Medicare managed care and lower admission severity: Evidence from Pennsylvania, ’94 -‘06

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Objective: To examine differences in post-enrollment disease severity by insurance types for angioplasty and stent patients, and to distinguish selection from managed care effects.

Data Sources: Retrospective secondary data from 1994 through 2006 for 486,000 adult percutaneous coronary interventions (PCI) admissions and PCI readmissions, as well as 52,000 non-PCI re-admissions for surgical revascularization, myocardial infarction, and major cardiac events leading to in-hospital death in Pennsylvania. Analyses were restricted to 192,167 non-emergent, in-state, Medicare managed care (MMC) or traditional Medicare insured patients without prior revascularization. Data included the MediQual Severity Score, generated from on-admission clinical and chart data.

Study Design: Admission severity was modeled at the patient-level as a reduced form outcome of patient, provider and insurer effects. Panel and MMC propensity score stratified panel regressions were estimated. Differences-in-differences relating to the key 1997 Balanced Budget Act (BBA) and 2003 Medicare Modernization Act policy changes were estimated.

Principal findings: MMC payor status was associated with substantially and significantly lower admission severity in unstratified as well as propensity score stratified analyses. The BBA’s impact in 1999-2000 allowed precise difference-in-difference estimates of significantly lower admission severity for MMC patients.

Conclusions: Pennsylvanian PCI patients insured by MMC had substantially and significantly lower admission severity, conditional on admission for PCI. Positive evidence for selection as well as process of care differences was found. Our findings emphasize the need for continued exploration of appropriate risk adjustment methodologies. Finding, funding and encouraging better processes of managing care should continue to be important research and policy priorities.

Keywords: Managed care, pre-existing health status, sorting and screening

Are managed care insured members healthier than those with other types of insurance? If so, is biased selection or better management likely to be more responsible? While the conventional wisdom is that Medicare managed care enrollees are healthier due to biased selection (Dallek, Biles et al, 2003; Biles, Dallek, et al, 2004; Orszag, 2007; Park, 2007) there is only sparse recent evidence of such favorable selection or of such health status differences (Mello et al, 2002; Cao and McGuire, 2003; Mello et al, 2003; Chernew et al, 2008). The existence of such differences and their putative mechanism clearly informs entitlement reform, risk-pricing, and – more fundamentally – the rationale for managed care itself.

In this article we address these questions by focusing on the relationship between insurance type and a novel measure of post-enrollment health status. We use an objective measure of on-admission cardiovascular disease severity determined by a third party using chart and clinical data at the time of admission. We construct simple reduced form models in which this measure of post-enrollment health status is plausibly affected by baseline health differences between members (i.e. *input* effects), as well as differences in the quantity and quality of care between enrollment and observed admission for ischemic heart disease (i.e. *process* effects).

To identify the independent effects of baseline health versus on-going quality and quantity of care differences we adopt two complementary approaches. In the first, we use propensity score modeling to control for selection biases in the 'assignment' of managed care insured status in long panels. Any favorable effect of Medicare managed care can then be plausibly interpreted as a process effect.

In the second approach, significant entitlement policy changes are exploited as natural experiments (Wilensky, 2000; Seshamani et al, 2006). Discontinuous changes in Medicare managed care payment policies which led to large and quick changes in enrollments in either direction may render selection of inputs visible. We hypothesize that insurer-unfavorable payment changes lead to insurer-favorable net membership composition changes. We advance the argument that in the short run, insufficient time exists for process effects to confound such input effects. Given the pathogenesis of the ischemic heart disease which characterizes all our patients, we argue that this is a reasonable assumption.

To operationalize this we examine the relationship between insurance type and health status, examining patients who underwent a percutaneous coronary intervention (PCI). This is the most common therapeutic procedure to treat obstructed coronary arteries and one of the most common reasons for hospitalization (Clark et al, 2005), with over 1.3 million procedures performed in the United States annually (Lloyd-Jones et al, 2009).

We used a rich 14 year panel of more than 486,000 percutaneous coronary interventions (PCI) from Pennsylvania. From this we are able to capture far higher proportions of Medicare managed care than earlier work (Mello et al, 2003). In particular the unbroken panel spans three years before and after the key policy changes of the Balanced Budget Act of 1997 (BBA) as well as the Medicare Modernization Act of 2003 (MMA). Conservative exclusion restrictions (Malenka et al, 2008) yield 192,167 Medicare beneficiaries or Medicare managed care enrolled patients.

