $2,296, or 12.9%. Variable costs fell by nearly 25% while fixed costs per case rose about the same, percentage-wise, as in DRG 106.

If one assumes, conservatively, that input price inflation averaged about 16% over the same period, then variable costs in real terms may have fallen as much as 25% in DRG 106 and 41% in DRG 107. These remarkable gains were offset to some extent by the increase in average fixed costs, especially in 1991 due a major facility expansion.

The three largest cost components, as expected, were direct variable salaries, including OR, ICU, and routine nursing, amounting to $5,203 in DRG 106 in 1993; direct variable nonsalary costs, including drugs, central supplies, OR supplies, cath and other lab supplies, etc., averaged $6,136; while indirect fixed nonsalary costs were $3,975.

Based on the hospital's costing definitions, two-thirds of bypass costs were considered variable. This is a far higher percentage than in other demonstration hospitals. This implies that 10% growth in bypass volume would only reduce average costs by 3.3% as it would only reduce average fixed costs.

At the same time average costs were falling in St. Joseph's Hospital, total charges were rising but only by 7.7% over four years. Price increases were offset almost completely by fewer services per admission.

Demonstration hospitals, of course, are not paid their charges, and net revenue is the relevant variable for cash flow. For 1990, the year before the demonstration, St. Joseph's Hospital received $20,636 in Medicare prospective payments for DRG 106 bypass patients and $16,865 for DRG 107 patients. Net incomes, or profits per patient, were -$1,482 for DRG 106 and -$891 for DRG 107. Over the next three years of the demonstration, average net revenues rose 8.2% for DRG 106 and 12.5% for DRG 107. Revenues for 1991-93 were based on the negotiated global rates, updated for the Medicare market basket, local wage changes, and any changes in the relative value weights for the two DRGs. Thus, for DRG 106, the hospital turned a loss, on average, into a $2,126 gain by 1993, due to absolute cost savings. For DRG 107, the turnaround was even more dramatic. By 1993, the hospital was enjoying a profit of $3,513 per case due to the large absolute decline in costs.

The impact of the cost savings is far greater when considering variable margins. For DRG 106, these margins rose from roughly $5,700 to over $10,000 for DRG 106, and from roughly $4,600 to over $9,700 on DRG 107. That is, over the short run, given that one-third of hospital costs were fixed, additional Medicare demonstration patients were contributing approximately $10,000 each to short-run profits. Not only did St. Joseph's Hospital enjoy significant volume growth and increased market share in Atlanta, it also significantly reduced

its costs to become a big financial winner under the demonstration. What the hospital did with the extra monies is described in Chapter 13 in the distribution of profits to physicians.

6.3.2 Departmental Costs

Tables 6-3 and 6-4 decompose trends in direct costs alone by major cost center. Indirect costs are ignored as they are assumed to be little affected by changes in the management of bypass patients. In 1990, the hospital incurred $16,155 in average direct costs per DRG 106 patient, of which the operating room and recovery was the largest contributor (22%) followed by ICU nursing (18%). These two cost centers remained the most expensive through 1993, but their relative importance diverged considerably. Operating room costs actually rose nearly 20% on average while ICU nursing costs fell nearly 25%. Thus, by 1993, operating room costs were 30% of average direct costs while ICU nursing costs had fallen to 16%.

The 13.4% decline in average direct costs over four years was primarily due to declines in ICU nursing, general floor nursing, the pharmacy, and the laboratory. Several other departments also saw their direct costs fall per bypass patient.

Similar results obtain for DRG 107. Over the four years, the share of direct costs incurred in the operating room increased along with the department's costs while overall costs fell almost 19%. Again, the source of declining costs are found in the same four cost centers.

Table 6-3

DRG 106 Average Direct Costs Per Medicare Patient by Department, 1990-1993: St. Joseph's Hospital, Atlanta

Cost Center	July-Dec 1990	May-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	90	140	221	246	-
Nursing ICU	2,885	2,923	2,656	2,177	-24.5 %
Nursing General	1,998	1,981	1,607	1,351	-32.4 **
Pharmacy	1,551	1,334	1,306	1,059	-31.7 **
OR & Recovery	3,559	3,910	4,338	4,252	+19.5 **
Anesthesia	236	220	271	260	+10.2 **
Radiology	358	288	352	299	-16.5
Laboratory	1,180	617	617	432	-63.3 **
Physical Therapy	64	69	87	70	+9.4
Respiratory Therapy	949	1,046	1,070	852	-10.2
Blood Bank	835	727	736	678	-18.8
EKG & EEG	345	430	355	293	-15.1 *
Catheter Lab	1,443	1,752	1,584	1,477	+2.4
Rehabilitation	105	125	119	113	+7.6
Central Supply	376	451	570	415	+10.4
IV Therapy	112	99	104	66	-41.4 **
Other	159	246	311	201	+26.4 **
Total	16,155	16,218	16,082	13,996	-13.4

NOTES: Direct costs are for services directly assigned patients in the listed departments. Exclude indirect overhead costs centers.

** = Significant at 5%
* = Significant at 10%

SOURCE: Developed from Micro-cost datafiles, St. Joseph's Hospital, Atlanta.

Table 6-4

DRG 107 Average Direct Costs Per Medicare Patient by Department, 1990-1993: ST. Joseph's Hospital, Atlanta

Cost Center	1990	1991	1992	1993	Percent Change 1990-93	
Number of Patients	216	261	424	419	-	
Nursing ICU	2,265	2,293	1,920	1,569	-30.7 %	**
Nursing General	1,611	1,682	1,313	1,191	-26.1	**
Pharmacy	1,375	976	987	750	-45.5	**
OR & Recovery	3,715	3,765	4,193	4,186	+12.7	**
Anesthesia	230	213	263	253	+10.0	**
Radiology	327	242	270	242	-26.0	**
Laboratory	1,023	555	519	370	-63.8	**
Physical Therapy	67	50	78	62	-7.5	
Respiratory Therapy	893	1,011	862	740	-17.1	
Blood Bank	679	601	639	459	-32.4	**
EKG & EEG	281	377	267	203	-28.8	**
Catheter Lab	44	30	41	38	-13.6	
Rehabilitation	107	131	114	108	+1.0	
Central Supply	297	354	383	311	+4.7	
IV Therapy	97	83	84	56	-42.2	**
Other	75	242	112	132	+76.0	
Total	13,086	12,606	12,047	10,670	-18.5	**

NOTES: Direct costs are for services directly assigned patients in the listed departments. Exclude indirect overhead costs centers.

** = Significant at 5%
* = Significant at 10%

SOURCE: Developed from Micro-cost datafiles, St. Joseph's Hospital, Atlanta.

The largest contributing factor to lower costs in both DRGs is shorter stays that conserve on scarce nursing inputs and other nursing-related services, e.g., bedside telemetry, central supplies. Notable savings have also been realized in the pharmacy. In Chapters 10 and 11, the patient and organizational changes that were implemented to realize such large savings are discussed.

6.4 Cost and Margin Trends in Boston University Hospital

6.4.1 Overall Costs and Margins

Tables 6-5 and 6-6 present trends in costs, charges, revenues, and margins, or profits, for Boston University Hospital. During the baseline period, 1990, the average total cost of DRG 106, excluding physician costs, was $33,111. Three years later, DRG 106 costs averaged $30,886, a 6.7% reduction representing a savings of $2,225. Average total costs for DRG 107 fell by 4% as well. Any reductions in absolute costs is a remarkable achievement over a period with input prices rising several percent a year alone, without taking into account greater intensity of services each year.

Boston University Hospital provided a fixed-variable cost breakdown only for direct costs, assuming all indirect costs are fixed in the short run. On this basis, the hospital assumed that only about one-third of average total bypass costs in DRG 106 were variable. (The proportion was closer to 40% in DRG 107.) Hence, increased bypass volumes would have pronounced effects on average costs by spreading fixed costs over more cases.

Table 6-5

DRG 106 Average Costs, Revenues, and Margins Per Demonstration Patient, 1990-1993: University Hospital, Boston

Category	July-Dec 1990	May-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	109	60	75	82	
Total Charges	44,665	43,448	51,020	49,038	9.8 %
Total Direct Cost	**14,898**	**13,456**	**14,746**	**15,633**	4.9
-Variable Cost	12,699	11,067	12,612	12,722	0.2
-Fixed Cost	2,199	1,889	2,134	2,911	32.4
Total Indirect Cost	**18,214**	**15,805**	**16,627**	**15,253**	-16.3
Total Cost	**33,111**	**29,261**	**31,373**	**30,886**	**-6.7**
Net Revenue	34,517	30,801	30,804	31,976	-7.4
Net Income	1,406	1,540	-569	1,090	-22.5
Variable Margin	21,818	19,734	18,192	19,254	-11.8

NOTES:

1. Variable Margin = Net Revenue - Variable Cost;
2. Net Income = Net Revenue - Total Cost.
3. Net revenue for 1991-93 = Part A amount estimated by HCFA/ORD.

SOURCE: University Hospital Micro-Cost Accounting System.

Table 6-6

DRG 107 Average Costs, Revenues, and Margins Per Demonstration Patient, 1990-1993: University Hospital, Boston

Category	July-Dec 1990	May-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	103	65	125	141	
Total Charges	32,380	37,059	36,509	35,125	8.5 %
Total Direct Cost	**9,758**	**10,781**	**10,410**	**10,576**	8.4
-Variable Cost	8,202	9,224	8,925	8,516	3.8
-Fixed Cost	1,556	1,557	1,485	2,060	32.4
Total Indirect Cost	**11,714**	**12,608**	**11,773**	**10,045**	-14.3
Total Cost	**21,471**	**23,389**	**22,182**	**20,621**	**-4.0**
Net Revenue	31,406	29,938	30,737	27,206	-13.4
Net Income	9,935	6,549	8,555	6,685	-
Variable Margin	23,204	20,714	21,812	18,690	-19.5

NOTES:

1. Variable Margin = Net Revenue - Variable Cost;
2. Net Income = Net Revenue - Total Cost.

SOURCE: University Hospital Micro-Cost Accounting System.

By 1993, the direct-indirect cost split for DRG 106 was almost exactly 50-50. Interestingly, the 6.7% reduction in costs was achieved on the fixed portion. Direct patient costs rose nearly 5%; still a modest change over three years. If the cost reductions were due to the demonstration, one would have predicted they would have come in the direct cost centers that are most affected by improvements in patient care management. There are several explanations for this result. First, indirect costs are not all fixed. Changes in capital depreciation allowances, overhead management staff, etc. can occur over several years. Second, if the growth in direct costs in bypass-oriented departments was slower than for other conditions and procedures, then fewer indirect costs may have been allocated to them. Third, there may have been a shift of some costs from indirect to direct over the period. Fourth, there may have been significant increases in hospital volume, either of bypasses or other conditions, that spread fixed costs over more cases. Only the second reason (and possibly the fourth) could be ascribed to demonstration effects. Thus, it is unlikely that the demonstration was responsible for the absolute decrease in DRG 106 and 107 costs. On the other hand, it may have been the principal reason why direct costs rose so slowly.

At the same time average total costs were falling, average charges for Medicare patients were rising between 8.5% (DRG 107) and 9.8% (DRG 106). Net revenues under the demonstration, however, moved in the opposite direction, falling 7.4% for DRG 106 and 13.4% for DRG 107. The net result of declining demonstration revenues and costs was a $316 dollar decline in net incomes for DRG 106 and a $3,250 decline for DRG 107. Hence, the hospital was not able to overcome the (estimated) Part A hospital discounts by lowering

costs to break/even. It should be remembered, though, that the negative cost increases no doubt pertain to all bypass patients, not just Medicare. For other payers paying discounted charges, it is possible that profits have improved considerably.

Because Boston University Hospital considers so few costs to be variable, its variable, short-run margins on demonstration patients are extremely high. Even though these margins fell over the three years, they still exceeded $18-19,000 in 1993. Even on a direct cost basis, BU's margins would have been on the order of $16,000. Hence, the hospital should consider these patients quite profitable. Of course, the hospital could receive even more under the PPS program, but then it may not have achieved its cost reductions without the change in incentives.

6.4.2 Departmental Costs

Tables 6-7 and 6-8 decompose trends in direct patient costs by department. In 1990, the baseline year, the hospital incurred $14,717 on average on DRG 106 Medicare patients. This figure grew 6.2% over the next three years, but was not statistically different from the 1990 base. (This increase is slightly more than reported on Table 6-5 due to slightly fewer cases.) Several departments showed absolute cost savings over the period, although only two declines were statistically significant: (1) the laboratory fell 25.6%; and (2) the catheter lab fell 29.2%. The other notable reduction was in general nursing, where costs fell nearly $300, or 10.4%, but the difference was not quite statistically significant.

Table 6-7

DRG 106 Average Direct Costs Per Medicare Patient by Department, 1990-1993: Boston University Hospital, Boston

Cost Center	July 1990 to June 1991	July - Dec 1991	Jan - Dec 1992	Jan - Dec 1993	Percent Change 1990 - 93
Number of Patients	104	60	75	82	
Nursing ICU	3,388	3,272	3,352	3,417	+0.9 %
Nursing General	2,730	2,300	2,481	2,456	-10.4
Pharmacy	898	789	915	1,003	+11.0
OR and Recovery	2,229	2,005	1,961	2,342	+9.7
Anesthesia	585	404	436	525	-2.2
Radiology	535	379	527	514	-12.4
Laboratory	862	727	726	643	-25.6 **
Physical Therapy	310	251	307	287	-7.7
Respiratory Therapy	403	366	501	389	-14.0
Blood Bank	899	1,013	1,627	1,802	+102.2 **
EKG & EEG	69	70	67	65	-5.8
Catheter Lab	1,708	1,765	1,261	1,211	-29.2 **
Other	101	46	301	264	+161.3 **
Total	14,717	13,387	14,460	14,918	+6.2

NOTES: 1. Direct costs are for services directly assigned patients in the listed departments. Exclude indirect overhead costs centers.
2. Totals to not equal departments due to smaller unallocated departments.

** = Significant at 5%
* = Significant at 10%

SOURCE: Developed from Micro-cost datafiles, Boston University hospitals.

Table 6-8

DRG 107 Average Direct Costs per Medicare Patient by Department, 1990-1993: Boston University Hospital, Boston

IPDGROUP	July 1990 to June 1991	July - Dec 1991	Jan - Dec 1992	Jan - Dec 1993	Percent Change 1990 - 93
Number of Patients	91	65	125	141	
Nursing ICU	1,969	2,467	2,111	1,781	-9.5 %
Nursing General	2,053	2,108	1,734	1,833	-10.7
Pharmacy	679	785	643	703	+3.5
OR and Recovery	2,207	2,060	1,782	2,302	+4.3
Anesthesia	558	448	428	524	-6.1
Radiology	410	502	366	385	-6.1
Laboratory	587	654	487	397	-32.3 **
Physical Therapy	261	305	714	214	-18.0 **
Respiratory Therapy	292	494	420	288	-1.4
Blood Bank	555	1,004	1,262	1,316	+137.1 **
EKG & EEG	47	45	39	36	-23.4 **
Catheter Lab	26	21	24	32	+23.1
Other	94	85	126	115	+22.3
Total	9,738	10,978	10,137	9,925	+8.5

NOTES: Direct costs are for services directly assigned patients in the listed departments. Exclude indirect overhead costs centers.

** = Significant at 5%
* = Significant at 10%

SOURCE: Developed from Micro-cost datafiles, Boston University hospitals.

DRG 107 showed a similar cost increase (8.5%) that, again, was not statistically distinct from 1990. Nursing costs were down, in total, from roughly $4,000 in 1990 to $2,600 in 1993, although the difference in either department was not statistically significant. Statistically significant reductions occurred again in the laboratory as well as physical therapy. It is also worth noting that the combined costs in the operating room and recovery, including anesthesia, rose only $61 in three years in this DRG. Pharmacy costs were kept almost flat as well.

One large increase occurred in the blood bank, with average costs rising from $555 to $1,316 in DRG 107. A similar large increase in blood processing, products, and administration was also found in DRG 106. The reason for this increase in unknown.

6.5 Cost and Margin Trends in St. Joseph Mercy Hospital, Ann Arbor

6.5.1 Overall Costs and Margins

Tables 6-9 and 6-10 present data on costs and margins for St. Joseph Mercy Hospital in Ann Arbor. In 1990 before the demonstration began, average total costs for DRG 106 patients were $27,541. Four years later, costs had fallen to $21,106, a reduction of 23.4%. In DRG 107, the success of the hospital in reducing costs was much less, but still a 2% savings in average total direct costs was achieved. In DRG 106, average variable costs fell 36.7% while in DRG 107 they fell 19.3%. Average fixed costs moved in opposite directions in the two DRGs, falling nearly 7% in DRG 106 while rising 19% in DRG 107. Again, any

Table 6-9

DRG 106 Average Costs, Revenues, and Profits Per Medicare Demonstration Patient, 1990-1993: St. Joseph Mercy Hospital, Ann Arbor

Category	July-Dec 1990	Jan-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	69	153	167	124	-
Total Charges	$50,942	$43,640	$43,210	$43,831	-14.0 %
Variable Cost	15,225	13,098	12,798	9,644	-36.7
Fixed Cost	12,316	11,112	11,179	11,463	-6.9
Total Direct Cost	**14,787**	**12,729**	**12,817**	**11,914**	**-19.4**
-Variable Salary	8,919	7,351	7,034 *	-	-21.1 [a]
-Supplies	4,687	4,287	4,272 *	-	-8.9 [a]
-Other Costs	814	749	763 *	-	-6.3 [a]
-Variable Costs	-	-	10,861	8,915	-
-Fixed Costs	367	342	1,956	2,999	+717.2
Total Indirect Cost	**12,755**	**11,581**	**11,161**	**9,191**	**-27.9**
-Administration	3,339	3,040	3,151 *	-	-5.6 [a]
-Benefits	1,609	1,421	1,457 *	-	-9.4 [a]
-Support	2,961	2,691	2,839 *	-	-4.1 [a]
-Building	1,541	1,342	1,389 *	-	-9.9 [a]
-Other Costs	3,304	3,089	3,208 *	-	-2.9 [a]
Total Cost	**27,541**	**24,309**	**23,977**	**21,106**	**-23.4**
Net Revenue	27,771	27,265	27,558	29,972	+7.9
Net Income	230	2,956	3,581	8,866	-
Variable Margin	12,546	14,167	14,760	20,328	+62.0

NOTES:
1. Variable Margin = Net Revenue - Variable Cost;
2. Net Income = Net Revenue - Total Cost.
3. Includes only Medicare patients.
4. Variable costs assumed to include direct variable salaries, supplies, and other costs plus one-half of indirect benefits. In 1993, indirect benefits assumed to equal $1,457.
5. 1990 Net Revenues include PPS passthrough amounts.

* Detailed cost categories available for patients only through first six months of 1992. Subtotals do not add to totals which are based on all 167 patients in 1992.

[a] Percent change based on available data for 1992 vs. 1990.

SOURCE: St. Joseph Mercy Hospital Micro-Cost Accounting System.

Table 6-10

DRG 107 Average Costs, Revenues, and Profits Per Medicare Demonstration Patient, 1990-1993: St. Joseph Mercy Hospital, Ann Arbor

Category	July-Dec 1990	Jan-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	66	134	185	79	-
Total Charges	$33,944	$32,532	$34,073	$36,590	+7.8 %
Variable Cost	9,996	9,591	10,665	8,063	-19.3
Fixed Cost	8,239	8,433	8,484	9,803	+19.0
Total Direct Cost	**9,692**	**9,296**	**10,029**	**9,917**	+2.3
-Variable Salary	5,922	5,367	5,698 *	-	-3.8 [a]
-Supplies	3,036	3,152	3,674 *	-	+21.0 [a]
-Other Costs	504	530	653 *	-	+29.6 [a]
-Variable Costs	-	-	-	7,423	-
-Fixed Costs	230	247	1,499	2,494	+984.3
Total Indirect Cost	**8,543**	**8,727**	**9,119**	**7,947**	**-7.0**
-Administration	2,163	2,236	2,728 *	-	+26.1 [a]
-Benefits	1,068	1,083	1,279 *	-	+19.8 [a]
-Support	2,061	2,123	2,505 *	-	+21.5 [a]
-Building	1,028	1,013	1,224 *	-	+19.1 [a]
-Other Costs	2,221	2,274	2,744 *	-	+23.5
Total Cost	**18,235**	**18,023**	**19,148**	**17,865**	**-2.0**
Net Revenue	22,370	21,544	22,352	20,733	-7.3
Net Income	4,135	3,521	3,204	2,868	-
Variable Margin	12,374	11,953	11,687	12,670	+2.4

NOTES:
1. Variable Margin = Net Revenue - Variable Cost;
2. Net Income = Net Revenue - Total Cost.
3. Includes only Medicare patients.
4. Variable costs assumed to include direct variable salaries, supplies, and other costs plus one-half of indirect benefits. In 1993, indirect benefits assumed to equal $1,457.

* Detailed cost categories available for patients only through first six months of 1992. Subtotals do not add to totals which are based on all 167 patients in 1992.

[a] Percent change based on available data for 1992 vs. 1990.

SOURCE: St. Joseph Mercy Hospital Micro-Cost Accounting System. CMC016.SAS

reduction in average costs is a notable achievement when input prices were rising several percentage points annually, not to mention the secular trend towards greater intensity.

Based on hospital definitions, roughly 55% of DRG 106 and 107 costs were considered variable in 1990 compared to 45% four years later. This would imply that a 10% increase in bypass volume would translate into about a 5% reduction in average total cost given that roughly half of costs are variable and would rise with greater volume.

Not only did total costs fall for DRG 106 patients, but average charges fell as well (-14%). Charges rose slightly for DRG 107 (+7.8%). Hospital net revenues were unchanged over the 1990-92 period for DRG 106 before being updated by HCFA by approximately $2,400 in 1993. Average payments rose 7.9% in DRG 106 between the baseline year and the third year of the demonstration. Net revenues actually fell by a similar percentage for DRG 107; again all the change taking place in 1993 as the DRG was revalued by HCFA.

Hospital net incomes, or average margins, were positive for both DRGs in the pre- and post-demonstration periods. Average profits increased by over $8,000 in DRG 106 due to the 23% decline in costs and the 8% increase in net revenues. Net incomes fell by slightly over $1,000 for DRG 107, even though total costs fell 2%, due to the reduction in HCFA estimated payments for the hospital Part A portion of the global rate.

Variable margins on both DRGs remained in excess of $12,000 per case. In DRG 106, variable margins rose $8,000, peaking at over $20,000 per case in 1993. The hospital was more successful in controlling variable than fixed costs in DRG 107. As a result

variable margins remained at a constant $12,000-plus between the baseline and the third demonstration year.

6.5.2 Departmental Costs

Tables 6-11 and 6-12 decompose trends in direct patient costs by department. Unlike the other three hospitals in the demonstration, St. Joseph Mercy submitted data on all their bypass patients, not just Medicare. For consistency with earlier tables, only the Medicare cost data are reported here. The significant decline in direct costs in DRG 106 was the result of declining costs in many departments at St. Joseph Mercy Hospital. Nursing costs fell 34-40% over three years, pharmacy costs fell 34%, radiology costs fell 25%, lab costs fell 20%, and respiratory therapy costs fell 29%. Even operating room costs, which rose considerably in other hospitals, fell 13%. Of the significant cost centers, only catheter lab costs showed an increase per case (= 19%), although even this growth was not statistically significant.

Direct costs, by contrast, actually rose 2.3% over the period in DRG 107. This was true even though nursing costs fell 12-18%. The only category to show a significant increase was "other costs". (A similar increase was found for DRG 106 as well.) This could be due to real increases in other, unlisted, departments, or possibly to a reassignment of some costs from a reported cost center to a miscellaneous category.

In general, these results confirm the case study findings of significant changes in patient care management in the hospital, particularly regarding lengths of stay in the ICU and

Table 6-11

DRG 106 Average Direct Costs Per Medicare Patient by Department, 1990-1993: St. Joseph Mercy Hospital, Ann Arbor

Cost Center	1990	1991	1992	1993	Percent Change 1990-93	
Number of Patients	69	153	167	124		
Nursing ICU	4,358	3,408	3,085	2,869	-34.2 %	**
Nursing General	1,475	1,081	1,097	882	-40.2	**
Pharmacy	1,101	844	870	718	-34.8	**
OR & Recovery	3,190	3,181	3,098	2,771	-13.1	**
Radiology	384	298	317	287	-25.3	**
Laboratory	1,319	812	938	1,057	-19.9	*
Physical Therapy	60	14	19	8	-86.6	**
Anesthesia	449	409	352	286	-36.3	**
Respiratory Therapy	862	712	771	616	-28.5	*
EKG & EEG	7	1	1	1	-75.0	**
Other	325	670	986	884	+172.0	**
Rehabilitation	-	-	0	-	-	
Cardiology	28	86	113	98	+250.0	**
Hemodialysis	30	5	8	15	-50.0	
Catheter Lab	1,201	1,207	1,161	1,423	+18.5	
Total	14,789	12,728	12,816	11,915	-19.4	**

NOTES: Direct costs are for services directly assigned patients in the listed departments.
Excludes indirect overhead costs centers.

** = Significant at 5% level
* = Significant at 10% level

SOURCE: Developed from Micro-cost datafiles, St. Joseph Mercy Hospital.

Table 6-12

DRG 107 Average Direct Costs Per Medicare Patient by Department, 1990-1993: St. Joseph Mercy Hospital, Ann Arbor

Cost Center	1990	1991	1992	1993	Percent Change 1990-93	
Number of Patients	66	134	185	(79)		
Nursing ICU	2,611	2,312	2,291	2,305	-11.7%	
Nursing General	1,037	908	969	847	-18.3	
Pharmacy	613	590	662	669	+9.1	
OR & Recovery	2,937	3,113	3,048	2,834	-3.5	
Radiology	286	244	284	286	0.0	
Laboratory	888	628	725	893	+0.5	
Physical Therapy	25	11	12	10	-60.0	
Anesthesia	399	406	342	306	-23.3	**
Respiratory Therapy	561	576	584	657	+17.1	
EKG & EEG	3	2	4	2	0.0	
Other	171	410	876	856	+400.5	**
Rehabilitation	-	-	-	-	-	
Cardiology	15	48	77	67	+346.6	**
Hemodialysis	30	4	23	20	-33.3	
Catheter Lab	116	45	133	167	+44.0	
Total	9,692	9,297	10,030	9,918	+2.3	

NOTES: Direct costs are for services directly assigned patients in the listed departments. Excludes indirect overhead costs centers.

** = Significant at 5% level
* = Significant at 10% level

SOURCE: Developed from Micro-cost datafiles, St. Joseph Mercy Hospital

on the routine floors. Reductions in pharmacy, operating room/anesthesia, and radiology and lab costs are also evident.

6.6 Cost and Margin Trends for the Ohio State University Hospitals

6.6.1 Overall Trends

Tables 6-13 and 6-14 present data on costs, revenues, and margins for Ohio State University Hospital for the 1990-93 period. The hospital only decomposes costs into direct and indirect. Over the three year period, average bypass costs rose 10.9% for DRG 106 and 24.2% for DRG 107. Both direct and indirect costs rose faster for DRG 107. Thus, unlike other demonstration hospitals, OSU Hospital was not able to reduce costs per case, although DRG 106 cost inflation was relatively modest compared with the historical rate of inpatient cost increases for bypass surgery elsewhere in the United States.

Based on the hospital's cost definitions, slightly more than half of total costs were directly attributable to departments treating patients. The direct proportion of costs rose over the demonstration period, reaching 58% in DRG 106 and 107 in 1993.

Average charges rose roughly ten percentage points faster in the hospital over the four year period. Net revenues per case, however, fell dramatically beginning with the demonstration. This was due to the deep discounts the hospital offered to the Medicare program. Thus, net revenues fell 15.5% in DRG 106 beginning in May 1991, and 21.4% for DRG 107. The hospital also agreed to forego any updates in their negotiated rates over the first three years that further added to its financial problems.

Table 6-13

DRG 106 Average Costs, Revenues, and Margins Per Demonstration Patient, 1990-1993: Ohio State University Hospital, Columbus

Category	June 1990-April 1991	May-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	53	42	73	93	-
Total Charges	$33,502	$37,502	$38,472	$41,020	+22.4 %
Total Direct Cost	**14,397**	**14,640**	**14,904**	**16,342**	**+13.5**
Total Indirect Cost	**10,987**	**11,760**	**11,479**	**11,815**	**+7.5**
Total Cost	**25,384**	**26,400**	**26,383**	**28,157**	**+10.9**
Net Revenue	28,376	23,972	23,972	23,972	-15.5
Net Income	2,992	-2,428	-2,411	-4,185	-
Direct Margin	13,979	9,332	9,068	7,630	-45.4

NOTES:
1. Direct Margin = Net Revenue - Direct Cost. Variable costs not reported separately.
2. Net Income = Net Revenue - Total Cost.
3. 1991-93 Net revenues based on HCFA negotiated rates.

SOURCE: Ohio State University Hospital Micro-Cost Accounting System.

Table 6-14

DRG 107 Average Costs, Revenues, and Margins Per Demonstration Patient, 1990-1993: Ohio State University Hospital, Columbus

Category	June 1990-April 1991	May-Dec 1991	Jan-Dec 1992	Jan-Dec 1993	Percent Change 1990-93
Number of Patients	50	28	54	51	-
Total Charges	$27,294	$32,643	$33,606	$36,996	+35.5 %
Total Direct Cost	**11,628**	**12,534**	**12,987**	**14,834**	+27.6
Total Indirect Cost	**8,836**	**9,916**	**10,018**	**10,588**	**+19.8**
Total Cost	**20,464**	**22,449**	**23,005**	**25,442**	**+24.2**
Net Revenue	23,773	18,697	18,697	18,697	-21.4
Net Income	3,310	-3,752	-4,308	-6,725	-
Direct Margin	12,145	6,163	5,710	3,863	-68.2

NOTES:
1. Direct Margin = Net Revenue - Direct Cost. Variable costs not reported separately.
2. Net Income = Net Revenue - Total Cost.
3. 1991-93 Net revenues based on HCFA negotiated rates.

SOURCE: Ohio State University Hospital Micro-Cost Accounting System.

The failure to reduce costs, coupled with flat global payment rates, resulted in negative net incomes for both DRGs. For DRG 106, the hospital reported a positive net income, or average margin, of $2,992 in the year before the demonstration. In 1991, this gain turned into a loss of $2,428 that grew to $4,185 by 1993. This amounted to roughly a $7,000 turnaround in average profits. For DRG 107, the negative trend was even larger. A $3,310 profit in 1990 turned into a $6,725 loss by 1993.

Unfortunately, Ohio State University Hospital's accounting system could not decompose costs into fixed versus variable in order to determine short-run profitability. Direct cost margins were calculated instead.[1] Assuming direct costs approximate variable costs, OSU Hospital enjoyed a short-run profit of almost $14,000 on DRG 106 patients prior to the demonstration. This profit was eroded over the course of the demonstration so that by 1993, it amounted to $7,630. Because of fewer effective cost controls on DRG 107 patients, direct margins fell even more. By 1993, the hospital was covering only $3,863 of its estimated $10,588 in indirect costs.

6.6.2 Department Costs

Decomposing OSU's cost trends by department over time is fraught with difficulties. For example, costs are never separated into fixed and variable, as was mentioned above. But more limiting was the inability of the hospital to provide direct costs at the department level;

[1] According to the data furnished by the established micro-cost system in St. Joseph's Hospital in Atlanta, roughly 84% of direct patient costs are variable compared with just 24% of indirect costs. Thus, it may not be too erroneous to assume that OSU's direct cost approximate variable costs overall.

only total costs after loading on overhead cost centers were available for analysis. For individual patients, only their charges by department were provided along with a global cost-to-charge ratio that included stepped-down costs in the numerator. Cost centers were classified using a three-digit code while cost-to-charge ratios were provided initially at the four-digit level. A crosswalk was provided at a later date, but inconsistencies may remain in aligning ratios with departments.

