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Managed Care, Adoption of Cardiac Care Technologies, and Health of AMI Patients

Laurence C. Baker, Ph.D.*
Chris Afendulis, Ph.D.**

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Abstract

Managed care may influence technology diffusion in health care. This paper empirically examines the relationship between HMO market share and the diffusion of cardiac care technologies including cardiac catheterization, percutaneous transluminal coronary angioplasty (PTCA), and coronary artery bypass graft (CABG) surgery. Higher HMO market share is associated with slower adoption of PTCA and CABG. Further evidence from data on patient treatment patterns and outcomes suggests that limiting the availability of these services reduces the probability that a heart attack patient will receive potentially beneficial intensive treatments.

*Stanford University and the National Bureau of Economic Research. Email: laurence.baker@stanford.edu. Mailing address: the Department of Health Research and Policy, HRP Redwood Building, Rm 110, Stanford University, Stanford, CA 94305-5405

**Stanford University and the National Bureau of Economic Research. Email: afenduli@stanford.edu. Mailing Address: Department of Health Research and Policy, Stanford University, Stanford, CA 94305-5405.

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1. Introduction

For many years, the health care financing system in the U.S. generously compensated the development and use of new medical technologies, fueling continual advances that produced often-valuable benefits for patients as well as persistently increasing medical costs (Aaron, 1991; Newhouse, 1992; Fuchs, 1996; Weisbrod, 1991; Cutler and McClellan, 2001). Over the past couple of decades, however, more stringent payment regimes and attempts to limit the use of some new technologies have arisen, eroding some of the incentives that encouraged technological advances. In particular, growth in managed care has often led to reduced payments for providers and attempts to reduce spending for high cost services (e.g. Chernew et al., 1998), particularly new technologies at the most advanced institutions.

Previous studies suggest that managed care activity is associated with slower adoption of new technologies. Cutler and Sheiner (1998) studied a wide range of hospital-based technologies and found evidence that hospitals in states with higher HMO market share had slower rates of adoption of some technologies during the 1980s and 1990s. Work on MRI adoption and use finds that areas with high HMO market shares adopted MRI more slowly than low market share areas during the 1980s and 1990s (Baker, 2001; Baker and Atlas, 2004; Baker and Wheeler, 1998). Baker and Phibbs (2002) reported that high HMO areas adopted NICUs more slowly than low market share areas.[1]

Managed-care-induced changes in technology availability could have important impacts on health care costs as well as treatment patterns and outcomes, and thereby on social welfare. Though it seems plausible to infer the potential for reduced costs via reduced technology

[1]Though the evidence is not unanimous. Baker and Spetz (1999) used an index of hospital technological advancement and did not find evidence of an overall effect on managed care on hospital technology adoption.

adoption from existing work, the size and direction of changes in treatment patterns and outcomes are less clear. One study of which we are aware, Baker and Phibbs (2002), links managed-care induced changes in NICU adoption to changes in treatment patterns for newborns, suggesting the potential for improved outcomes with reduced NICU diffusion. While instructive, it seems likely that effects on treatments and outcomes could vary from technology to technology, complicating extrapolation. Developing a stronger understanding of the impacts of managed-care-induced changes in technology adoption on patient care and outcomes will require analyses of a broader range of technologies.

This paper investigates the relationship between managed care activity and the adoption of cardiac care technologies. These technologies are useful to study for several reasons. A substantial portion of their diffusion occurred during the 1980s and early 1990s, a time period in which managed care played an active role in the health care system in some areas. Since setting up and using these technologies is expensive, and since managed care plans often attempt to reduce their spending on expensive advanced services and may more generally limit the resources available to hospitals to subsidize equipment purchases, growth in managed care could influence their adoption. Finally, studying cardiac care provides a strong chance to learn about the implications for patient care. Good data on the care of heart attack patients is available, and research shows that new technologies can have important impacts on outcomes (Cutler and McClellan, 1996; Cutler, McClellan, and Newhouse, 1998).

We empirically examine the impact of HMO market share on the diffusion of three cardiac technologies over the period 1985-2000 using proportional hazard models. We find evidence that areas with high HMO market shares, as compared to low market share areas, were more likely to adopt some limited cardiac care technologies than to have no cardiac care capability, but less likely to adopt the full set of services we study. To study the effects on outcomes, we use detailed data on fee-for-service Medicare patients with heart attacks (acute myocardial infarctions, or AMIs) between 1985 and 2000 and find evidence consistent with the view that the changes in technology availability that we see associated with increasing HMO market share could be associated with worse outcomes.

This work builds on a large literature that provides support for the idea that growth in managed care could affect the health care system. Managed care appears associated with the health care patients receive, which may be a reflection of technology availability (e.g. Heidenreich et al., 2002; Baker and McClellan, 2001; Bundorf et al, 2004; Meara et al, 2004),[2] as well as with health care spending and health insurance premiums.[3] Managed care appears associated with financial incentives for hospitals. For example, Chernew et al (2002) studied hospital provision of CABG services in California, and found that the returns to providing CABG services vary by payer, with HMOs among the less generous payers. Finally, there is a well developed literature on the adoption and diffusion of technologies in a variety of sectors including health care,[4] which consistently suggests that changes in the profitability of a new technology and other environmental factors are important determinants of adoption patterns.

2. Managed care activity and the adoption of new technologies

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[2]Though not all literature finds associations. Keating et al (2005, 2006) studied cancer patients and found no relationship between HMO market share and treatment patterns.

[3]For example, Baker (1997, 1999), Baker and Corts (1996), Feldman, Dowd, and Gifford (1993), Goldberg and Greenberg (1979), Wickizer and Feldstein (1995), Chernew (1995), Feldman et al. (1986), McLaughlin (1987, 1988), Noether (1988), Robinson (1991, 1996), Welch (1994).

[4] See, e.g. Mansfield (1968) or Reinganum (1989), for general reviews. Some studies of health technology adoption are Anderson and Steinberg (1984), Baker (1979), Banta (1980), Cutler and McClellan (1996), Fendrick et al. (1994), Globerman (1982), Hillman and Schwartz (1985), Hillman et al. (1984), Lee and Waldman (1985), Romeo, Wagner, and Lee (1984), Salkever and Bice (1976), and Russell (1977).

Before the advent of managed care, health insurers typically paid health care providers using fee-for-service reimbursement and exercised little oversight of treatment decisions made by patients and their doctors. The desire of patients and physicians for ever more advanced (and costly) health care, coupled with the readiness of third party payers to meet the costs of providing it, generated ample encouragement for speedy technological advancement (Weisbrod, 1991).

"Managed care" describes a collection of health plan activities designed to reduce the high levels of utilization and spending that accompanied unfettered fee-for-service medicine. Rather than paying on a fee-for-service basis, many managed care plans use reimbursement mechanisms that reduce or eliminate the rewards associated with performing more, and more expensive, treatments. Managed care plans also often assert control over some of the treatment decisions made for patients by, for example, requiring authorization before conducting expensive tests and procedures, monitoring the use of resources by providers, or using gatekeeper physicians who must approve all referrals to specialists. Finally, managed care plans typically selectively contract with providers, and may both favor low-cost providers and attempt to exploit their control over increasing numbers of patients against any surpluses of health care providers they encounter to extract concessions. The belief on the part of plans appears often to be that fee-for-service medicine was characterized by excessive use of expensive tests and procedures, and they have frequently focused their attention on curbing the use of these services and reducing the amount they pay for them (Miller and Luft, 1997).

Growth in managed care could influence the incentives associated with adopting a new technology in several ways. First, managed care could change expectations about the effect adoption would have on a firm's discounted profit stream. Models of technology adoption frequently suggest that changes in expected profitability will change adoption timing (see, e.g., Reinganum, 1989, or Rose and Joskow, 1990, for discussions). Typically, models suggest that firms with higher profit expectations will tend to adopt earlier than firms with lower projections. If managed care reduces the expected profitability of a new technology, firms in high managed care areas will tend to adopt later than otherwise identical firms in areas with less managed care, or perhaps not adopt at all.

Increases in HMO market share could impact expected profits from adoption through effects on expected prices. HMOs are often assumed to have elastic demand and bargain aggressively to obtain low prices, as opposed to FFS patients with little incentive to incorporate price into their decisionmaking. Price discriminating providers may thus be expected to set per-service prices lower for services they sell to HMOs and their patients, so that moving more patients to HMOs would reduce revenues. HMOs could also affect the quantity of care provided. HMOs are sometimes thought to discourage their members from using technologies and services they view as excessive, and may encourage the use of care they view as cost effective.

The presence of HMOs in a market may influence demand even from non-HMO patients. For example, HMOs use various mechanisms to encourage physicians working for them to practice in accordance with the organizations' preferences, which might include reducing use of expensive new technologies. These physicians may incorporate changed practice patterns when they care for non-HMO patients. Alternately, as managed care activity increases, the competitive pressure felt by traditional insurers may also increase, leading to changes in the kinds of services they cover (e.g., Baker and Corts, 1996; Feldman and Dowd, 1986; Frank and Welch, 1985; Goldberg and Greenberg, 1979). In the case of expensive new technologies that are not clearly cost-effective, one would expect the impact of managed care to be to slow adoption through both reductions in prices and reductions in demand.