We leverage an objective measure of post-enrollment health status in our data. In Pennsylvania, acute care hospitals are mandated to use Atlas Outcomes algorithms to calculate an admission severity variable using a large number of clinical and chart data. This measure of health status mitigates some of the subjectivity inherent in using self-reported Medicare beneficiary survey data to determine health status (Mello et al, 2002; Mello et al, 2003). It also obviates the use of administrative data to 'fit' a model of expected in-hospital mortality.[1]

In the next sections we describe the construction and validation of the dataset, the control variables and the strategy we use to quantify the impact of selection biases and processes of care on differences in disease severity.

DATA AND DESCRIPTIVE STATISTICS

We obtained commercially available data from the Pennsylvania Health Care Cost Containment Council (PHC4). Our database query, the PHC4 extract construction and our dataset validation is further described in the appendix. Our data is patient-level

administrative discharge records for index PCI admissions and repeat admissions within 12 months for acute myocardial infarction (AMI), major cardiac event and in-hospital death, or further PCI or CABG revascularization. All patients were admitted to state-regulated hospitals between January 1, 1994 and December 31, 2007.[2] We merged PHC4 supplemental data files containing facility names and characteristics, as well as physician names with our patient-level data.

Our data contains two fields which we used to ascertain the payor of record. We used the <*paytype1*> code representing primary payor billed, and the <*healthplanid1*> code representing either the National Association of Insurance Commissioners (NAIC) unique company code for a private insurer, or a PHC4 assigned code (e.g. for entitlement FFS payors). We obtained NAIC company names using the NAIC codes in the Pennsylvania Uniform Billing Form Reporting Manual for Inpatient Facilities, June 2008, available at PHC4.org, and from web searches at NAIC.org. Field changes, coding methodology and conflict resolution are described in the appendix.

The final dataset contained 538,308 admissions by 356,688 unique patients. A total of 486,932 PCI admissions and 51,376 non-PCI follow-up admissions were observed. Of the unique patients, 241,696 were observed only once for a single PCI admission, while 114,992 patients were observed more than once for repeat PCI, CABG surgical revascularization, MI or major cardiac event terminating in death.

Dependent variable

Our dependent variable of interest is the Atlas MediQual predicted probability of death. This variable is supplied by PHC4. In PA, acute care hospitals are mandated to use Atlas Outcomes algorithms to calculate this admission severity variable using clinical and chart data. These (PHC4, 2006, p7) include "lab tests, EKG readings, vital signs, the patient's medical history, imaging results, pathology, age, sex, and operative/endoscopy findings…. Some pre-admission data are also captured (e.g., cardiac catheterization findings) as are some history findings."

Admission severity is computed as the fitted values from Atlas' proprietary logistic regression model, and provided as categories. A category value of 0 implies a predicted in-patient mortality probability of 0.000 – 0.001, while 1 corresponds to 0.002-0.011, 2 to

0.012-0.057, and 3 to 0.058-0.499. The highest category 4 implies a predicted probability in the range 0.500-1.000. In our estimations we used the midpoints of these bands.[3]

Control variables

We coded for patient demographics (age, gender, ethnicity and race), presentation acuity (emergent, urgent and elective), admission source (physician referral, hospital or clinic referral, ER referral or healthcare facility transfer) and admission timing (afterhours and weekend) and generated indicators for patient's county of residence. Depending on specification, we also used dummy variables for the treatment facility, or for the treating physician.

We also extracted co morbidity conditions from the primary and eight secondary diagnostic code fields in this rich dataset. This was done by a combination of direct search for ICD9 diagnostic codes, as well as by using the Healthcare Cost and Utilization Project's Clinical Classifications Software (CCS) to extract indicators for higher-level aggregated conditions available at http://www.hcup-us.ahrq.gov/toolssoftware/ccs.

Our inclusion and coding was closely informed by the specialist literature (Block et al, 1998; Cowper et al, 2000; Hannan et al, 2005; Malenka et al, 2008; Ryan et al, 2009). The set of control variables and their codes is lengthy and relegated to the appendix.

Summary statistics

We report summary statistics for selected variables in our main dataset, categorized by insurance status, in Table 1. Full summary statistics are reported in the appendix. The differences in age, risk factor prevalence and outcomes between the elderly Medicare FFS and MC populations and the far younger commercially insured populations is clear.