Another problem in comparing costs over time has been the constant change in department definitions. First, new departments have been added to the three-digit listing over time. These fall into the "other costs" category, but may be drawing away costs from other departments in later years to an unknown extent. Second, broader departments such as EKG and Blood Processing are decomposed into subdepartments in later years, e.g., Holter Monitor, telemetry, blood administration. These were folded back into the broader center definitions to be consistent with earlier years, but errors may have occurred. Third, cost-to-charge ratios in a few departments appeared erroneous from year to year. For example, Medical Supplies usually had cost-to-charge ratio of 0.33, implying a tripling of prices over supply costs. In one year, however, the ratio was .98. We substituted the more common lower ratio where it seemed more reasonable. Fourth, in the operating room there was a dramatic jump in patient charges from 1991 to 1992 without a corresponding reduction in the department's cost-to-charge ratio. We did not make any adjustment as it may be due to a legitimate jump in costs and charges for OR services. Finally, the baseline sample

reporting departmental costs was smaller than the one reporting overall patient costs. This appeared to produce underestimates of costs by department and overstated cost increases.

With these caveats in mind, the results on department cost trends are shown in Tables 6-15 and 6-16. The numbers in the tables are generally much higher than seen in previous tables for other hospitals that excluded indirect costs. Little systematic trends exist across departments. ICU nursing shows large increases while general nursing shows large decreases. Pharmacy costs, which seem to be less affected by accounting problems than other departments, show significant increases in both DRGs. Operating room costs appear to have exploded, but this may be due to inaccurate charge or cost-to-charge data. Catheter lab costs for DRG 106 seem particularly low given that they represent loaded costs. In any event, they show an increase of 65% over three years.

From these tables, it is impossible to draw conclusions about the impacts of any cost containment efforts in particular departments. Some of the physicians that we interviewed complained about the limitations of the hospital's cost accounting system in isolating the true costs, tests, and procedures performed on bypass patients. While the detailed data at the hospital are better than provided to the evaluator, they still suffer from too many drawbacks to be useful in monitoring performance and supporting cost effective changes in clinical behaviors.

Table 6-15

DRG 106 Medicare Demonstration Average Direct Costs Per Patient by Department, 1990-1993: Ohio State University Hospital, Columbus

Cost Center	1990	1991	1992	1993	Percent Change 1990-93	
Number of Patients	27	68	73	93		
Nursing ICU	3,531	5,147	4,604	5,406	+53.1 %	**
Nursing General	5,830	5,040	3,607	3,085	-38.8	**
Pharmacy	1,398	1,758	1,714	1,782	+27.5	**
OR & Recovery	2,540	4,284	7,117	6,791	+267.3	**
Radiology	483	623	568	566	+17.2	
Laboratory	1,860	2,019	1,492	1,590	-14.5	*
Physical Therapy	125	147	182	60	-52.0	**
Anesthesia	540	333	358	403	-25.4	**
Respiratory Therapy	714	920	933	736	+3.1	
EKG & EEG	2,651	3,317	1,381	1,064	-59.9	**
Other	109	342	347	318	+191.7	
Rehabilitation	-	-	32	76	-	
Cardiology	177	254	184	330	+86.4	
Hemodialysis	-	75	6	34	-	
Catheter Lab	717	826	1,077	1,185	+65.3	**
Central Supply	599	924	1,621	2,313	+286.1	**
IV Therapy	86	110	137	247	+187.2	**
Blood Bank	414	444	1,104	1,908	+360.8	**
Total	21,774	26,563	26,464	27,894	+28.2	**

NOTES: Direct costs are for services directly assigned patients in the listed departments.
Excludes indirect overhead costs centers.

** = Significant at 5% level
* = Significant at 10% level

SOURCE: Developed from Micro-cost datafiles, Ohio State University Hosptial.

Table 6-16

DRG 107 Medicare Demonstration Average Direct Costs Per Patient by Department, 1990-1993: Ohio State University Hospital, Columbus

Cost Center	1990	1991	1992	1993	Percent Change 1990-93	
Number of Patients	28	49	54	51		
Nursing ICU	2,374	3,447	4,059	4,544	+91.4 %	**
Nursing General	4,418	4,288	2,889	2,917	-34.0	**
Pharmacy	1,167	1,404	1,599	1,928	+65.2	**
OR & Recovery	2,597	3,993	6,755	6,494	+150.1	**
Radiology	349	490	485	577	+65.3	**
Laboratory	1,489	1,640	1,312	1,484	-0.3	
Physical Therapy	112	121	145	104	-7.1	
Anesthesia	528	385	374	414	-21.6	**
Respiratory Therapy	567	844	940	783	+38.1	
EKG & EEG	2,466	2,714	1,073	888	-64.0	**
Other	183	350	180	139	-24.0	
Rehabilitation	-	-	33	63	-	
Cardiology	57	21	50	53	-7.0	
Hemodialysis	-	153	316	17	-	
Catheter Lab	56	125	127	205	+266.1	**
Central Supply	616	921	1,595	2,204	+257.8	**
IV Therapy	47	69	90	207	+340.1	**
Blood Bank	279	532	1,066	2,375	+751.3	**
Total	17,305	21,497	23,088	25,396	+46.7	**

NOTES: Direct costs are for services directly assigned patients in the listed departments.
Excludes indirect overhead costs centers.

** = Significant at 5% level
* = Significant at 10% level

SOURCE: Developed from Micro-cost datafiles, Ohio State University Hospital.

6.7 Summary of Findings

Table 6-17 presents a summary of trends in costs and profits for the four demonstration hospitals. In three of four hospitals, average total costs per case fell in absolute terms over the 1990-93 period. The range of decline was from -2% (in St. Joseph's Mercy for DRG 107) to -23.4% (again for St. Joseph's Mercy for DRG 106). Assuming at least 5% annual inflation in input prices and ignoring secular increases in intensity, these reductions amount to even large hospital savings on a real resource basis. Ohio State University Hospital, while not actually achieving cost reductions, was successful in holding cost inflation to under 11% over a three-year period for DRG 106. The hospital appeared to be less successful in DRG 107.

Both nonacademic medical centers were quite successful in improving net income, or profits, per demonstration patient, especially in DRG 106. University Hospital less successful, although net incomes in DRG 106 fell only slightly. Ohio State University Hospital suffered significant losses compared to the year before the demonstration. This was due to a combination of very large discounts plus cost increases, especially for DRG 107.

Most important to hospital financial managers are variable margins as they reflect short-run profits. Positive variable margins mean that demonstration patients are more than covering their own direct costs and contributing to fixed costs as well. The four sites varied greatly in their definition of variable costs. In 1990, University Hospital reported variable margins of $22-23,000 per case compared with only about $5,000 per case in Atlanta. Such large differences are attributable to the Atlanta facility classifying two-thirds of its bypass

Table 6-17

Summary of Cost and Profit Trends: 1990-1993

	DRG 106			DRG 107		
Total Cost Per Case	1990	1993	Percent (or Dollar) Change 1990-93	1990	1993	Percent (or Dollar) Change 1990-93
St. Joseph's	22,118	20,208	-8.6 %	17,756	15,460	-12.9 %
St. Joseph Mercy	27,541	21,106	-23.4	18,235	17,865	-2.0
University Hospital, Boston	33,111	30,886	-6.7	21,471	20,621	-4.0
OSU Hospital, Columbus	25,384	28,157	+10.9	20,464	25,442	+24.2
Net Income Per Case						
St. Joseph's	-1,482	2,126	+$3,608	-891	3,513	+$4,404
St. Joseph Mercy	230	8,866	+8,636	4,135	2,868	-1,267
University Hospital, Boston	1,406	1,090	-316	9,935	6,685	-3,250
OSU Hospital, Columbus	2,992	-4,185	-7,177	3,310	-6,725	-10,035
Variable Margin						
St. Joseph's	5,685	10,295	+81.1 %	4,610	9,741	+111.1 %
St. Joseph Mercy	12,546	20,328	+62.0	12,374	12,670	+2.4
University Hospital, Boston	21,818	19,254	-11.8	23,204	18,690	-19.5
OSU Hospital, Columbus	13,979	7,630	-45.4	12,145	3,863	-68.2

SOURCE: Developed from Micro-cost files on demonstration hospitals.

costs as variable versus only one-third in Boston. Assuming that two-thirds of all costs in treating bypass patients is fixed seems unrealistically high. Most operating room, central supply, nursing, drug, catheter, lab, blood bank, and central supply costs are variable. Thus, the extraordinary variable margins at University Hospital certainly overstate short-run profits to the facility.

Within-hospital trends in variable margins under the demonstration are mixed. The two nonacademic facilities show very large increases (except for DRG 107 in Ann Arbor), implying highly successful financial outcomes. The two academic medical centers, but contrast show large, or in the case of OSU, very large declines in variable margins. Some of this change may be due to reclassifications of fixed to variable costs, but still the short-run profitability of Medicare bypass surgery, while still positive, has declined in both places. Had volumes increased significantly, thereby spreading fixed costs across more cases, the lower variable margins would have been more tolerable.

7 Impact of Bundled Payments on Patient Outcomes

7.1 Introduction

Bundled payment systems, such as that embodied in the CABG demonstration, provide financial incentives to physicians and hospitals to reduce the cost of an admission. Cost savings, may be derived, for example, from reducing lengths of stay, using generic pharmaceuticals, or transferring tasks from surgeons to lower-cost health professionals. Another response might be for hospitals to select less severely ill patients for surgery in an attempt to maintain favorable outcomes while reducing costs. Ideally, cost savings would result from efficiency improvements. Cost savings achieved by the demonstration at the expense of quality would be unacceptable to HCFA. Thus, an important aspect of this demonstration evaluation involves measuring the impact of the payment system on the outcome and quality of care provided by participating demonstration hospitals.

The key policy questions to be answered are:

- Did participation in the demonstration affect mortality rates for CABG patients in participating hospitals?
- Did the demonstration result in changes in other measurable outcomes that reflect quality of care, e.g., post-operative complications, readmission, etc.?

Under the current evaluation, quality of care and outcomes have been measured through descriptive and multivariate analyses using clinical data collected from each of the

demonstration sites. An initial evaluation of these important questions was conducted half way through the demonstration analyzing the characteristics and clinical outcomes of patients who received CABG surgery in the four original demonstration sites between May 1991 and December 1993 and in the three new demonstration sites between May and December 1993 (Cromwell, *et al*, 1995). The primary finding was that no statistically significant trend in in-hospital mortality, adjusted or unadjusted, could be shown. An important secondary finding was reached that none of the hospitals had mortality rates significantly different than predicted by the multivariate regression model.

Examining trends in inpatient mortality under the demonstration is challenging because of possible concurrent changes in factors that may influence mortality rates; factors which may or may not be within the hospital/physician's power to control and may lead to spurious conclusions. Of primary concern is a change in the severity of cases presenting to the demonstration hospitals. If the severity of cases increased during the demonstration, then one might actually see an ***increase*** in mortality, although clinical care might have actually improved during the demonstration. On the other hand, if demonstration hospitals were able to select easier cases then one might observe a ***decrease*** in mortality rates although clinical care may not have improved during the demonstration period. Considerable effort has been devoted in this demonstration evaluation to constructing valid and reliable quality measures and risk-adjusters. Selection of appropriate risk-adjusters is essential to measuring the impact of the demonstration because of the need to control for case-mix differences across hospitals and over time.

Recent work by researchers of the Northern New England Cardiovascular Disease Study Group (O'Connor *et al*, 1996) highlight the critical importance of capturing changes in case-mix when evaluating inpatient mortality rates for CABG patients over time. O'Connor and others examined clinical data for 15,095 patients undergoing CABG procedures in Maine, New Hampshire, and Vermont hospitals between July 1, 1987 and July 31, 1993. Although their population was younger, on average, than the Medicare population in this demonstration, there was clear evidence of increasing case-mix severity. Patients presenting in the later years of their study were older, more likely to be women, had more co-morbid disease as measured by the Charlson Index, were more likely to have had a previous CABG, had worse hemodynamic measurements as measured by left ventricular ejection fraction, and had greater clinical acuity as measured by degree of coronary artery stenosis and reported urgency of hospital admission.

In this chapter, we examine changes in the inpatient mortality of Medicare beneficiaries undergoing CABG procedures at the seven demonstration hospitals between May 1, 1991 and June 30, 1996. Descriptive statistics are presented first, followed by multivariate analysis. We begin our evaluation by examining trends in crude inpatient mortality rates over the course of the five-year demonstration period, in total and by demonstration site. Next, we examine the bivariate relationship between pre-operative risk factors and inpatient mortality. This will allow us to begin to form an opinion about the importance of a change in the proportion of patients presenting with the particular pre-operative risk factor on a hospital's mortality rate, *ceteris paribus*. Post-operative

complications, length of stay, and readmission rates within 90 days of the CABG procedure are also evaluated.

Multivariate logistic regression analyses follow, allowing us to control statistically for those risk-factors identified through descriptive analysis as being causally related to the outcomes of interest, in-hospital and one-year mortality. Changes in hospital lengths of stay, total and post-operative, are also examined as additional measures of hospital efficiency and physician behavior. For each outcome, results are shown for the demonstration population as a whole and for individual hospitals.

7.2 Specification of Patient Outcomes

The two primary outcome variables of interest in this evaluation are in-hospital and one-year mortality. Secondary outcome measures include length of stay, post-operative complications, and readmission rates. Below we provide specifications of each of these patient outcome variables:

- **In-hospital mortality:** Deaths occurring after CABG surgery and prior to discharge from the hospital performing the surgery. In-hospital mortality was reported in the clinical data provided by each hospital.

- **Mortality during the first year after CABG surgery:** Calculated for patients operated upon between May 1, 1991 and December 31, 1995 from the date of CABG surgery through 1, 3, 6, 9, and 12 months post-surgery.

- **Post-operative complications:** Patient-specific complications were reported in the clinical data provided by each hospital. Complication rates are analyzed both by type of complication and in terms of whether a patient suffered any complication. Types of complications

reported include re-operation for bleeding, new myocardial infarction after CABG surgery, infection, neurologic complication, pulmonary complications, renal failure, vascular complication, and other unspecified complications.

- **Pre- and post-operative and total length of stay during the CABG admission: Total length of stay** was calculated from the date of admission to the date of discharge from the hospital performing the CABG surgery, plus one day. Thus, total length of stay would be one day, if the date of admission and date of discharge were the same. **Pre-operative length of stay** was calculated from the date of admission through the day before CABG surgery. **Post-operative length of stay** was calculated from date of CABG surgery to the date of discharge, plus one, thus, including the day of surgery in the post-operative calculation. This may produce one day longer stays than reported in the clinical literature that does not count the day of surgery.

- **Hospital re-admissions within 90 days after CABG surgery:** Obtained from an analysis of Medicare claims data for all patients who had a CABG procedure prior to January 1, 1996. Patients are classified as having any or no re-admissions to any hospital during the 90-day period following surgery (multiple re-admissions for an individual are not counted).

7.3 A Note on Research Evaluation Design

As a note of clarification, some mention should be made about the earlier discussions regarding the evaluation design. Ideally, this evaluation would have relied upon a comparison group of hospitals or patients in a pre-post design to assess the impact of bundled payment on the quality and outcome of care. Consideration was given to identifying a comparison group of hospitals within each demonstration site's market area. These "control" sites would then provide detailed medical records abstracts on a random sample of bypass patients. We believed that it would be unlikely that hospitals would be willing to volunteer

such data, especially those which were in direct competition with a demo hospital. Even if some hospitals would have participated, adding comparison hospitals would have also required a substantially larger budget to fund data collection efforts. HCFA ultimately rejected as too costly the concept of comparison hospitals -- at least for providing medical records information.

Consideration was also given to identifying a comparison group of patients. Here patients would be randomly assigned to the "treatment" group or to the "control" group. Because of the complexity of the bundled payment mechanism and the clear difficulty in having clinicians treat patients differently based on the payment method, HCFA and the evaluation team decided that randomization was not feasible. It appeared that only a patient population at (a) competitor hospital(s) would have served as a suitable control group for a demonstration site.

Lastly, consideration was given to a simple pre-post demonstration design. In such a design, the treatment group serves as its own comparison group. While such a design has limitations — in particular, it is not possible to control for trends and factors that would have occurred in the absence of the intervention — it does control for hospital-specific factors otherwise not measured in the collected clinical data. HCFA's desire to initiate the demonstration soon after selecting the participating hospitals precluded the collection of detailed clinical data on CABG surgery patients for the pre-period demonstration. Hence, the resulting quasi-experimental design is one in which patients discharged early in the demonstration became the *de facto* control group. Multivariate statistical methods were used

to assess time trends while adjusting for differences in patient severity across hospitals over time. However, if significant changes in patient mortality occurred during the early months of the demonstration (the baseline period), our quasi-experimental research design would fail to account for them. There is little reason to believe, however, that the professional staffs at these facilities would respond immediately to any perceived payment incentives, if at all, in ways detrimental to patients.

How the demonstration hospitals performed relative to their competitors during the demonstration period is examined in more detail using Medicare claims data in Chapter 8. There, mortality rates are compared between demonstration sites and competitor hospitals across the demonstration years using claims-based risk factors.

7.4 Data Sources and Cleaning

7.4.1 Clinical Data

A data collection instrument was designed to obtain the clinical data needed to measure a hospital's casemix. This was used to adjust for casemix differences when comparing the clinical outcomes of CAB6 surgery at the hospitals. Information was collected on the patients' demographic characteristics, medical history, physical examination, cardiac catheterization data (including left ventricular function and coronary artery anatomy), pre-operative risk assessment, operative data, post-operative treatment, in-hospital mortality, and discharge disposition.

Development of the clinical data collection form was influenced by three considerations:

1. the need to adjust clinical outcomes for relevant differences in case-mix;
2. the goal of developing a database that would permit valid comparisons among demonstration sites; and
3. the desire to make maximum possible use of existing cardiac catheterization and cardiac surgery registries (in an effort to reduce the data collection burden on the sites).

It would have been desirable to have a "standardized" cardiac surgery registry format already in place in the participating surgery programs. However, existing registries at the hospitals varied widely both in content and in stage of development. We, therefore, developed a data collection instrument specifically for the demonstration. In doing so, existing recognized registry formats such as that developed by the Society of Thoracic Surgeons for a National Cardiac Surgery Database (SUMMIT) were used as models. The data collection instrument was subjected to several rounds of review and comment by the cardiovascular surgical programs at the demonstration sites. The final draft of the data collection was pre-tested in a sample of patients from each site.

The demonstration sites were provided with a glossary of definitions in an effort to facilitate standardized reporting of data across the hospitals and over time (see Appendix D). For example, standard definitions were suggested for the urgency of re-vascularization procedures, distal disease, angina, congestive heart failure, exercise stress test results, and

"shed blood." However, not all sites adopted these definitions nor did all sites use these definitions consistently over time.

The most notable inconsistency appears in the reporting of re-vascularization urgency. There is wide variation across the demonstration sites in the proportion of cases that are identified as urgent or emergent,[1] as opposed to elective. In discussing the use of these terms during our site-specific visits to the demonstration hospitals, it was clear that site-specific norms prevailed in the use of these terms. For example, in one hospital an emergent status might be a necessary designation in order to obtain an ICU bed within a short period of time, while in another there is no such requirement. There are also differences in physicians' personal beliefs as to how cases should be characterized; ranging from "all patients who are sufficiently ill to require a CABG are by definition urgent or emergent" to "we reserve the use of urgent or emergent for truly ill patients." In addition, different physicians may be making the revascularization priority determination. For example, a patient being admitted with an evolving MI would likely be classified as "emergent" by the attending physician, but after stabilization and at the time of surgery could be classified as urgent by the surgeon.

[1] A patient undergoing a CABG has an urgent revascularization priority if the patient is unstable, has disease that warrants revascularization within 7 days, or the patient is stable but has suffered a complication or event within 14 days that substantially increases the risk of revascularization. A patient is classified as emergent if the patient is unstable clinically, and his/her condition requires immediate revascularization within 24 hours.

7.4.2 HCFA Denominator Files

The Medicare Denominator Files for 1991 through 1996 provided a second source of data. The Denominator file is an annual summary file created each April and contains data on all Medicare entitled beneficiaries from the previous calendar year. The Denominator files contain demographic information such as state and county of residence as of December 31st of the previous year, date of birth and death, sex, race, reason for entitlement, and monthly indicators for different types of eligibility (Part A, Part B, HMO coverage, etc.)

The denominator files were used in this analysis to obtain dates of deaths for all CABG demonstration patients by linking data from these files to the clinical data base. Unfortunately, this linkage is not straightforward. The clinical data base contains the CABG demonstration patients' name, home address, social security number, birth date, sex, and race. Unfortunately, it does not contain the patients' Medicare identification number (HICNO). The HICNO is an eleven digit number, of which the first nine digits is a social security number (SSN), and the last two digit character suffix contains information on the relationship between the SSN and the Medicare beneficiary. For the majority of Medicare beneficiaries, the HICNO contains their own SSN and there is no two digit character suffix. However, for a subset of Medicare beneficiaries who are entitled to Medicare on basis of their spouses' work history, their HICNO will contain their spouses' SSN, not their own, as well as a two digit character suffix stating the familial relationship. These beneficiaries' HICNOs may change during the course of their lives. If, for example, their spouse should

die and they remarry, the beneficiary may obtain continuing Medicare coverage through their new spouses' eligibility. It is estimated that roughly 1.5 percent of all Medicare beneficiaries change their HICNO during the course of any particular year. We used a HCFA-developed cross-reference file that allows for the identification of every HICNO a particular person has ever used during their entire time of Medicare eligibility.

The first step in the matching was to construct a subset of the Denominator file, which contained one record for each HICNO and the variables, date of birth, sex, and any cross-referenced HICNOs. Then all years of the Denominator files were scanned looking for a valid date of death. If found, the date of death was appended to the HICNO record in the subset file. To conduct the matching, we used the SSN, date of birth[2], and sex from the clinical data base and the first nine digits of the HICNO (and/or cross-referenced HICNOs), date of birth, and sex from the Denominator files. Of the 10,546 records in the clinical data base, 9,340 were successfully matched with the Denominator file records. The primary reason for non-matches was an invalid SSN on the clinical data base. All non-matching demonstration patients were excluded from the one year mortality analyses. (Matching beneficiary utilization and survival data with demo hospital clinical data is not necessary for studying in-hospital mortality.)

It is important to note that the date of death on the Denominator file is obtained from the Social Security Administration (SSA) rather than from a living relative or death certificate. Because Social Security benefits have monthly eligibility periods, SSA's primary

[2] We allowed a two day window on either side of the date of birth for purposes of matching. This increased our match rate by approximately 200 records.

interest is in ensuring a valid month of death, and not necessarily date of death. Thus, there tends to be a larger than expected number of Medicare beneficiaries with dates of death given as the last day of the month in the Denominator file. Use of this date of death is likely to understate, slightly, the cumulative mortality rates following CABG surgery at a given time point.

7.4.3 Medicare Claims Data

Medicare claims data for the demonstration and competitor hospitals were used to analyze differences in three outcome measures: post-operative complications, mortality, and readmission within 90 days of CABG surgery. Medicare Part A hospital claims (contained in the MEDPAR file) and Part B physician claims (contained in the NCH 100% files) for patients discharged in DRG 106 and 107 during the years 1990 through 1996 will be analyzed. ICD-9 diagnosis and surgical codes will be utilized to identify risk factors and post-operative complications.

Although Part A claims data can be used to identify risk factors and complications, there are some drawbacks that should be noted. The ICD-9 codes present in the claims data help reveal risk factors and complications, but it may not always be possible to distinguish between the risk factors and the complications. For instance, acute myocardial infarction or renal failure, could either be a risk factor or a complication depending on whether it occurred prior to or after CABG surgery; this distinction cannot be made from Part A claims data. The date entered for the insertion of the intra-aortic balloon pump (IABP) can be used to identify

whether this procedure was performed before or after bypass surgery. Unfortunately, if the procedure were reported on the date of the CABG surgery, then it will not be possible to distinguish whether it represents a risk factor or a complication.

In this analysis, in addition to hospital admission information, claims submitted by physicians (Part B) were also utilized. Diagnoses reported by physicians prior to the date of the surgery assisted in distinguishing risk factors from complications.

7.4.4 Data Collection and Management

Each of the seven demonstration sites submitted clinical data for the evaluation. Because these data contain information on mortality and complications, we report hospital-level statistics only in an encrypted format with hospitals designated using the letters A-G.

Clinical data collection instruments were distributed to the four original sites early in 1991 and to the three additional sites in 1993, and schedules for data submission were established. In general, there were three data submissions for the four original sites and two data submissions for the three sites that joined half way through the demonstration period. Demonstration sites were encouraged to collect and submit data by whatever method would impose the least burden on hospital staff. Each hospital responded differently. Hospital D chose to complete the clinical data collection form manually, and submitted hard copies of the collection instrument to the evaluation team. All other sites submitted their data in electronic formats that required varying degrees of manipulation prior to being included in the clinical data base.

At the outset of the demonstration, Hospital A developed a computerized registry modeled after the HER data collection instrument, but subsequently changed to abstracting the requested information from a SUMMIT data base. Hospitals B and G also used their in-house SUMMIT data bases as the primary data source, and Hospital C used a combination of their SUMMIT data base and a second internal clinical data base. However, data provided by these four hospitals were not cross-walked to our particular format prior to submission requiring considerable manipulation upon receipt. For example, Hospital B submitted the data to the evaluation team in approximately a dozen different electronic files, which required considerable data manipulation.

In addition, the SUMMIT format changed during the course of the evaluation period. The change affected, most notably, the level of reporting of cardiovascular disease and conduit sites; there was a reduction in the number of coronary artery segments for which information was collected. Hospitals E and F's data submission were electronic and were much more similar in format to our data collection instrument, but also varied in format to some degree during the course of the demonstration period.

7.4.5 Data Cleaning and Problem Resolution

Consistency and reasonability tests were conducted to assure the validity of the data collected from the demonstration hospitals and to identify any data anomalies. Three types of problems were addressed in cleaning the data: 1) invalid characters and miscoding; 2) inconsistency between related questions; and 3) clinical infeasibility. Missing data will be

discussed in the next separate section. Invalid characters appeared in the electronically transmitted data sets (Hospitals A, B and C) as a result of human error in the original coding of the data or in the conversion programs used to translate the data into analytic files. These errors were detected through the examination of the response frequencies for each variable. Appropriate steps were taken to recode the data after consulting with the demonstration hospitals where necessary.

Several items in the clinical data collection instrument relate to a previous item either directly or indirectly. For example, item C-1 (see Appendix D) asks for the patient's clinical presentation at the point of CABG hospitalization (stable angina, unstable angina, acute MI); item C-3 then asks, "If patient was admitted with an acute MI, time from onset of MI to date of CABG surgery" (less than 7 days, etc.). In several cases, either the response to the second part of the question was inconsistent with the first part (e.g., a patient presented with stable angina and less than seven days was circled for C-3) or the first part of the response was missing. In the former case, other indicators were examined for evidence of which part of the clinical record was in error and the responses were made internally consistent. In the latter case, an imputation was made where there was a high degree of certainty that the missing data could be filled in accurately. In some cases, however, we were unable to resolve apparent contradictions in the data. For example, Hospital D classified 45.8 percent of its patients as undergoing CABG surgery on an elective basis, but also recorded clinical presentation as unstable angina for 69.4 percent. According to our clinical definition of

unstable angina, these results are conflicting. We were unable to make a retrospective adjustment to the data without further information.

Infeasible responses were encountered most often in items that required the respondent to "circle all that apply". For example, question H-4 requests information regarding the type of myocardial protection used and lists six possible answers, of which the respondent may select all that apply. However, clearly "intermittent cross-clamp" and "continuous perfusion/no cross-clamp" are mutually exclusive. In cases where such a response was encountered, the response was recoded as "don't know" for the purpose of analysis.

7.4.6 Missing Data

Because of the potential for biased results, missing data were explored at length. In our earlier reports, we noted that initial results indicated that missing data might be a significant problem. At several points during the course of the demonstration, letters were sent to the participating hospitals detailing areas identified to be a problem with that hospital's data collection efforts. In particular, the importance of accurate reporting of variables judged *a priori* to be significant risk factors was emphasized. Efforts at obtaining missing data were mixed. For example, we were able to obtain only 55 percent of DRG assignments for demonstration patients undergoing CABG surgery at Hospital G.

In some cases, missing responses were a result of the ambiguity of the data instrument or a misunderstanding on the part of the respondent. For example, question I-4

asks the respondent whether the patient suffered post-operative complications. The instrument directs the respondent to answer the rest of the section on the nature of the complications if, and only if, the answer to I-4 is 'yes'. Death in the hospital is the last item in the complications section. In a few instances, missing values for death occurred because the respondent did not interpret death as a complication. In these cases, a phone conversation resolved the matter. Similar conversations indicated that under certain circumstances missing values for other variables (e.g., specific types of complications or co-morbid conditions) could be interpreted as 'nos'. Imputations were made accordingly, but are reported in the descriptive tables as "no/missing data". Unfortunately, there were some questions for which no imputation could be made. Missing data percentages are shown in the descriptive tables for these data elements.

Despite efforts to obtain missing data from all sites, it must be recognized that the reporting of specific data elements and the degree of completeness varied across hospitals and across the demonstration evaluation period. Hospitals participating in the demonstration were not provided additional compensation for the collection of this information. Thus, they typically relied upon a number of different staff members to obtain the requested information from the "best available sources" and within the time constraints of other job-related demands.

Because of concern about potential biased results due to missing data and limited personnel resources of the participating hospitals to obtain the missing data, an extensive analysis of the patient records for which key data fields were missing was conducted fairly

early in the evaluation period. The general finding was that the pool of patients missing a key data item reflected a healthier population than that for patients with complete data. Mortality rates appeared relatively low among those missing clinical presentation, ejection fraction, certain comorbid variables, or height.

Because we evaluate the effect of a large number of co-morbid conditions and post-operative complications on mortality rates and length of stay, we are hesitant to drop observations from the multivariate analyses for which there might be only one unreported data element, or a data element for which we presume "missing" is actually "no." For example, Hospital G did not report post-operative stroke information on any of its patients. Thus, all observations from this hospital would be dropped for every multivariate analysis in which post-operative complications are included. In creating our dummy variables, we set missing values to 0 and retain the majority of cases for the regression analyses. Presuming that the missing-data group is, in fact, a healthier group, this decision rule should not bias the mortality results downward. Further, to the extent that a particular hospital did not report one of the risk adjustors, the estimation of a fixed-effects model will capture within that particular hospital's intercept term the effect on mortality of the unreported data.

7.5 Descriptive Results

In this section, we examine trends in CABG surgery volume during the course of the five year demonstration period and the bivariate relationship between patient co-morbidities, clinical presentation, and post-operative complications with in-hospital mortality. We

conclude with an examination of changes in average length of stay over the five year period. Data are provided for each hospital separately and pooled together. Because of the large number of comparisons, we display the majority of the associations graphically. This visual inspection is intended to provide a sense as to the pre-operative risk factors and post-operative complications that are most likely to be correlated with in-hospital mortality. The underlying proportion of cases that have a particular condition, the mortality rate associated with that condition and an estimate of the relative risks are provided in Appendix L. The actual relationships between the pre- and post-factors and mortality are tested empirically in a multivariate analysis later in this chapter.

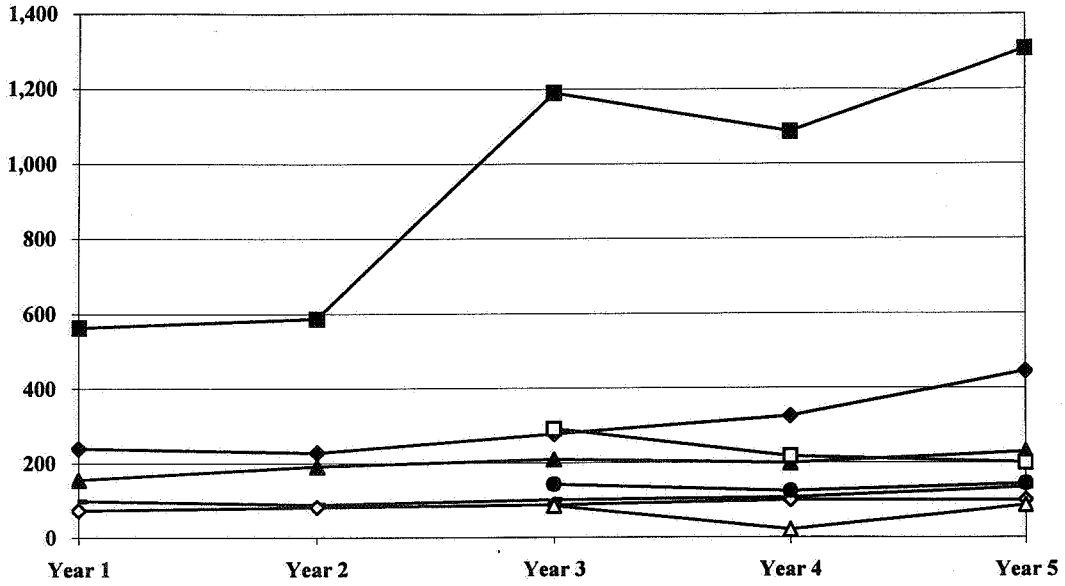
7.5.1 Volume Trends in Demonstration Sites

Figure 7-1 shows Medicare patient volumes for DRGs 106 and 107 for the five years of the demonstration overall and by hospital. Results, based on clinical abstracts submitted by participants, are presented for the four original sites for the entire period from May 1991 through June 1996 and for the three more recently added sites from May 1993 through June 1996. Figures for May and June of the start-up years were incomplete because hospitals were beginning to implement the demonstration during these periods. Presumably, the major reassignment of DRG 108 CABG patients to DRG 106 or 107 occurred between 1990 and 1991 and does not affect the 1991-96 trends.