The full effect of a new technology on profitability must also incorporate effects on other services, for which a new technology may be a substitute or complement. If the presence of managed care shifts patterns of use of substitutes or complements, growth in managed care could affect profitability projections. Adopting new technologies has also been viewed as a general way of improving the image of a hospital and attracting business. Under fee-for-service, doctors and patients frequently selected hospitals with the most advanced technologies, even if they only needed relatively simple services. Selectively contracting managed care plans seem to make decisions about the providers their members will use in very different ways. Although they might value the presence of technologies in deciding which hospitals to contract with, managed care plans also place weight on costs, so that adopting new technologies that raise the contract price a hospital could offer would have disadvantages as well.

Some literature on technology adoption stresses the importance of strategic interactions between firms (e.g. see Vogt, 1997). The specific assumptions and focus of strategic interaction models, and hence their predictions for diffusion processes, vary from model to model, but the importance of these factors is increasingly clear. Most models focus on the returns to being the first adopter in a market and the incentive for a firm to delay after a rival has adopted. It is not difficult to believe that managed care could influence strategic interactions, although it is difficult to predict the direction of the effect. If the providers that initially win managed care contracts have an advantage in negotiations in subsequent years, and HMOs value the presence of a NICU in the choice of providers to contract with, growth in managed care could increase the premium associated with first adoption. Rivals of the first adopter might then perceive that they should immediately adopt, leading to rapid adoption throughout the market. On the other hand, rivals could perceive that the opinions of managed care plans with respect to the quality of hospitals will have been formed based on the initial adoption so that there is little to be gained by subsequent adoption, and choose to postpone adoption which would raise the mean time to adoption as HMO market share rises. In formal modeling, the direction of the strategic effects would depend on the specific assumptions about the preferences of managed care organizations, and the expectations of hospitals about the returns to various adoption scenarios.

There are a range of other possible effects of HMO activity that could come through a variety of channels. For example, HMO activity that reduced revenues from many services could have influenced the overall financial position of hospitals, which could easily have affected the internal resources available to support investments in new services and their ability to raise capital externally. The uncertainty associated with being in an environment where HMO activity was growing may also have led to changes in technology adoption patterns.

Although these theories make clear the potential for managed care growth to impact technology diffusion in health care, in the case of cardiac technologies (and most technologies), it is not clear *a priori* which way each of these effects would go or which would be most important, leaving the net impact of managed care on adoption patterns theoretically ambiguous.

3. Cardiac Care Technologies

We investigate the relationship between HMO market share and adoption of three major intensive technologies associated with cardiac care. The first is cardiac catheterization, a procedure that can detect whether blood flow to the heart has been significantly blocked. Diagnosing such blockages may suggest the need for revascularization procedures to restore blood flow. The second two technologies we study are important revascularization procedures: percutaneous transluminal coronary angioplasty (PTCA), and coronary artery bypass graft surgery (CABG). A hospital's decision to adopt any one of these costly technologies will involve significant capital investment, as well as the employment of specially trained physicians and nurses. Catheterization and CABG were developed in the 1960s, while PTCA came into use into the 1970s. From the early 1980s to the present, all three technologies have experienced significant increases in use.

Two important relationships between these technologies influence the patterns with which they are adopted. First, similar equipment is used for both catheterization and PTCA. Second, it is also commonly expected that hospitals performing PTCA will have the capability to perform CABG surgery in case of difficulties during a PTCA procedure. In part because of these relationships, three patterns of adoption are most frequently observed across hospitals. First, some hospitals will not adopt any of the three technologies. Second, some hospitals will adopt a catheterization capability to diagnose patients, but will choose not to adopt either of the two revascularization capabilities. Though these hospitals could fairly cheaply add a PTCA capability, the requirement that PTCA hospitals also have at least backup CABG facilities would provide a reason to adopt only catheterization. Third, hospitals may choose to offer all three services to their patients. One would seldom expect to see hospitals with the more advanced revascularization capabilities that had not also adopted the diagnostic catheterization capability as well.

4. Analysis of Market share and the diffusion of cardiac technologies

4.1. Cardiac technology data

To form our analysis sample, we first identified the 4,290 Medicare-certified, non-federal general medical and surgical hospitals in the continental United States that were observed in Medicare claims data in 1985.[5] Facilities in rural areas may behave quite differently than hospitals in other areas, so we excluded 1,417 hospitals located outside of Metropolitan Statistical Areas (MSAs). We also excluded 225 hospitals with missing data for one of more of the analysis variables, leaving us with an analysis sample of 2,648 hospitals.

We used Medicare claims files containing detailed information on all FFS Medicare patients admitted to hospitals between 1985 and 2000 to identify the year in which each hospital adopted each of the three technologies. For each hospital, we first identified the first 365 day period within which we observed 10 patients receiving the procedure. We then defined the year of adoption as the year in which the first of these 10 procedures was observed. Hospitals that could not be followed all the way from 1985 to 2000 were treated as censored.[6] We do not attempt to account for hospitals that shut down a service, which appears to occur only rarely.

Three adoption states are most commonly encountered in the data. Among the 2,011 sample hospitals that are not censored by 2000, 483 appear in 2000 with none of the three, 619 appear with catheterization only, and 830 appear with all 3 technologies. Together, these account for 96% of the hospitals. 77 hospitals appear in the data as if they have catheterization and PTCA capabilities but no CABG capability. We expect that these hospitals would have had at least a backup CABG capability, but it is plausible that it would not have appeared in the data

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[5] The restriction that the hospitals had to be in 1985 eliminates some hospitals that are only observed beginning in subsequent years. The majority of these hospitals are the entities that resulted from hospital mergers.

if there were no emergencies that arose in their use of PTCA. Two hospitals appear as if they have catheterization and CABG capabilities but no PTCA capability. Though technically possible, we find this combination odd since the equipment needed for PTCA is very similar to that used for catheterization, and these hospitals would have had the needed backup CABG capability. For analysis, we coded these 79 (and the small number of analogous cases in other years) as having all three technologies.

Table 1 summarizes information about the number of hospitals observed by year, and technology adoption patterns. Figure 1 plots the share of observed hospitals in each year in each of the three adoption states. Figure 2 plots the share of observed hospitals making transitions between the adoption states in each year. Over time, the number of hospitals observed falls by about 600, consistent with overall trends in the hospital industry over this period. The primary transitions observed in the data are from having none of the three to having catheterization only, and from catheterization only to having all three. The numbers of transitions from none to all and none to catheterization only are high in 1985, capturing all transitions that occurred in and before 1985. Thereafter, in the average year 4.7% of the hospitals with none of the technologies will transition to having catheterization only and about 4.5% of hospitals with catheterization only will transition to having all three technologies. Transitions from having none of the three to having all of the three are rare. On average, only about 0.2% will transition directly to having all 3 technologies, and most of these are observed in the early years of the sample. No none-to-all transitions are observed in 1991, 1992, 1994, 1996, 1997, or 1999.

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[6] The primary reason for censoring was hospital closure or merger. Merged hospitals were treated as censored because the behavior of a merged entity might be quite different than the behavior of each constituent hospital, so assigning adoption information from a merged entity to each of the constituent hospitals seemed inappropriate.

The number of hospitals with all three technologies increases noticeably, from 23% of observed hospitals to 45%. The number of hospitals with catheterization only rises with transitions from none to catheterization only and falls with transitions from catheterization only to all three. The share of observed hospitals with catheterization only rises from 21% in 1985 to a high of 32% in the late 1990s, and then falls back slightly. The share of hospitals with none of the 3 technologies falls from 56% to 24%.

4.2. HMO market share data

We measure the level of managed care activity in each hospital's metropolitan statistical area (MSA) using data on HMO market share (i.e., the percent of the population enrolled in HMOs). Though there are many types of health care plans that could conceivably exert influence on technology diffusion processes, we use HMO market share since good geographically detailed data on HMOs is available for the time period under study. We expect that focusing on HMO activity will not strongly bias the results since HMOs were by far the most prevalent form of managed care during much of the relevant time period, and thus HMO activity probably provides a good proxy for the general level of managed care activity at this time. Even in the more recent years that we study (up through 2000), the presence of HMOs is likely a good proxy for the overall presence of strong managed care organizations since HMOs tend to use more stringent utilization management and have been more aggressive in reducing payments to providers than other forms of managed care plans like PPOs.

Conceptually, at any given time, the decision about whether and when to adopt a technology should be a function of the current level of HMO market share and hospital expectations about future levels. Diffusion patterns up through 2000 should thus cumulatively be functions of the actual levels of market share in each year and the expectations about future levels held at times along the way. Measures of the expectations of hospital managers are not available. We classify MSAs based on the average market share over the years 1990-1999. We expect this to be a reasonable proxy for actual and expected HMO market shares during the 1980s and 1990s for two reasons. First, areas that had high 1990s market shares also tended to have high market shares in other years. Second, areas that had high average 1990s HMO market shares also tended to have high growth in market share over the 1980s and 1990s (see Baker and Phibbs, 2001). If hospitals were able to forecast HMO growth in their areas with some degree of accuracy, hospitals in areas with high 1990s average market share would also have had higher expected future market share levels at any given time during the time period when the technologies we study were diffusing.