<<TABLE 1 ABOUT HERE>>

We restrict the full set to minimize unobserved heterogeneity for our main analyses. We describe these exclusion restrictions in detail in the appendix. In summary, their effect is to leave 192,167 in-state residents enrolled in traditional or managed care Medicare in whom an unobserved prior PCI is less likely, who did not have an AMI on admission, in

whom no evidence of a prior myocardial infarction or prior revascularization with CABG existed, and who did not present emergently.

We used STATA v10 for data management and all statistical analyses, report two-sided *p* values, and consider *p* values of 0.05 or less as significant. This study was approved by all of the authors' respective IRBs.

ECONOMETRIC SPECIFICATION AND ESTIMATION

We estimate long-run average effects using a reduced form panel model. This yields the net sum of selection and process of care impacts. We isolated process of care effects by re-estimating a panel model stratified by quintiles of the propensity score for being insured with managed care. We attempt to isolate selection biases by estimating short-run difference-in-difference models around two key policy changes.

Panel model with provider and/or hospital fixed effects

We assume that there is an unknown structural model in which PCI admission severity is determined as a function of clinical factors, general health status, genetics, prior medical care and other factors. Prior medical care, in turn, is determined by individual behavior, socioeconomic status, insurance type and other factors. The insurance type chosen by an individual prior to requiring admission for PCI is determined by individual and insurer information, preferences and decisions, market structure and other factors. Finally, insurer decisions are determined jointly by provider and insurer market forces, payment and cost levels and insurer-observed information on the individual applying for or enrolled in the observed plan.

Plausible functional forms for any of these causal relationships and their simultaneous relationship are many and arbitrary. The required data is unlikely to be collectable. These considerations render estimation infeasible: we shall instead focus on the following reduced form approximation:

$$Y_{i,\,p,\,h,\,q} = \alpha_0 + \alpha_1 X_{i,\,p,\,h,\,q} + \alpha_2 Payor\_Type_{i,\,q} + \alpha_3 c_p + \alpha_4 c_h + \alpha_5 \mu_t + \varepsilon_{i,\,h,\,p,\,q}$$

The dependent variable $Y_{i,h,p,q}$ is admission severity, i indexes patients, p indexes operating physicians, h indexes hospitals, and q indexes quarterly periods from Q1, 1994 through Q4, 2007. Fixed effects μ_t for calendar years correspond to the quarter of discharge q, while fixed effects for physician c_p and/or hospital c_h are also used in some specifications. The vector X collects patient and admission specific demographic, acuity and co-morbidity control covariates. For patients presenting again in different quarters, this vector may differ between admissions (e.g. age, presence of co-morbidities, physician, and hospital).

Following Mello et al (2003) and Chernew et al (2008) we also control for geographical penetration of managed care. We include the degree of managed care penetration conditional on admission for PCI in the patient's home county in the time period of discharge, or lagged by twelve months. For example, for a patient insured by traditional Medicare, this variable measured the ratio of total Medicare managed care insured admissions for PCI to the total of all types of Medicare insured admissions.

The focal variable of interest is the *Payor_Type* in the quarter of admission. In most of our specifications we restrict observations to those within Medicare (either HMO, PPO, POS, or FFS) while in some supplemental specifications we consider other insurance types such as Blue Cross of any sort, or non-Blue Cross Commercial of any type. We estimate this model using ordinary least squares with dummy variables absorbed for providers or hospital or both.[4] This approach is equivalent to a panel model with respective fixed effects. To the extent that there are time-invariant selection effects within provider-patient or hospital-patient relationships, this approach will control for them and thus represents an improvement over pooled regressions. We re-estimate this basic panel using progressively more restrictive patient inclusion criteria described above.

We anticipate finding in this panel model that α_2 is negative; managed care insurance type is associated with a reduced severity index. However, we can't be sure whether this expected finding is due to *input* effects (selection of better risks into managed care plans through marketing or benefit design), or *process* effects (better

management under managed care) or (most likely) a mixture of the two. To attempt to distinguish this using our observational data we turned to two different approaches.

Propensity score modeling

We use an alternative approach that corrects to an unknown extent for the presence of selection bias (Hannan et al, 2005; D'Agostino, 2007). We use the conditional likelihood of a patient being insured with managed care as a quasi-random mechanism to 'assign' the 'treatment' of managed care status to individual patients. In this approach we modeled a reduced form regression of the propensity of patients enrolled in Medicare of any type to choose Medicare managed care.