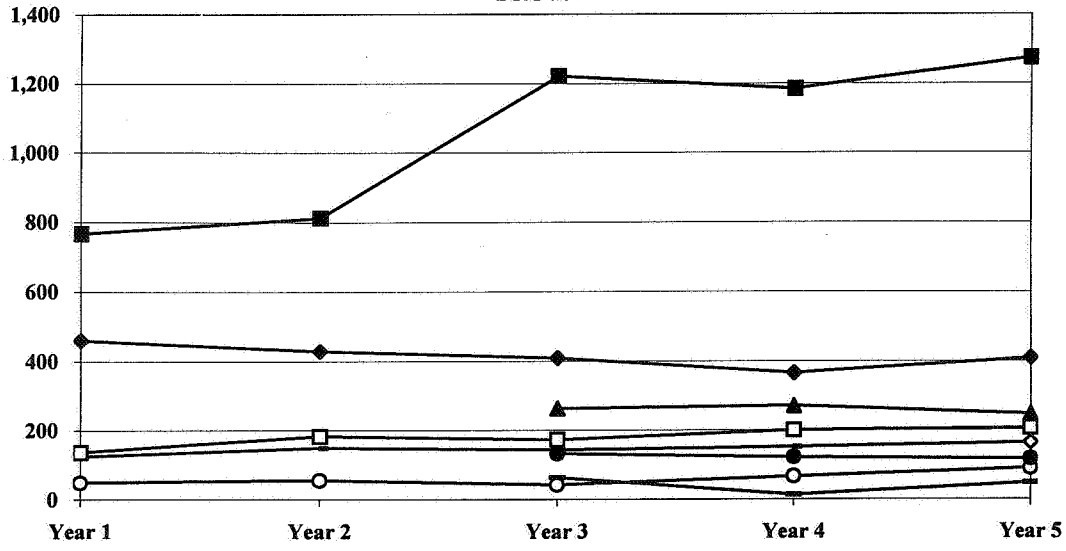
Figure 7-1

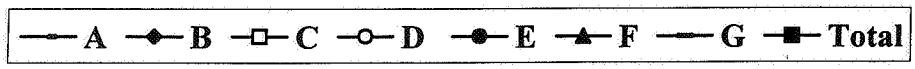
Medicare Demonstration Patient Volume By Hospital and Year

DRG 106



DRG 107





* represents small sample size - 5% or less of all patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

A total of 10,546 Medicare patients underwent CABG surgery in the demonstration at some time over the five year period, including 4,745 in DRG 106 (45 percent) and 5,267 in DRG 107 (50 percent). Five percent of the patient population was not classified in either DRG 106 or 107, of which the majority were missing DRG information. Eleven observations were assigned to DRG 108. DRG 106 volume increased from 42.3 percent of the total in the first year of the demonstration period to 50.7 percent in the final year.

The mix of patient volume between DRG 106 and 107 among the participating hospitals varied considerably. The three hospitals with a larger share of DRG 107 patients than DRG 106 (Hospitals A, B and F) are major referral centers, and likely see many patients who are admitted to the hospital after having an angiography in an outside catheter lab.

Medicare CABG volumes in the four initial sites in 1992, the first full year of data, ranged from 120 in the smallest participant to 697 in the largest. Across the five-years, all four hospitals experienced a increase in the average annual volume of patients, ranging from 22 to 58 percent. The three hospitals that entered the demonstration at a later date all experienced declining volumes over the last three years.

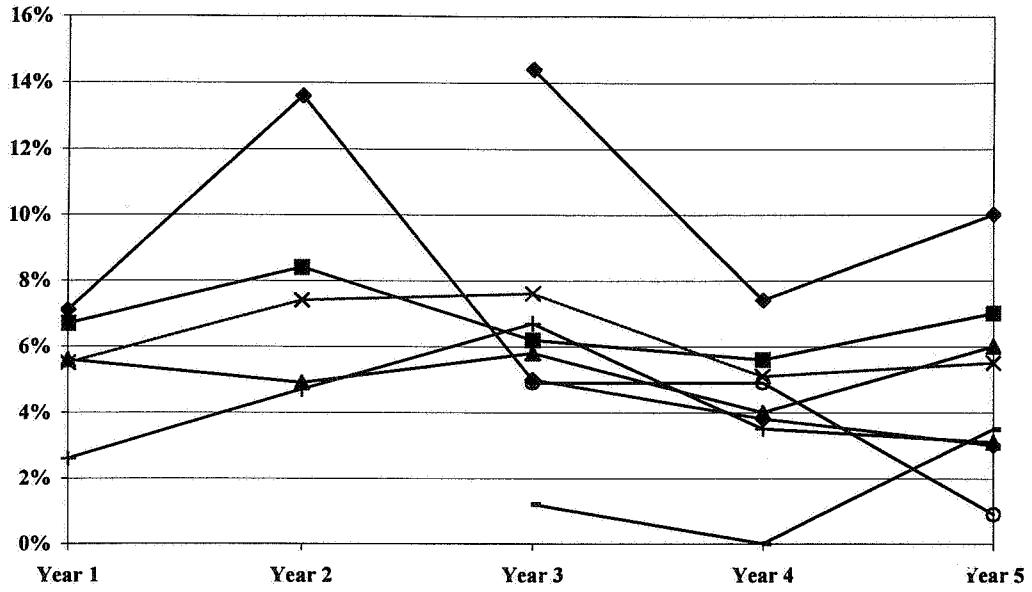
7.5.2 In-Hospital Mortality

Figure 7-2 presents unadjusted in-hospital mortality rates by year during the demonstration. Overall mortality across all hospitals and periods averaged 4.6 percent. The range for initial sites during the five years was from 3.6 percent in Hospital A to 4.8% in Hospital B. Mortality in the new sites during the latter half of 1993 to June 1996 ranged

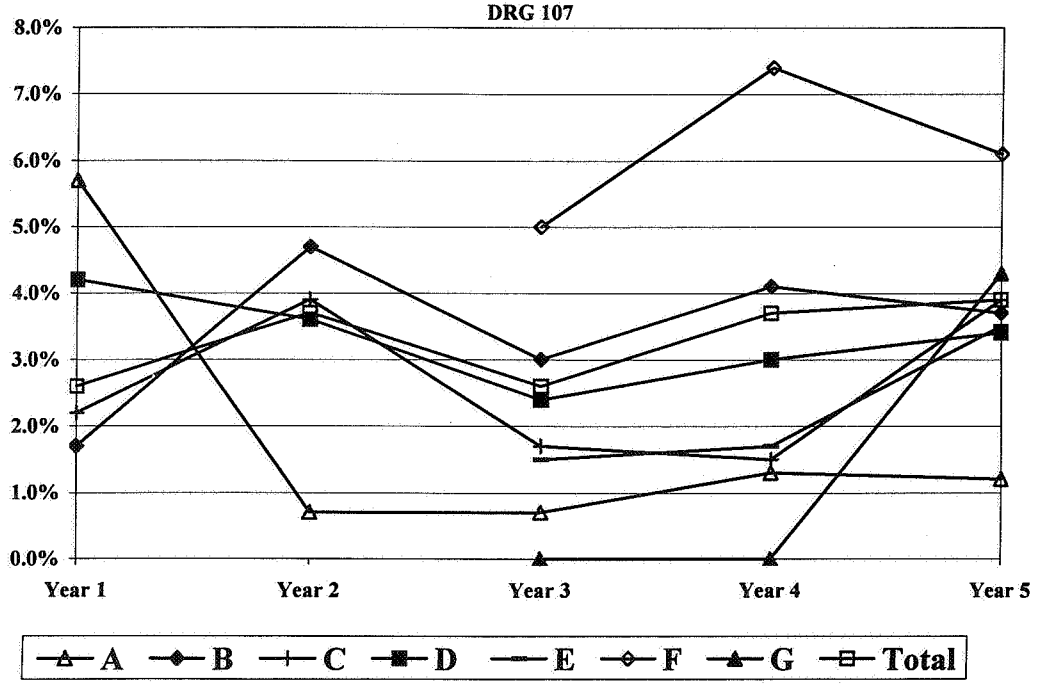
Figure 7-2

In-Hospital Unadjusted Mortality By Hospital and Year

DRG 106



DRG 107



* represents small sample size - 5% or less of all patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

from 2.3 percent in Hospital G to 8.5 percent in Hospital F. DRG 106 mortality was a little less than twice that for DRG 107 (6.2 percent vs. 3.3 percent). As DRG mix varies greatly by hospital, as seen in section 7.5.1, care should be taken in comparing mortality rates based on overall averages of the two DRGs.

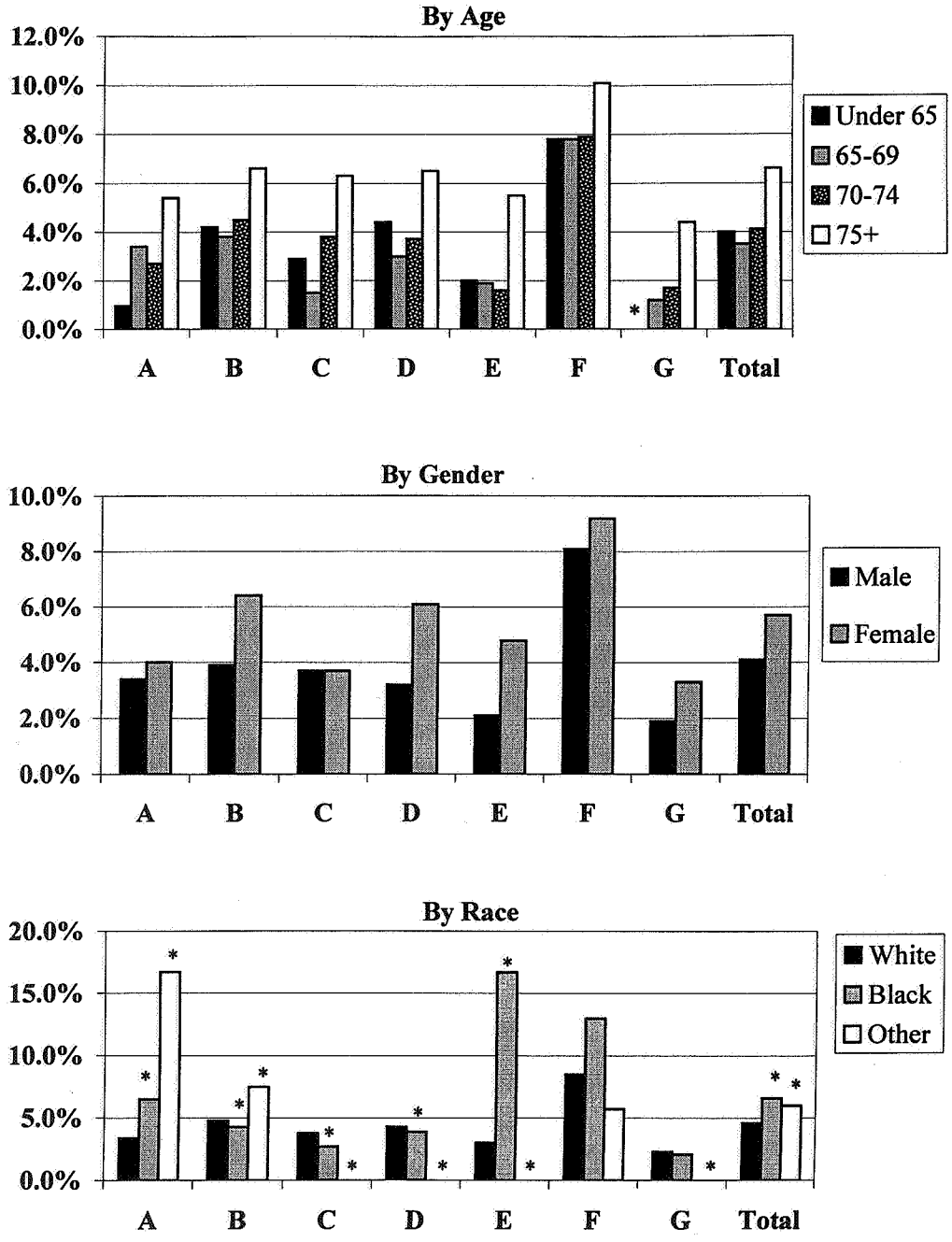
No obvious time trend is evident in in-hospital mortality during the demonstration in the initial sites. Hospital G seems to have very low mortality rates for both DRG 106 and 107. This could be misleading, however, because data inconsistencies labeled more than half of the patients from Hospital G as having missing DRG assignment. Over its three year period in the demonstration, Hospital G had an overall mortality rate of only 2.3 percent and essentially zero in the first two years. See Appendix Table L-7-2 for greater detail. In contrast, Hospital F had the highest mortality rates consistently across time. This could be a reflection of a sicker case mix, a hypothesis that is tested in the multivariate analysis.

7.5.3 In-Hospital Mortality Stratified By Patient Demographic Characteristics

Figure 7-3 presents the age, sex, and race distributions of patients for each hospital and the associations of these demographic characteristics with in-hospital mortality. The mean age for the population is 70.2 years. Overall, the distribution of cases among age groups 65-69, 70-74, and 75 and over is approximately equal; with considerably fewer patients assigned to the under-65 age group, as expected. Hospitals E and G had the highest proportion of patients 75 years of age or older (31.5 and 31.4 percent respectively) and Hospital D had the lowest (24.4 percent).

Figure 7-3

In-Hospital Mortality by Demographic Characteristics



* represents small sample size - 5% or less of all patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

Ignoring the small, under-65 group, in-hospital mortality increased directly with age from 3.5 percent in individuals 65-69 years of age to 6.6 percent in those 75 years of age or older (risk ratio 1.9). Mortality was higher for the under-65 age group than for the 65 - 69 age group (relative risk 1.1). Most Medicare beneficiaries who are under age 65 are entitled to benefits because of a disability; thus it is not surprising that they exhibit a slightly higher mortality rate than the 65 - 69 age group who are eligible because of investiture through a work history. Age-related patterns vary among hospitals but mortality is uniformly highest in the oldest age group, especially in Hospital E.

Male patients outnumbered females by two to one. The proportion of male patients ranged from a low of 63 percent in Hospital D to 69.7 percent in Hospital E. Mortality was considerably higher in females than in males (5.7 percent vs. 4.1 percent; risk ratio 1.4). Higher mortality in females was found in all hospitals except Hospital C, in which the mortality rates were exactly equal.

White patients predominated, making up 93 percent of demonstration patients; 3.2 percent were black and 2.5 percent were Hispanic or other races. The proportion of white patients ranged from 83.1 percent in Hospital F to 96.3 percent in Hospitals C and D. In-hospital mortality was higher in blacks than in whites (6.6 percent vs. 4.6 percent; risk ratio 1.4). Hospital F is the only hospital that presents a similar mortality rate for all races (5.7 percent); approximately 10 percent of their patient load is minority. In contrast, the other six hospitals have 2.5 percent or fewer of their patients assigned to this category. Thus, for example, the mortality rate for patients with a race designation of "other" in hospital A is 17

percent. However, patients with this designation make up less than 5 percent of the patients in hospital A (designated by the * in Figure 7-3) so the high mortality rate may not be statistically meaningful.

7.5.4 In Hospital Mortality Stratified By Clinical Presentation and Pre-Operative Course

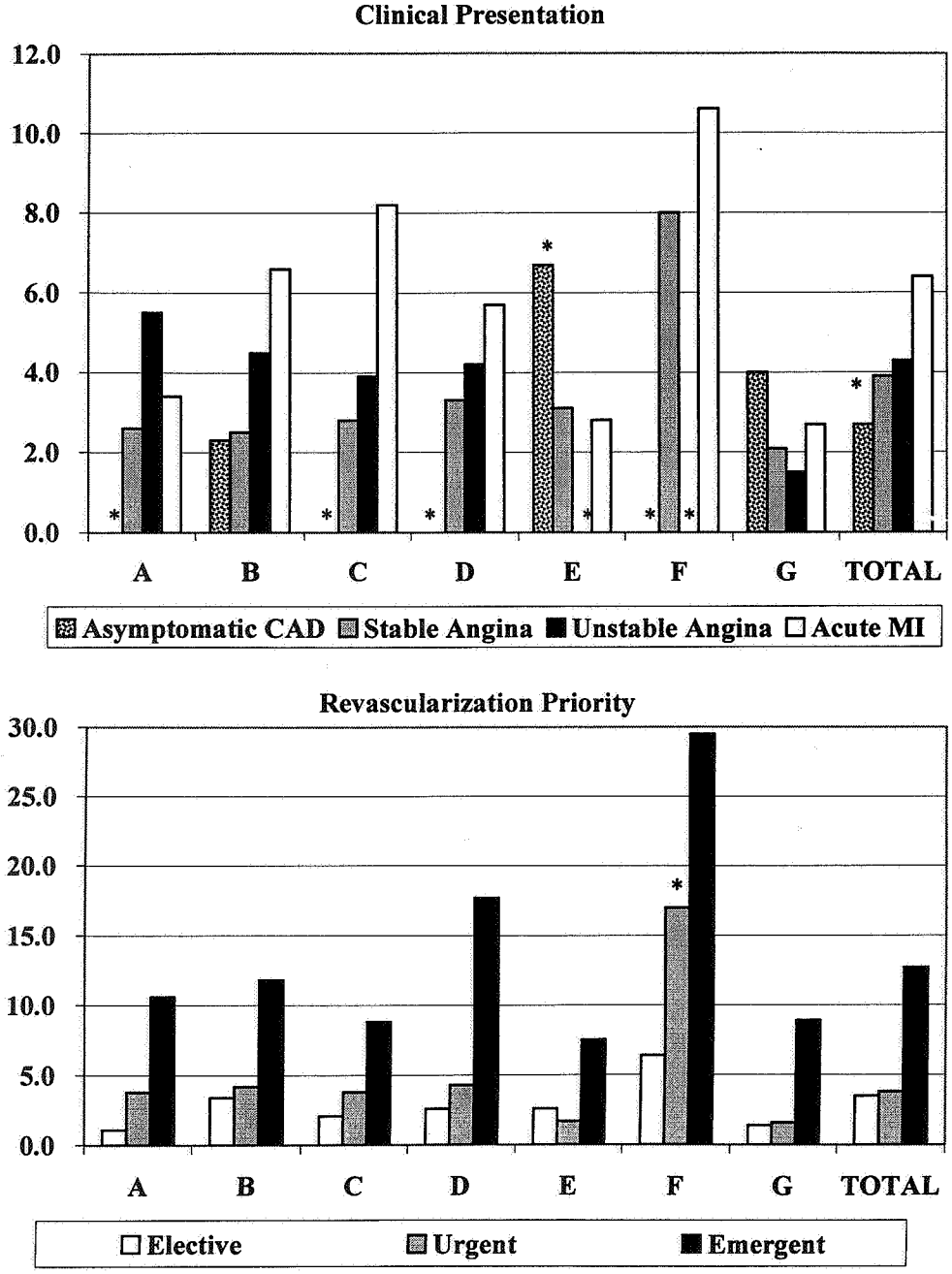
Figure 7-4 presents the associations of the patient's clinical presentation to the hospital, revascularization priority (elective, urgent, or emergent), pre-operative insertion of an intra-aortic balloon pump (IABP), and history of previous CABG surgery to in-hospital mortality. The clinical data collection instrument defined three priority levels for CABG surgery:

- elective: patient is clinically stable and does not require revascularization within the next 7 days;
- urgent: patient may be unstable, have disease that warrants revascularization within 7 days, or be stable but have suffered a complication or event within the past 24 days that substantially increases the risk of revascularization (e.g. AMI);
- emergent: patient is unstable, and his/her condition requires revascularization within 24 hours.

Approximately one third of patients (33.6 percent) were operated on for a clinical presentation classified as unstable angina; another 32 percent of patients had stable angina; and 26.7 percent of patients were operated on during an admission with an acute myocardial infarction. Patterns of clinical presentation varied dramatically among hospitals, and as discussed earlier, are likely to reflect more than the clinical condition of the patient. For

Figure 7-4

In-Hospital Mortality (%) By Clinical Presentation and Pre-Operative Course
All Years Combined

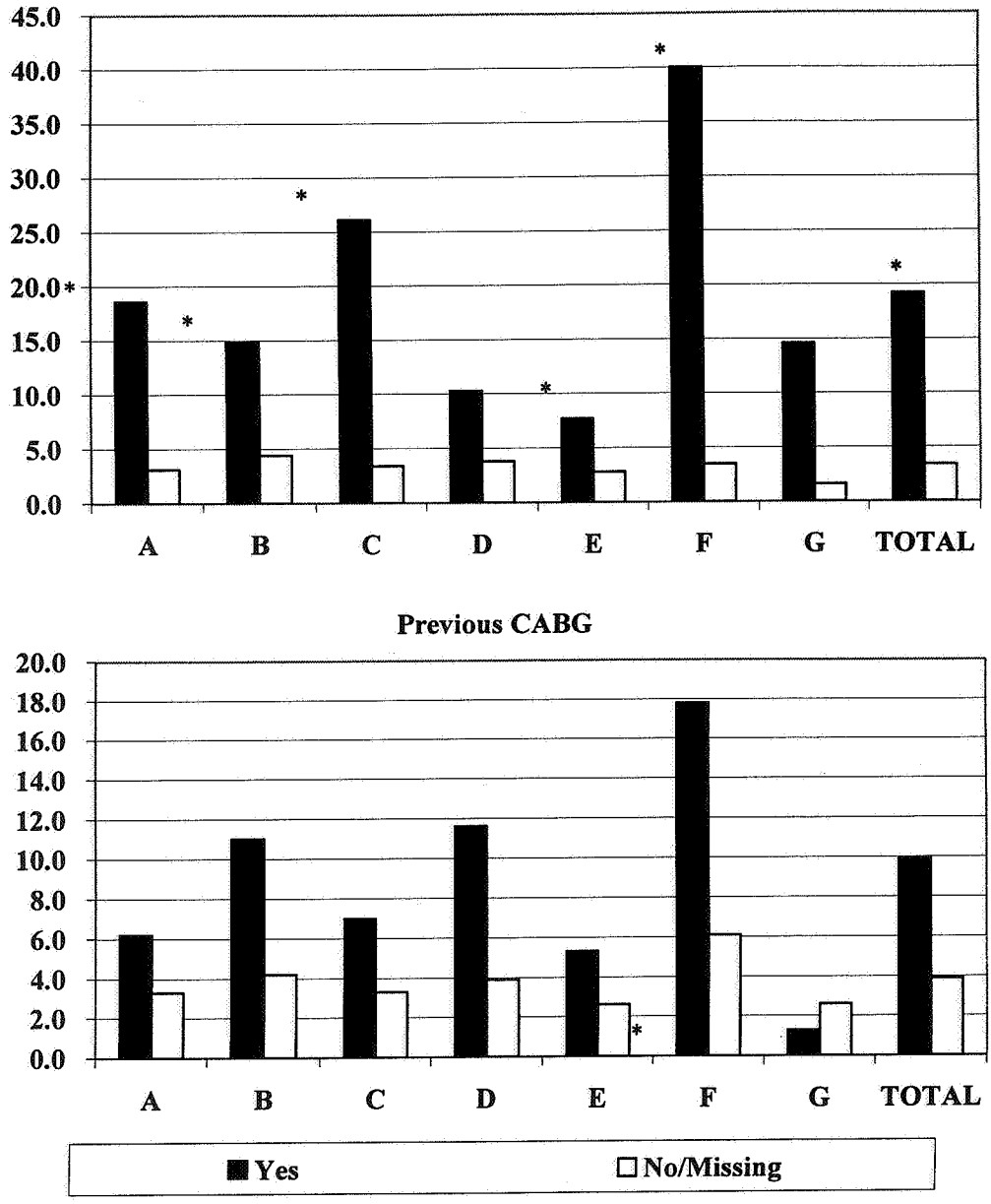


* represents small sample size - 5% or less of all patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

Figure 7-4 (continued)

In-Hospital Mortality (%) By Clinical Presentation and Pre-Operative Course
All Years Combined



* represents small sample size - 5% or less of all patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

example, Hospital B operated upon only 5.6 percent of patients with stable angina versus 56.7 percent of patients with unstable angina; by contrast, Hospital E operated on 72.8 percent of patients with stable angina and only 2.3 percent with unstable angina. Other hospitals exhibited intermediate patterns. These differences almost certainly reflect varying definitions of unstable angina, at least in part. Thresholds for operating on patients soon after their AMIs appear to vary widely. Only 9.3 percent of patients operated upon at Hospital C had been admitted with an AMI compared to 40.3 percent in Hospital A and 39.5 percent in Hospital F. The latter hospitals either admit more AMIs, operate on a higher proportion of those who are admitted, or both.

In-hospital mortality increased from 3.9 percent in patients with stable angina to 4.3 percent (risk ratio 1.1) and 6.4 percent (risk ratio 1.6), respectively, in patients with unstable angina or an AMI. Figure 7-4 may reflect some of the confusion in categorization, as mortality rates by clinical presentation are remarkably different among different hospitals.

Revascularization priority and pre-operative insertion of an IABP describe aspects of the pre-operative course. Both were strongly associated with in-hospital mortality. Overall, 55.7 percent of patients underwent elective surgery, 29.7 percent urgent surgery, and 10.7 percent emergent surgery. The proportion of patients undergoing emergent surgery ranged from 6.8 percent in Hospital D to 13.6 percent in Hospital B. An emergent CABG operation conveyed a mortality risk 3.6 times that of an elective procedure (mortality 12.7 percent v. 3.5 percent). Urgent procedures displayed intermediate mortality rates, 3.6 percent. Also note that similarity in mortality rates between elective and urgent cases,

suggesting most sites do not clinically distinguish patients in terms of relative risk as to elective versus urgent.

Pre-operative use of an intra-aortic balloon pump was a very strong risk indicator of mortality (19.4 percent vs. 3.4 percent; risk ratio 5.7). The IABP is inserted into the femoral artery up to the ascending aorta to help improve the blood flow in patients with very poor left ventricular function. It is used only for the sickest of patients, and involves a high risk of infection.

A previous CABG operation had been performed in 12 percent of patients, ranging from a lower of 5.7 percent in Hospital D to 21.6 percent in Hospital G. Overall, in-hospital mortality was 9.9 percent in patients with a previous bypass operation and 3.9 percent in those without one (risk ratio 2.5).

7.5.5 In-Hospital Mortality Stratified by Severity of Coronary Artery Disease

Coronary artery anatomy and left ventricular ejection fraction, respectively, are used to describe the extent of coronary artery disease and its effects on heart function. "Critical" obstructions of the coronary arteries were defined as greater than or equal to 70 percent of the cross-sectional diameter for the left, right and circumflex coronary arteries and greater than or equal to 50 percent for the left main coronary artery (LMCA).

Overall, 21.3 percent of patients had LMCA disease , 49.6 percent had three-vessel disease, 32.8 percent had two-vessel disease, 11.80 percent had disease in only a single vessel. (LMCA and extent of disease are not mutually exclusive.) Another way to look at

the extent of coronary artery disease is in terms of the total number of "critical" obstructions, regardless of location. Three or more critical obstructions were found in 46.4 percent of patients. (Coronary angiography data were missing in 26.2 percent of patients.)

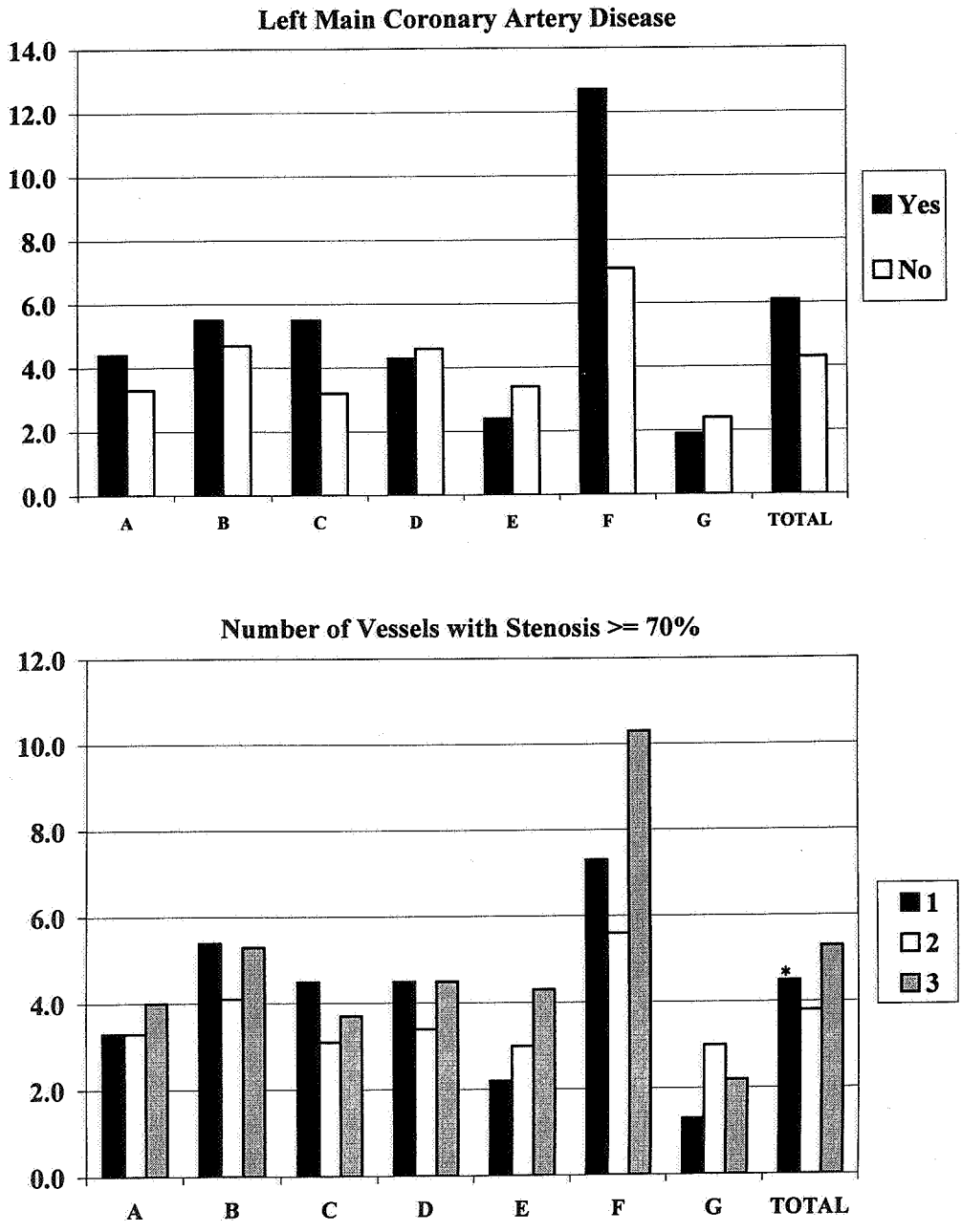
In-hospital mortality was somewhat higher in patients with LMCA disease than in other patients (6.1 percent versus 4.3 percent; risk ratio 1.4), see Figure 7-5. Patients with three-vessel disease had a higher in-hospital mortality than those with two-vessel or single vessel disease (5.3 percent vs. 3.8 percent and 4.5 percent, respectively).

Questions about the appropriateness of CABG surgery arise especially in patients with no critical lesions or single vessel disease. Angioplasty is generally the treatment of choice in the latter group if the obstruction is less than 1.5 cm in length and accessible to the balloon catheter.