The estimates of market share we use were constructed using data from the Group Health Association of America (now the Association of American Health Plans) and Interstudy reports of total enrollment and counties served for all HMOs operating in the United States in each year 1990-1999. Using this data, county-level estimates were constructed by apportioning the enrollment of each HMO among the counties served based on county population and distance from HMO headquarters, and estimates for MSAs were constructed by aggregating the county-level estimates (Baker, 1997). The nationwide mean of the average 1990-1999 market share, weighted by population, is 22%. Across MSAs in the sample, average 1990-1999 market shares range from 0 to 56%. For purposes of modeling, we define areas with 0-10% average market share to be “low” market share areas, areas with 10-30% to be “medium” market share areas, and areas with market share over 30% to be “high” market share areas. About 15% of sample hospitals fall into the low market share category, about 65% fall in the middle category, and about 20% fall in the high category.

4.3. Hazard models of the relationship between HMOs and NICU diffusion

Models of the Adoption of All Three Technologies

We begin by considering the relationship between HMO market share and the probability that a hospital adopts all three technologies, leaving aside for the moment the potential for hospitals to adopt catheterization only as a sort of intermediate step between having none of the technologies and having all of them. Hazard models provide a natural framework for modeling adoption probabilities (e.g. Rose and Joskow, 1990; Cutler and McClellan, 1996; Baker, 2001). Denoting the cumulative probability that hospital i has adopted these technologies at a time t by $F_i(t)$ and the density function as $f_i(t)$, the hazard is defined as the probability that hospital i acquires the technologies at time t conditional on not having acquired it up to that point: $\lambda_i(t)=f_i(t)/[1-F_i(t)]$. We parameterize the hazard using a proportional hazard form: $\lambda_i(t)=\lambda_0(t)\ exp(x_i'\beta)$ where x_i denotes covariates that determine the proportionality in the hazard and $\lambda_0(t)$ is the baseline hazard. Since we observe the intervals within which the technologies are adopted rather than the exact time of adoption, we estimate parameters using the standard discrete-time formulation of the proportional hazard model:

(1) $\text{pr}(adopt_{i,j}) = 1–\exp(–\exp(\ \gamma_j + x_i\beta\ )$

where $\text{pr}(adopt_{i,j})$ is the probability that hospital i adopts in period j, and γ is a set of variables that capture the baseline hazard of adoption by period. We use a non-parametric specification for the baseline hazard (Prentice and Gloeckler, 1978).

We include dummies for areas with medium and high HMO market share. These are interacted with dummies for three time periods: 1985, 1986-1991 and 1992-2000 to allow the effect of being in a higher HMO market share area to vary over time. The 1985 interaction will capture pattern in adoption that occurred up to 1985. We do not expect HMO activity to have strong impacts on adoption that occurred up to that point. The 1986-1991 interaction will capture effects during a time when HMO activity was growing, but not reached it strongest. In 1992 and later, we expect HMO effects to be strongest.[7]

The models also include a set of hospital and other area characteristics as covariates in the models. Descriptive statistics are shown in Table 2. Included hospital characteristics are the average bed size of the hospital over the study period and dummies for hospitals that are members of the council of teaching hospitals and hospitals that otherwise have an affiliation with a teaching hospital. A set of area controls is designed to account for the degree of urbanization and includes the MSA population, MSA population per square mile, and the percent of the population that lives in an urban area. The models also control for the percent of the MSA population over age 65, the percent of the MSA population that graduated from high school and that graduated from college, and per capita income of the MSA population, as well as the per capita number of hospitals, generalists, total specialists, and cardiologists in the MSA. We measure all of the area variables as of 1985. Some models also include dummy variables for states. We compute robust standard errors, accounting for the potential for clustering by MSA.

Results are shown in Table 3. The first column presents results from the baseline model with no state dummies. There is no strong evidence for a relationship between HMO market

[7] Other similar specifications of the time periods, such as using only two time periods 1985-1991 and 1992-2000, or 1985-1992 and 1993-2000, produce generally consistent results.

share and adoption up through 1985. In the 1986-1991 period, the HMO market share coefficients are negative and the medium market share area coefficient is statistically significant.. In the 1992-2000 period, the HMO market share coefficients are negative and significant, indicating slower adoption in higher HMO market share areas. Medium market share areas have adoption hazards nearly 40% lower than low market share areas, and high market share areas have adoption hazards nearly 70% lower. Holding all covariates fixed at their sample means, these coefficients would predict an average annual adoption hazard in the 1992-2000 period of 1.9% in the low market share areas, 1.2% in the medium market share areas, and 0.6% in the high market share areas. To illustrate the predicted effect on cumulative adoption, Figure 3 plots the predicted cumulative adoption probabilities for hypothetical markets that started in 1985 with 20% adoption and had average values for all covariates, but had low, medium, and high HMO market share.[8] The coefficients imply slightly slower adoption with increasing market share through 1991, and more clearly divergent paths thereafter, with low market share areas reaching 40% adoption by 2000, compared with 33% in medium market share areas and 31% in low market share areas.

These models are fundamentally cross-sectional in nature, raising the possibility of bias from unobserved heterogeneity. If the areas in which HMOs choose to locate have systematically lower technology adoption rates for other reasons, our results may overstate the adoption-slowing effects of HMOs. The fact that adoption rates for all technologies observed at the beginning of our sample period in 1985, at a point in time where being in what would become a high market share area should still have had little effect on adoption patterns, do not

[8] These predictions start at 20% adoption in 1985 based on the actual observed adoption in 1985. With covariates held at their sample means, the predicted 1985 levels are somewhat lower – 12% in low market share areas, 11% in

show strong variations by market share category, consistent with the view that there are not strong underlying biases of this type. We also estimated several alternate specifications to further investigate. First, we included state dummies in the models, as a way of controlling for unobserved variations in state policies, population preferences or other characteristics, health care system characteristics, or other factors that could affect both HMO market share and technology adoption.[9] Results from this model are shown in column 2. Results similar to those reported in column 1 are observed, though the HMO market share coefficients in the 1992-2000 period are somewhat smaller.

Another approach to the unobserved heterogeneity is to control for adoption patterns of technologies that diffused before managed care could have played an important role in adoption decisions. If there is some fixed characteristic of high market share areas that causes them to adopt new technologies more slowly than other markets, this should be reflected in the diffusion of earlier technologies, so controlling for prior technology adoptions should reduce heterogeneity bias. Here, we control for the presence of cardiac intensive care units (CICUs), hospital units specifically designed to care for seriously ill patients with heart attacks and other cardiac conditions. The diffusion of CICUs occurred primarily during the 1960s and 1970s, so that they were largely diffused by the early 1980s before managed care began to play a noticeable role in the U.S. health care system. In 1982, about 28% of surveyed hospitals reported having CICU beds. About 30% of hospitals surveyed in 1996 reported having CICU beds. We expect the presence of a CICU in a hospital by the early 1980s to indicate an underlying propensity for the

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medium market share areas, and 13% in high market share areas.

[9] Because too few adoptions are observed in some states, we combined Idaho and Montana; New Hampshire and Vermont; and Delaware, DC, and Maryland.

hospital to adopt other advanced hospital technologies, independent of an effect of HMOs, and vice versa.

We use data on the presence of CICUs in 1982 based on AHA survey reports. The third column of Table 3 presents results in which we include data on CICUs in addition to the state dummies. Hospitals that adopted a CICU by 1982 are more likely to adopt the other cardiac technologies, but controlling for CICU adoption does not have a substantial impact on the HMO market share coefficients – if anything it increases the magnitude of the effects in the 1992-2000 period. We interpret this as evidence that there are not time-invariant characteristics of hospitals in high HMO market share areas that lead them to be very late adopters or non-adopters of cardiac technologies.

Another potential source of unobserved heterogeneity is variation in the health status of the population – perhaps HMOs are more likely to enter markets with healthier patients. If this were the case, lower adoption rates could be due to lower consumer demand in these markets rather than the practices of HMOs. To investigate, we estimated fourth model in which we further added a covariate that measures the average one-year mortality among patients in our AMI cohorts by MSA in 1984 (the year before our sample period begins). Results are shown in column 4 of Table 3. This variable has almost no relationship with adoption hazard, and adding it has very little impact on the HMO coefficients.

Finally, some work suggests modeling unobserved heterogeneity as a multiplicative additional source of error in the adoption equation, so that the hazard becomes $\lambda_i(t) = \theta_i \lambda_0(t) exp(x_i'\beta)$ where θ_i is a random variable capturing the unobserved heterogeneity, assumed to be independent of x_i (Heckman and Singer, 1984; Meyer, 1990). Estimates from a model that incorporates a gamma-distributed random effect are shown in column 5 of Table 3. Though the estimated variance of the random effect is significantly different from zero, indicating some heterogeneity, the interpretation of the HMO market share coefficients is not affected. In fact, this model results in the strongest relationship between market share and adoption in the 1992-2000 period, suggesting that, if anything, results from the other models are biased downward by unobserved heterogeneity.