We considered all the demographic, acuity and co morbidities used in the previous panel, and ran a propensity score algorithm on the binary 'outcome' of Medicare managed care payor type (unspecified Managed Care, HMO, PPO, or POS). This propensity score – the fitted value from a probit regression – was used to stratify patients so that across strata of patients the mean score was the same in patients who chose Medicare FFS as in patients who chose Medicare managed care. We followed Hannan et al (2005) and did not balance covariates within each stratum.[5] We report summary statistics of these strata in appendix Table A3.

We expect that repeating the same panel analyses within the blocks of patients defined by the propensity score algorithm will lead to negative values of α_2, as will an appropriately weighted average of 'treatment' effects across the blocks. We then appeal to the strong and untestable assumption that, conditional on propensity score (and thus only observable covariates), admission severity is independent of 'assignment' to managed care insurance status. If this strong assumption holds, our interpretation of these effects will be that they are not due to selection biases. Rather, we should interpret them as due to true 'treatment' effects and thus improved quantity and quality of care differences in managed care enrollees.

Difference in difference models

The second approach we use is to exploit the natural experiments of discontinuous Medicare payment policy changes to identify short-run input effects around the key

policy milestones. The BBA Act of 1997 and its subsequent amendments were followed by a net decrease in enrollments nationally while the MMA Act of 2003 led subsequently to a net increase in enrollments nationally. Although the BBA was enacted in mid 1997, we expect these effects to be most pronounced over the 1999-2000 period. This is consistent with the delayed effect of the payment policy changes on service area cutbacks and contract terminations in 1999-2000 (Wilensky, 2000). Given the pathogenesis of the underlying disease, we assume that input effects swamp production effects over such short-run enrollment changes.

<<FIGURE 1 ABOUT HERE>>

In Figure 1 we show the national enrollment changes in Medicare HMO/PPO over time, and the corresponding subset of Pennsylvanian enrollees hospitalized for PCI and follow-up admissions. Inspection of the later MMA policy change reveals that enrollments appeared to increase in our data *pari passu* with the national proportion. In contrast, the effects of the earlier BBA on enrollment decreases appear to have taken at least one year longer in our data than nationally. Whether the risk composition changed sooner is an empirical question to be addressed below.

We estimate difference-in-difference models at various periods before, during and after the BBA and MMA time points to understand whether the enrollment changes due to these policy changes also led to changes in admission severity. These models have the following generic form:

$$Y_i = \beta_0 + \beta_1 Year\_Policy_i + \beta_2 Policy\_Sensitive\_Payor\_Type_i + \beta_3 (Year\_Policy_i * Policy\_Sensitive\_Payor\_Type_i) + \varepsilon_i$$

The dependent variable Y_i is again admission severity, i indexes patients, $Year\_Policy_i$ is a binary indicator for a patient discharged in the year following the policy change as opposed to the year of the change (or the year before the change, in some specifications). The binary indicator $Policy\_Sensitive\_Payor\_Type_i$ is for the 'treatment' of Medicare managed care payor type anticipated to be sensitive to the BBA or MMA payment policy

changes as opposed to a control payor type.[6] Unlike the previous panel models, we did not restrict the patient records analyzed. We thus included all patients enrolled in Medicare managed care and, respectively, those patients insured with the control payor type.

The to-be-estimated parameter β_1 yields the effect of any secular trend in admission severity across the pre- and post-policy years, assumed to be equivalent for policy sensitive and control payor type insured patients. The parameter β_2 estimates the time-invariant difference in the dependent variable between the 'treatment' and control payor types. The focal variable of interest is the interaction of the two binary indicators and the parameter β_3 estimates the independent impact of the 'treatment'.

We expect β_3 to be negative in the models assessing the BBA policy change, and expect this to be most prominent around the 1999-2000 period. Put differently, we expect the lowered enrollments to be due to active net disenrollment from Medicare managed care insurers of unfavorable risks, lowering the average admission severity of admitted members.

Conversely, we expect β_3 to be close to zero in the models assessing the MMA change. There we hypothesize that Medicare managed care insurers' increased enrollments were driven by attractive plans that did not actively enroll lower risk members. We omit patient covariates in these models as they would inadvertently 'soak up' the compositional changes that we anticipate capturing in β_3.