Left ventricular ejection fraction (LVEF) reflects the proportion of blood expelled by the heart during each contraction. A normal LVEF is 50 percent or higher while anything less than 25 percent indicates severely compromised cardiac function. Data on LVEF were missing in almost 10 percent of patients, including 68.5 percent of patients in Hospital G. Of all patients, 49.5 percent had a normal LVEF and 12.8 percent had values of less than 35 percent. Mortality showed a graded relationship to ejection fraction, increasing from 3.4 percent in patients with LVEF of 50 percent or greater to 10.8 percent in those with LVEF of less than 25 percent or less (risk ratio 3.1). Patients with missing data had lower average mortality rates than patients with normal ejection fractions.

Figure 7-5

In-Hospital Mortality (%) By Coronary Artery Anatomy, All Years Combined

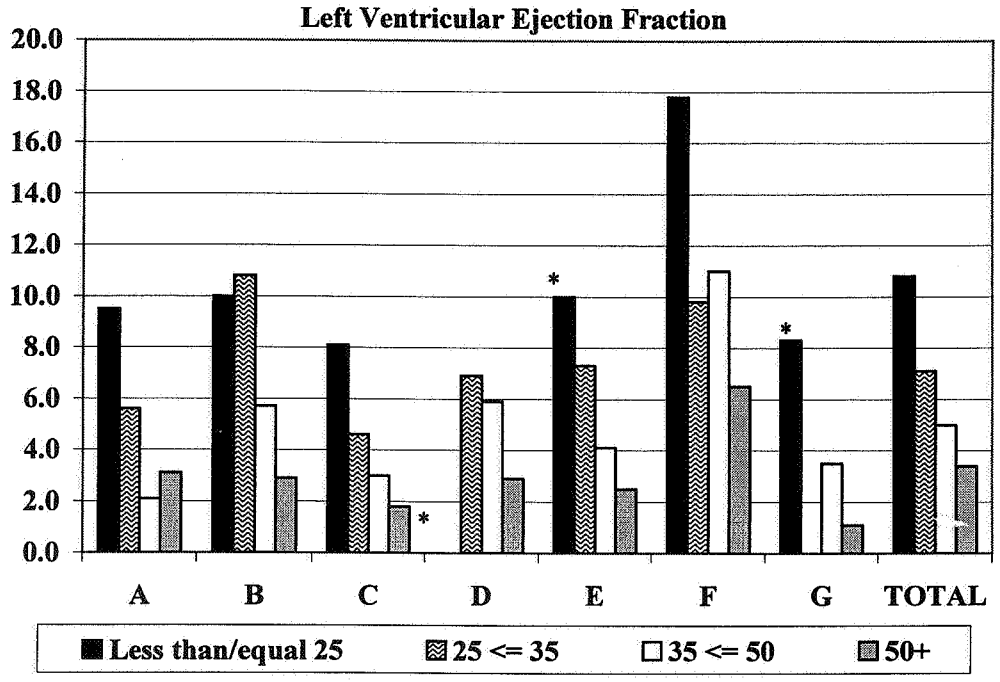


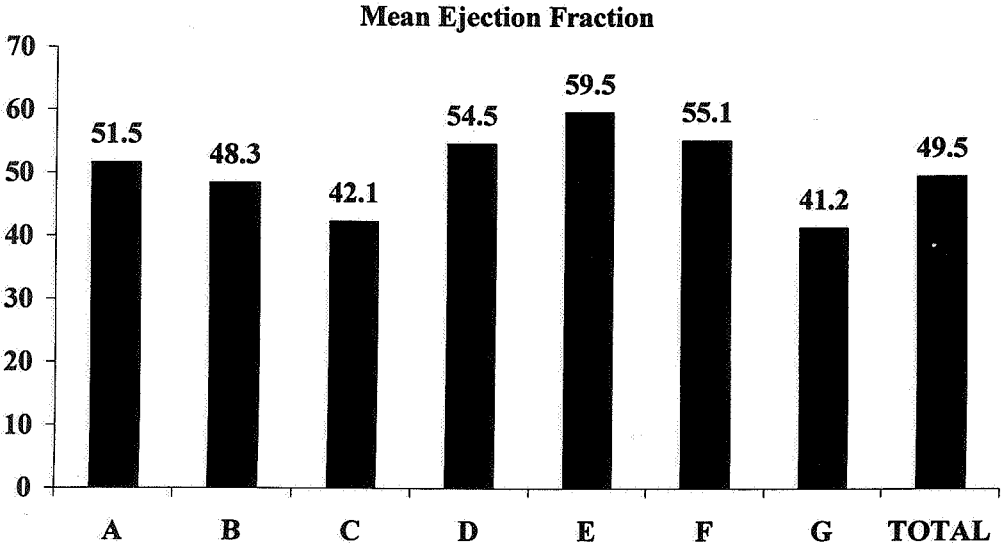
* represents small sample size - 5% or less of all patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

Figure 7-5 (continued)

In-Hospital Mortality (%) By Coronary Artery Anatomy, All Years Combined





* represents small sample size - 5% or less of all patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

7.5.6 In-Hospital Mortality Stratified By Presence of Co-morbidities

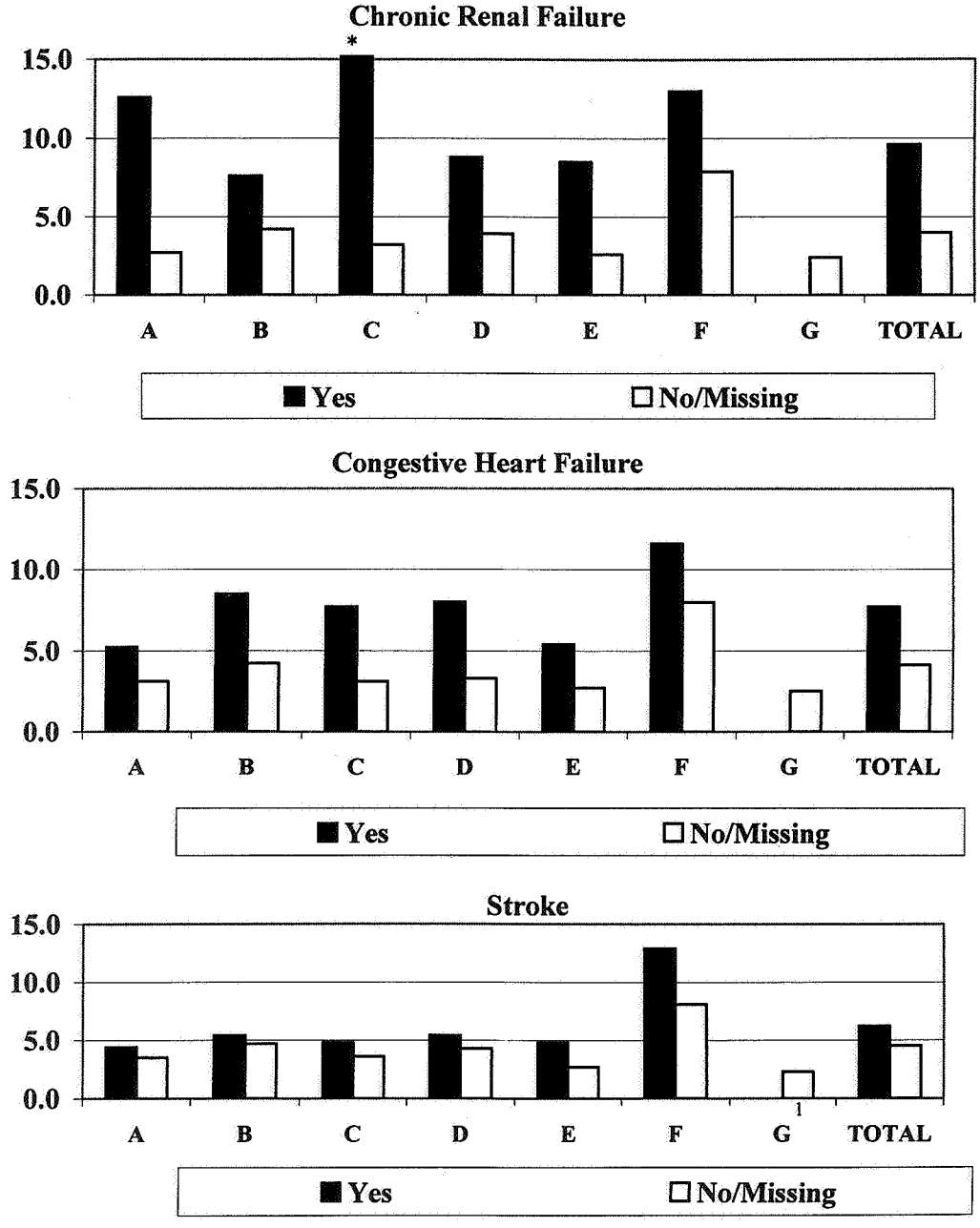
The effects of co-morbid diseases on mortality are shown in Figure 7-6. Chronic renal failure (CRF), defined as a serum creatinine greater than 2.0 mg percent, and a clinical diagnosis of congestive heart failure (CHF), had the strongest associations with in-hospital mortality. Patients with CRF or CHF had mortality rates 2.4 and 1.9 times higher, respectively, than patients without these conditions. Mortality rates in patients with hypertension or chronic obstructive pulmonary disease were 1.3 times higher. Mortality rates for patients with a previous history of stroke or transcient ischemic attack were 1.4 times higher, and the presence of diabetes raised the risk of mortality by 1.2 times.

7.5.7 In-Hospital Mortality Stratified By Height and Body Mass Index

The associations of height and body surface area (BSA) to in-hospital mortality are shown in Figure 7-7. Patients who are shorter or who have less body surface area tend to have higher mortality rates. Mortality in patients less than 1.65 meters in height is 1.3 times that of patients 1.65-1.74 meters in height. The relationship to height is a graded one between these extremes. Body surface area provides a measure of relative obesity. The relationship between in-hospital mortality and BSA is similar to that observed for height. Patients who have a BSA of less 1.75 are 1.7 times more likely to die than those of average BSA (4.8 mortality rate).

Figure 7-6

In-Hospital Mortality (%) By Patient Co-Morbidities, All Years Combined



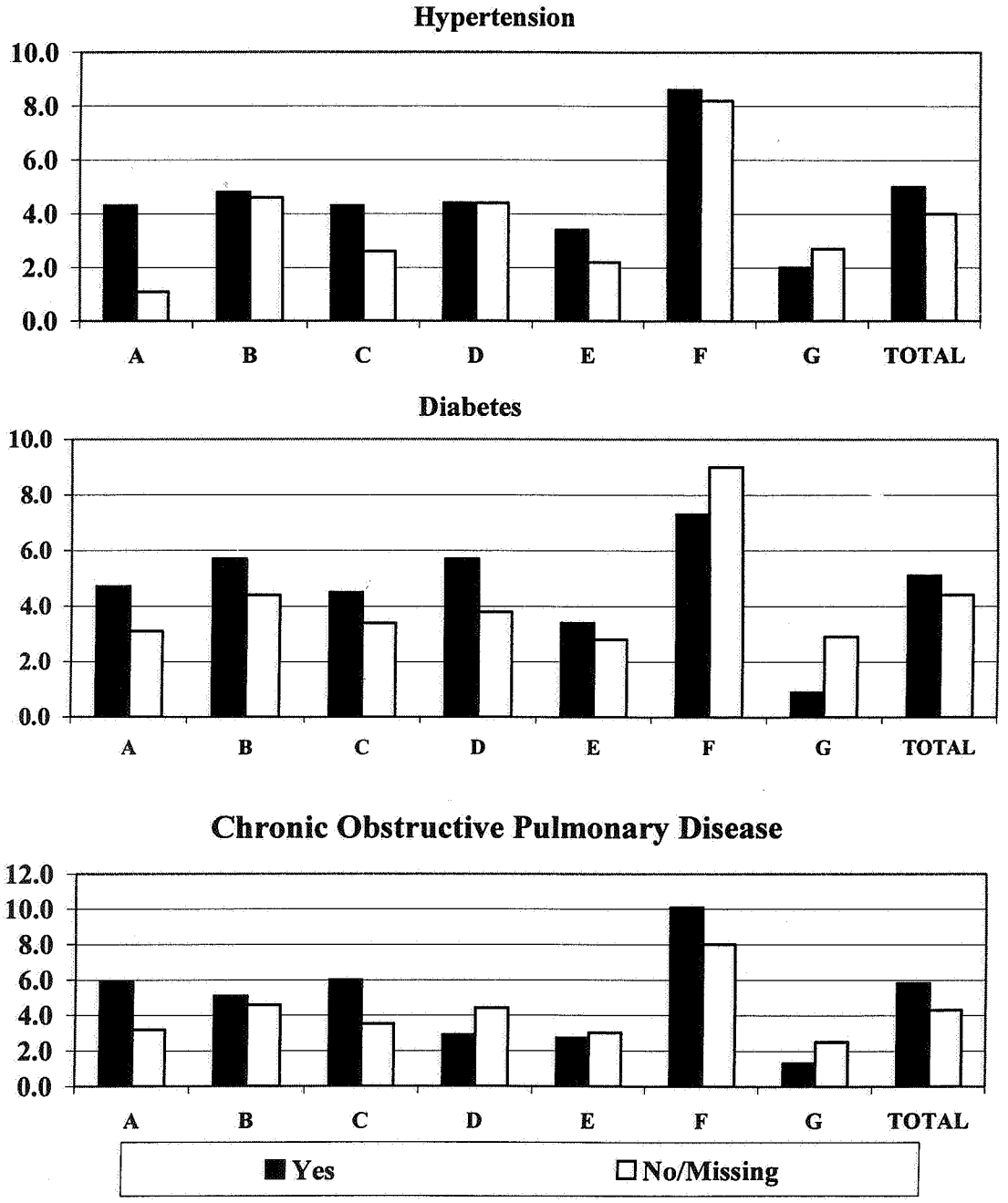
[1] Stroke was not reported for this site.

* represents small sample size - 5% or less of all patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

Figure 7-6 (continued)

In-Hospital Mortality (%) By Patient Co-Morbidities, All Years Combined



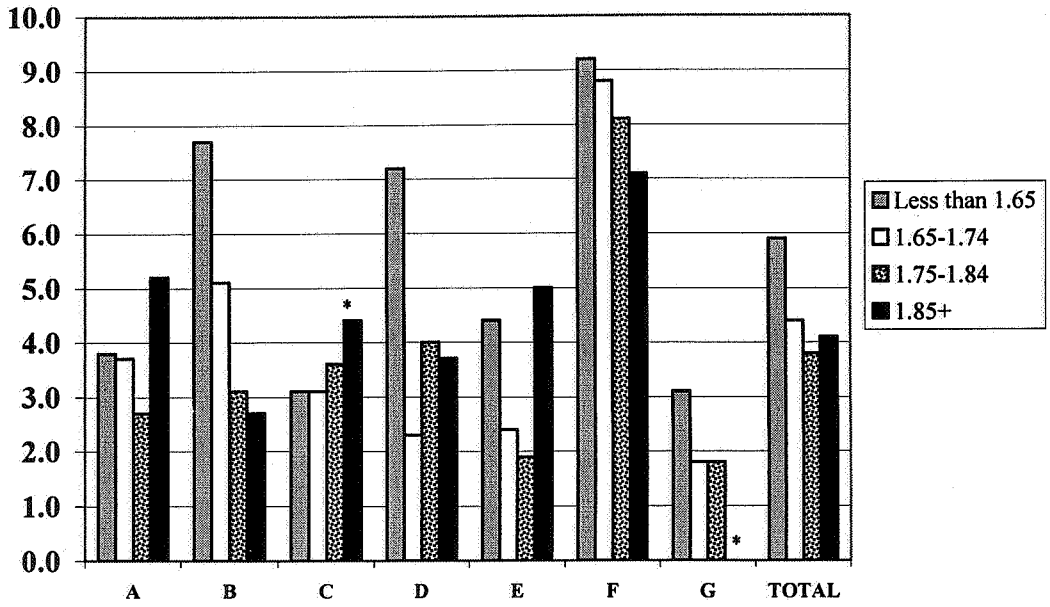
* represents small sample size - 5% or less of all patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

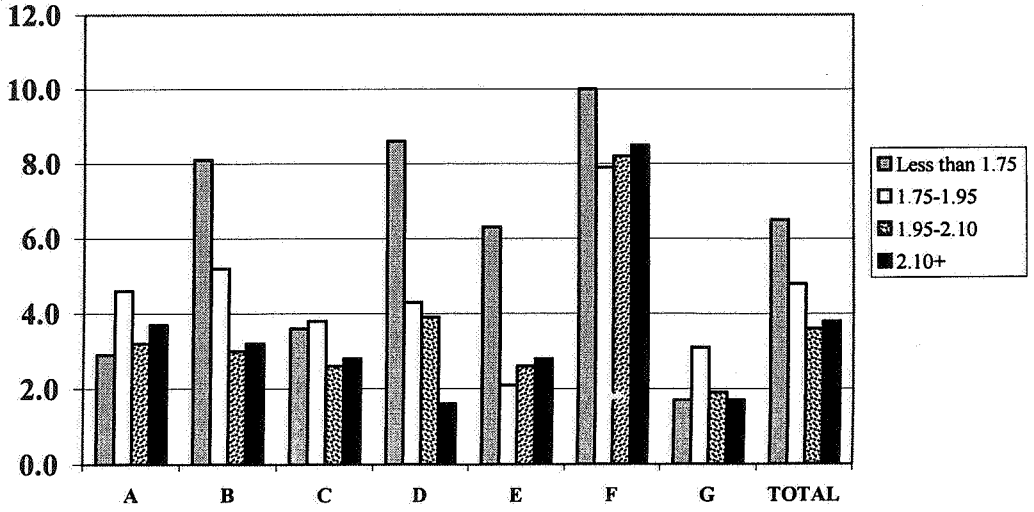
Figure 7-7

In-Hospital Mortality (%) By Height and Body Surface Area, All Years Combined

Height (in meters)



Body Surface Area



* represents small sample size - 5% or less of all patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

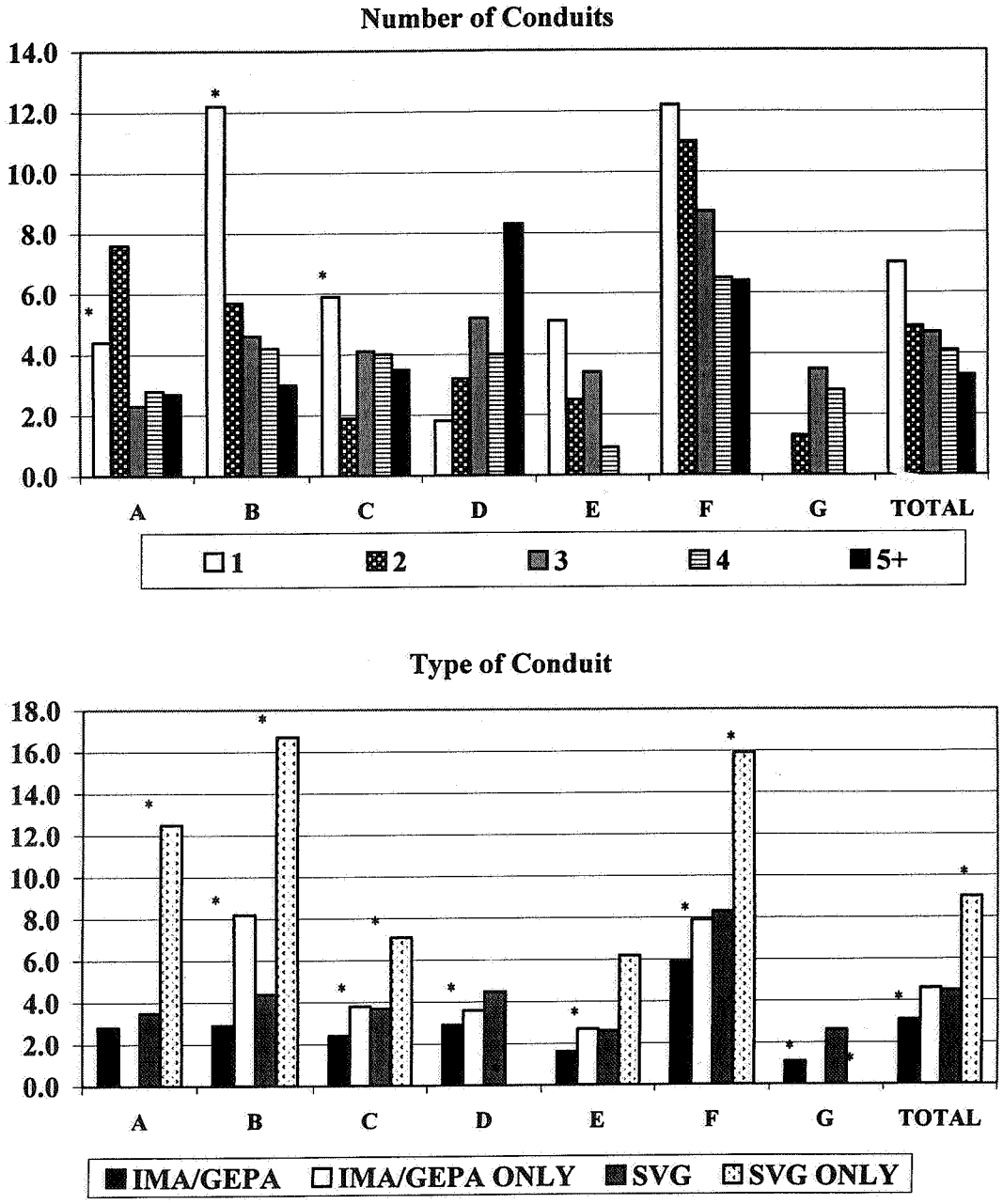
7.5.8 In-Hospital Mortality Stratified By Characteristics of CABG Surgery

Selected characteristics of the CABG operation were examined in relation to hospital mortality (Figure 7-8). Interpretation of findings requires consideration of the strong relationships among the extent of anatomic coronary artery disease, severity of myocardial disease, the type and number bypass conduits, and the length of the operation. The number of conduits inserted varied considerably across the demonstration patients with a modal value of 3 conduits. Only modest differences in patterns were found among hospitals. Mortality was highest (7.0 percent) in the small proportion (5.0 percent) of patients who received only one conduit. These patients were probably extremely ill and may have received only a graft to the left main coronary artery. Among patients who received one or more conduits, there was an inverse relationship between mortality and the number of conduits. In-hospital mortality ranged from 3.3 percent in patients who received 5 or more conduits to 4.9 percent in those who received only 2 conduits. Possible explanations for these findings include decisions to limit the duration of surgery in relatively sick patients and a inverse relationship between the more complete revascularization achieved with more conduits and in-hospital mortality.

Commonly used types of conduits include saphenous venous grafts (SVG) and arterial grafts of the internal mammary artery or gastro-epiglotic artery. Overall, 62.8 percent of patients received an arterial graft and 93.1 percent received one or more saphenous venous grafts. The proportion of patients who received an arterial graft ranged from 54.8 percent in Hospital D to 81.2 percent in Hospital A. This is a striking difference in view of the well-

Figure 7-8

In-Hospital Mortality (%) By Characteristics of CABG Surgery, All Years Combined

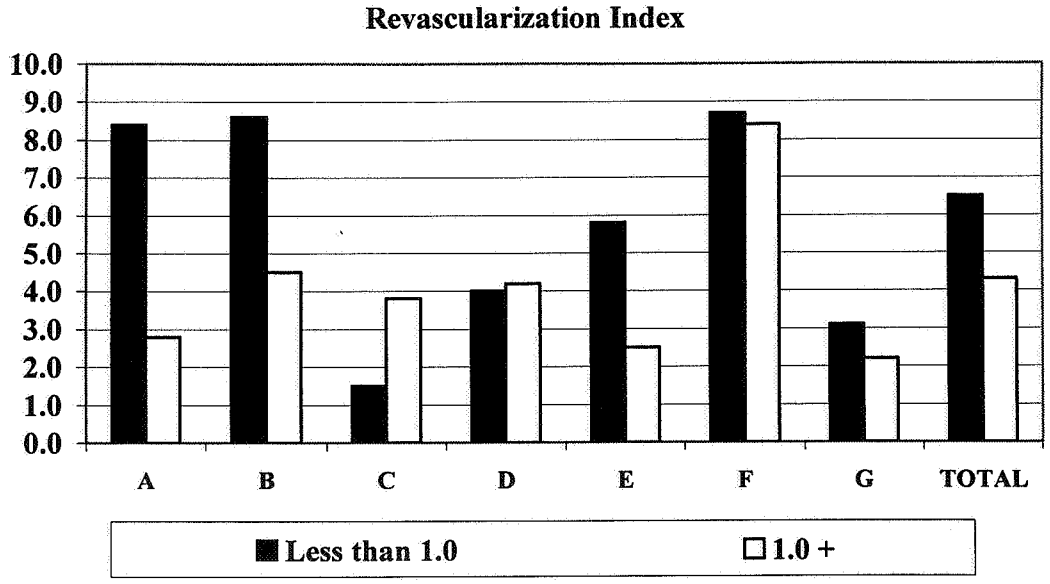


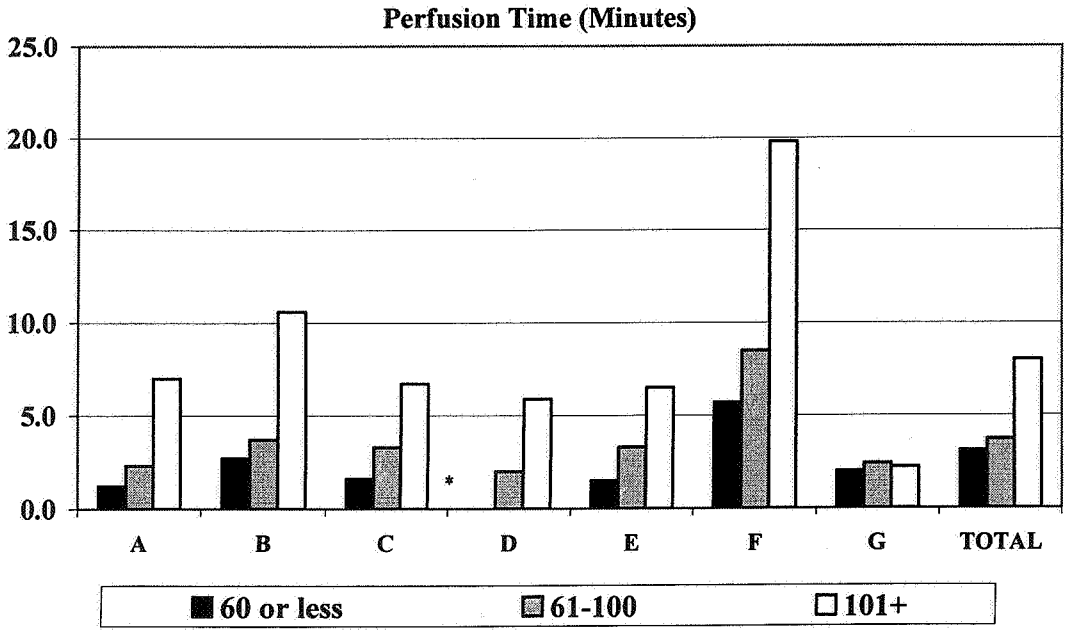
* represents small sample size - 5% or less of all patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

Figure 7-8 (continued)

In-Hospital Mortality By Characteristics of CABG Surgery, All Years Combined





* represents small sample size - 5% or less of all patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

documented greater longevity of arterial grafts. The larger number of SVGs reflects the large modal number of conduits (3) and the limited number of available arterial grafts. The slightly higher mortality in patients who received a SVG (4.5 percent vs. 3.1 percent) may reflect more extensive coronary disease in these patients.

The revascularization index represents an attempt to estimate the extent of revascularization achieved relative to the extent of anatomic disease. The index was calculated by dividing the total number of conduits by the number of critical obstructions. An index of 1.0 indicates an equal number of obstructions and conduits or "complete revascularization." Mortality is slightly higher in patients with less than "complete" revascularization.

Perfusion time on the cardiopulmonary bypass machine may be related to hospital mortality for at least two reasons. First, considering the inherent risk of surgery, patients with more extensive disease need more conduits and will require longer OR times; second, longer periods of perfusion increase damage to red blood cells and the inherent risk of surgery. Data are missing for 2.8 percent of patients including 14.2 percent of those in Hospital E. Wide variations are observed in the proportions of patients who had perfusion times in excess of 100 minutes, ranging from 11.3 percent of patients in Hospital F to 60.0 percent in Hospital D. Mortality was nearly 2.2 times higher in patients with perfusion times in excess of 100 minutes compared to those with perfusion times of 60 to 100 minutes (8.0 percent vs. 3.7 percent).

7.5.9 In-Hospital Mortality Stratified By Post-Operative Complications

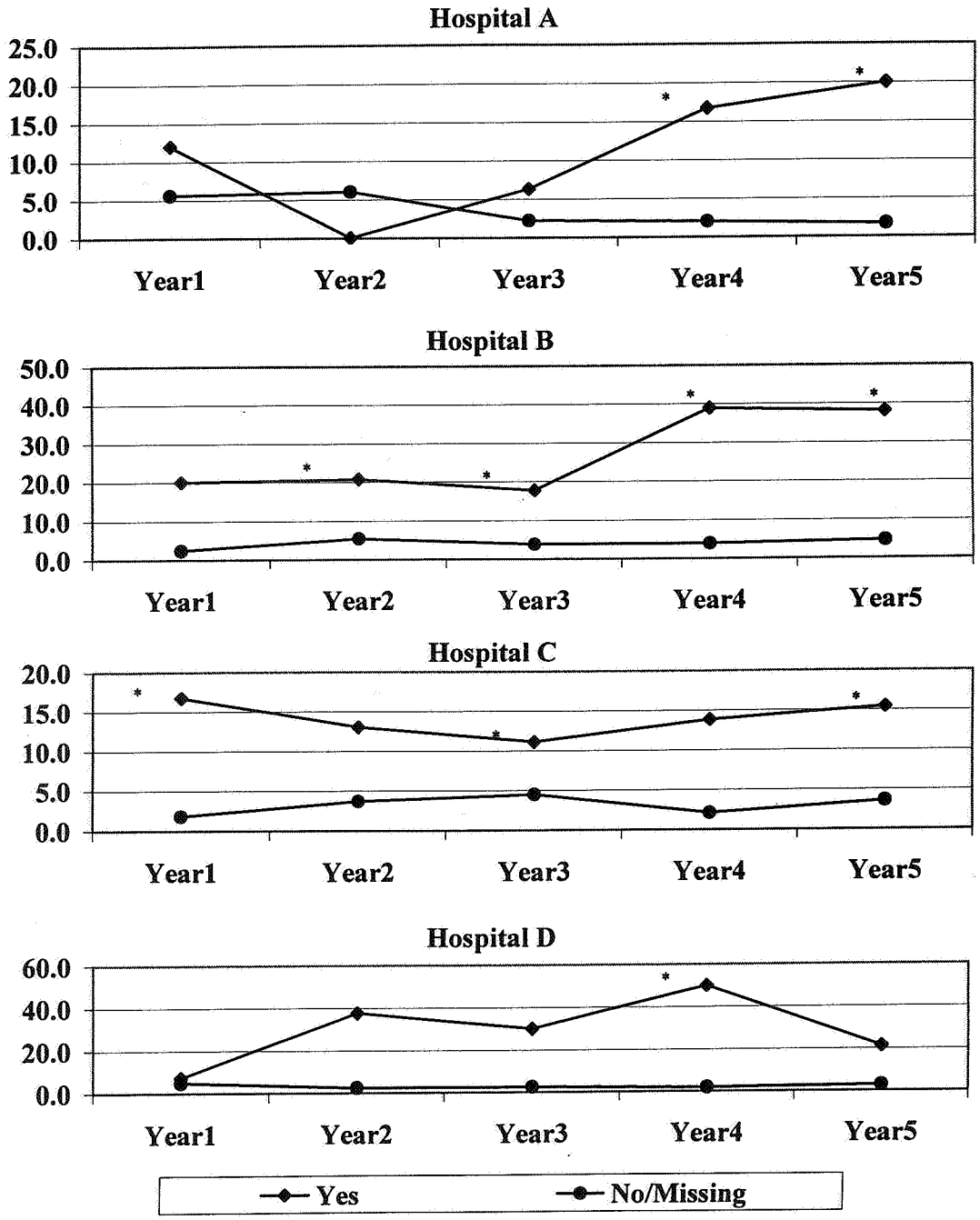
Returns to the operating room for re-operations after CABG surgery may be required for bleeding, graft occlusion, or other reasons. The associations between reoperation in-hospital mortality by hospital are shown in Figure 7-9. The percentage of cases that underwent a second procedure during the same admission varied across the demonstration period, ranging from 6.8 percent in Year 1 to 3.6 percent in Year 5. The rate of re-operations varied considerably across all hospitals and across time. Hospital F ranged from 7.0 to 10.1 percent of their patients having a re-operation during the CABG admission. In contrast, Hospital G's re-operation rates ranged from 0.9 to 2.9. The need for re-operation was strongly related to in-hospital mortality (risk ratios ranging from 3.3 to 7.9 times higher over the course of the demonstration).