<u>Models Incorporating Adoption of Catheterization Only</u>

In addition to hospitals that adopt all three technologies, many hospitals are observed to adopt catheterization only. To incorporate this possibility, we extended the estimation framework to encompass three possible transitions hospitals could make: nothing to catheterization only, nothing to all three, and catheterization to all three. We implement this using three proportional hazard models. In the first two we use a competing hazard framework to estimate the probabilities that hospitals that start with none of the technologies adopt either all three or catheterization only. In the third, hospitals that have adopted catheterization only become "at risk" to adopt all three, and we estimate a separate model for the probability that these hospitals do so.[10]

Table 4 presents results from a model that includes the baseline covariates, state dummies, the 1982 CICU covariate, and the 1984 AMI mortality rate covariate. In the model capturing the transition from none of the technologies to catheterization only, results suggest faster adoption of catheterization in the pre-1985 period in high HMO market share areas.

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[10] One issue this framework raises is the treatment of hospitals that are observed to have all three technologies at the beginning of our sample period, in 1985. We treat all of these transitions as having been none-to-all transitions since presumably all of these hospitals began at some initial time 0 with none. This means that the first year that hospitals could be at risk for moving from catheterization only to all is 1986.

Thereafter, the results show a less clear pattern with limited statistical significance, but tend, if anything, to suggest somewhat higher probabilities of adoption in high market share areas. The estimates for the transition from none to all of the technologies shows very little effect, perhaps due to the very small numbers of transitions from none to all observed in the data (including no transitions from none to all in the 1992-2000 period in high market share areas). In the estimates capturing transitions from catheterization only to all, there is evidence that higher HMO market shares are associated with lower adoption probabilities in the 1992-2000 period. The HMO market share coefficients are negative and statistically significant, and suggest adoption hazards about 40% lower in medium compared to low market share areas, and about 60% lower in high relative to low market share areas.

Table 5 presents the average annual adoption hazards implied by these results, holding all covariates other than HMO market share and year fixed at their sample means. In the 1992-2000 period, hospitals with catheterization only in high market share areas average about a 1.6% chance of transitioning to having all three, relative to a 3.0% chance in low market share areas. Predicted hazards for the transition from none to catheterization only show somewhat higher probabilities of adoption in higher HMO areas, though statistical significance of these results is limited and patterns are not entirely consistent with a true HMO effect.

One can use these results to compute predictions for the share of hospitals in each of the three possible adoption states by year, accounting for transitions out of the state of having none of the technologies, into and out of the state of having catheterization only, and into the state of having all three technologies (Figures 4 and 5). In a market that begins in 1985 with 20% adoption of catheterization only and 20% adoption of all technologies, these results predict somewhat faster adoption of catheterization only in high market share areas, coupled with much slower transitions from of catheterization only to having all three after 1992, so that hospitals in the high market share areas are predicted to end up in 2000 with a cumulative probability of having catheterization only that is10 percentage points higher than hospitals in low market share areas. Despite the somewhat faster predicted adoption of catheterization only in high market share areas, the much slower rate of transition to having all three technologies results in a predicted cumulative probability of having all three that is about 5 percentage points lower for high HMO hospitals compared to low HMO hospitals.

5. Impacts on treatment patterns and outcomes

Our analyses of adoption patterns suggest the possibility that managed care prevalence affects treatments and outcomes for individual patients by affecting the availability of services. To investigate these issues more carefully, we analyze data on a 20% sample of FFS Medicare patients who lived in a Metropolitan Statistical Area and who had a new AMI between 1996 and 2000. We defined these cohorts using Medicare claims files and applying techniques similar to those previously applied by McClellan, McNeil, and Newhouse (1994). Patients in the cohorts were followed for one year after their initial hospitalization, including transfers and readmissions as well as the initial hospitalization. Our cohort of patients with new AMIs in 1996-2000 contains 148,170 patients. For each patient, we coded the technology adoption status of the patient's index hospital in the year of the index admission, and whether the patient received a catheterization, PTCA and/or CABG within 90 days after the initial hospital admission date.

We first consider whether HMO prevalence affects the probability that a patient will initially be treated at a hospital with none of the three technologies, catheterization only, or all three. We model the probabilities using a multinomial logistic regression:

(2)
$$\Pr[HOSPITAL\ \ TYPE_i = j] = \frac{\exp(\beta_j' x_i)}{1 + \sum_{k=1}^{2} \exp(\beta_k' x_i)}$$

where j=1 indicates hospitals with none of the three technologies, j=2 indicates hospitals with catheterization only, and hospitals with all three technologies are the omitted reference group. The key independent variables are our measures of HMO prevalence. We also include a range of covariates: dummy variables for 20 cells interacting sex, race (black or non-black), and age (65-69, 70-74, 75-79, 80-84, 85 and over); dummy variables that identify patients who had one or more admissions in the prior two years for each of the following conditions: ischemic heart disease, congestive heart failure, ventricular arrhythmia, or any other cause; dummy variables to identify patients with each of the following conditions at admission: cancer, diabetes, dementia, heart failure, hypertension, stroke, peripheral vascular disease, chronic obstructive pulmonary disease, respiratory failure, renal failure, or hip fracture; area per capita income; the total area population; the area population density; the percent of the population that graduated from high school; the percent that graduated from college; the percent of the work force that is considered white collar; the share of Medicare beneficiaries enrolled in a Medicare HMO, squared terms for all of the income, population, education, work force and Medicare HMO measures; and dummies for states and years. Table 6 summarizes model covariates.

Table 7 presents results. In the top panel, the coefficients on the HMO market share dummies indicate that increases in HMO market share are associated with lower probabilities of receiving initial treatment in a hospital with none of the technologies, and increases in the probability of being treated in a hospital with catheterization only, relative to receiving treatment in a hospital with all three technologies. (Full regression results are shown in the appendix.) The bottom portion of Table 7 presents predicted probabilities of treatment in different settings, computed holding all covariates fixed at their sample means. In high HMO areas, AMI patients are about 8 percentage points more likely to be treated in a catheterization-only hospital, while they are about 6 percentage points less likely to be treated in a hospital with none of the technologies and about 2 percentage points less likely to be treated in a hospital with all three technologies. These patterns are consistent with the hospital-level patterns observed above.

We next consider whether the probability of receiving different treatments within 90 days of initial admission is affected by technology availability in the patient's index hospital. Our dependent variable in these regressions is an unordered polychotomous variable with four possible values representing the different possible treatment combinations: catheterization only, PTCA and catheterization, CABG and catheterization regardless of PTCA, and medical management (i.e. no catheterization, no PTCA, and no CABG). We specify these models using multinomial logit regression, with medical management as the omitted category.

Table 8 presents results. Being treated in a hospital with all 3 technologies increases the likelihood of receiving catheterization only, PTCA, and CABG, relative to the probability of receiving none of these treatments. Being treated in a hospital with catheterization only is associated with reductions in the probability of receiving catheterization, PTCA, and CABG. This is a counterintuitive result and will require further investigation. It may be that hospitals with none of the technologies are quicker to transfer their patients to high capability hospitals where they are more likely to receive advanced treatment than catheterization only hospitals. Table 9 demonstrates a direct link between HMO market share and the probability of receiving different treatments. Increases in HMO market share are associated with reductions in the probability of receiving both PTCA and CABG. Moving from a low to a high market share area reduces the probability of receiving PTCA by about 3 percentage points, and the probability of receiving CABG by about 1 percentage point.

If it is the case that increasing HMO prevalence affects technology diffusion, ultimately reducing use of catheterization, PTCA, and CABG for AMI patients, there could be impacts on outcomes. Some other literature argues that these technologies can be beneficial for patients (e.g. McClellan, McNeil, and Newhouse 1994). SAY MORE HERE

6. Conclusions

Increases in HMO activity slowed the diffusion of PTCA and CABG, two important therapeutic technologies for the care of heart attack patients, during the 1990s. Our results across a series of different models consistently suggest a large and significant slowing in the probability that hospitals would adopt all three of the technologies we study. We take this as evidence that the changes in incentives that managed care brings about can influence technology diffusion in health care.

The effects of HMO activity on the diffusion of cardiac catheterization, a diagnostic technology that is usually a precursor to the therapeutic technologies PTCA and CABG, are less clear. The results we obtain suggest faster adoption of catheterization in high market share in the time period before 1985. During this time period, we expect that HMOs had relatively little chance of having a meaningful impact on hospital behavior, and thus we interpret this finding as suggesting that HMOs were more likely to enter areas that had historically higher rates of catheterization adoption, as has also been suggested previously by Cutler and Sheiner (1998). After 1985, we find less evidence for a relationship between HMO activity and catheterization diffusion, but what we do find tends still to suggest somewhat faster diffusion in high market share areas, though with a narrowed difference. It is not immediately clear why HMOs would have disproporationately entered areas that more quickly adopted managed care in the pre-1985 period. One possibility is simply that HMOs considered many factors when identifying markets for expansion and the fact that they did enter markets that had experienced fast catheterization diffusion does not reflect a particular preference for high catheterization markets per se. On the other hand, it may be that the presence of catheterization hospitals is a marker of area characteristics that HMOs favor.