We use other non-Medicare managed care payors as the control payor types, since we expect that the unobserved time trend captured by β_1 will be similar across the managed care payors. In contrast, we argue that using Medicare FFS as a control would fail important assumptions necessary for unbiased estimation of β_3. Compositional differences within Medicare managed care must be inverse to compositional changes within traditional Medicare in the short run since movement outside the entitlement program is unlikely. This may violate the assumption of 'parallel trends'.

Additionally, systematic overpayments to insurers participating in Medicare managed care are likely to be reflected in higher premiums for traditional Medicare fee for service beneficiaries and may thus influence the time trend within this group. This linkage violates the exogeneity assumption of the error term in the specification.

In our main specifications we took records from a calendar year and the year before. In robustness checks reported in the appendix we washed out an intervening year: taking records from a calendar year and from two years before, but ignoring the year between.

Donald and Lang (2007) caution analysts on the generic possibility of random yearly fluctuations leading to spuriously significant estimates unrelated to any incidental policy change. We investigate the robustness of our results to such risks by running placebo regressions for a 'policy change that did not happen'. Practically, we repeat the analysis as if a policy change had not happened in 1997 and 2003, but instead in 1995, 1996, 1998, 1999, 2000, 2001, 2002, 2004 or 2005. We expect to find that the coefficient β_3 on the interaction dummy is insignificant in all these other placebo regressions.

FINDINGS

Unstratified panel models

We report a series of exploratory models using the unrestricted dataset in appendix Table A2. As expected, given uncontrolled patient heterogeneity, the impact of managed care is not significant until the panel is restricted as described earlier. We analyze this restricted cohort further in Table 2, introducing covariate blocks sequentially. Doing so did not show parameter instability and the choice of hospital or treating physician or both as fixed effect led to qualitatively very similar estimates of the focal variable.[7]

<<TABLE 2 ABOUT HERE>>

The marginal effect of Medicare managed care status is associated with a reduction in admission disease severity of -0.002 or 0.2% points (p = .002). Compared to the mean admission severity of 5.6% in this restricted panel, the effect of managed care corresponds to a relative 3.6% improvement in our measure of post-enrollment health status.[8]

Propensity stratified panel models

To better distinguish the complementary explanations of selection bias or care differences, we performed a propensity score analysis. A probit regression on managed care status was used to generate predicted probabilities of having Medicare managed care insurance, conditional on observables.

This propensity score was used to stratify these Medicare fee for service or managed care patients into 5 strata corresponding to quintiles (see appendix Table A3 for summary statistics of the quintiles). Within each quintile we repeated the same panel regression, following Hannan et al (2005) and report the results in appendix Table A4. In the two quintiles with the highest conditional likelihood of having managed care status, the coefficient on managed care was significant, negative and qualitatively of the same magnitude as in the unstratified analysis. An unreported separate estimation was also performed of the average treatment effect on the treated (ATT) which weighted the individual strata estimates by the number of treated units in each stratum. The weighted ATT was estimated as -0.005 ($p<.001$), broadly in line with the unstratified analysis' estimate of -0.002 ($p = .002$).

Recall that the propensity analysis attempts to control for the possibility of selection bias. If the assumptions of the propensity score analysis hold, then we may interpret these estimates of favorable post-enrollment admission severity as coarse evidence for care production effects.

Difference-in-difference models

In contrast, we used difference-in-difference models to obtain further evidence for selection effects. In Table 3 we report different model's estimates for β_3, the difference in admission severity across two years for Medicare managed care patients less the difference in admission severity over the same two years for members of a control group. Each row represents a different window, each column a different control group. We report results using four separate control groups, and also report the results obtained using Medicare FFS for completeness. As discussed above, the high likelihood of biases due to 'parallel trend' violations make this final column unreliable.

<<TABLE 3 ABOUT HERE>>

Of immediate interest is the row representing a series of models around the 2000-1999 window. Regardless of control group, the estimate of the impact of Medicare managed care is precisely estimated and of the predicted (favorable) sign. Across the control groups, the 'true' impact of Medicare managed care is estimated as between -0.009 ($p<.01$) and -0.0018 ($p<.001$). Given the average time of twelve months between the sets of observations, it is difficult to argue that these are quantity and quality of care differences changing post-enrollment health status. It is, rather, consistent with a net insurer-favorable disenrollment of worse risks resulting in subsequently improved admission disease severity.

We had hypothesized that the rise in enrollments after the MMA would be neutral in terms of baseline health status, but a favorable impact is also estimated here in the 2005-2004 window. This, although far less precisely estimated, is consistent with net insurer-favorable enrollments of better risks who then have improved admission severity.