The frequencies of other types of complications and their associations with in-hospital mortality are shown in Figure 7-10. Comparisons among hospitals need to be interpreted with caution because of differences both in the definitions used for classifying complications (e.g., wound infection or neurologic event) and differences in the completeness of documentation.

One or more complications was reported in 33.8 percent of patients overall and ranged from 12.5 percent in Hospital G to 56.6 percent in Hospital C. The most common types of complications were pulmonary, seen in 10.7 percent of patients, and neurologic events such as strokes or altered consciousness, seen in 5.4 percent of patients. Wound infections were reported in 3.9 percent of patients, renal failure requiring dialysis in 2.1

Figure 7-9

In-Hospital Mortality (%) By Reoperation By Hospital

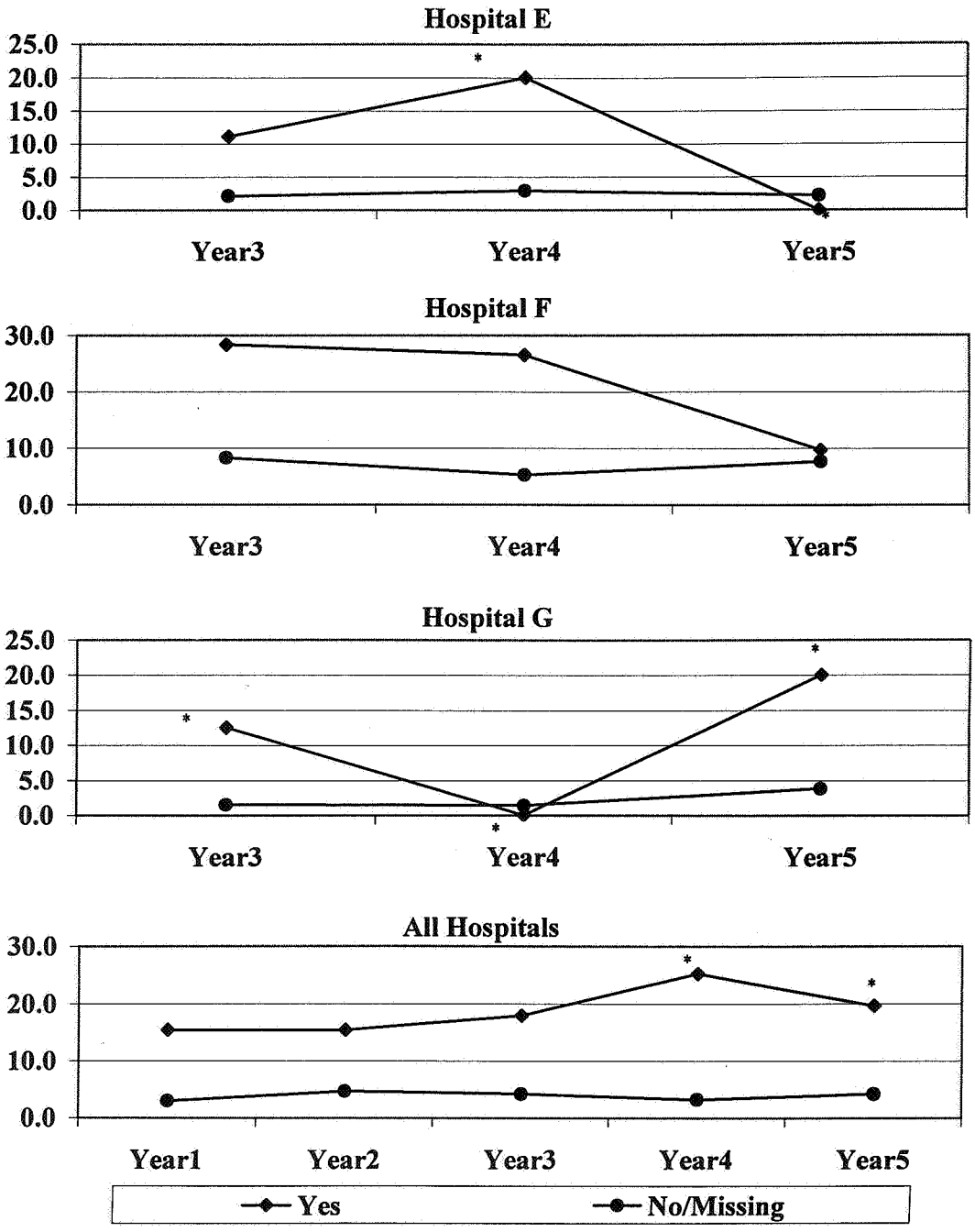


* represents small sample size - 5% or less of all patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

Figure 7-9 (continued)

In-Hospital Mortality (%) By Reoperation By Hospital

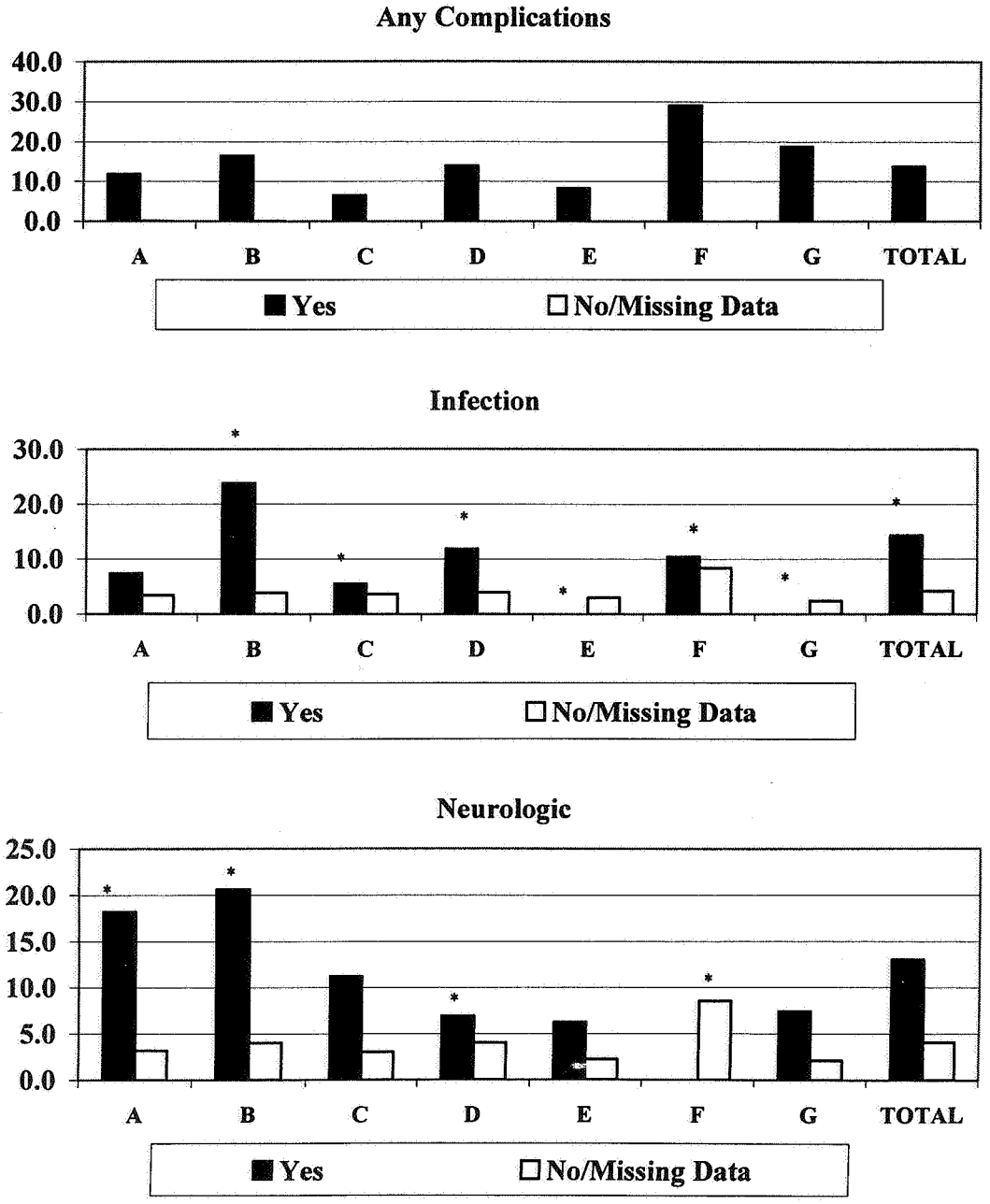


* represents small sample size - 5% or less of all patients.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

Figure 7-10

In-Hospital Mortality (%) By Post-Operative Complications, All Years Combined

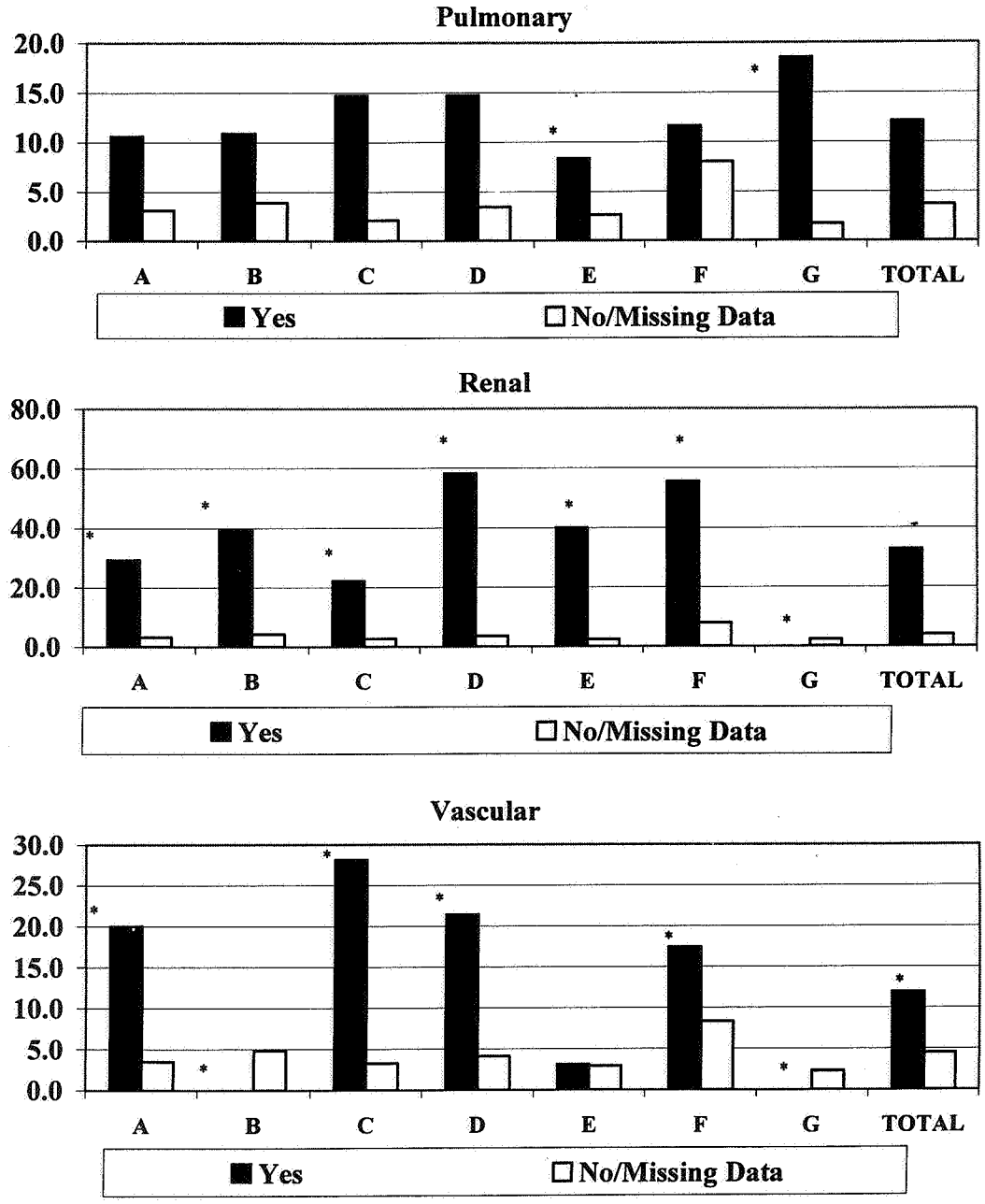


* represents small sample size - 5% or less.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

Figure 7-10 (continued)

In-Hospital Mortality (%) By Post-Operative Complications, All Years Combined

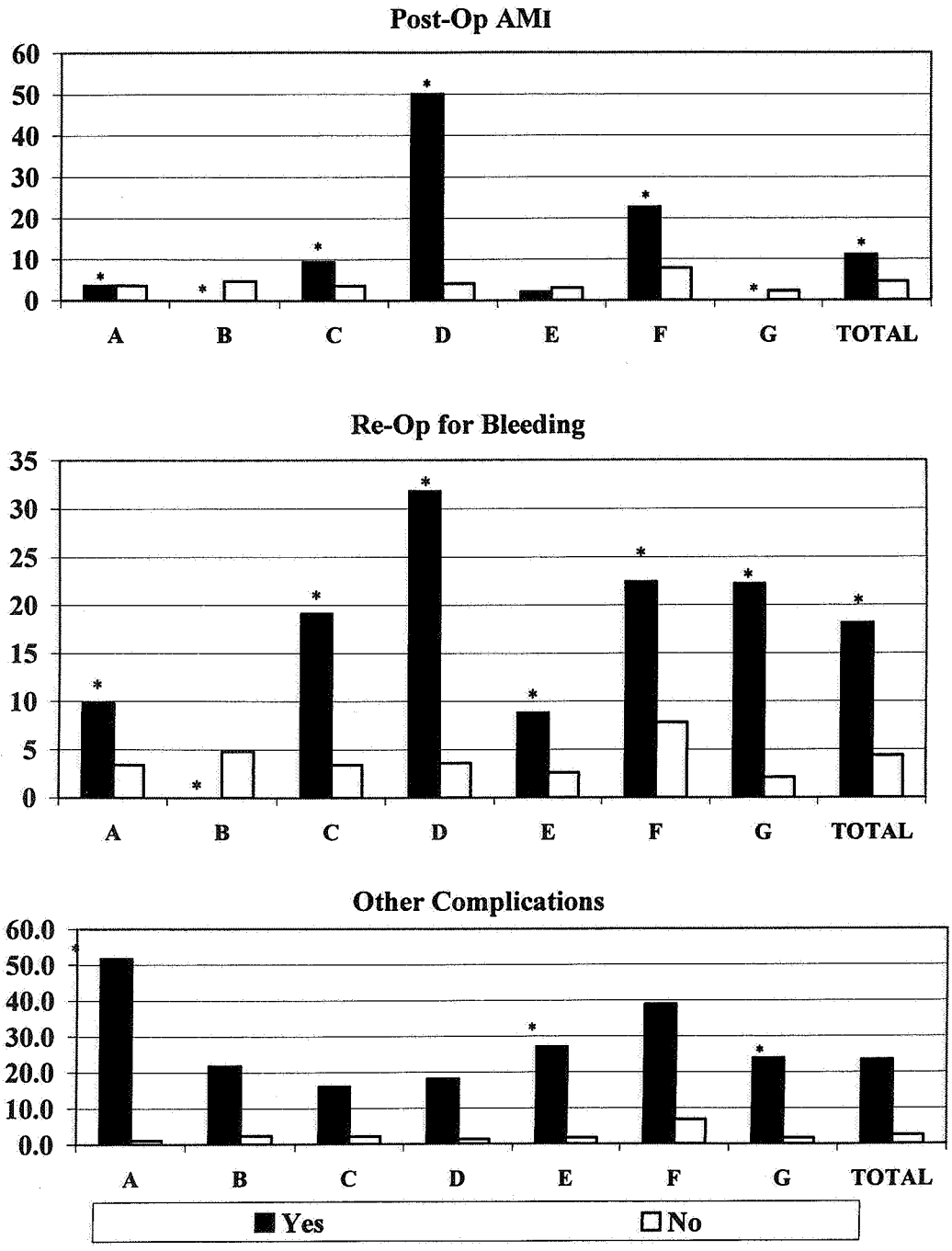


* represents small sample size - 5% or less.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

Figure 7-10 (continued)

In-Hospital Mortality (%) By Post-Operative Complications,



* represents small sample size - 5% or less.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

percent, and vascular complications such as arterial emboli and ilio-femoral or aortic dissection in 1.7 percent. The occurrence of complications was consistently and strongly associated with increased in-hospital mortality. Risk ratios were 8.22 for renal failure, 2.6 for vascular complications, 3.2 for neurologic events, 3.3 for pulmonary complications, and 3.4 for wound infections.

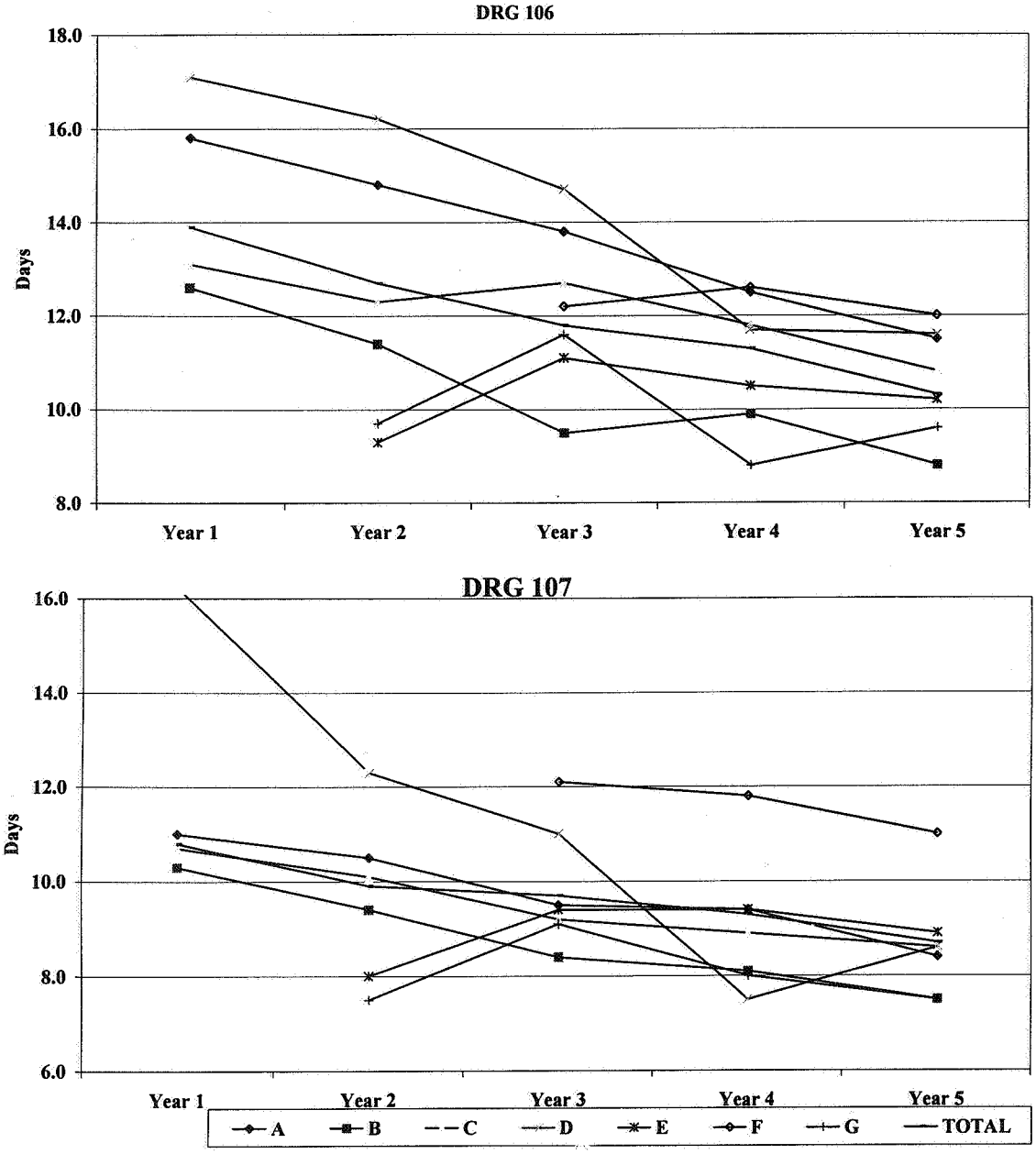
The presence of "other" complications is strongly associated with in-hospital mortality (risk ratio=9.0). This category includes a set of complications that do not occur frequently in the CABG surgery population, but can result in severe post-operative morbidity or mortality. For example, cardiac tamponade and cardiac arrest are classified in the "other" category; both represent significantly morbid clinical conditions.

7.5.10 Hospital Length of Stay

Bundled payments create powerful incentives to reduce lengths of stay and other costs. Figure 7-11 shows time trends in CABG lengths of stay for DRG 106 and 107, separately, and documents such a reduction. For DRG 106 (coronary angiogram and CABG surgery on the same admission), the mean total length of stay fell from 13.9 days in Year 1 to 10.3 days in Year 5. All hospitals reduced their lengths of stay over the course of the demonstration. The reductions were most notable for the post-operative portion of the stay. Across all hospitals, post-operative length of stay fell from 10.1 days to 7.8 days. In contrast, pre-operative lengths of stay fell from 3.8 days to 2.9 days.

Figure 7-11

Length of Stay for DRG 106 and 107, By Hospital and Period



* represents small sample size - 5% or less.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

For DRG 107 (CABG surgery only during the admission), mean total length of stay in ranged from 10.8 days in Year 1 to 8.7 days in Year 5. Once again, all hospitals exhibited this downward trend. Not unexpectedly, the largest gain in length of stay reductions was in the post-operative period; the average post-operative length of stay fell from 9.5 days in Year 1 to 7.6 days in Year 5. In contrast, pre-operative length of stay fell from 1.2 to 1.1 during the five year demonstration period.

7.5.11 Summary

The previous set of figures demonstrate that there is a consistent pattern of increased mortality and length of hospitalization associated with the presence of most pre-operative risk factors and post-operative complications. However, the actual mortality rates and lengths of stay with and without these factors vary considerably across the demonstration sites. Two hospitals, in particular, stand out as being consistently different; Hospital F consistently has higher than average mortality rates and lengths of stay and Hospital G consistently has lower than average mortality rates and lengths of stay. The pattern holds even for those patients without a particular risk factor or complication. Such an observation leads us to ask whether these two hospitals are treating patient populations that systematically differ from populations undergoing CABG surgery at the other demonstration sites. If Hospital F were treating a sicker population than average, then ***higher*** mortality rates and lengths of stay would be expected. Conversely, if Hospital G were treating a

healthier population than average, then ***lower*** mortality rates and lengths of stay would be expected.

We evaluated the proportion of cases presenting with selected pre-operative risk factors at these two hospitals: COPD, diabetes, and renal failure. We selected these factors as they are strong predictors of patient morbidity with the Charlson Index, an index that has been demonstrated to be a strong predictor of cardiovascular-related in-hospital mortality. The construction of this index is discussed in more detail in Chapter 8. We use these three factors as a measure of the patient case mix within these two hospitals.[3] Hospital F demonstrates the second highest proportion of cases with COPD and renal failure. Its proportion of cases with diabetes is about the same as all other hospitals. Thus, using the weights assigned to the presence of these co-morbid conditions in the Charlson Index, Hospital F demonstrates the second highest case mix. In contrast, Hospital G has the lowest proportion of cases with renal failure and ranks fifth in the proportion of cases with COPD and diabetes. Once again, using the weights assigned to the presence of these co-morbid conditions in the Charlson Index, Hospital G exhibits the lowest case mix of all seven hospitals.

Other pre-operative risk factors can also be analyzed in an effort to explain differences in case mix between these two hospitals and the remaining demonstration sites. For example, Hospital F exhibits a high proportion of cases with a left ventricular ejection fraction of less than 35 percent (18 percent), while Hospital G reports a considerably smaller

[3] The proportions of cases with these three comorbid conditions are presented in Appendix L and Table 7-2 later in this chapter.

proportion of cases with poor ejection fraction (11 percent). Hospital F has a high proportion of cases with greater than 50 percent obstruction of their left main coronary artery (24 percent). Hospital G has about half of Hospital F's proportion of cases (14 percent). Of course, patients with combinations of co-morbid conditions and other pre-operative risk factors greatly increase a hospital's case mix. Thus, as discussed in the next section of this chapter, multivariate analysis is necessary to control simultaneously for pre-existing factors that affect mortality.

7.6 Multivariate Analysis of In-hospital and One-year Morality

7.6.1 Rationale

Bivariate analysis of mortality rates by hospital or risk factor, while useful, can often result in misleading conclusions, especially when many of the risk factors are highly correlated and occur in different hospitals with varying frequency. For example, patients with low ejection fractions may be more likely to be experiencing a heart attack upon admission; if the heart attack is the key risk factor for survival, rather than the low ejection fraction, simple comparisons of patients by ejection fraction will overstate the importance of this factor in patient mortality. Similarly, differences in hospital death rates might be due more to differing combinations of risk factors, in which case bivariate comparisons using a single risk factor will be misleading. Absent a rigorous randomized trial, multivariate statistical analysis is needed in order to properly assess the mortality effects of each patient characteristic, controlling for all others.

7.6.2 Methods

Model. The standard method for modeling a binary outcome such as mortality is logistic regression. Linear least squares, in which a dichotomous outcome (survival or death coded as 0 or 1) is regressed directly on a set of explanatory variables, produces biased and inefficient coefficient estimates. Probit estimation, a common alternative to logistic regression, produces efficient and unbiased estimates, but its parameter coefficients lack a convenient, straightforward marginal interpretation. Logistic regression, efficient and unbiased, produces an odds ratio for every regression, thus providing simple estimates of each regression's effect on the dependent variable.

The logistic model is used in this study to evaluate differences in the risk of mortality attributable to differences across hospitals, patient risk factors, and time since entering the demonstration. The model is specified as:

$$P_i = 1/(1+e^{-\beta X_i})$$

where P_i = the probability that the i-th individual will die during a given admission, and βX_i = an index value for the i-th individual based on his or her specific set of characteristics (represented by the X_i vector), and e = the base of natural logarithms.

Unlike least squares regression, the coefficients from logistic regression are not directly interpretable. Fortunately, a convenient interpretation of the coefficients is found in the odds ratio. Assume we are interested in assessing the effects of the presence or absence of congestive heart failure (CHF) on in-hospital mortality. In this hypothetical model, y is a (0,1) variable indicating mortality (1 if the patient died in the hospital), and x

is a (0,1) variable indicating the presence of congestive heart failure (x=1 if CHF is present). The odds of in-hospital death occurring among those with CHF is defined as $\pi(1)/[1-\pi(1)]$, where $\pi(1)$ is the probability of death given the presence of CHF. Similarly, the odds of death among those not suffering from CHF is defined as $\pi(0)/[1-\pi(0)]$, where $\pi(0)$ is the probability of death given the absence of CHF. The odds ratio, denoted by Ψ, is defined as the ratio of the odds of death for x=1 to the odds for x=0, and is represented by the equation

$$\psi = \frac{\pi(1)/[1-\pi(1)]}{\pi(0)/[1-\pi(0)]} = e^{\beta_{CHF}} \tag{7.1}$$

where β_{CHF} is the congestive heart failure coefficient in the logistic regression. The odds ratio approximates relative risk, or how much more likely is in-hospital death given the presence of CHF. An odds ratio of 1.35, for example, indicates that a CABG patient with CHF is thirty-five percent more likely to die than a patient without CHF, while an odds ratio of .50 indicates he is half as likely to die. Relative risk is defined as the ratio $\pi(1)/\pi(0)$. Ψ is a good estimate of relative risk when $\pi(x)$ is small for both x=0 and x=1, as in the case of our mortality model.[4] Note that an odds ratio must be greater than zero; variables having a negative effect on the outcome variable will have an odds ratio between 0 and 1. Because $e^0 = 1$, and $e^{-\beta}<1$, negative logistic coefficients imply odds ratios below 1.0.

[4] Relative risk as a function of Ψ is

$\pi(1)/\pi(0) = \psi \bullet [(1-\pi(1)]/[(1-\pi(0)]$. For $\pi(1) \approx \pi(0) \Rightarrow 0, \psi \Rightarrow \pi(1)/\pi(0)$.

Interpretation of the marginal effects of dichotomous variables is very straightforward. The interpretation of continuous variables is only slightly more complicated, as the odds ratio is dependent on the scale of the continuous variable. The odds ratio reported by logistic regression for a continuous variable reports the change in the likelihood of mortality given an increase of "1" unit in x. For example, we are interested in testing whether the monthly time trend in mortality is statistically significant. If the trend coefficient was estimated at -.005, the per month odds ratio of dying post-CABG is 0.995.

To estimate the decline in the odds of dying over 36 months, we multiply the coefficient by 36, and exponentiate: exp(-.005x36) = .835. Thus, over 3 years, the odds of dying would have fallen 16.5 percent, holding other risk factors constant. If expected mortality was 5 percent at the demonstration's beginning, the rate would have fallen to approximately 4.2 percent over 36 months.[5]

All logistic regression results reported below are converted to odds ratios, with p-values for the actual coefficients. Most of the independent variables analyzed are binary variables with exponentiated coefficients signifying odds ratios. Odds ratios of continuous variables have not been scaled in the tables but are scaled to longer time intervals with text.

Equation Specification. Logistic regression was performed using two different dependent variables: in-hospital mortality and mortality within one year following CABG surgery. The general specification of the logistic model was as follows:

[5] Derived by setting Ψ=.835 and $\pi(0)$=.05 and solving for $\pi(1)$ using the formula, (7.1), for the odds ratio.

$$P[O_{ih} = 1 | X_{ih}] = f\,[H_{ih}; STRTDEMO_{ih}; RF_{ih}; C_{ih}]$$

where the dependent variable is the probability, P, of an outcome O_{ih}= 1 if death occurred for the i-th patient at hospital h, given the set, X_{ih}, of patient and hospital characteristics. For purposes of this evaluation, the relevant set of independent variables include a vector of dummy variables for the demonstration hospitals (H_{ih}); a trend variable indicating the month during which the CABG surgery occurred relative to when the hospital entered the demonstration ($STRTDEMO_{ih}$), coded as 1 during the first month of participation, 2 during the second month of participation, etc. through month 60; a vector of pre-operative risk factors associated with the i-th patient in hospital h (RF_{ih}); and a vector of post-operative complications (C_{ih}). Complications, of course, are often used as indicators of poor quality care, but they may be indicative of a pre-existing condition not accurately captured by the set of pre-operative risk factors. Hence, models are estimated with and without their inclusion.

The set of dummy variables representing each hospital effectively creates a parsimonious fixed-effects model in that the coefficient of each dummy variable captures variation across the hospitals not otherwise captured by other included variables, such as pre-operative risk factors. One example would be volume of CABG surgeries. There is a body of research that has demonstrated a positive volume/outcome relationship for CABG surgery. Thus, one might hypothesize that volume of CABG surgery at each of the demonstration sites would be an important control variable to include in the multivariate regression

analysis. However, all hospitals selected for this demonstration were by definition "high volume" hospitals. Specifically adding this variable to the regression equation would not likely increase the predictive power of the model.