It is also not clear why their diffusion-slowing effects would affect PTCA and CABG more acutely than catheterization. If HMOs entered areas with stronger underlying preferences for catheterization, it is possible that as managed care became more established, it did in fact slow the adoption of catheterization relative to what would have happened in the those same areas. [BUT WE CONTROLLED FOR LOTS OF POTENTIAL CONFOUNDERS…] The timing of diffusion may also be important. Much of the diffusion in cardiac catheterization occurred before the rise of HMOs in the 1990s, while PTCA and CABG diffusion took place after HMOs were in place (Cutler and Sheiner 1998) [CHECK THE CUTLER DATA SINCE OUR 1985 ADOPTION DATA SHOW ABOUT EQUAL ADOPTION OF THESE BY THEN]. It may be that managed care could have a more powerful effect on the diffusion of PTCA and CABG because their diffusion trajectory was less established by the time managed care came to influence decisionmaking, whereas the potential to change the already partially established diffusion trajectory for catheterization was more limited.

In the end, the combination of similar, or even increased, rates of catheterization in high market share areas, coupled with slower transitions from having catheterization to having all three technologies, leaves high market share areas with more hospitals with catheterization only and fewer hospitals with all three technologies by the end of our sample period.

Since some diffusion of these technologies is still ongoing, our results do not prove that these differences will persist in equilibrium, though that would be a natural outcome of the trends we have observed through 2000. An important caveat, of course, is that any shifts in demand and changes in reimbursement associated with HMOs that led to the results we observed remain consistent over time. Substantial changes in the activities of health plans could lead to changes in patterns of equilibrium availability. As managed care has become a less potent force in the health care marketplace over the past several years, its effects could have weakened.

There are a number of potential mechanisms by which managed care could influence adoption patterns, including reducing expected profitability through reductions in demand or price, and reducing capital that hospitals have to invest in new equipment. We are not able to distinguish between these competing explanations.

Reductions in the adoption of technologies can have powerful welfare implications through a number of channels, including savings from foregone adoptions and reduced utilization as well as changes in health outcomes. Reductions in adoption will clearly produce savings, and could also affect outcomes. It appears that in this case, they run the risk of making patients worse off. Our results suggest that HMO market share is associated with a higher probability of AMI patients receiving treatment in a catheterization-only hospitals, and that this is associated with a smaller probability of receiving intensive treatments that are likely to be beneficial. These results are broadly consistent with other work (Meara et al, 2004) which finds that increases in HMO market share are associated with small declines in the probability of catheterization for AMI patients. The results we report here are thus consistent with a classic welfare tradeoff in health care between costs and outcomes, in which we must consider the potential for savings compared to any resulting reductions in quality. There are also intertemporal issues that could play roles in welfare calculations. For example, slower adoption could reduce future capabilities that could have developed through learning by doing or slow basic research into new techniques.

Extrapolating these results to other technologies should be done with care. Other technologies may have very different characteristics. For example, new genetic screening procedures have quite different characteristics and may be adopted and used in quite different ways. Our results suggest the power of managed care to influence technology adoption, health outcomes, and spending, but a complete understanding will only be obtained by examining broad patterns in health care delivery.

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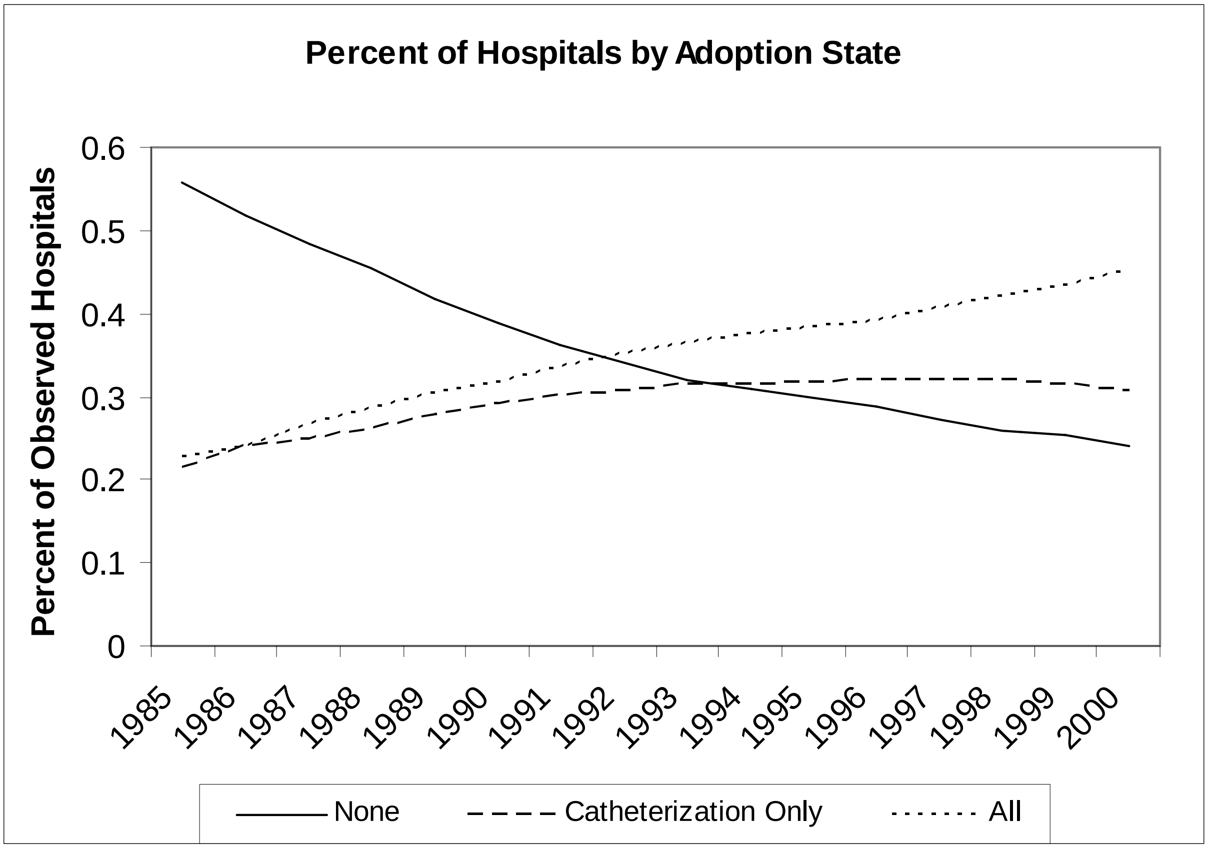
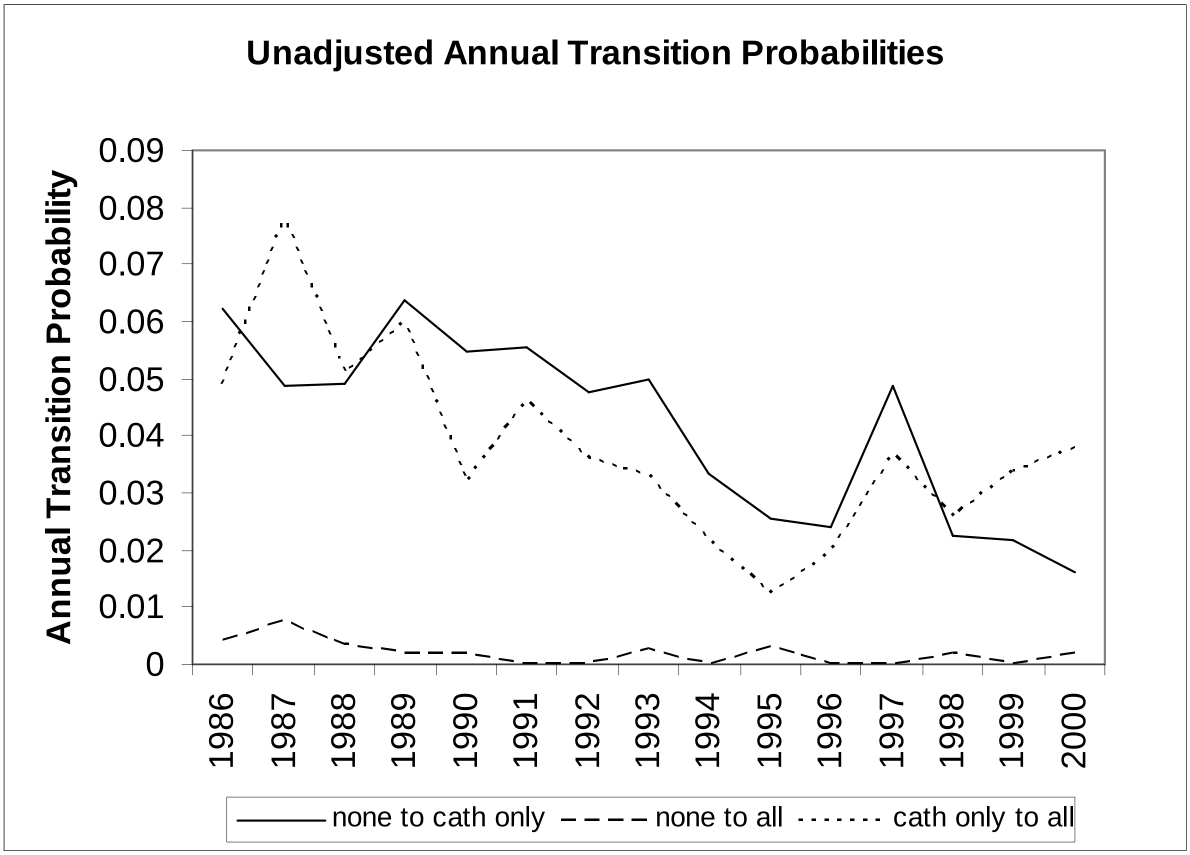
Figure 1