We note that the placebo regressions (the 'policy changes that did not happen') in other time windows led to estimates generally statistically indistinguishable from zero. This renders the above results in the 2000-1999 and 2005-2004 windows more convincingly identified off of the BBA and MMA policy changes. We investigated whether our results were robust to using a window such as 2000-1998, ignoring the 1999 observations. There were no essential differences in magnitude, sign or precision (see appendix Table A4).

DISCUSSION

We conducted an analysis of the impact of managed care payor status on post-enrollment disease severity. Our retrospective analysis included over 192,000 Medicare beneficiaries or Medicare managed care enrolled adults hospitalized for PCIs in Pennsylvania, without prior revascularization or AMI, and presenting non-emergently. We found that patients in

managed care plans consistently had lower disease severity on admission. We used complementary methodological approaches in an attempt to discern whether observed differences were attributable to: a) biased selection on the part of the enrollee or the health insurer (inputs) or b) the quality and quantity of services received (processes of care). We found evidence of both.

Several prior studies have found biased selection among MMC enrollees (Call et al, 1999; Maciejewski et al, 2001; Mello et al, 2003). However, other evidence suggests that managed care may increase preventive services and promote higher quality of care, providing support for the 'processes of care' alternative (DeLaet et al, 2002; Landon et al, 2004; Balsa et al, 2007; Miller and Luft, 2002).

First, we estimated a reduced form panel model to examine the association between health plan type and on-admission severity. In an unstratified analysis we found significantly lower severity of disease among the managed care members. This reduction was approximately 0.2% points off of a mean admission severity of 5.6%. When we stratified these patients by propensity scores, we found a similar, yet slightly stronger estimate of reduction in disease severity for managed care patients. To the extent that the propensity score methodology was able to reduce selection effects, these findings suggest that process of care may have a complementary and favorable impact on disease severity.

Second, we used difference-in-difference models to assess whether changes in payment policy, including the BBA and MMA, impacted severity. This use of the timing of policy changes as natural experiments was in the style of Morrissey et al (2008) who used tort reform to estimate changes in defensive medicine and premium reductions. The Balanced Budget Act of 1997 severed the link between average local Medicare FFS costs and Medicare Managed Care payments, lowering MMC payment rates by 6% on average (CBO 1999). Only during the time period of the BBA implementation (from 1999 to 2000) did the disease severity of MMC patients drop significantly, relative to control groups. This suggests biased selection, as it is not likely that processes of care would suddenly change based on payment reduction or have such immediate impacts on health status. It is more likely that payment reform changed either enrollee or insurer behavior in some way and resulting compositional changes led to a net improvement in managed care enrollee health status.

In contrast to the BBA, the Medicare Modernization Act of 2003 increased payments to private health plans in Medicare in an effort to expand competition and ultimately to drive down costs (Biles, Nicholas et al, 2004; Kennedy and Thomas, 2004). Hence, we expected to see less or absent insurer-favorable risk selection during the 2003 to 2004 period as payments increased. Our findings, however, suggest the opposite effect. Following the MMA, the severity of illness among MMC enrollees compared to control groups again decreased significantly, though was less precisely estimated. One explanation might be that managed care plans newly entering the market after MMA offered products that attracted healthier enrollees or were otherwise engaged in selection to a greater extent than managed care plans that existed previously.

In the most comprehensive study to date, Mello et al (2003, p.985) found that "Medicare enrollees are not markedly healthier than nonenrollees on most measures," but that they differ in the prevalence of chronic conditions. They concluded that the extent of biased selection revealed in previous studies depended on the measure of health status and the study methodology.

Our findings, in contrast, provide evidence of consistent and significant differences in disease severity between MMC and Medicare FFS patients. The strengths of this study include a comprehensive assessment of patient severity, using an objective indicator that incorporates detailed chart data for PCI patients, and a multifaceted identification strategy.

There are several limitations to our study. First, as our analysis focused on patients admitted to Pennsylvania hospitals for PCI, our results may not generalize to patients with other conditions. However, if managed care is going to have an impact, it needs to do so in the management of chronic, serious illness such as ischemic heart disease, so our focus on this population seems reasonable. Moreover, PCI is one of the leading reasons for hospitalization in the United States (Clark et al, 2005), with over 1.3 million procedures performed annually (Lloyd-Jones et al, 2009).