Specification of Mortality Models. Four sets of pooled models were estimated with in-hospital and one-year mortality as the dependent variables. The first of these simply included dummy variables representing six of the seven sites. Hospital C, having the lowest in-hospital mortality rate among the original sites and a participant throughout the entire demonstration, was chosen to be the hospital of comparison, and its mortality rate is included along with other factors by the intercept. The positive hospital coefficient estimates in this first regression thus reflect differences between the six hospitals and Hospital C before controlling for any patient risk factors. These hospital dummy coefficients form a "relative mortality" baseline upon which to compare the effects of controlling for demonstration participation time trends and the institutional mix of patient risk factors. If none of the hospital coefficients change as the other variables are stepped into the regression, we conclude that patient mix is uncorrelated with site of surgery across participants.

The second model includes the hospital dummies and steps in the demonstration participation time trend variable. Inclusion of the trend variable in this stage tests whether outcomes across all sites differ systematically *as a group* between the early versus later months of the demonstration. Again, this regression does not control for any patient risk factors. An insignificant time trend at this stage would imply that there was no discernible improvement or decline in inpatient mortality prior to controlling for differences in patient

severity. This is an important finding in its own right. This one coefficient represents the overall time effect of bundled payments on inpatient mortality across all participating hospitals; an insignificant finding suggests that bundled payment had no mortality effect in the aggregate before considering any systematic temporal case-mix change.

The third model includes the hospital dummies, the demonstration participation trend variable, and a comprehensive list of patient risk factors. This full in-hospital mortality model, represented in Equation 3, controls for all pre-operative patient risk factors thought to be related to in-hospital mortality. Because the data base contains a very large number of clinical variables, we employed a model-building strategy recommended by Hosmer and Lemeshow (1989) whereby univariate logistic regressions are estimated for all candidate variables that might influence in-hospital or one-year mortality. The likelihood ratio chi-square test is used to identify the variables that exhibit a reasonable level of association with the dependent variable.

A ten percent confidence level is used as the standard for assessing association and statistical significance of the time trend and other coefficients. As evaluators, we must balance the need to be confident that a trend in mortality truly exists with the desire to avoid overlooking a trend, particularly an adverse one. A Type II error occurs when a null hypothesis of no significant effect is accepted, when, in fact, one exists. In the case of the time trend and hospital dummies, it is crucial to avoid a Type II error. Insistence on a high confidence threshold might cause us to reject a pertinent risk factor or significant time trend simply because the variable was not always accurately reported. For these reasons, a 10

percent confidence level is shown along with the more common 5 or 1 percent confidence levels. With over 10,000 observations, the model has considerable power in a Type II error, although the very low number of deaths and missing data occasionally present problems in some models.

A fourth model was generated using only those variables with p-values of .10 or less. A likelihood ratio test, which employs the *G* statistic, is used to evaluate the superiority of the reduced form model relative to the full model. Under the null hypothesis that the *n* coefficients of the excluded variables are jointly equal to zero, the distribution of *G* will be chi-square with *n* degrees of freedom. Unless otherwise reported, the reduced form model performed as well as the full model leading us to conclude that the omitted variables had regression coefficients that were not significantly different from zero.

Because inclusion of insignificant variables increases the variance in estimation of individual probabilities, stepwise regression was used to also estimate a model that includes only variables significant at the 0.05 level. Independent variables from the full model were selected for forward step wise entry into this model if they had a p-value of .05 or better. The result is a "deleted" model which should report coefficients and odds ratios closely representing the "true" effects of the risk factors.

Since the length of time participating in the demonstration differed across the hospitals, hospital-specific models were also estimated using the set of independent variables appearing in Model 4. Separate hospital regressions test for trends in hospital-specific mortality. This approach avoids cross-facility data definition problems, and picks up

differences in outcome trends across hospitals that the pooled model does not. The disadvantage is a loss in statistical power resulting from the smaller sample sizes. We report hospital-specific in-hospital mortality rates using the reduced form model rather than the model based on the forward stepwise regression process. We believe the insistence on a high confidence threshold in the forward step wise regression method might cause us to ignore a pertinent risk factor in a particular hospital simply because the variable was not always accurately reported.

Variable Specification. The dependent variables examined in this logistic analysis are in-hospital mortality and one-year cumulative mortality, recorded as a 1 for death, 0 otherwise. Death is not the only outcome of interest; other outcomes such as readmission rates and length of stay are also important, and are discussed elsewhere in this report.

Table 7-1 provides definitions of all dependent and independent variables used in the multivariate mortality analyses. Mean values for each variables are displayed by hospital in Table 7-2. Table 7-3 reports mean values (pooled across sites) for five different time periods for the regression variables. The first period is the first 12 months of the demonstration (May 1991 through April 1992), the next four are each twelve months, for a total of 60 months. Mean values for dichotomous variables typically represent the proportion of cases for which the condition was present. There is considerable consistency across the sites in the age distribution of their patients as well as the proportion of patients who are female. In contrast, there is considerable variation in the proportion of patients with a revascularization priority of urgent or emergent, a classification system that appears to be quite subjective. For

Table 7-1

Description of Risk Factor and Complication Variables Used In Multivariate Analysis

Variables	Description
Hospital Dummy Variables	A set of seven dummy variables, one for each demonstration hospital. Each equals 1 if patient was discharged from that hospital.
Urgent	equals 1 if patient was admitted as urgent (= 0 is otherwise).
Emergent	equals 1 if patient was admitted as emergent (= 0 is otherwise).
Unstable	equals 1 if patient was admitted with unstable angina (= 0 otherwise).
M12Week	equals 1 if patient experienced a heart attack within two weeks prior to CABG surgery admission (= 0 otherwise).
PREVCABG	equals 1 if patient underwent CABG surgery previously (= 0 otherwise).
DRG	equals 1 if patient was admitted under DRG 106 (with catheterization) (= 0 for admission under DRG 107).
CHF	equals 1 if patient had congestive heart failure (= 0 otherwise).
Diabetes	equals 1 if patient was a diabetic (= 0 otherwise).
Stroke	equals 1 if patient has had a previous stroke or transient ischemic attack (= 0 otherwise).
COPD	equals 1 if patient is on medication for chronic obstructive pulmonary disease (= 0 otherwise).

Table 7-1 (continued)

Description of Risk Factor and Complication Variables Used In Multivariate Analysis

Variables	Description
Hypertension	equals 1 if patient is hypertensive (= 0 otherwise).
Renal Failure	equals 1 if patient has chronic renal insufficiency, with creatinine > 2 mg% (= 0 otherwise).
Age 65-69	equals 1 if the patient was between the age of 65 and 69 inclusive.
Age 70-74	equals 1 if the patient was between the age of 70 and 74 inclusive.
Age 75-79	equals 1 if the patient was between the age of 75 and 79 inclusive.
Age 80+	equals 1 if the patient was 80 years of age or older.
Sex	equals 1 if patient was female.
Height	patient height in centimeters.
IABP	equals 1 if patient had an intra-aortic balloon pump inserted prior to surgery (= 0 otherwise).
Artery70	equals the number of arteries with 70 percent or more stenosis.
LMCA	equals 1 if obstruction of Left Main Coronary Artery was 50% or greater (= 0 otherwise).
LVEF ≤35%	equals 1 if patient's reported left ventricular ejection fraction was ≤35% (= 0 otherwise).

Table 7-1 (continued)

Description of Risk Factor and Complication Variables Used In Multivariate Analysis

Variables	Description
STRTDEMO	equals 1 to 60 depending upon month patient had CABG relative to the month the hospital entered the demonstration.
BSA	body surface area calculated as $e^{((-3.751)+(0.422*\ln(height))+(0.515+\log(weight)))}$
BMASS	body mass calculated as weight/height^2.
AGE	continuous variable for age as of date of CABG surgery
REOPBLD	equals 1 if the patient underwent a reoperation during the initial hospitalization because of bleeding (= 0 otherwise).
Infection	equals 1 if the patient experienced an infection (= 0 otherwise).
STROKCMP	equals 1 if the patient experienced a stroke (= 0 otherwise).
Pulmonary	equals 1 if the patient experienced a pulmonary complication (= 0 otherwise).
RENALCMP	equals 1 if the patient experienced renal failure (= 0 otherwise).

Table 7-1 (continued)

Description of Risk Factor and Complication Variables Used In Multivariate Analysis

Variables	Description
Vascular	equals 1 if the patient experienced a vascular complication (= 0 otherwise).
POAMI	equals 1 if the patient experienced a heart attack post-surgery during the hospitalization (= 0 otherwise).
OTHERCMP	equals 1 if the patient experienced any other complication not otherwise reported (= 0 otherwise).
POSTOPCM	equals 1 if patient experienced any complications after surgery.
DDEAD	equals 1 if the patient died post-surgery during the hospitalization (= 0 otherwise).
YR1MORT	equals 1 if patient died within one year of date of CABG surgery (= 0 otherwise).

Table 7-2

Mean Values By Hospital For Variables Used In Multivariate Analyses

Variable	Overall (N=10,546)	Hospital A (N=1,256)	Hospital B (N=3,598)	Hospital C (N=1,973)	Hospital D (N=754)	Hospital E (N=753)	Hospital F (N=1485)	Hospital G (N=727)
URGENT	0.30	0.53	0.11	0.60	0.47	0.31	0.04	0.35
EMERGENT	0.11	0.10	0.14	0.09	0.07	0.12	0.08	0.12
UNSTABLE	0.38	0.25	0.59	0.26	0.73	0.02	0.27	0.18
MI2WEEK	0.22	0.40	0.27	0.09	0.13	0.14	0.14	0.35
PREVCABG	0.12	0.09	0.09	0.11	0.06	0.13	0.20	0.22
DRG	0.45	0.42	0.42	0.50	0.58	0.51	0.48	0.61
CHF	0.14	0.24	0.13	0.12	0.15	0.07	0.13	0.06
STROKE	0.09	0.11	0.10	0.08	0.12	0.11	0.09	0.00
DIABETES	0.30	0.32	0.29	0.31	0.30	0.28	0.30	0.29
COPD	0.19	0.15	0.30	0.09	0.09	0.10	0.23	0.11
HYPERTENSION	0.66	0.77	0.65	0.65	0.66	0.58	0.70	0.49
RENAL FAILURE	0.10	0.09	0.17	0.04	0.08	0.06	0.11	0.01
AGE 65-69	0.32	0.28	0.32	0.34	0.31	0.28	0.34	0.35
AGE 70-74	0.31	0.33	0.32	0.29	0.25	0.33	0.31	0.33
AGE 75-80	0.20	0.22	0.19	0.21	0.17	0.22	0.19	0.22
AGE 80+	0.08	0.09	0.07	0.09	0.07	0.09	0.09	0.09
SEX	0.34	0.36	0.34	0.32	0.37	0.30	0.32	0.34
BSA	1.95	1.91	1.95	1.95	1.97	1.97	1.95	1.93
HEIGHT	170.19	169.07	171.73	168.79	170.31	167.43	171.13	168.90

Table 7-2 (continued)

Mean Values By Hospital For Variables Used In Multivariate Analyses

Variable	Overall (N=10,546)	Hospital A (N=1,256)	Hospital B (N=3,598)	Hospital C (N=1,973)	Hospital D (N=754)	Hospital E (N=753)	Hospital F (N=1485)	Hospital G (N=727)
IABP	0.04	0.03	0.04	0.01	0.09	0.02	0.05	0.06
ARTERY70	2.33	2.21	2.30	2.36	2.48	1.93	2.52	2.49
LMCA	0.21	0.25	0.24	0.17	0.22	0.16	0.24	0.14
LVEF	0.19	0.16	0.16	0.38	0.09	0.08	0.18	0.11
POSTOPCM	0.28	0.38	0.27	0.32	0.30	0.29	0.24	0.09
POAMI	0.02	0.02	0.00	0.02	0.01	0.06	0.04	0.00
PULMONARY	0.11	0.07	0.13	0.12	0.09	0.05	0.13	0.04
REOPBLD	0.02	0.03	0.00	0.02	0.03	0.05	0.05	0.01
INFECTION	0.04	0.05	0.05	0.04	0.05	0.01	0.03	0.01
STROKCMP	0.09	0.29	0.05	0.09	0.05	0.18	0.00	0.04
RENALCMP	0.02	0.02	0.01	0.05	0.02	0.01	0.01	0.00
VASCULAR	0.02	0.01	0.00	0.02	0.02	0.13	0.02	0.00
OTHERCMP	0.10	0.05	0.12	0.11	0.18	0.05	0.05	0.03
1YRMORT	0.08	0.08	0.09	0.05	0.06	0.06	0.12	0.05
DDEAD	0.05	0.04	0.05	0.04	0.04	0.03	0.08	0.02

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

Table 7-3

Mean Values By Year For Variables Used In Multivariate Analyses

Variable	1991-1992 (N=1,332)	1992-1993 (N=1,423)	1993-1994 (N=2,564)	1994-1995 (N=2,524)	1995-1996 (N=2,698)
DDEAD	0.04	0.05	0.05	0.04	0.05
URGENT	0.25	0.31	0.23	0.33	0.34
EMERGENT	0.13	0.12	0.12	0.10	0.08
HOSPITAL A	0.17	0.17	0.10	0.10	0.11
HOSPITAL B	0.52	0.46	0.27	0.27	0.32
HOSPITAL C	0.22	0.26	0.15	0.18	0.17
HOSPITAL D	0.09	0.10	0.05	0.07	0.07
HOSPITAL E	0.00	0.00	0.11	0.10	0.09
HOSPITAL F	0.00	0.00	0.22	0.19	0.17
HOSPITAL G	0.00	0.01	0.11	0.09	0.08
UNSTABLE	0.51	0.51	0.37	0.34	0.32
MI2WEEK	0.20	0.18	0.23	0.22	0.23
PREVCABG	0.08	0.10	0.17	0.11	0.10
DRG	0.42	0.42	0.46	0.43	0.48
CHF	0.13	0.15	0.12	0.14	0.14
STROKE	0.07	0.09	0.09	0.09	0.11
DIABETES	0.24	0.29	0.29	0.31	0.32
COPD	0.18	0.16	0.19	0.21	0.21
HYPERTENSION	0.57	0.65	0.67	0.67	0.68
RENAL FAILURE	0.05	0.11	0.12	0.10	0.11
AGE 65-69	0.32	0.31	0.34	0.33	0.30
AGE 70-74	0.32	0.31	0.32	0.30	0.31
AGE 75-80	0.20	0.20	0.20	0.20	0.21
AGE 80+	0.07	0.08	0.07	0.09	0.10
SEX	0.33	0.35	0.33	0.32	0.35
BSA	1.94	1.94	1.95	1.95	1.95
HEIGHT	170.07	170.83	169.61	170.61	170.06

Table 7-3 (continued)

Mean Values By Year For Variables Used In Multivariate Analyses

Variable	1991-1992 (N=1,332)	1992-1993 (N=1,423)	1993-1994 (N=2,564)	1994-1995 (N=2,524)	1995-1996 (N=2,698)
POSTOPCM	0.24	0.25	0.32	0.28	0.26
POAMI	0.01	0.01	0.03	0.01	0.01
REOPBLD	0.03	0.02	0.03	0.02	0.01
INFECTION	0.03	0.05	0.04	0.04	0.04
STROKCMP	0.05	0.06	0.14	0.10	0.05
PULMONARY	0.10	0.11	0.11	0.11	0.10
RENALCMP	0.03	0.03	0.02	0.02	0.02
VASCULAR	0.01	0.01	0.05	0.01	0.01
OTHERCMP	0.09	0.08	0.08	0.09	0.12
IABP	0.03	0.04	0.02	0.04	0.06
ARTERY70	2.14	2.22	2.32	2.43	2.42
LMCA	0.19	0.23	0.21	0.22	0.22
LVEF ≤35%	0.19	0.21	0.17	0.19	0.19

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

example, Hospital C reports that 69 percent of its patients are classified as either emergent or urgent while Hospital F reports only 12 percent of its patients in these two classifications. Similar variation is observed across the majority of pre-operative risk factors used in the multivariate regressions. Once again, Hospital C reports a high percentage of their patients (38%) have an ejection fraction of less than 35 percent. In contrast, Hospital E reports that only 8 percent of their patients have an ejection fraction of less than 35 percent. Part of the observed variation is due to incomplete reporting, another part to inconsistent reporting across the sites, and get a third part to our inability to cross-walk some of the hospitals' submitted data to our clinical data base format.

Over time, we observe increasing proportions of patients with pre-operative risk factors presenting to the demonstration hospitals (see Table 7-3). The proportion of cases with diabetes rises from the mid-twenties to the low thirties over the five year period. Similarly, increases are observed for patients presenting with hypertension, renal failure, and previous strokes. The average number of vessels with 70 percent or greater stenosis also rose over the five year period, from 2.14 to 2.42, as did the proportion of cases in which there was 50 percent or greater stenosis of the left main coronary artery, from 19 to 22 percent. In addition, we observe a shifting of the age distribution toward an older population.

Dummy variables for six of the seven hospitals are included in the regressions. Hospital C, the hospital with the lowest observed mortality rate of the four original hospitals, appears as part of the intercept term. This specification effectively tests differences in mortality in the other six hospitals in a pairwise fashion with Hospital C. Statistically

nonsignificant coefficients (at the 0.10 level) for the six dummy variables implies no differences among any of the seven hospitals.

The inclusion of the time trend variable indicating when the hospital entered the demonstration allows for a direct test of the effect of bundled hospital/physician payment on patient outcomes. STRTDEMO does not refer to any particular calendar year or time point. It is also important to note that censoring of the STRTDEMO variable occurs for the three sites that entered the demonstration in 1993. For the four original sites, STRTDEMO ranges from 1 to 60 while for the three additional sites, STRTDEMO ranges from 1 to 36 months.

A rich set of clinical data was available on nearly all patients. From this set, a smaller subset of critical risk factors was selected based on the literature, expert opinion, and the results of the likelihood ratio chi-square test. The variables included in the analysis are detailed in Table 7-1. Most of these specifications are straightforward and the variables entered in the regression model as (0,1) dummy variables. Age was specified in four categories, with the under-65 Medicare demonstration patients placed in the intercept. Inspection of the mortality data indicated breaks in death rates across these age groups. An alternative specification would include continuous age and squared age variable, but the categorical use of dummy variables was preferred on the grounds of ease of interpretation. A log likelihood ratio test suggested that the model containing age as categorical variables performed as well as a model with age as a continuous variable.

One issue of importance to the interpretation of the dummy variables is that the under-65 Medicare population differs from the over-65 groups, not only in age, but in health

and eligibility status as well. Under-65 beneficiaries are disabled persons, often more severely ill than even older beneficiaries whose eligibility is based on age rather than disability. For example, the in-hospital death rate among under-65 CABG patients here is near 4 percent while the in-hospital death rate for those age 65-69 is around 3 percent. A reasonable argument can be made for placing the 65-69 group with the lowest mortality in the intercept. Nonetheless, we placed the under-65 patients in the intercept in order to avoid confusion.

Another issue concerns the question of the point during the admission at which a risk factor is measured. Since a key aspect of this evaluation concerns trends in outcomes over time, pre-operative risk assessment variables are used in order to avoid biasing the time trend variable. Including post-operative complication variables potentially biases the time trend if they are the result of a downward trend in hospital performance during the demonstration. Analysis of the time trend, therefore, makes use only of pre-operative risk data. Following our discussion of the trend findings, we step in post-operative complications in order to better assess the mortality impacts of the patient risk factors, independent of complications.

Including insertion of intra-aortic balloon pump (IABP) among the pre-operative variables is worthy of note. While use of IABP may be thought as a part of the surgery itself, we chose to include it as a pre-operative risk variable indicating substantial patient mortality risk perhaps not captured elsewhere in the model. IABP is used only on the sickest of patients, or those with the weakest cardiac output. Its inherent risks (it carries a high added risk of infection and can necessitate amputation of the leg) suggest that IABP patients are

among the most severe cases. Moreover, there was considerable variation in the reporting of this variable across hospitals as well in the timing of insertion. In some sites, it is possible that the IABP variable captures not only pre-operative use but intra-operative use as well.

Bias and Specification Issues. Hospital dummy variables, a demonstration participation time trend, and patient risk factors are included in a fixed effects format in Model 3. Since the principal focus of the multivariate analysis is to assess any time trend in outcomes over the period of the hospital's participation in the demonstration, obtaining an unbiased time trend coefficient is critically important. The inclusion of patient risk factors in this model was motivated by this goal. Patient risk factor variables should indicate differences in severity of case mix over time, and the hospital dummy variables will reflect both the effects of unmeasured (or poorly measured) case-mix differences across sites. Hopefully, this leaves the time trend coefficient estimate unbiased. Thus, it is not the case that higher mortality odds ratios for some participants indicate solely poor quality.

There is a potentially serious problem with the generalizability of the results, however, since only seven hospitals were examined, and random variation cannot be assumed. With only seven hospitals, we cannot assume that the relative risk estimates for the patient risk factors obtained from this analysis are representative of all hospitals, particularly given the selection process for participation in the demonstration. It may be that demonstration hospitals are systematically better, on average, in performing second CABGs on older patients, to cite just one example. The focus of the analysis, however, is not on the risk factors themselves, but on the time trend coefficient.

The question of how to include risk factors in the model depends upon one's assumptions about causality and consistency in measurement. By entering risk factors in non-interacted form, as in this analysis, and pooling the data across hospitals, one assumes that risk factor coefficients and their associated marginal effects are equal across the seven facilities. On the other hand, it is possible that one hospital is much better at treating very sick patients but no different in treating the average patient. This second possibility is addressed by the within-site regressions that allow risk factor odds ratios to vary by hospital.

7.6.3 Logistic Time-Trend Results on In-hospital and One-year Mortality

Time Trend Results on In-hospital Mortality. Table 7-4 reports odds ratios and chi-square p-values for three of the four in-hospital mortality models. Coefficient estimates themselves are not reported because they are not directly interpretable; attention is instead focused on odds ratios that indicate the degree to which the presence of a risk factor affects mortality. The overall model chi-square (and p-value) and the number of observations are included at the bottom of each regression.

Model 1 contains only the six dummy variables indicating the hospital at which the CABG surgery occurred with Hospital C embedded in the intercept. Three of these hospital dummy variables are significant at the 0.10 level or better suggesting some cross-sectional differences in in-hospital mortality, unadjusted for patient severity. The risk of in-hospital mortality is 31 percent higher at Hospital B than at Hospital C and roughly 35 percent lower at Hospital G relative to Hospital C. However, most notable is Hospital F, which exhibits

Table 7-4

Pooled In-Hospital Mortality Logistic Results

	Model 1		Model 2		Model 3	
Variable	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value
INTERCEPT	.038 ***	.00	.041 ***	.00	0.013 ***	0.00
STRTDEMO	-	-	0.998	.57	0.993 **	0.03
HOSPITAL A	0.967	.88	0.970	.88	1.017	0.94
HOSPITAL B	1.307 *	.06	1.310 *	.06	1.452 **	0.04
HOSPITAL D	1.150	.54	1.150	.52	1.467	0.11
HOSPITAL E	0.783	.32	0.760	.28	0.924	0.77
HOSPITAL F	2.413 ***	.00	2.350 ***	.00	2.454 ***	0.00
HOSPITAL G	0.630 *	.09	0.610 *	.07	0.584 *	0.09
URGENT	-	-	-	-	1.316 *	0.06
EMERGENT	-	-	-	-	3.274 ***	0.00
MI2WEEK	-	-	-	-	1.028	0.82
PREVCABG	-	-	-	-	3.013 ***	0.00
DRG	-	-	-	-	1.213 *	0.07
CHF	-	-	-	-	1.266 *	0.08
STROKE	-	-	-	-	1.180	0.28
COPD	-	-	-	-	1.275 **	0.04
HYPERTENSION	-	-	-	-	1.174	0.15
RENAL FAILURE	-	-	-	-	2.070 ***	0.00
AGE 65-69	-	-	-	-	1.087	0.69
AGE 70-74	-	-	-	-	1.188	0.40
AGE 75-80	-	-	-	-	1.845 ***	0.00
AGE 80+	-	-	-	-	2.125 ***	0.00
SEX	-	-	-	-	1.460 ***	0.00
BSA	-	-	-	-	0.759	0.20
IABP	-	-	-	-	3.220 ***	0.00
ARTERY70	-	-	-	-	1.022	0.71
LMCA	-	-	-	-	1.176	0.18
LVEF ≤ 35%	-	-	-	-	1.865 ***	0.00
No. Observations	10,478		10,474		10,096	
Overall Chi-Square (p-Value)	64.40	0.0001	64.70	0.0001	487.90	0.00

NOTE:
*** indicates significance at the .01 level, ** at the .05 level, and * at the .10 level.

* The numbers reported here are odds ratio, not regression coefficients (see text). An odds ratio less than 1 represents a negative relationship between the independent and dependent variables.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

an odds ratio of 2.41 (p=0.0001). Thus, patients undergoing CABG surgery at Hospital F are 141 percent more likely to die than patients undergoing CABG surgery at Hospital C. A review of the hospital-specific mean values of pre-operative risk factors does not provide any immediate explanation for such a large difference in relative mortality risk. Presumably, the differences in relative risk reflect differences in mix and severity of patients, a presumption that is tested in Model 3. In the absence of any controls for patient severity, in-hospital mortality among half of the sites does differ significantly from Hospital C.

Model 2 includes the same hospital dummy variables, as well as the monthly trend variable reflecting the timing of the CABG surgery relative to the hospital entering the demonstration. The same three hospital dummy variables remain significant in Model 2, and their direction and magnitudes are all but unaffected by inclusion of the time trend variable, which is insignificant as well. We conclude that in the absence of any controls for patient severity, there has not been any statistically discernible trend in pooled in-hospital mortality among the seven sites over the 60 months during which the demonstration has taken place.

Model 3 includes the hospital dummy variables, time trend, and the complete set of patient risk factors. The number of observations in Model 3 (N=10,096) falls modestly from the number of observations used in estimating Models 1 and 2 due to missing values for only a couple of variables included in Model 3. Re-call that many of the "missing" values were presumed to have been "nos" and set equal to zero in creating certain of the risk factors. Again, the magnitude and direction of the hospital dummies are little affected by the inclusion of the patient risk variables, indicating no significant correlation between site and

patient severity. This finding also suggests that the unadjusted mortality differences between Hospitals B, F, and G versus Hospital C are not necessarily because of differences in patient severity. Although the unexplained patient severity effect on mortality could be reflected in the hospital-specific dummy variables, it is difficult to see what severity differences remain unmeasured in Model 3.

The time trend odds ratio, statistically insignificant (p=.57) in Model 2, becomes statistically significant with the inclusion of the patient risk factors, 0.993 (p=.03). The odds ratio of 0.993 means that the risk of dying ***decreased*** by roughly 7/10ths of one percent for each additional month of participation in the demonstration. Thus, patients who undergo CABG surgery in the second year of a hospital's participation in the demonstration would have an 8 percent lower risk of in-hospital mortality than patients at the outset of the demonstration. This is a highly significant finding. As displayed in Table 7-3, over time there were increasing proportions of patients undergoing CABG surgery in the demonstration hospitals with pre-existing conditions. Thus, certain *paribus*, one would have expected an increase in the risk of dying over time. Once case-mix trends are controlled for, the insignificant mortality trend turns negative and is statistically significant at the 5 percent level.

Many of the patient risk factors are highly significant in Model 3. Revascularization priority (urgent, emergent) appears to affect in-hospital mortality. The risk of in-hospital mortality associated with having a revascularization priority of "emergent" was greater than that from any other risk factor examined here. With an odds ratio of 3.27 (p<.01), an emergent case is over three and one quarter times more likely to die in-hospital than an

elective case. An urgent case is 32 percent more likely to die in-hospital than a non-urgent case. Surprisingly, the effect of clinical presentation (unstable angina, MI2WEEK) is not strong. In fact, our model building strategy did not result in unstable angina being included in this model. We believe its exclusion is more reflective of inappropriate coding in some demonstration sites rather than its lack of clinical relevance in predicting mortality. As with unstable angina, a clinical presentation of an AMI within two weeks, surprisingly, does not significantly affect in-hospital mortality. In contrast, the risk of in-hospital mortality associated with having undergone CABG surgery previously is quite high. Those patients with a previous bypass surgery had an odds ratio of 3.01 ($p<.01$).

Patients admitted under DRG 106 (bypass with catheterization) are more 1.2 times more likely to die in-hospital than patients admitted under DRG 107(bypass without catheterization). We would expect those patients given diagnostic catheterization and bypass surgery during the same stay to be at least as severe, and often more severe, than those who were referred from another institution or who took additional time out-of-hospital to consider the risks and benefits of surgery.

Three of the co-morbid illnesses increase the risk of in-hospital mortality. Congestive heart failure, chronic renal insufficiency, and chronic obstructive pulmonary disease are all significant at $p<.08$ or better, with odds ratios of 1.27, 2.07, and 1.28, respectively. Stroke and hypertension do not have a significant effect on in-hospital mortality, *ceteris paribus*. Diabetes was excluded from this regression model because there was no discernable bivariate relationship between the presence of the condition and in-hospital mortality.

Ceteris paribus, the odds of dying during the CABG admission rose montonically with age. CABG patients in the two oldest age cohorts face significantly increased risks of in-hospital mortality compared to under-65 patients. Those aged 75-79 have an odds ratio of 1.85 ($p<0.01$), while those over 80 are more than twice as likely to die while in the hospital (odds ratio = 2.13, $p<0.04$) than patients under age 65. Women are found to be at significantly higher risk of dying in the hospital then men, with an odds ratio of 1.46 ($p<0.01$). Body surface area, a measure that evaluates weight relative to height, is insignificant in this regression model.

The insertion of an intra-aortic balloon pump prior to surgery is associated with greatly increased in-hospital mortality risk. The IABP odds ratio is 3.22 ($p<.01$). This is not surprising given the clinically unstable nature of patients who require an IABP pre-operatively. Insertion of an IABP carries with it a high risk of complications such as infection or infarction of the femoral artery, and is inserted to provide circulatory assistance only to the most physiologically compromised patients.

Except for ejection fraction, the anatomy of coronary disease had no predictive power for in-hospital mortality. The presence of an obstruction of more than 50 percent in the left main coronary artery (LMCA) is not significant, as is the number of arteries with at least 70 percent blockage. Left ventricular ejection fraction, however, is highly significant ($p<.01$). Patients with an ejection fraction less than 35 percent are 87 percent more likely to die than a similar patient with an ejection fraction greater than 35 percent.

Model 4 was constructed using the variables contributing the most to Model 3 (the exact selection criteria are discussed above). The reduced-form model (4a) is estimated once in its entirety based on all variables with p<=.10, and then again (4b) using the forward stepwise technique requiring at least a significance level of 0.05. Although the stepwise model explains slightly less variation than the full reduced-form model (as evaluated by the reported log likelihood), there is no statistically significant difference between the two. Because the direction and magnitude of the effects are so similar, we focus, primarily, on the (slightly expanded) reduced-form Model 4a in the center column in Table 7-5. Model 3 is displayed for comparison purposes.

Generally speaking, the magnitudes of the relative risk estimates in Model 4a do not differ greatly from their counterparts in Model 3. Hospitals F and G continue to exhibit statistically significant higher and lower relative risks of mortality, respectively, than any of the other demonstration sites relative to Hospital C. Patients in Hospital B also exhibit a higher relative risk of dying than in Hospital C, but the difference is no longer statistically significant at the 0.10 level. Interestingly, both Hospital F and Hospital B's relative risks of mortality fall slightly as selected pre-operative risk factors are removed from the regression models. For example, Hospital F's odds ratio falls from 2.45 to 2.03 when statistically insignificant variables at the 0.05 or better level are removed from Model 3.