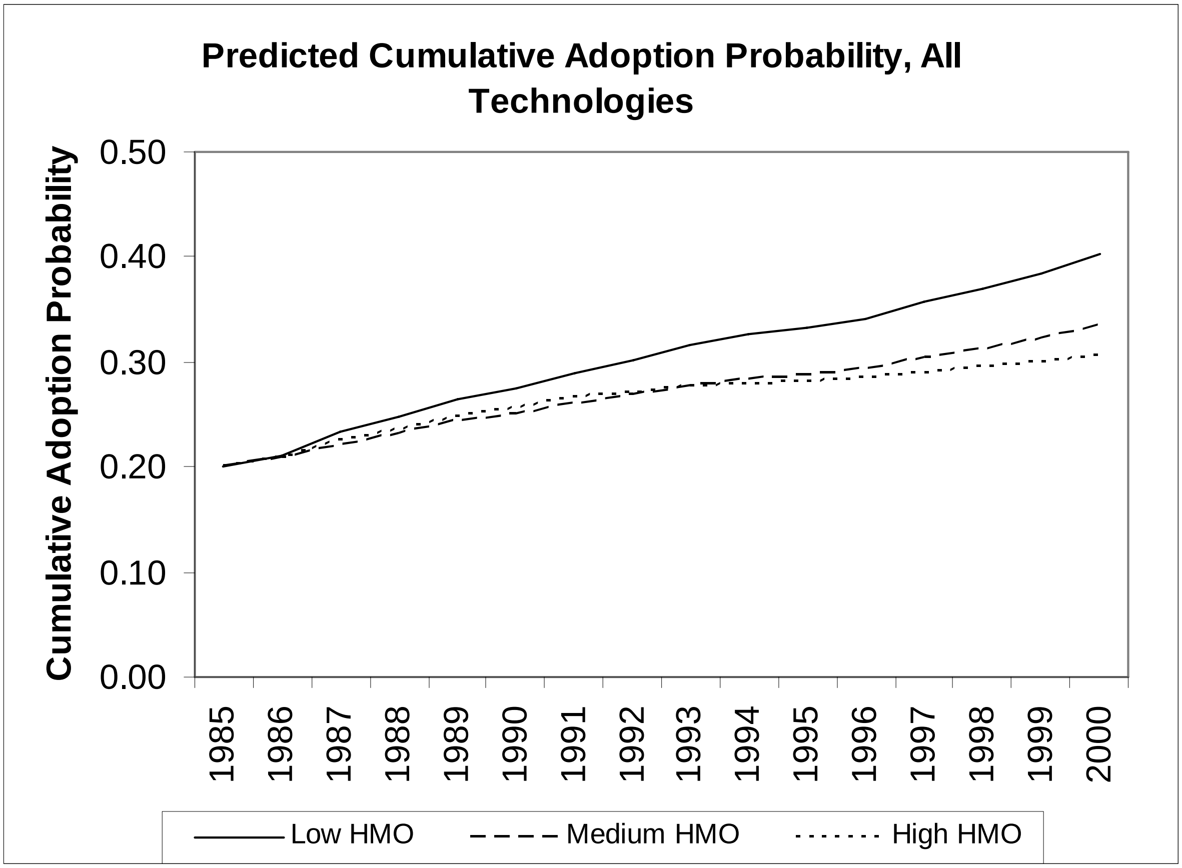
Note: Baseline N=2,648 sample hospitals observed in 1985. The sample for each year is the number of hospitals observed in that year, which falls over time.

Figure 2



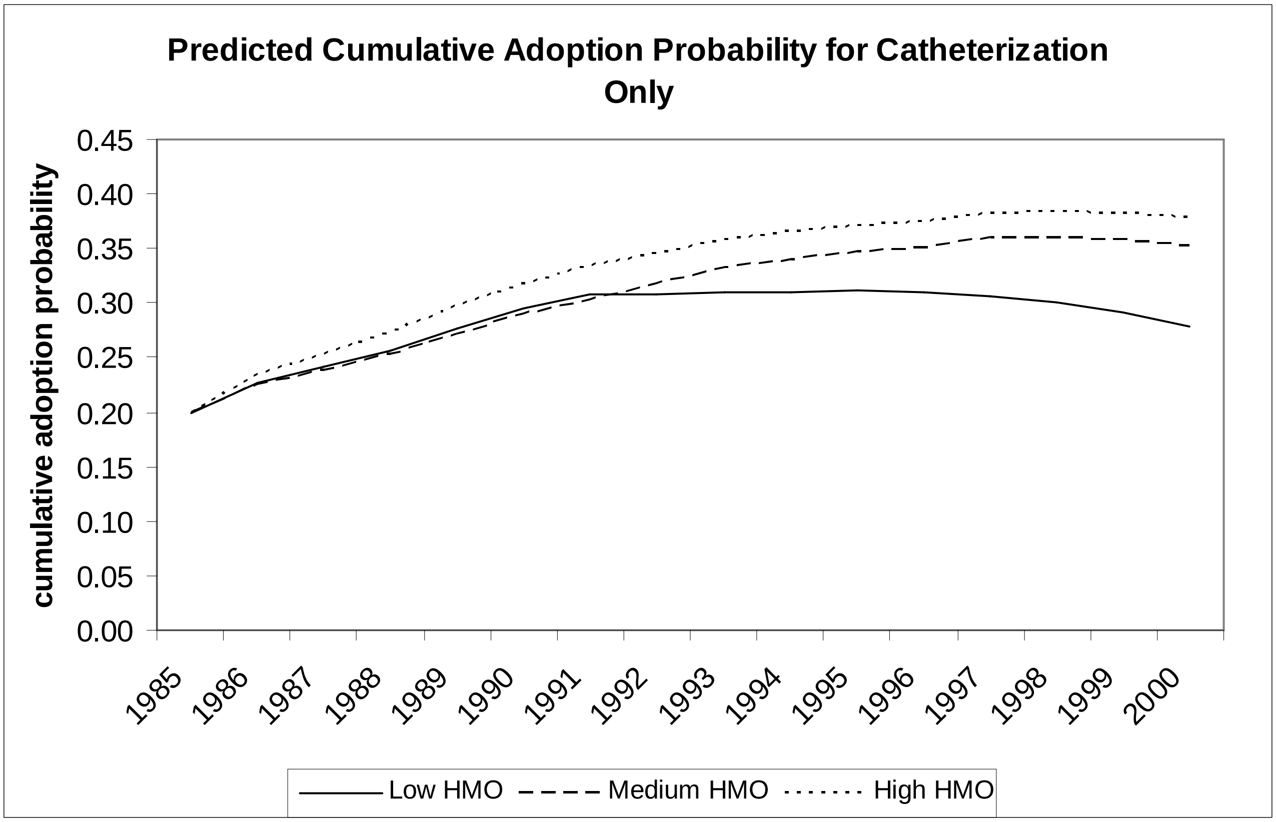
Note: Baseline N=2,648 sample hospitals observed in 1985. The sample for each year is the number of hospitals observed in that year, which falls over time.