Another limitation is that we did not know the severity of a patient's condition at the time they were choosing a health plan or if there was a change in health between enrollment and hospitalization for PCI. We maintain the implicit assumption that such limitations do not systematically bias our results, but this is untestable in our data. This

limits our ability to differentiate more clearly between the impacts of inputs versus processes of care. However, evidence that medications that reduce coronary artery disease progression and improving outcomes typically manifest their effects 1-2 years after their initiation (LaRosa et al, 2009; Heart Outcomes Prevention Evaluation Study Investigators, 2000; Ridker et al, 2008; Collaborative Group of the Primary Prevention Project, 2001) suggest that patients' health status soon after the time of enrollment more likely reflects input rather than changes in patient care.

Finally, in terms of processes of care, we have not been able to measure the quality, quantity or mix or services received by patients related to payer type. Hence, while we assert that processes of care may explain part of the disparity, we do not attempt to identify specific mechanisms.

Our study highlights the need for risk adjusted payments. However, CMS' HCC risk-adjustment methodology, which was developed based on retrospective analyses of Medicare SAF files, may miss a large, and crucially, differing set of patients with *prima facie* different *ex ante* risk. For instance, while the HCC methodology has separate categories for 'vascular disease' and 'vascular disease with complications', these blunt categories may not distinguish, adequately, between the risk level of two different health plans for patients who are potentially very costly. With an increasing number of detailed disease-specific datasets available at the state-wide level, it may be worth examining the benefit of developing more detailed risk models for specific, costly subgroups, such as patients undergoing PCI or cancer patients. When constructing risk models, however, it is important to make sure all relevant data are captured, as several studies have found that while survival does not differ by payer type, site of care varies (Retchin et al, 1997; Bian et al, 2006).

Further study is needed to better understand selection on the part of health plans and enrollees. Growing evidence suggests that while low-income individuals and minorities are the more likely to enroll in MMC, primarily due to differences in premiums (Atherly et al, 2004; Florence et al, 2006), they are also more likely to disenroll, suggesting that these plans may not be meeting their needs (Laschober, 2005; Nicholas 2009).

Finally, our study also implies that 'overpayments' to Medicare managed care (Biles, Nicholas, et al, 2004) may not be completely unwarranted, as not all differences in admission severity were due to selection effects. Finding, funding and encouraging better processes of managing care may continue to be important research and policy areas. Care coordination, selective contracting with providers, and similar managed care activities may be valuable functions, at least for chronic, progressive, well-understood, high evidence base, commonly prevalent illnesses.

ACKNOWLEDGMENTS

<to be added>

DISCLOSURE

The second author discloses half-time employment at an independent licensee of the Blue Cross and Blue Shield Association as research manager. This firm is primarily a PPO plan. It has a Medicare cost contract, but does not have a Medicare Managed Care plan. This research was conducted independently of this firm, including there being no funding support, and there being no editorial control or review conducted.

ENDNOTES

[1] Not relying on the administrative discharge records avoids confounding of 'present on admission' co morbidity with ex interim complications sustained in-hospital. As Moscucci et al (1999) note, in-hospital deaths in PCI have long been mostly 'disease-related' as opposed to 'procedure-related' making correct risk-adjustment vital. Miscoding is a well-known problem with administrative discharge data.

[2] Records from the last calendar year 2007 are exclusively repeat admissions for earlier cohorts of index PCI admissions.

[3] We checked the internal consistency of the MediQual admission severity values with an unreported probit regression on in-hospital death and found reasonable but not perfect concordance. The Pearson correlation between the MediQual category midpoint probability and the probit fitted value probabilities of in-hospital mortality was 0.48 ($P<.000$). This discrepancy is consistent with the MediQual category being a measure of on-admission disease severity rather than predicting in-hospital mortality from a model conditional on diagnosis related group, procedure, physician, hospital, region etc. It is also consistent with the well-known difficulty in properly risk-adjusting outcomes based on administrative as opposed to chart and clinical data (Tsai et al, 2006).

[4] Given the ordinal dependent variable, we also specified an ordered logit model instead of the linear probability model. The sign and significance of the focal variable was very similar, but estimation is more difficult to interpret. Accordingly all results presented use the more intuitive linear marginal effects.

[5] We attempted this using STATA's *pscore* command suite but were not able to achieve balancing within all blocks. This was partly due to the creation of up to 50 blocks to ensure equal mean propensity score across 'treated' and 'untreated' patients within block.