Emergent revascularization priority, assignment to DRG 106, previous CABG, the presence of COPD or chronic renal insufficiency, pre-operative insertion of an IABP, an ejection fraction of 35 percent or less, and being female or 75 years of age and older are all

Table 7-5

Pooled In-Hospital Mortality Logistic Results Comparison of Full and Reduced Form Models

	Model 3		Model 4a Reduced Form		Model 4b Forward Stepwise	
Variable	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value
INTERCEPT	0.010 ***	0.00	0.010 ***	0.00	0.010 ***	0.00
STRTDEMO	0.993 **	0.03	0.995	0.11		
HOSPITAL A	1.017	0.94	0.957	0.83		
HOSPITAL B	1.452 **	0.04	1.298	0.12		
HOSPITAL D	1.467	0.11	1.315	0.24		
HOSPITAL E	0.924	0.77	0.821	0.46		
HOSPITAL F	2.454 ***	0.00	2.288 ***	0.00	2.034 ***	0.00
HOSPITAL G	0.584 *	0.09	0.552 **	0.04	0.528 ***	0.01
URGENT	1.316 *	0.06	1.294 *	0.07		
EMERGENT	3.274 ***	0.00	3.455 ***	0.00	3.126 ***	0.00
MI2WEEK	1.028	0.82				
PREVCABG	3.013 ***	0.00	2.867 ***	0.00	2.848 ***	0.00
DRG	1.213 *	0.07	1.219 *	0.06	1.268 ***	0.02
CHF	1.266 *	0.08	1.243 *	0.09		
STROKE	1.180	0.28				
COPD	1.275 **	0.04	1.279 **	0.04	1.334 ***	0.01
HYPERTENSION	1.174	0.15				
RENAL FAILURE	2.070 ***	0.00	2.194 ***	0.00	2.322 ***	0.00
AGE 65-69	1.087	0.69				
AGE 70-74	1.188	0.40				
AGE 75-80	1.845 ***	0.00	1.699 ***	0.00	1.698 ***	0.00
AGE 80+	2.125 ***	0.00	1.992 ***	0.00	2.009 ***	0.00
SEX	1.460 ***	0.00	1.550 ***	0.00	1.580 ***	0.00
BSA	0.759	0.20				
IABP	3.218 ***	0.00	3.179 ***	0.00	3.293 ***	0.00
ARTERY70	1.022	0.71	1.058	0.28		
LMCA	1.176	0.18				
LVEF ≤ 35%	1.865 ***	0.00	1.895 ***	0.00	1.990 ***	0.00
No. Observations	10,096		10,541		10,541	
Overall Chi-Square (p-Value)	487.9	0.0001	503.4	0.0001	489.6	0.0001

NOTE:

*** indicates significance at the .01 level, ** at the .05 level, and * at the .10 level.

* The numbers reported here are odds ratio, not regression coefficients (see text). An odds ratio less than 1 represents a negative relationship between the independent and dependent variables.

Reduced Form Model includes only the variables with a Wald Chi-Square Statistic where $p<0.10$.

Forward Stepwise Model includes the variables with a Wald Chi-Square Statistic where $p<0.10$, and retaining those with final parameter estimates of $p<0.05$.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

strongly and positively associated with a higher risk of mortality. Urgent revascularization priority and presence of congestive heart failure are weakly associated with a higher odds of dying. It is important to note that the two older-age odds ratios in the reduced form regressions differ in their interpretation from those in the full model. Since the only age variables in the reduced form regressions represent age groups 75-79 and 80 and over, their odds ratios are interpreted relative to under-75 patients. The odds ratios in Model 3 are interpreted relative to under-65 patients.

The most notable difference in Model 4 is the statistical insignificance of the time trend coefficient (odds ratio of .995, p=0.11). This suggests that the time trend variable is sensitive to how changes in patient severity are being captured.

To summarize, the key findings in the in-hospital mortality logistic analysis are:

- there is a significant overall time trend in mortality among the demonstration sites when controlling fully for patient severity. Patients who undergo a CABG procedure later in the demonstration have a lower risk of in-hospital mortality than those that have their CABG earlier in the demonstration period. However, this trend is sensitive to the degree to which changes in patient severity is captured over time.

- three of the six demonstration sites exhibited statistically significant differences in in-hospital mortality risk relative to Hospital C, even after accounting for pre-operative risk factors. Hospital G consistently demonstrated a significantly lower risk of mortality than Hospital C, while Hospitals B and F demonstrated significantly higher risks of mortality than Hospital C. However, the site-specific relative risks for Hospital B versus C appear to be quite sensitive to the pre-operative risk factors included in the regression models.

Within-Hospital In-hospital Mortality Logistic Results. The possibility that the demonstration might result in differing time trends by hospital motivated within-site mortality analysis. The results of our within-site logistic regressions are reported in Table 7-6. The risk factors chosen for these regressions are those appearing in Model 4a (i.e., the reduced form model). While these within-site regressions offer insights into how the demonstration affects individual institutions, they suffer the drawback of much smaller sample sizes than in the pooled analysis. Institutional-level inferences are therefore more difficult to draw.

The key finding among the site-specific regressions in Table 7-6 concerns the time trend. This trend, which was statistically significant in the pooled logistic in-hospital mortality full Model 3 (odds ratio = 0.993, p=0.03) is highly significant (p<.01) in the regression models only for Hospitals A and F. Both have odds ratios less than unity, indicating a ***decrease*** in in-hospital mortality during their participation in the demonstration. Hospital A's unadjusted mortality rate declined steadily during the 60 months of the demonstration, from an annualized rate of 6.3 percent in 1991 to 1.7 in 1996 (see Appendix Table L-7-2). Hospital F's unadjusted mortality rate also declined over the course of its 36 months of participation in the demonstration, from an annualized rate of 9.9 percent in 1993 to 7.8 percent in 1996. Apparently large unadjusted mortality improvements could be due to several factors, including systematic changes and patient case mix. Even controlling for case mix, however, we see a downward trend in

Table 7-6

Within-Site In-Hospital Mortality Logistic Results
Reduced Form Model 4

	Hospital A		Hospital B		Hospital C		Hospital D		Hospital E		Hospital F		Hospital G	
Variable	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value
INTERCEPT	0.010 ***	0.00	0.010 ***	0.00	0.010 ***	0.00	0.010 ***	0.00	0.000 ***	0.00	0.000 ***	0.00	0.000 ***	0.00
STARTDEMO	0.972 ***	0.01	1.003	0.58	1.001	0.92	1.002	0.84	0.992	0.73	0.968 ***	0.00	1.042	0.13
URGENT	1.292	0.60	0.836	0.54	2.031 *	0.06	1.541	0.39	0.614	0.43	2.193 *	0.06	0.831	0.80
EMERGENT	2.863 *	0.08	3.059 ***	0.00	4.861 ***	0.00	7.228 ***	0.00	2.873 *	0.08	4.289 ***	0.00	4.566 **	0.03
PREVCABG	3.178 **	0.02	3.247 ***	0.00	2.911 ***	0.00	2.875 *	0.07	2.849 *	0.07	3.024 ***	0.00	1.097	0.92
DRG	2.425 **	0.02	1.373 *	0.07	0.711	0.26	1.074	0.88	0.932	0.89	1.165	0.48	0.572	0.40
CHF	1.008	0.98	1.408	0.11	1.566	0.15	1.319	0.56	0.892	0.89	0.965	0.90	0.000	0.97
COPD	2.802 **	0.01	1.133	0.48	1.622	0.18	0.422	0.34	1.011	0.99	1.423	0.12	0.314	0.33
RENAL FAILURE	5.064 ***	0.00	1.619 **	0.01	4.027 ***	0.00	3.174 **	0.04	2.664	0.13	1.912 **	0.02	0.000	0.99
AGE 75-80	1.595	0.24	1.660 ***	0.01	2.568 ***	0.00	1.670	0.28	2.330	0.12	1.380	0.19	2.189	0.22
AGE 80+	4.584 ***	0.00	1.228	0.48	2.700 ***	0.01	2.259	0.16	4.202 **	0.02	1.708	0.12	6.989 ***	0.00
SEX	1.100	0.79	1.910 **	0.00	0.910	0.72	2.060 *	0.06	2.190	0.10	1.530 *	0.06	1.330	0.60
IABP	2.880 *	0.06	2.170 ***	0.01	6.140 ***	0.00	0.910	0.87	0.620	0.70	6.970 ***	0.00	8.000 ***	0.00
ARTERY70	0.954	0.77	1.004	0.96	0.947	0.70	0.866	0.48	1.698 **	0.04	1.212	0.10	1.496	0.24
LVEF ≤ 35%	1.965 *	0.09	2.352 ***	0.00	1.856 **	0.02	3.374 **	0.02	2.176	0.25	1.430	0.15	1.012	0.99
No. Observations	1,256		3,598		1,973		749		753		1485		727	
Overall Chi-Square (p-Value)	76.6	.0001	153.8	.0001	77.9	.0001	36.1	0.001	30.9	0.0058	142.8	0.0001	37.1	0.0007

NOTES:

*** indicates significance at the .01 level, ** at the .05 level, * at the .10 level.

* The numbers reported here are odds ratio, not regression coefficients (see text). An odds ratio less than 1 represents a negative relationship between the independent and dependent variables.

** Reduced Form Model includes only those variables with a Wald Chi-Square statistic where p<0.10.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

mortality. Table 7-6 reports that no other sites showed a significant trend in in-hospital mortality during the 60 months of the demonstration.

The risk variables included in the within-site regressions were not, in general, as significant as they were in the pooled analysis, no doubt due largely to reduced sample sizes. Admission under DRG 106, for example, was statistically significant only in Hospitals A and B, while congestive heart failure was not significant at any hospital. Only emergent revascularization priority — the variable with the greatest quantitative impact on mortality risk in the pooled model — was significant in all seven site-specific regressions, although previous CABG was significant in all but Hospital G.[6]

Coefficients that are significant differ substantially by hospital, suggesting that hospitals might differ in their ability to cope with co-morbid illnesses and other risk factors. Take, for example, chronic renal disease. The renal disease odds ratios for Hospitals A, C, D, F, and B are 5.06, 4.03, 3.17, 1.91 and 1.62, respectively. All are at the 0.05 or better significance level. Yet, Hospitals E and G show no significantly increased risk from renal disease.

COPD, pre-operative IABP, and an ejection fraction of 35 percent or less — all had very large and significant effects on in-hospital mortality when pooling across all the hospitals. Yet, COPD is statistically significant only in Hospital A (odds ratio 2.8, $p<.01$). Insertion of an IABP prior to surgery shows very large significant increases in risk at Hospital A, B, C, F, and G (odds ratios of 2.88, 2.17, 6.14, 6.97, and 8.00, respectively) but

[6] Nonreporting of previous CABG for some patients in Hospital G may have biased the coefficient downwards.

not in D and E. Ejection fraction is significant only in Hospitals A, B, C, and D, with odds ratios ranging from 1.86 to 3.37.

The relative risk of age also differed by hospital. Hospitals D and F showed no significantly increased risk for patients aged 75 and older. Hospital B showed a large and significant increase in risk associated with patients 75-79 (odds ratio=1.66, $p<0.01$), but no such increase in risk for patients 80 years and above (odds ratio=1.23, $p=0.48$). Hospitals A and G both showed large and highly significant increases in risk associated with patients 80 and older, with odds ratios of 4.58 and 6.99 (both $p<.01$). Only Hospital C showed large and significant increases in risk associated with patients 75-79 (odds ratio=2.57, $p<0.01$) and 80 years of age and older (odds ratio=2.70, $p<0.01$).

The key finding from the within-site in-hospital mortality model concerns the time trend.

- Both Hospitals A and F exhibit odds ratios less than unity, indicating a ***decrease*** in in-hospital mortality during their participation in the demonstration, holding case mix trends contrast. It is important to note that these two hospitals entered the demonstration two years apart; Hospital A entered in 1991 and Hospital F entered in 1993.

- No other sites showed a significant trend in in-hospital mortality during the 60 months of the demonstration.

- The risk variables included in these within-site regressions were not, in general, as significant as they were in the pooled analysis, no doubt due largely to reduced sample sizes.

In-hospital Mortality Including Complications. The general in-hospital mortality model (Model 3 of Table 7-4) includes only pre-operative risk variables because of the

priority placed on estimating an unbiased trend coefficient. Invariably, patients die from complications due to the surgery or from the failure to revascularize successfully. Complications from surgery may or may not be the result of the surgical team or those responsible for post-operative care. If they are, they should not be controlled for in measuring cross-hospital or temporal differences in mortality. If complications "simply happen" in the vast majority of patients regardless of the team's efforts, then controlling for them provides a more comprehensive control for case mix severity. Moreover, one would also expect that pre-operative risk factors are associated with complication rates. This is a testable hypothesis. If controlling for various complications, certain risk factor coefficients fall dramatically, this strongly suggests a causal link. In this section, we test for the independent contribution of complications, when they occur, on inpatient CABG mortality as well as the effects they have on the other model coefficients.

Table 7-7 reports the results from four logistic regressions. The first column is the same regression model reported in Model 3 of Table 7-4, with a (0,1) dependent variable indicating whether a patient died in-hospital and using pre-operative risk factors, only, as independent variables. It is replicated here so that odds ratios can be directly compared with their counterparts in the model including post-operative variables. The second regression, Model 5, has the same dependent variable and pre-operative risk factors as independent variables as in Model 3, plus a set of eight post-operative complications thought to be correlated with in-hospital mortality. The third column presents Model 6, a reduced form model estimated in the same manner as before based on all variables from the full model

Table 7-7

Pooled Inpatient Mortality and Complication Logistic Results
Comparison of Full and Reduced Form Models

	Model 3		Model 5 Pre- and Post-Op		Reduced Form Model 6 Pre- and Post-Op		Post-Op Complication Model 7	
Variable	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value
INTERCEPT	0.010 ***	0.00	0.010 ***	0.00	. ***	0.00	0.270 ***	0.00
START DEMO	0.993 **	0.03	0.991 ***	0.01	0.992 **	0.02	1.002 *	0.08
URGENT	1.316 *	0.06	1.308	0.10	1.329 *	0.06	1.000	1.00
EMERGENT	3.274 ***	0.00	2.532 ***	0.00	2.791 ***	0.00	1.623 ***	0.00
HOSPITAL A	1.017	0.94	1.392	0.18	1.206	0.42	1.350 ***	0.00
HOSPITAL B	1.452 **	0.04	1.931 ***	0.00	1.602 **	0.01	0.727 ***	0.00
HOSPITAL D	1.467	0.11	1.485	0.14	1.327	0.26	0.950	0.61
HOSPITAL E	0.924	0.77	1.031	0.92	0.897	0.72	0.843	0.10
HOSPITAL F	2.454 ***	0.00	4.785 ***	0.00	4.253 ***	0.00	0.626 ***	0.00
HOSPITAL G	0.584 *	0.09	1.359	0.37	1.102	0.75	0.225 ***	0.00
MI2WEEK	1.028	0.82	0.974	0.84				
PREVIOUS CABG	3.013 ***	0.00	3.002 ***	0.00	2.936 ***	0.00	1.477 ***	0.00
DRG	1.213 *	0.07	1.196	0.13			1.127 **	0.02
CHF	1.266 *	0.08	1.234	0.15			1.148 **	0.04
DIABETES							1.045	0.39
STROKE	1.180	0.28	1.169	0.35			1.278 ***	0.00
COPD	1.275 **	0.04	1.350 **	0.02	1.345 **	0.02	1.298 ***	0.00
HYPERTENSION	1.174	0.15	1.042	0.74			1.237 ***	0.00
RENAL FAILURE	2.070 ***	0.00	1.619 ***	0.00	1.777 ***	0.00	1.432 ***	0.00
AGE 65-69	1.087	0.69	1.038	0.87			0.967	0.70
AGE 70-74	1.188	0.40	1.091	0.69			1.012	0.90
AGE 75-79	1.845 ***	0.00	1.673 **	0.02	1.632 ***	0.00	1.095	0.33
AGE 80+	2.125 ***	0.00	1.625 *	0.06	1.622 ***	0.00	1.610 ***	0.00
SEX	1.462 ***	0.00	1.462 ***	0.00	1.568 ***	0.00	1.041	0.43
BSA	0.759	0.20	0.729	0.20			1.017	0.75
IABP	3.220 ***	0.00	3.230 ***	0.00	3.290 ***	0.00	1.440 ***	0.00
ARTERY70	1.022	0.71	1.036	0.56			0.957 *	0.09
LMCA	1.176	0.18	1.336 **	0.03	1.373 ***	0.01	0.979	0.73
LVEF ≤ 35%	1.865 ***	0.00	1.697 ***	0.00	1.876 ***	0.00	1.211 ***	0.00
REOPBLD			1.831 **	0.01	1.774 **	0.01		
POAMI			1.635	0.11				
INFECTION			1.388 *	0.08	1.298	0.16		
STROKCMP			2.308 ***	0.00	2.278 ***	0.00		
PULMONARY			1.371 **	0.02	1.479 ***	0.00		
RENALCMP			5.098 ***	0.00	4.751 ***	0.00		
VASCULAR			1.804 *	0.07	1.691 *	0.09		
OTHERCMP			9.061 ***	0.00	8.821 ***	0.00		
No. Observations	10,096		10,096		10,541		10,541	
Overall Chi-Square (p-Value)	487.90	0.00	1074.9	0.0001	1089.8	0.0001	1087.9	0.0001

NOTE:
*** indicates significance at the .01 level, ** at the .05 level, and * at the .10 level.

* The numbers reported here are odds ratio, not regression coefficients (see text). An odds ratio less than 1 represents a negative relationship between the independent and dependent variables.

SOURCE: Abstracts of clinical records from demonstration hospitals, May 1991 through June 1996.

with p-value coefficients of the Wald chi-square of 0.10 or less. (A forward stepwise regression model retaining all variables that achieved a p-value of 0.05 or better also was estimated, but we do not report the results as the odds ratios are similar in direction and magnitude as those reported in Model 6.) The last regression, Model 7, has the same pre-operative risk factors as Models 3 and 5, but uses a (0,1) dependent variable indicating whether any post-operative complication occurred following surgery.

Post-operative complications contribute substantially to in-hospital mortality risk, as evidenced by the more-than-doubling of the overall chi-square between Models 5 and 6. Re-operation for bleeding, stroke complication, renal complication, vascular complication, and "other" complications are all associated with significant relative mortality risks at least 1.5 times as great as those faced by patients not suffering these complications.

Not surprisingly, the presence of an "other" complication is the most significant predictor of in-hospital mortality (odds ratio=9.061, $p<0.01$). As discussed earlier, this category includes infrequently occurring but very serious complications, such as cardiac tamponade, cardiac arrest, heart block requiring the insertion of a permanent pacemaker, gastro-intestinal (GI) complication, and multi-system failure. Cardiac arrest and cardiac tamponade are the two most frequently occurring complications within the other category for those who died in-hospital. In fact, two-thirds of the patients with cardiac arrest died in-hospital, demonstrating the severe nature of this complication.

Renal complications also have a large effect on mortality risk, with an odds ratio of 5.10 (p=.0001). Pulmonary complications and infection involve a relatively modest increase

in risk, with odds ratios of 1.37 (p=.02) and 1.39 (p=0.08). Notably, a post-operative AMI show a 64 percent increase in mortality risk, but the effect is statistically insignificant, possibly due to the low incidence of post-operative acute myocardial infarction AMI among these patients.

Model 5, once again, suggests a downward trend in mortality during the hospitals' participation in the demonstration (odds ratio = .991, p=.01). The significant negative mortality trend in Model 5 still could be consistent with a diminution in hospital performance if post-operative complications are the result of demonstration-initiated behaviors. We examine this issue more directly in regression model 7 predicting the overall complication rate. A modest upward (p=0.08) trend is found, implying more complications were reported for CABG patients operated on later in the hospitals' demonstration participation period, holding case mix constant.

Several of the hospital dummy variables in Model 5 are affected by the inclusion of post-operative complications. Controlling for both pre-operative and post-operative risk factors, Hospital G no longer shows a lower risk of inpatient mortality relative to referent Hospital C. This implies that patients in Hospital G are less likely to experience a complication versus Hospital C (as evidenced in Model 7).

Most notable, however, is the large increase in the odds ratio for Hospital F (odds ratio=4.79, p<0.001) when post-operative complications are included in the model. While a higher risk of mortality in Hospital F relative to Hospital C is consistent with other analyses, we believe that a substantial part of the increase could be related to coding of

complications. Hospital F reports that 29 percent of its patients experienced a complication. In contrast, Hospital C reports that 57 percent of its patients experienced a complication (see Model 7 and Table 7-10 in Appendix L). If there are differences in how these two sites define complications, with Hospital C using a more generous set of definitions, then the increased risk of mortality controlling for complications would appear in Hospital F's dummy variable and simply be a coding artifact.

Again, changes in the pre-operative variables' odds ratios from Model 3 to Model 5 reflect correlations between these and the complications variables. In general, variables that significantly increased the risk of mortality in Model 3 also contribute significantly to the risk of dying in Model 5; however, the odds ratios tend to fall reflecting the correlations between the pre-operative and post-operative variables. For example, emergent cases are 3.27 times more likely to die in-hospital when evaluating only the pre-operative risk factors' contribution to the risk of dying, but with the post-operative variables in Model 5, the emergent odds ratio falls (odds ratio=2.53) but still remains statistically significant. From this, we conclude that emergent patients are more likely than others to suffer deadly post-operative complications.

This notion is validated by an examination of Model 7 where the emergent variable odds ratio is 1.62 ($p<0.01$), implying emergent patients are 62 percent more likely to have a complication. A similar story can be told about patients assigned to DRG 106, patients who present with CHF or renal failure, patients 75 years and older as well as patients with

low ejection fractions. The inclusion of post-operative risk factors tends to reduce the independent effect of these pre-operative clinical conditions.

Model 7 also shows an important finding with regard to hospital differences in "reported" complications. Controlling for pre-operative patient risk factors, Hospitals B, E, F, and G all show significantly lower complication risks (at the $p<0.10$ level) than the referent, Hospital C. The magnitude of these differences is large: Hospital B's odds ratio is 0.73, Hospital G's odds ratio is 0.232, Hospital F's is.63, and Hospital E's is .84. Although not statistically significant, Hospital D's odds ratio is also less than unity, 0.95 ($p=0.63$). In contrast, Hospital A exhibits significantly higher complication risks than Hospital C, after controlling for pre-operative risk factors (odds ratio=1.35, $p<0.01$).

7.6.4 Regression Results: One-Year Mortality Regression

One-Year Mortality Regressions. In-hospital mortality, obviously an important outcome measure for CABG surgery, is not the only measure of interest. Since the risks from CABG surgery extend to periods far longer than the actual hospital stay, it is important to examine mortality outcomes over a longer period. We have chosen post-surgical cumulative one-year mortality as our longer-term outcome measure. Table 7-8 displays cumulative unadjusted mortality rates during the first year following CABG surgery. Patient post-discharge survival status is based on Medicare eligibility files. Demonstration patients who underwent CABG surgery after December 31, 1995 are excluded from this table as one-year mortality data were unavailable for these patients. In general, hospitals with the highest

Table 7-8

Cumulative Mortality Rates During First Year Following CABG Surgery By Hospital For Patients Undergoing CABG Surgery Through December 1995

	Time Following CABG Surgery					Number of Records Missing Either Date of Death or Date of CABG
	1 Month %	3 Months %	6 Months %	9 Months %	One Year %	
Hospital A (N=1,107)	4.3	5.4	6.2	6.9	7.7	147
Hospital B (N=3,180)	5.5	6.6	7.6	8.1	8.7	399
Hospital C (N=1,747)	3.5	3.9	4.3	5.0	5.4	219
Hospital D (N=654)	5.0	5.2	5.7	6.1	6.3	90
Hospital E (N=665)	4.1	4.7	5.0	5.4	5.6	87
Hospital F (N=1,284)	7.9	8.3	9.7	11.0	11.6	189
Hospital G (N=594)	2.6	4.1	4.7	5.6	5.6	128

NOTE: The cohort represented above excludes all CABG patients operated on after December 31, 1995, as one-year mortality data were unavailable for later patients (N = 9,231).

SOURCE: Tabulated from (1) medical records and physician clinical abstracts provided by participating hospitals, and (2) from the Medicare Denominator files, 1991 - 1996.

in-hospital mortality rates (4.3% to 7.9%) continue to demonstrate the highest one-year mortality rates (6.3% to 11.6%). However, the three hospitals with the lowest in-hospital mortality rates (2.6% to 4.1%) all converge to essential equivalent mortality rates between 5.4 and 5.6 percent. The 1-month range of 7.9 percent to 2.6 percent (a three-fold difference) also narrows to 11.6 percent to 5.4 percent (a 2.1-fold difference).

In this analysis, we replicate the basic mortality model used in the in-hospital mortality analysis. Pre-operative patient risk factors, hospital dummy variables, and the time trend variable serve again as independent variables, where the dichotomous variable is now cumulative one-year mortality. The one-year mortality logistic analysis, like the in-hospital mortality analysis, is conducted for all hospitals, with Hospital C continuing as the referent hospital. All records with a CABG surgery date after December 31, 1995 are excluded, because one-year follow-up data were available only through the end of 1996.

Table 7-9 reports the results from three logistic regressions. The first, Model 8, is the full pre-operative risk factor model with hospital dummy variables and time trend. The dependent variable is cumulative one-year mortality. The second model, Model 9a, is a reduced form model developed using the same methods used for the reduced form in-hospital model; all variables with a p-value of 0.10 or less in the full model were selected as candidate variables to be entered into the two reduced form regressions. In the forward stepwise logistic regression, Model 9b, all regressors that achieved a $p<0.05$ were retained.

We begin our discussion with Model 8. As with the in-hospital model, there is evidence of a ***decreasing*** time trend in one-year mortality (odds ratio=0.993, $p<0.02$). The

Table 7-9

Pooled Cumulative One-Year Mortality Logistic Results Using Pre-Operative Risk Factors: Comparison of Full and Reduced Form Models

	Model 8		Model 9a Reduced Form		Model 9b Forward Stepwise	
Variable	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value
INTERCEPT	0.030 ***	0.00	0.040 ***	0.00	0.020 ***	0.00
START DEMO	0.993 **	0.02	0.993 **	0.03	0.994 **	0.04
HOSPITAL A	1.372 *	0.07	1.377 *	0.07		
HOSPITAL B	1.928 ***	0.00	1.962 ***	0.00	1.652 ***	0.00
HOSPITAL D	1.455 *	0.08	1.485 *	0.06		
HOSPITAL E	1.216	0.38	1.229	0.36		
HOSPITAL F	2.448 ***	0.00	2.557 ***	0.00	2.180 ***	0.00
HOSPITAL G	0.931	0.78	0.933	0.78		
URGENT	1.323 **	0.03	1.380 ***	0.01	1.384 ***	0.01
EMERGENT	2.132 ***	0.00	2.238 ***	0.00	2.245 ***	0.00
MI2WEEK	1.213 *	0.05	1.214 **	0.05	1.219 **	0.04
PREVCABG	2.771 ***	0.00	2.806 ***	0.00	2.737 ***	0.00
DRG	1.100	0.29				
CHF	1.611 ***	0.00	1.645 ***	0.00	1.734 ***	0.00
STROKE	1.320 **	0.03	1.338 **	0.02	1.393 ***	0.01
COPD	1.282 **	0.01	1.275 **	0.02	1.278 **	0.02
HYPERTENSION	1.281 ***	0.01	1.284 ***	0.01	1.295 ***	0.01
RENAL FAILURE	1.944 ***	0.00	1.966 ***	0.00	1.989 ***	0.00
AGE 65-69	0.991	0.96				
AGE 70-74	1.253	0.18				
AGE 75-80	1.707 ***	0.00	1.543 ***	0.00	1.553 ***	0.00
AGE 80+	2.027 ***	0.00	1.849 ***	0.00	1.874 ***	0.00
SEX	1.270 **	0.02	1.250 **	0.03	1.400 ***	0.00
BSA	0.647 **	0.03	0.627 **	0.02		
IABP	2.770 ***	0.00	2.810 ***	0.00	2.840 ***	0.00
ARTERY70	1.048	0.32				
LMCA	1.116	0.29				
LVEF ≤35%	1.777 ***	0.00	1.788 ***	0.00	1.726 ***	0.00
No. Observations	8,828		8,828		8,828	
Overall Chi-Square (p-Value)	523.0	0.0001	513.6	0.0001	498.9	0.0001

NOTE:
*** indicates significance at the .01 level, ** at the .05 level, and * at the .10 level.

* The numbers reported here are odds ratio, not regression coefficients (see text). An odds ratio less than 1 represents a negative relationship between the independent and dependent variables.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

trend in odds ratios is less than unity and statistically significant at the 0.05 level in both reduced form models. Scaling this continuous variable to represent a full year's experience results in patients who undergo CABG surgery in the second year of a hospital's participation in the demonstration having an 8 percent lower risk of one-year mortality than patients at the outset of the demonstration.

The dummy variables representing Hospitals B and F remain highly significant, and suggest substantially increased one-year mortality risk relative to patients at the referent (Hospital C), controlling for pre-operative risk factors. Hospital B has an odds ratio of 1.93 ($p<.001$), suggesting that its patients are almost twice as likely to die within one year of surgery as those at Hospital C, *ceteris paribus*. In contrast, Hospital B's inpatient mortality odds ratio versus C was only 1.45. Hospital F's odds ratio is even larger at 2.45 ($p<.001$), identical to its inpatient ratio. Hospitals A and D also exhibit statistically significant higher relative risks of one year mortality not observed in the in-hospital mortality analysis.

The majority of pre-operative risk factors continue to be significantly related to one-year mortality, although the magnitude of effect is somewhat less than observed in the in-hospital model. Previous CABG, CHF, COPD, chronic renal insufficiency, pre-operative use of an IABP, low ejection fraction, being 75 years of age and older, and being female were significant in the one-year mortality regression and remain significant in the one-year mortality model. Interestingly, DRG assignment no longer exerts a significant effect on mortality, suggesting that this variable captures the acuity of the patient at the time of surgery

and does not reflect unmeasured co-morbid conditions that would have a longer term impact of mortality.

Model 9a and 9b report the results of the reduced form cumulative mortality models. Regardless of regression technique, the results are virtually identical. The trend odds ratio remains less than unity and statistically significant. The hospital dummy variables continue to exhibit the same relationships relative to the reference hospital. And, virtually all of the pre-operative risk factors continue to exert the same direction and level of magnitude as in the full model.

The key findings from the one-year cumulative mortality logistic analysis are:

- Evidence of a time trend among the pooled group of patients for whom there is complete one-year follow-up data. Patients who undergo CABG surgery later in the demonstration are at a lower risk of one-year mortality. This finding is consistent with the in-hospital mortality analysis.

- Controlling for pre-operative risk factors, one-year mortality is significantly higher at Hospitals A, B, D, and F than at the referent hospital with the lowest one-year mortality, Hospital C.

- The majority of pre-operative risk factors that contribute to in-hospital mortality continue to exert a strong effect on one-year mortality risks.

Regression Results: Within-Site One-Year Mortality. Just as in the case of in-hospital mortality, the possibility of differences in site-specific time trends in one-year mortality demanded that regressions be estimated for each hospital, individually. The risk factors used as independent variables are those appearing in Model 9 (i.e., the most significant variables from the reduced form one-year mortality model). The results are

reported in Table 7-10. Like the in-hospital analysis, few hospitals' time trend variable achieves statistical significance. Hospital F once again exhibits an odds ratio of less than unity (odds ratio=0.98). This time trend is slightly less significant than that for Hospital F's in-hospital mortality regression, but there fewer observations for the one-year regression (n=1236 compared to n=1485). Again, the time trend odds ratio is interpreted in monthly units; scaled to one year, the odds ratio becomes .79, meaning that a patient undergoing surgery one year later is estimated to be approximately 20 percent less likely to die within a year of surgery. The time trend variable is not significant for any other hospital-specific regression. However, the important point of this analysis is that there are no hospitals exhibiting increasing risks of mortality over the course of the demonstration.

As with the in-hospital mortality analysis, there is considerable variation across the sites in terms of pre-operative factors that affect mortality and the magnitude of the effect. None are significant across all of the sites. Hospitals D, E, and G have very few variables that contribute significantly to explaining the risk of mortality 1 year after surgery. These three hospitals also have the fewest number of patients in this analysis. Of the four hospitals with the most cases, previous CABG, renal failure, pre-operative insertion of an IABP, and an ejection fraction of 35 percent or less are all statistically significant and substantially increase the risk of mortality. Emergent admission and advanced age increase the risk of mortality one year from date of CABG in Hospitals B, D, and F. In general, the magnitude of effect of these pre-operative variables is less on one-year mortality risk than on in-hospital mortality risk.