Figure 3



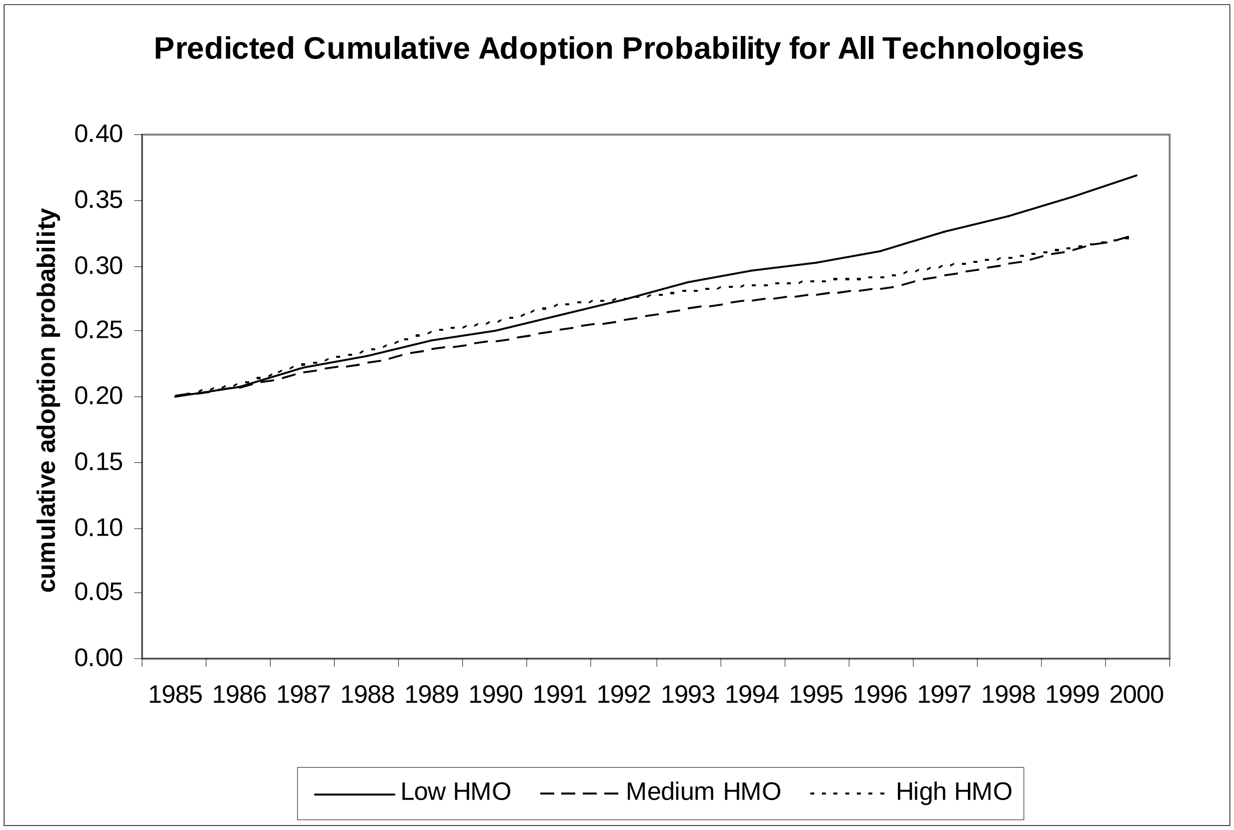
Note: Predictions based on hazard model for the adoption of all three technologies, Table 3, column 1. All covariates held fixed at their sample means. 1985 starting adoption probability of 0.2 assigned based on observed 1985 adoption rate.

Figure 4



Note: Predictions based on the “three-state” hazard models in Table 4. All covariates held fixed at their sample means. 1985 starting adoption probability of 0.2 assigned based on observed 1985 adoption rate.

Figure 5



Note: Predictions based on the “three-state” hazard models in Table 4. All covariates held fixed at their sample means. 1985 starting adoption probability of 0.2 assigned based on observed 1985 adoption rate.

Table 1: Summary of Annual Technology Availability Measures

Data Year	Hospitals Observed	Transitions Observed: None to Cath Only	Transitions Observed: None to All	Transitions Observed: Cath Only to All	Cumulative Number of Hospitals with…: None	Cumulative Number of Hospitals with…: Cath Only	Cumulative Number of Hospitals with…: All
1985	2648	569	601	0	1478	569	601
1986	2629	91	6	28	1363	631	635
1987	2600	65	10	49	1261	645	694
1988	2563	60	4	33	1162	672	729
1989	2518	72	2	40	1054	698	766
1990	2476	56	2	22	965	723	788
1991	2438	52	0	33	886	733	819
1992	2405	41	0	26	822	739	844
1993	2370	40	2	24	760	745	865
1994	2341	25	0	16	724	739	878
1995	2312	18	2	9	691	736	885
1996	2269	16	0	14	655	724	890
1997	2215	31	0	26	603	709	903
1998	2176	13	1	18	566	695	915
1999	2132	12	0	23	539	668	925
2000	2011	8	1	24	483	619	909

Table 2: Descriptive Statistics for Covariates in Technology Adoption Model

	Mean	SD
Low HMO prevalence	0.145	0.352
Medium HMO prevalence	0.660	0.474
High HMO prevalence	0.195	0.396
Teaching hospital	0.302	0.459
Medical school affiliation	0.278	0.448
Total beds, hundreds	2.709	2.055
MSA population, millions	1.981	2.320
MSA population density, millions/sq mile	0.966	1.489
MSA % pop urban	0.840	0.130
MSA % pop 65 and older	0.122	0.029
MSA % pop high school graduate	0.766	0.057
MSA % pop college graduate	0.217	0.057
MSA per capita income, $ thousands	19.418	3.488
MSA hospitals per thousand population	0.023	0.008
MSA generalists per thousand population	0.082	0.033
MSA specialists per thousand population	0.724	0.376
MSA cardiologists per thousand population	0.065	0.037
hospital had cardiac intensive care in 1982	0.897	0.304
MSA 1 year AMI mortality rate in 1984	0.394	0.028
N	2648	

Table 3: Regression Coefficients from Models of the Probability of Adopting All Three Technologies

	(1)	(2)	(3)	(4)	(5)
1985					
Medium HMO market share	-0.067	0.088	0.097	0.109	0.065
	(0.126)	(0.135)	(0.135)	(0.134)	(0.325)
	[0.935]	[1.092]	[1.102]	[1.115]	[1.067]
High HMO market share	0.059	0.289	0.290	0.301	0.527
	(0.179)	(0.204)	(0.202)	(0.201)	(0.477)
	[1.061]	[1.335]	[1.336]	[1.351]	[1.694]
1986-1991					
Medium HMO market share	-0.420	-0.274	-0.278	-0.269	-0.359
	(0.190)*	(0.178)	(0.178)	(0.178)	(0.326)
	[0.657]	[0.760]	[0.757]	[0.764]	[0.698]
High HMO market share	-0.295	-0.099	-0.099	-0.091	0.024
	(0.222)	(0.235)	(0.235)	(0.235)	(0.482)
	[0.745]	[0.906]	[0.906]	[0.913]	[1.024]
1992-2000					
Medium HMO market share	-0.501	-0.365	-0.413	-0.404	-0.781
	(0.198)*	(0.201)	(0.200)*	(0.201)*	(0.350)*
	[0.606]	[0.694]	[0.662]	[0.668]	[0.458]
High HMO market share	-1.149	-0.994	-1.026	-1.019	-1.520
	(0.340)**	(0.334)**	(0.336)**	(0.336)**	(0.542)**
	[0.317]	[0.370]	[0.358]	[0.361]	[0.219]
Hospital had CICU in 1982	---	---	1.481	1.483	---
			(0.235)**	(0.235)**	
MSA 1-year AMI mortality rate in 1984	---	---	---	0.753	---
				(1.165)	
Teaching hospital	0.613	0.695	0.651	0.658	0.408
	(0.199)**	(0.184)**	(0.192)**	(0.193)**	(0.476)
Medical school affiliation	0.333	0.381	0.346	0.339	1.214
	(0.198)	(0.186)*	(0.186)	(0.188)	(0.496)*
Total beds, hundreds	0.345	0.342	0.341	0.341	1.769
	(0.045)**	(0.050)**	(0.052)**	(0.053)**	(0.153)**
MSA % pop 65 and older	-0.517	2.901	2.393	2.431	-2.459
	(1.471)	(1.593)	(1.578)	(1.569)	(4.473)
MSA % pop high school graduate	2.238	0.913	0.276	0.317	-0.900
	(0.969)*	(1.122)	(1.107)	(1.110)	(2.702)

continued

Table 3, continued

	(1)	(2)	(3)	(4)	(5)
MSA % pop college graduate	4.497	4.422	4.488	4.517	8.606
	(1.318)**	(1.272)**	(1.249)**	(1.258)**	(3.290)**
MSA per capita income, $000s	-0.133	-0.066	-0.051	-0.051	-0.115
	(0.017)**	(0.019)**	(0.018)**	(0.018)**	(0.051)*
MSA % pop urban	2.005	0.162	-0.079	-0.086	0.435
	(0.401)**	(0.442)	(0.430)	(0.433)	(1.135)
MSA population, millions	-0.047	-0.075	-0.080	-0.079	-0.058
	(0.039)	(0.045)	(0.044)	(0.045)	(0.062)
MSA population density (mil/sq mile)	-0.179	-0.039	-0.036	-0.037	-0.299
	(0.047)**	(0.052)	(0.049)	(0.049)	(0.141)*
MSA hospitals per 1000 pop	0.572	-9.899	-9.366	-9.300	2.432
	(4.581)	(5.766)	(5.810)	(5.808)	(13.941)
MSA generalists per 1000 pop	3.169	1.429	0.993	0.946	1.414
	(1.586)*	(1.299)	(1.276)	(1.281)	(3.350)
MSA specialists per 1000 pop	-0.784	-0.720	-0.717	-0.728	-1.331
	(0.323)*	(0.318)*	(0.310)*	(0.313)*	(0.849)
MSA cardiologists per 1000 pop	5.370	5.876	5.838	5.990	12.115
	(2.714)*	(2.659)*	(2.620)*	(2.659)*	(7.635)
ln(var gamma)	---	---	---	---	1.183
					(0.124)**
State Dummies	No	Yes	Yes	Yes	Yes
N hospitals	2,648	2648	2648	2648	2648
Log-likelihood	-2,858	-2,782	-2,746	-2,746	-2,585
Chi2[4] for H0: HMO coefs jointly 0	18.048	16.382	16.995	16.765	24.661
Chi2 p-value	0.006	0.012	0.009	0.010	<0.001

Note: ** denotes p<0.01, * denotes p<0.05. Robust standard errors in parentheses. Relative hazards in brackets. Models also include 16 year dummies to capture a non-parametric baseline. CICU is cardiac intensive care unit. AMI is acute myocardial infarction.