Table 7-10

Within-Site One-Year Mortality Logistic Results
Pre-Operative Risk Factors: Reduced Form Model 9

	Hospital A		Hospital B		Hospital C		Hospital D		Hospital E		Hospital F		Hospital G	
Variable	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value
INTERCPT	0.010 ***	0.00	0.070 ***	0.00	0.100 *	0.09	0.130	0.28	0.020 *	0.07	0.110 **	0.03	0.060	0.26
START DEMO	0.985	0.12	0.993	0.14	0.996	0.65	1.007	0.56	0.997	0.88	0.981 *	0.10	0.988	0.70
URGENT	1.044	0.90	1.471 *	0.10	1.444	0.23	2.193 *	0.06	1.082	0.86	1.744	0.21	1.020	0.97
EMERGENT	1.583	0.32	1.871 ***	0.00	3.104 ***	0.01	4.593 **	0.02	3.981 ***	0.01	3.561 ***	0.00	1.170	0.81
MI2WEEK	1.420	0.29	1.164	0.30	1.031	0.94	1.211	0.70	0.720	0.55	1.213	0.45	2.024	0.13
PREVCABG	2.372 **	0.03	2.817 ***	0.00	3.384 ***	0.00	2.844 *	0.07	2.975 **	0.02	2.990 ***	0.00	1.438	0.52
CHF	1.435	0.22	1.939 ***	0.00	1.932 **	0.03	1.717	0.23	2.332	0.12	1.040	0.89	0.916	0.94
STROKE	0.919	0.83	1.363	0.11	1.353	0.41	1.443	0.43	1.496	0.43	1.452	0.21	.	.
COPD	1.353	0.37	1.295 *	0.07	1.439	0.30	1.145	0.83	1.678	0.34	1.220	0.38	0.606	0.54
HYPERTENSION	1.772	0.12	1.281 *	0.10	1.779 **	0.04	0.811	0.58	1.362	0.44	1.358	0.16	0.605	0.27
RENAL FAILURE	3.426 ***	0.00	1.579 ***	0.00	3.599 ***	0.00	1.806	0.29	2.093	0.18	2.164 ***	0.00	0.000	0.99
AGE 75-80	1.740 *	0.07	1.636 ***	0.00	1.950 **	0.02	1.982 *	0.10	1.463	0.40	1.317	0.25	1.230	0.70
AGE 80+	3.733 ***	0.00	1.382	0.16	2.228 **	0.03	1.143	0.83	3.782 ***	0.01	1.530	0.22	2.763 *	0.09
BSA	1.878	0.32	0.638	0.11	0.302 *	0.07	0.298	0.19	0.954	0.96	0.633	0.32	0.625	0.69
SEX	0.940	0.85	1.670 ***	0.00	0.600 *	0.10	1.590	0.29	0.950	0.91	1.190	0.48	1.570	0.39
LVEF ≤35%	1.579	0.16	2.007 ***	0.00	1.667 **	0.04	1.892	0.23	1.445	0.50	1.913 ***	0.01	1.102	0.88
No. Observations	983		3,150		1,665		639		640		1,236		515	
Overall Chi-Square	58.4	.0001	183.3	.0001	82.0	.0001	32.3	.0136	32.5	.0131	124.6	.0001	21.7	.1522

*** indicates significance at the .01 level, ** at the .05 level, * at the .10 level.

* The numbers reported here are odds ratio, not regression coefficients (see text). An odds ratio less than 1 represents a negative relationship between the independent and dependent variables.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

The key findings with regard to one-year mortality at the individual hospital level are:

- there is no evidence of an upward trend in one-year post-surgery mortality at any of the seven demonstration sites, controlling for risk factors with the greatest predictive power.
- Hospital F shows a significant and quantitatively large decline in the relative risk of mortality one year following surgery, just as it did with in-hospital mortality.

Cumulative One-Year Post-Discharge Mortality Including Complications. Table 7-11 reports the results from four one-year mortality logistic regressions. The first column is the same regression model reported in Model 8 of Table 7-9, with a (0,1) dependent variable indicating whether a patient within one year of CABG surgery and pre-operative risk factors as independent variables. It is replicated here so that odds ratios can be directly compared with their counterparts in the model including post-operative variables. The second regression, Model 10, has the same dependent variable and pre-operative risk factors as independent variables as in Model 8, plus a set of eight post-operative complications thought to be correlated with in-hospital mortality. *A priori*, we expect that where a variable is significant in Model 8, that variable's coefficient will change from the first to the second regression due to an association with post-operative complications raising the likelihood of death. The third column contains Model 11, a reduced form model estimated in the same manner in which the pre-operative risk factor reduced form model was estimated selecting all variables from the full model in which the p-value of the Wald chi-square is 0.10 or less. The last regression, Model 12, has the same pre-operative risk factors as Models 8, but uses a (0,1) dependent variable indicating whether any post-operative complication occurred

Table 7-11

Pooled Cumulative One-Year Mortality Logistic Results
Comparison of Full and Reduced Form Models
Pre-Operative Risk Factors and Post-Operative Complications

	Model 8 One-Year Mortality		Model 10 One-Year Mortality Pre- and Post-Op		Model 11 Reduced Form One-Year-Mortality Pre- and Post-Op		Model 12 Post-OP Complication	
Variable	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value	Odds Ratio	P-Value
INTERCPT	0.030 ***	0.00	0.020 ***	0.00	0.030 ***	0.00	0.210 ***	0.00
START DEMO	0.993 **	0.02	0.992 **	0.01	0.992 **	0.01	1.003	0.12
HOSPITAL A	1.372 *	0.07	1.550 **	0.02	1.580 **	0.02	1.653 ***	0.00
HOSPITAL B	1.928 ***	0.00	2.144 ***	0.00	2.150 ***	0.00	0.826 **	0.02
HOSPITAL D	1.455 *	0.08	1.415	0.13	1.430	0.12	1.023	0.83
HOSPITAL E	1.216	0.38	1.341	0.24	1.430	0.14	1.037	0.74
HOSPITAL F	2.448 ***	0.00	3.542 ***	0.00	3.720 ***	0.00	0.691 ***	0.00
HOSPITAL G	0.931	0.78	1.667 *	0.06	1.750 **	0.03	0.215 ***	0.00
URGENT	1.323 **	0.03	1.308 **	0.05	1.350 **	0.02	0.978	0.75
EMERGENT	2.132 ***	0.00	1.700 ***	0.00	1.760 ***	0.00	1.517 ***	0.00
MI2WEEK	1.213 *	0.05	1.163	0.16			1.212 ***	0.00
PREVCABG	2.771 ***	0.00	2.645 ***	0.00	2.660 ***	0.00	1.515 ***	0.00
DRG	1.100	0.29	1.050	0.61			1.158 ***	0.01
CHF	1.611 ***	0.00	1.605 ***	0.00	1.640 ***	0.00	1.139 *	0.08
STROKE	1.320 **	0.03	1.334 **	0.03	1.360 **	0.02	1.225 **	0.01
COPD	1.282 **	0.01	1.276 **	0.02	1.270 **	0.03	1.352 ***	0.00
HYPERTENSION	1.281 ***	0.01	1.194 *	0.08	1.200 *	0.07	1.278 ***	0.00
RENAL FAILURE	1.944 ***	0.00	1.636 ***	0.00	1.650 ***	0.00	1.478 ***	0.00
AGE 65-69	0.991	0.96	0.921	0.65			0.998	0.98
AGE 70-74	1.253	0.18	1.136	0.47			1.091	0.36
AGE 75-80	1.707 ***	0.00	1.469 **	0.03	1.430 ***	0.00	1.195 *	0.08
AGE 80+	2.027 ***	0.00	1.526 **	0.04	1.470 **	0.01	1.826 ***	0.00
SEX	1.270 **	0.02	1.230 *	0.05	1.240 **	0.04	1.080	0.18
BSA	0.647 **	0.03	0.599 **	0.01	0.590 ***	0.00	1.028	0.60
IABP	2.770 ***	0.00	2.619 ***	0.00	2.690 ***	0.00	1.351 **	0.02
ARTERY70	1.048	0.32	1.058	0.26			0.948 **	0.05
LMCA	1.116	0.29	1.232 *	0.06	1.280 **	0.02	0.970	0.64
LVEF ≤35%	1.777 ***	0.00	1.644 ***	0.00	1.690 ***	0.00	1.169 **	0.02
REOPBLD			1.339	0.19				
POAMI			1.334	0.32				
INFECT			1.463 **	0.02	1.480 **	0.02		
STROKCMP			1.982 ***	0.00	2.020 ***	0.00		
PULM			1.425 ***	0.00	1.440 ***	0.00		
RENALCMP			3.965 ***	0.00	4.070 ***	0.00		
VASC			1.158	0.63				
OTHCOMP			5.529 ***	0.00	5.700 ***	0.00		
No. Observations	8,828		8,828		8,828		8,828	
Overall Chi-Square (p-Value)	523.0	0.0001	985.2	0.0001	974.7	0.0001	522.3	0.0001

NOTE:
*** indicates significance at the .01 level, ** at the .05 level, and * at the .10 level.

* The numbers reported here are odds ratio, not regression coefficients (see text). An odds ratio less than 1 represents a negative relationship between the independent and dependent variables.

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

following surgery. It is identical to Model 7 except that it is estimated only on the sample of patients reporting one-year mortality.

Model 10, the one which controls for complications, still shows a significant downward trend in mortality (odds ratio = .992, p=0.01). But similar to the in-hospital analysis, Model 12 shows a statistically non-significant modest upward trend in the complication rate. If complications are unrelated to provider behavior under the demonstration, then controlling for them gives a more accurate measure of one-year mortality trends.

Several of the hospital dummy variables in Model 8 are affected by the inclusion of the post-operative variables. The relatively high one-year mortality odds ratios at Hospitals A, B, and F, reported in Model 8 and discussed earlier in Table 7-9, actually increase with the inclusion of the complications variables. Even controlling for potentially serious post-operative complications, demonstration patients treated in these two hospitals were (statistically) significantly more likely to die within a year of surgery compared with Hospital C. Hospital A's patients are 1.55 times more likely to die, Hospital B's patients are 2.14 times more likely to die, and Hospital F's patients are 3.54 times more likely to die. Like the in-hospital analysis, Hospital G's odds ratio changes considerably, from 0.93 to 1.67 and now exhibits significantly higher risks of mortality relative to Hospital C when complications are added to the regression model.

Post-operative complications contribute substantially to one-year mortality risk as observed in both Models 10 and 11. The coefficients in the pre-operative risk model did not

change much after post-operative variables were added. As observed with in-hospital mortality, the odds ratios tend to decrease modestly when complications are added to the model. This appears to be a function of the positive correlation between many of the pre-operative risk factors and the presence of a post-operative complication as displayed in Model 12. The presence of one of the "other" complications significantly increases the risk of one-year mortality as it did in in-hospital mortality (odds ratio = 5.529, $p<0.01$).

In summary, the key findings are:

- the inclusion of post-operative complications results in a significant downward time trend in one-year mortality. If complications are unrelated to provider behavior under the demonstration then this apparent downward trend in mortality is an accurate estimate of the actual trend in mortality.
- there is no evidence of increasing risk of complications during the demonstration using the one-year mortality model's pre-operative risk factors.

7.7 Multivariate Analysis of Length of Stay

7.7.1 Regression Results: Trends in In-hospital Lengths of Stay

Table 7-12 presents regression results explaining differences in patient total and post-operative lengths of stay among the seven demonstration hospitals and across time of participation in the demonstration, controlling for patient demographics, co-morbid conditions, disease anatomy, complications, and in-hospital death. All DRG 106 and 107 patients are pooled in a single regression with a dummy shift variable (DRG 106).

Table 7-12

OLS Regression Results: Total and Post Operative Length of Stay

	Total Length of Stay						Post-Operative Length of Stay	
	Model 13		Model 14		Model 15		Model 16	
Variable	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
INTERCEPT	12.840 ***	0.00	9.961 ***	0.00	9.355 ***	0.00	7.891 ***	0.00
HOSPITAL A	0.433 **	0.03	0.171	0.40	0.148	0.43	-0.091	0.58
HOSPITAL B	-1.513 ***	0.00	-1.073 ***	0.00	-0.769 ***	0.00	-0.384 ***	0.00
HOSPITAL D	1.820 ***	0.00	1.948 ***	0.00	2.041 ***	0.00	0.787 ***	0.00
HOSPITAL E	-1.780 ***	0.00	-1.500 ***	0.00	-1.075 ***	0.00	-0.447 **	0.02
HOSPITAL F	0.130	0.50	0.427 **	0.04	1.246 ***	0.00	1.953 ***	0.00
HOSPITAL G	-2.277 ***	0.00	-1.676 ***	0.00	-0.805 ***	0.00	-0.585 ***	0.00
START DEMO	-0.059 ***	0.00	-0.074 ***	0.00	-0.077 ***	0.00	-0.060 ***	0.00
URGENT	-	-	1.330 ***	0.00	1.410 ***	0.00	0.225 **	0.03
MI2WEEK	-	-	0.371 ***	0.00	0.172	0.14	0.072	0.49
PREVCABG	-	-	0.612 ***	0.00	0.454 ***	0.00	-0.055	0.67
DRG 106	-	-	1.630 ***	0.00	1.541 ***	0.00	0.093	0.27
CHF	-	-	1.519 ***	0.00	1.400 ***	0.00	0.641 ***	0.00
DIABETES	-	-	0.806 ***	0.00	0.631 ***	0.00	0.501 ***	0.00
RENAL	-	-	1.465 ***	0.00	1.118 ***	0.00	0.480 ***	0.00
COPD	-	-	0.736 ***	0.00	0.484 ***	0.00	0.320 ***	0.00
STROKE	-	-	0.851 ***	0.00	0.701 ***	0.00	0.483 ***	0.00
HYPER	-	-	0.333 ***	0.00	0.149	0.13	0.061	0.49
AGE 65-69	-	-	-0.121	0.55	0.025	0.89	0.154	0.33
AGE 70-74	-	-	0.478 **	0.02	0.536 ***	0.00	0.599 ***	0.00
AGE 75-79	-	-	0.879 ***	0.00	0.895 ***	0.00	1.023 ***	0.00
AGE 80+	-	-	1.498 ***	0.00	1.226 ***	0.00	1.181 ***	0.00
SEX	-	-	0.463 ***	0.00	0.501 ***	0.00	0.376 ***	0.00
BSA			0.026	0.84	-0.133	0.24	-0.031	0.76
IABP	-	-	0.215	0.44	0.477 *	0.06	0.693 ***	0.00
ARTERY70	-	-	0.017	0.75	0.039	0.43	0.050	0.25
LVEF ≤35%	-	-	0.412 ***	0.00	0.311 **	0.01	0.123	0.27
REOPBLD	-	-			1.594 ***	0.00	1.350 ***	0.00
POAMI	-	-			0.244	0.52	0.121	0.72
INFECTION	-	-			6.494 ***	0.00	6.556 ***	0.00
STROKECMP	-	-			2.478 ***	0.00	2.366 ***	0.00
PULMONARY	-	-			3.304 ***	0.00	3.229 ***	0.00
RENALCMP	-	-			3.136 ***	0.00	3.175 ***	0.00
VASCULAR	-	-			-0.039	0.92	0.145	0.68
OTHERCMP					3.026 ***	0.00	3.185 ***	0.00
DDEAD	-	-			-5.284 ***	0.00	-5.291 ***	0.00
R-Squared	0.07		0.16		0.3		0.3	
Mean	10.50 days		10.50		10.5		8.53	
No. Observations	10,438		10,004		10,004		10,004	

NOTE: *** = significant at 1% level
** = significant at 5% level
* = significant at 10% level

SOURCE: Abstracts of clinical records from the demonstration hospitals, May 1991 through June 1996.

Hospital C, under-65, uncomplicated patients are included in the intercept. Ordinary least squares was used as the estimation method.

In Model 13, only the hospital the patient was treated in and the month of surgery relative to the hospital entering the demonstration (embedded in the STRTDEMO variable) are controlled for. The results indicate that two hospitals in the model had significantly longer lengths of stay than Hospital C beginning the demonstration; Hospital A's stays were 0.43 days longer and Hospital D's stays were 1.8 days longer. Three hospitals had significantly shorter lengths of stay than Hospital C: Hospital B's stays were 1.5 days shorter, Hospital G's stays were 2.3 days shorter, and Hospital E's stays were 1.8 days shorter. Hospital F had similar lengths of stay as compared with Hospital C. These results are consistent with data displayed in Figure 7-11.

The monthly trend coefficient, equal to -0.06, implies that patients discharged ten months after the beginning of the demonstration had average stays that were 0.6 days shorter than those discharged in the demonstration's first month. Extended across the full period of our clinical data base from June 1991 through December 1996, i.e., roughly 60 months, the average reduction in lengths of stay across all the original demonstration hospitals was 2.6 days. For the three hospitals that entered the demonstration mid-way, the average reduction in lengths of stay across all these hospitals would be just under two days. This trend is highly significant.

In Model 14, DRG and other patient characteristics are controlled for, but not complications. Controlling for patient characteristics and DRG actually raises the trend

coefficient modestly (to -0.07), implying that factors in the hospitals' case mix leading to longer stays became more frequent over the demonstration period. When multiplied by 60 months, the point estimate of the case mix-adjusted length of stay fell by 4.2 days.

Compared to DRG 107, DRG 106 patients remained hospitalized 1.63 days longer, even after controlling for patient demographics, co-morbid conditions, and disease anatomy. All eight co-morbid conditions added to stays relative to less complicated patients. Both congestive heart failure and renal failure added about 1.5 days to the hospital stay.

Compared to the under-65 Medicare eligibles, patients aged 70 and older experienced longer stays. Length of stay rose monotonically with age with patients over 80 staying 1.5 days longer, *ceteris paribus*. Females stayed approximately one half day longer than males, regardless of age.

Patients admitted as urgent stayed 1.3 days longer. Interestingly, emergent cases did not demonstrate a sufficiently strong correlation with length of stay to warrant inclusion in Model 14. This may be a reflection of extreme clinical variance in the types of cases defined as emergent; ranging from extremely ill patients who die early in the hospitalization to those for whom the designation was given to obtain a hospital bed. A patient having an MI within two weeks before admission appears to lengthen stay by about one-third of a day. On the other hand, if a patient had had a previous bypass, their stay was lengthened by roughly two-thirds of a day.

Three variables describing disease anatomy and severity affected lengths of stay differently. The number of coronary arteries with 70 percent or more stenosis and pre-

operative use of an IABP did not increase total length of stays. In contrast, patients with ejection fractions 35 percent or less stayed on average about one half day longer than those with higher ejection fractions.

Controlling for patient demographics, co-morbid disease, clinical presentation, and disease anatomy increased the equation's explanatory power from 7 percent to 16 percent. This reflects the fact that variations in patient lengths of stay depend more on individual patient risk factors than in which hospital or in which month of the hospital's participation in the demonstration a patient received their surgery.

Model 14 only controls for those characteristics that precede the bypass surgery and are assumed to be unaffected by provider behavior. In Model 15, complications related to the bypass surgery, including death, are included. The bi-variate relationships between presence of complication and length of stay are displayed in Table 7-13. Across all hospitals, patients with post-operative complications have longer lengths of stay. This trend does not hold for in-hospital death; not surprisingly, these patients have lower average lengths of stay than patients discharged alive.

As expected, inclusion of the post-operative complication variables in Model 15 doubles the explanatory power of the model compared with just controlling for pre-operative factors. Six of the eight post-operative complication variables were found to be highly significant; only post-operative acute myocardial infarction and vascular complications did not seem to add to days of the stay. The proportion of cases that had these complications were very small. Infections, pulmonary complications, renal complications, strokes, and

Table 7-13

Comparison of Average Lengths of Stay for Medicare CABG Demonstration Patients With and Without Complications By Hospital

		Total (N=10,556)		Hospital A (N = 1,256)		Hospital B (N = 3,598)		Hospital C (N = 1,977)		Hospital D (N = 754)		Hospital E (N = 753)		Hospital F (N = 1,485)		Hospital G (N = 733)	
		DRG 106	DRG 107	DRG 106	DRG 107	DRG 106	DRG 107	DRG 106	DRG 107	DRG 106	DRG 107	DRG 106	DRG 107	DRG 106	DRG 107	DRG 106	DRG 107
Complications	(YES)	14.1	12.1	14.7	10.9	13.5	12.0	14.1	11.8	16.6	15.2	12.6	10.8	13.7	14.0	14.4	11.9
	(NO)	10.6	8.6	12.6	9.0	8.8	7.7	11.0	8.5	12.8	8.9	9.8	8.7	11.8	10.9	9.7	7.8
Reoperation	(YES)	16.1	14.5	18.5	13.3	13.3	11.3	15.3	12.6	17.7	19.1	13.6	13.4	18.2	18.2	20.0	12.5
	(NO)	11.2	9.4	14.1	10.6	10.1	8.7	11.9	9.3	13.7	13.0	10.4	9.0	11.7	11.0	10.1	8.2
MI Presenting New Q-waves	(YES)	12.7	11.8	16.4	12.4	0.0	13.7	12.3	10.5	17.3	0.0	11.7	9.4	12.3	13.1	0.0	20.0
	(NO)	11.6	9.5	13.4	9.6	10.2	8.8	12.1	9.4	14.0	10.6	10.6	9.3	12.2	11.6	10.3	8.2
Infection	(YES)	19.2	18.0	20.9	14.4	20.2	19.3	14.4	13.1	23.2	21.8	14.1	33.0	20.8	21.0	0.0	16.0
	(NO)	11.3	9.3	13.0	9.5	9.6	8.3	12.0	9.3	13.6	10.1	10.6	9.1	12.0	11.3	10.4	8.3
Neuro. Comp.	(YES)	14.9	12.2	13.9	10.3	16.8	15.2	15.1	13.5	23.3	19.2	12.1	10.4	0.0	0.0	16.5	15.8
	(NO)	11.3	9.3	10.0	9.4	9.8	8.5	11.8	9.1	13.6	10.2	10.3	9.0	12.2	11.6	10.0	8.0
Pulmonary Comp.	(YES)	15.8	13.7	20.2	15.0	14.6	13.0	15.7	13.5	20.2	17.1	15.2	14.1	14.5	14.6	18.9	10.9
	(NO)	11.1	9.1	12.9	9.3	9.4	8.2	11.6	8.9	13.4	10.0	10.4	9.1	11.9	11.2	9.8	8.1
Renal Failure	(YES)	15.6	17.5	17.5	17.0	17.9	18.8	14.5	13.6	16.5	20.5	17.7	25.0	11.9	24.5	0.0	13.9
	(NO)	11.5	9.4	13.4	9.6	10.0	8.7	11.9	9.2	13.9	10.4	10.5	9.1	12.2	11.5	10.3	8.3
Vascular Comp.	(YES)	13.3	11.9	0.0	16.0	0.0	0.0	14.9	10.4	14.8	18.4	12.7	9.4	12.8	16.8	0.0	15.0
	(NO)	11.6	9.5	13.5	9.6	10.2	8.8	12.0	9.4	14.0	10.5	10.3	9.3	12.2	11.5	10.3	8.3
DEATH	(YES)	9.6	9.5	8.4	8.0	10.1	9.3	10.2	11.7	8.7	10.0	9.6	10.0	8.9	9.1	14.3	4.0
	(NO)	11.8	9.6	13.8	9.7	10.2	8.8	12.2	9.3	14.3	10.6	10.7	9.3	12.7	11.8	10.3	8.4

SOURCE: Abstracts of clinical records from seven demonstration hospitals, May 1991 through June 1996. Hospitals E,F, and G entered the demonstration two years after the others.

re-operation for bleeding added 6.5, 3.3, 3.1, 2.5, and 1.6 days, respectively, to the average stay. Post-operative complications, other than those specifically listed in the clinical data, added 3 days to the average stay.

Patients dying in the hospital after bypass surgery had much shorter stays, 5.3 days less than survivors. Most likely, average stays for patients who die in the hospital exhibit a bimodal distribution with some having short and others very long stays. The large negative coefficient, however, is interpreted as the impact of dying on length of stay after controlling for co-morbid disease, age, and other complications.

If one assumes that all complications are unrelated to the quality of care received in any hospital, they can be interpreted as additional controls for case mix severity across demonstration hospitals. Comparing the hospital coefficients for Models 14 and 15 show modest change. Average lengths of stay differences between the included hospitals and Hospital C tend to moderate, the primary exception being Hospital F whose length of stay increased from 0.43 days longer than Hospital C's to 1.3 days longer. As in the in-hospital and one-year mortality analyses, including the set of complications variables worsens Hospital F's performance relative to Hospital C. The same effect is seen for Hospital G, although its stay is still .8 days shorter than Hospital C.

Controlling for complications, the time trend coefficient becomes even more negative, implying even greater reductions in lengths of stay once intertemporal differences in complication rates are held constant.

Controlling for complications negates the impact that having had an AMI within two weeks of the CABG surgery has on length of stay. In contrast, pre-operative use of an IABP becomes statistically significant, probably because of its association with the higher likelihood of dying. It's estimated impact is to increase length of stay by roughly one-half of a day.

Complications almost always extend a patient's stay. Thus, controlling for them in Model 15 should reduce the size of other positive coefficients that are associated with complications, and vice-versa, if they are negative. For example, the coefficients for many of the co-morbid conditions are reduced. On the other hand, co-morbid disease patients are also more likely to die in the hospital (correlation coefficients with death are positive), which should raise their effects on length of stay if discharge status is not controlled for. The fact that the coefficients for the co-morbid diseases fall when complications and death are included implies that, overall, the presence of co-morbid diseases lengthen stays in spite of shortening stays significantly for the few patients who die in the hospital. The same argument is true for patients undergoing their second CABG. Very similar effects are observed for patient age, i.e., greater age has less of an effect in prolonging stays once complications are controlled for.

Of course, if complications are assumed to be the result of the care received while hospitalized, then controlling for them would be inappropriate in evaluating hospital differences and trends in lengths of stay. If, for example, one hospital exhibited a relatively long stay that disappeared once its high complication rate was accounted for, it would be

wrong to conclude it did not have, in fact, a longer-than-average stay. As it turns out, controlling for complication rates does not alter the basic conclusions of Model 15, which are (a) there is variation in lengths of stay across most of the hospitals, even after controlling for case mix severity differences, and (b) the downward trend in length of stay is unrelated to changes in the complication rates.

Model 16 presents results on a narrower definition of stays; namely, the time between surgery and discharge. Prior expectations are that pre-operative variables should be less important while post-operative complications should increase in relative importance, if not in absolute value. This hypothesis is borne out somewhat in the comparison of Model 16 with Model 15. Many of the variables found to be significant in explaining total days of stay exert somewhat less of an effect on length of stay in the post-operative period. These include most notably such variables as urgent status, DRG, having had a previous CABG or an MI within two weeks. Post-operative stays average roughly three-quarters of a patients's total stay on average for cases assigned to DRG 106 and almost 90 percent of a patient's total stay on average for cases assigned to DRG 107. Hence, variables with similar coefficients in Models 15 and 16 have a substantially greater impact on post-operative versus total stays depending upon which denominator is used.

Comparing the hospital coefficients for Models 15 and 16 isolate the source of the differences in longer stays. As with total stays, post-operative lengths of stay differ between Hospital C and all other hospitals, except Hospital A. When the short-stay Hospital C is compared to Hospital B by segment of the stay, the 0.8 day difference in average total stays

is found to be made up by a 0.38-day portion after the bypass operation and a 0.41-day portion (= 0.77 - .36) prior to the operation, holding DRG mix and many other factors constant. In other words, the shorter stays in Hospital B relative to C are due 53 percent to pre-surgical days and 47 percent to post-surgical days. Similar decompositions can be done for the remaining hospitals.

Model 16 also provides information on the decline in post-operative portions of patient stays. The negative trend coefficient of -0.06 implies that after sixty months in the demonstration, the "average" patient discharged in June 1996 experienced a 3.6-day shorter post-operative stay compared with similar patients discharged in the demonstration's first month in June 1991, holding other factors constant. The decline in overall stays from Model 15 is estimated to be 4.8 days. Thus, roughly 75 percent of the reduction in overall average stays has come from shortening the time between bypass surgery and discharge.

7.8 Re-admissions Within 90 Days of CABG Surgery

One of the most widely used outcome measures for surgical care in the Medicare population is the rate of readmission following major surgery. Patients readmitted shortly after discharge (e.g., within 90 days of surgery) is viewed as a poor outcome when evaluating hospital performance. Estimating readmission rates as a function of time since surgery provides an opportunity to identify complications and other untoward clinical events that occurred after discharge but that might not be captured in the clinical data base due to shortened lengths of stay. Thus, variations in complication rates, including re-operation,

could vary across demonstration sites simply as a function of the follow-up period captured in the clinical data base.

One way in which hospitals can reduce costs under the bundled payment demonstration is to discharge patients earlier. In Section 7.7, such a trend in reduced lengths of stay was observed for the demonstration sites. Because of this trend, we observe less of the post-operative course of the patient in the hospital at the end of demonstration than we do at the beginning of the demonstration. Using Medicare claims data for the Medicare CABG patients, however, allows us to examine the post-surgery period that extends beyond discharge.

Table 7-14 reports comparisons of 90-day post-CABG readmission rates between the seven demonstration hospitals and competitor hospitals within each of their respective market areas for the years 1994 and 1995, unadjusted for case mix. These two years were selected in order to focus on the shortest average lengths of stay within the demonstration. Medicare hospital discharge records from the 1994 and 1995 MedPAR files were used to construct this table. For each of the seven demonstration hospitals, all hospitals located within the market area were selected for this comparative analysis. Readmission rates are defined as the number of patients who had at least one readmission during the year. No consideration is given to multiple readmissions for the same patient. The readmission need not have been to the same hospital at which the surgery was performed. Pairwise t-tests were conducted between the demonstration sites and their respective market area hospitals for each year.

Table 7-14

Comparison of Proportion of Cases Readmitted Within 90 Days of CABG Surgery: Demonstration Hospitals vs. Competitor Hospitals

	1994				1995			
Hospital	N	Readmission Rate	t-test		N	Readmission Rate	t-test	
Hospital A	247	0.43			284	0.48		
Market A	2851	0.41	*-0.61*		2999	0.41	*-2.26*	**
Hospital B	738	0.26			758	0.24		
Market B	1159	0.29	*1.43*		1253	0.25	*0.51*	
Hospital C	423	0.24			418	0.25		
Market C	2634	0.30	*2.65*	***	2738	0.30	*2.18*	**
Hospital D	145	0.30			181	0.27		
Market D	2631	0.30	*0.00*		2897	0.28	*0.29*	
Hospital E	497	0.40			391	0.31		
Market E	428	0.21	*-6.44*	***	417	0.25	*-1.90*	*
Hospital F	603	0.29			513	0.30		
Market F	1126	0.31	*0.87*		1198	0.30	*0.00*	
Hospital G	330	0.25			305	0.25		
Market G	1119	0.33	*2.89*	***	1176	0.29	*1.42*	

NOTE:
*** indicates significance at the .01 level, ** at the .05 level, and * at the .10 level.
test of proportions significance levels (two-tailed test):
1 percent: Z>2.33
5 percent: Z>1.96
10 percent: Z>1.65

SOURCE: 1994 and 1995 Medicare MedPAR records.

According to Medicare claims data, the overall readmission rate among all CABG patients in all hospitals across the nation was 32 percent in 1994 and 31 percent in 1995. The demonstration sites collectively experienced 30 and 28.9 percent readmission rates over the two year period, respectively. In contrast, hospitals in the demonstration sites' adjacent market areas experienced readmission rates of 32.6 in 1994 and 31.4 percent in 1995. Readmission rates ranged from 24 percent at Hospital C to 43 percent at Hospital A for the demonstration sites, and from 21 percent in Market area E to 41 percent in Market area A.

In 1994, Hospitals C and G have significantly lower readmission rates than competitor hospitals in their respective market area; Hospital C experienced a 24 percent readmission rate in comparison to its competitor hospitals who collectively experienced a 30 percent readmission rate. Hospital G experienced a 25 percent readmission rate in comparison to its competitor hospitals who collectively experienced a 33 percent readmission. Only Hospital E had a statistically significant higher readmission rate than its competitor hospitals, 40 percent versus 21 percent. The remaining hospitals had no statistically significant differences in their readmission rates as compared to their competitors.

By 1995, the gap between Hospital E's readmission rate as compared with its competitors' readmission rate had narrowed but remained statistically significant (31 percent vs 25 percent). In addition, Hospital A experienced an increase in its readmission rate (from 43 to 48 percent) not observed in other bypass hospitals in its market area. The difference between Hospital A's readmission rate versus its competitor hospitals becomes statistically

significant at the five percent level. The readmission rate differential between Hospital G and competitor hospitals in its market area disappears in 1995 (25 percent vs. 29 percent), but remains statistically significant for Hospital C relative to its competitor hospitals at the 5 percent level (25 percent vs 30 percent).

The key findings from this analysis are:

- readmission rates were lower in the demonstration hospitals as a group relative to competitor hospitals.
- Readmit rates were not uniformly lower across all of the demonstration sites.