Table 4: Regression Results from Three State Adoption Models

	Nothing to Cath Only	Nothing to All	Cath Only to All
1985			
Medium HMO market share	0.113	0.022	---
	(0.141)	(0.150)	
	[1.120]	[1.022]	
High HMO market share	0.582	0.006	---
	(0.253)*	(0.228)	
	[1.790]	[1.006]	
1986-1991			
Medium HMO market share	-0.152	-0.222	-0.203
	(0.157)	(0.607)	(0.211)
	[0.859]	[0.801]	[0.816]
High HMO market share	0.172	0.184	0.031
	(0.310)	(0.801)	(0.302)
	[1.188]	[1.202]	[1.031]
1992-2000			
Medium HMO market share	0.467	0.155	-0.534
	(0.219)*	(1.123)	(0.228)*
	[1.595]	[1.168]	[0.586]
High HMO market share	0.339	---	-0.891
	(0.341)		(0.362)*
	[1.404]		[0.410]
Hospital had CICU in 1982	0.694	1.827	0.682
	(0.114)**	(0.381)**	(0.283)*
MSA 1-year AMI mortality rate in 1984	0.451	0.672	-0.044
	(1.336)	(1.605)	(1.919)
Teaching hospital	0.190	0.624	0.668
	(0.207)	(0.254)*	(0.240)**
Medical school affiliation	-0.067	0.672	-0.363
	(0.223)	(0.235)**	(0.255)
Total beds, hundreds	0.101	0.329	0.272
	(0.022)**	(0.064)**	(0.059)**
MSA % pop 65 and older	3.158	0.894	4.820
	(1.948)	(2.157)	(3.172)
MSA % pop high school graduate	1.773	-1.495	0.775
	(1.042)	(1.525)	(1.744)
MSA % pop college graduate	-1.480	5.295	5.990
	(1.384)	(1.728)**	(2.458)*

continued

Table 4, continued

	Nothing to Cath Only	Nothing to All	Cath Only to All
MSA per capita income, $000s	-0.035	-0.037	-0.070
	(0.023)	(0.025)	(0.034)*
MSA % pop urban	0.895	0.776	-1.297
	(0.429)*	(0.703)	(0.815)
MSA population, millions	-0.021	-0.106	-0.075
	(0.026)	(0.066)	(0.047)
MSA population density (mil/sq mile)	-0.038	-0.044	0.067
	(0.038)	(0.072)	(0.073)
MSA hospitals per 1000 pop	-11.559	-7.324	-14.410
	(6.106)	(8.388)	(8.920)
MSA generalists per 1000 pop	-3.708	1.470	-0.285
	(1.608)*	(1.509)	(2.660)
MSA specialists per 1000 pop	0.119	-0.751	-0.637
	(0.388)	(0.421)	(0.457)
MSA cardiologists per 1000 pop	0.607	5.361	5.041
	(3.358)	(3.596)	(5.307)
State Dummies	Yes	Yes	Yes
Log-likelihood	-3595	-1068	-1464
Chi2[4] for H0: HMO coefs jointly 0	13.011	0.484	10.163
Chi2 p-value	0.043	0.993	0.038

Note: ** denotes p<0.01, * denotes p<0.05. Robust standard errors in parentheses. Relative hazards in brackets. Models also include 16 year dummies to capture a non-parametric baseline. CICU is cardiac intensive care unit. AMI is acute myocardial infarction.

Table 5: Mean Predicted Annual Hazards

	None to Cath Only	None to All	Cath only to all
Mean Predicted Annual Hazard			
1986-1991			
Low HMO	0.052	0.002	0.037
Medium HMO	0.045	0.002	0.030
High HMO	0.061	0.003	0.038
1992-2000			
Low HMO	0.021	0.001	0.030
Medium HMO	0.033	0.001	0.022
High HMO	0.029	0.000	0.016

Note: Based on estimates shown in Table 4. All covariates except HMO market share and year held constant at their sample means.

Table 6: Characteristics of AMI Patients

Variable	Mean
Low HMO market share area	15.1%
Medium HMO market share area	71.1%
High HMO market share area	13.8%
Index hospital: no technologies	29.4%
Index hospital: catheterization only	12.5%
Index hospital: all technologies	58.0%
Demographics	
Female	51.0%
Male	49.0%
Black	6.9%
Non-black	93.1%
Age 65-69	15.6%
Age 70-74	21.4%
Age 75-79	22.6%
Age 80-84	32.9%
Age 85-89	7.5%
Admissions in prior 2 years for	
Ischemic heart disease	2.6%
Congestive heart failure	2.5%
Ventricular arrhythmia	0.1%
Any other cause	16.9%
Comorbidities at Index Admission	
Cancer	1.5%
Diabetes	17.0%
Dementia	1.8%
Heart failure	38.2%
Hypertension	24.8%
Stroke	2.9%
Peripheral vascular disease	3.3%
Chronic obstructive pulmonary disease	14.3%
Respiratory failure	1.6%
Renal failure	2.7%
Hip fracture	0.2%
Area (MSA) Characteristics	
Population (millions)	1.89
Population density (1,000s/sq mile)	1.02
Medicare HMO share	7.0%
Percent college graduate	23.1%
Percent high school graduate	79.9%
Per capita income ($10,000s)	2.27
Percent white collar	61.9%
AMI Year	
1996	21.7%
1997	20.3%
1998	19.5%
1999	19.8%
2000	18.8%

Table 7: Results from multinomial logit for index hospital capabilities

	None	Catheterization Only	All Technologies
Regression Coefficients			
medium HMO market share	-0.027	0.294 **	---
	(0.037)	(0.026)	
high HMO market share	-0.672 **	0.346 **	---
	(0.052)	(0.042)	
Predicted Probability of Treatment			
Low Market Share Area	0.129	0.228	0.643
Medium Market Share Area	0.117	0.284	0.599
High Market Share Area	0.064	0.312	0.624

Note: N=148,170 AMI patients. ** denotes p<0.01; * denotes p<0.05. Standard errors in parentheses. Models also include controls for demographics, health status, health system characteristics, state dummies, and year dummies. The omitted regression dependent variable category is all 3 technologies. Predicted probabilities computed holding all covariates fixed at their sample means.

Table 8: Results from models of treatments received as a function of index hospital capabilities

	Treatment Received…			
	Catheterization Only	Catheterization and PTCA	Catheterization and CABG	Medical Management
Regression Coefficients				
Index hospital: catheterization only	-0.396 **	-0.178 **	-0.126 **	---
	(0.030)	(0.028)	(0.030)	
Index hospital: all technologies	0.468 **	0.946 **	0.638 **	---
	(0.020)	(0.019)	(0.020)	
Predicted Probability of Treatment				
Index hospital: no technolgies	0.157	0.148	0.110	0.585
Index hospital: catheterization only	0.116	0.136	0.106	0.642
Index hospital: all technologies	0.176	0.268	0.146	0.411

Note: N=148,170 AMI patients. ** denotes p<0.01; * denotes p<0.05. Standard errors in parentheses. Models also include controls for demographics, health status, health system characteristics, state dummies, and year dummies. The omitted regression dependent variable category is medical management. Predicted probabilities computed holding all covariates fixed at their sample means.

Table 9: Results from models of treatments received as a function of area HMO market share

	Treatment Received…			
	Catheterization Only	Catheterization and PTCA	Catheterization and CABG	Medical Management
Regression Coefficients				
Medium HMO market share	0.001	-0.125 **	-0.109 **	---
	(0.032)	(0.029)	(0.032)	
High HMO market share	-0.021	-0.242 **	-0.172 **	---
	(0.053)	(0.047)	(0.052)	
Predicted Probability of Treatment				
Low Market Share Area	0.157	0.233	0.138	0.472
Medium Market Share Area	0.164	0.214	0.129	0.493
High Market Share Area	0.166	0.198	0.126	0.510

Note: N=148,170 AMI patients. ** denotes p<0.01; * denotes p<0.05. Standard errors in parentheses. Models also include controls for demographics, health status, health system characteristics, state dummies, and year dummies. The omitted regression dependent variable category is medical management. Predicted probabilities computed holding all covariates fixed at their sample means.