[6] Our omission of patient-level covariates is deliberate as we hypothesize that there will be compositional changes in response to insurer or patient level incentives. Adding patient-level covariates would risks 'soaking up' these changes and leaving the managed care impact unidentified.

[7] We investigated whether differently insured consumers may have different chances of not surviving to reach the hospital or their admission severity may increase as a result of such delay. For example, rural managed care enrollees are systematically further from balloon than urban traditional fee for service beneficiaries. Pennsylvania contains 48 rural counties and 19 urban counties, and approximately 70% of all Medicare managed care enrollees or traditional Medicare beneficiaries reside in urban counties. We tested for such biases in unreported analyses. As expected, an indicator for urban residence significantly reduced admission severity in a multivariate adjusted regression with physician fixed effects in patients insured with Medicare fee for service or managed care with no evidence of prior CABG, PCI or AMI. However, the sign and magnitude of the marginal impact of managed care was qualitatively the same as previously estimated without controlling for county urban or rural status. This provides some comfort that survivorship biases are less likely to impact our results.

[8] In further restrictions (last two columns of Appendix Table A2), the estimated impact of managed care lost significance. This is consistent with either a far smaller sample size, or two views of the nature of managed care biases. In the first, selection effects attributable to patients and insurers who are aware of a realized cardiovascular disease history are driving the coefficient estimate in Column 4, but these patients are absent in Columns 5 and 6. In the second view, managed care may have the most beneficial production effects on patients who are known to have serious cardiovascular disease. Since such patient cohorts are absent in the last two columns, this may explain the insignificant estimate of managed care effects.

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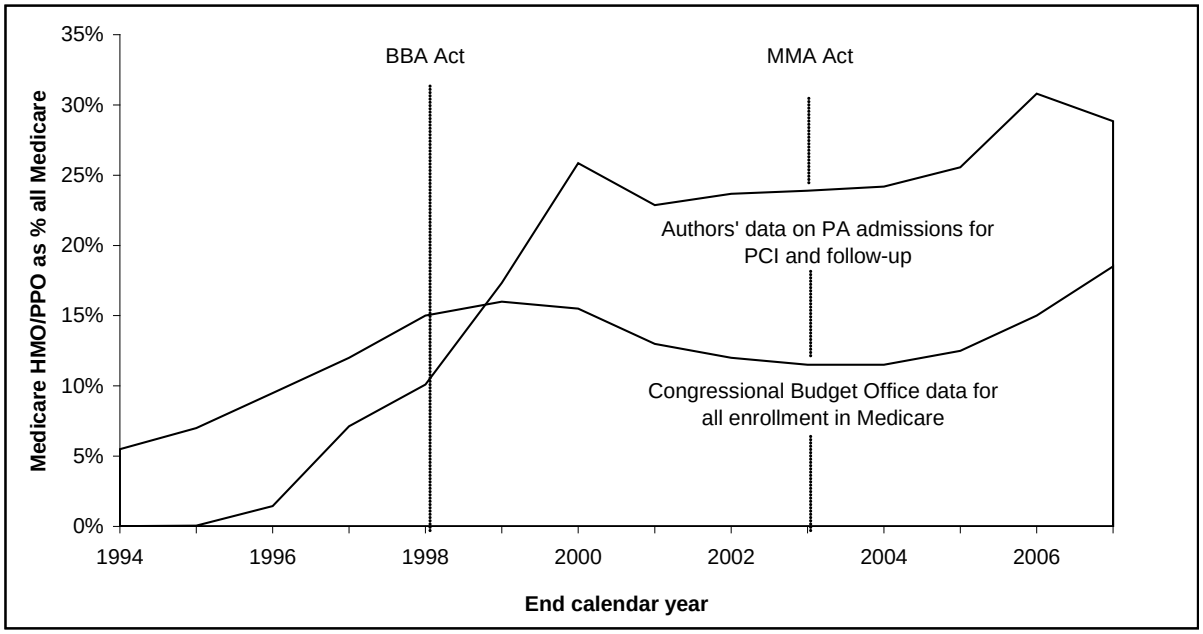
FIGURES AND TABLES

Figure 1: Secular insurance trend

National Medicare HMO/PPO enrollment, Pennsylvanian PCI enrollment



Note: US data represents all enrollees and beneficiaries, whereas PA data represents only admissions for PCI and follow-up in state-regulated hospitals for Medicare managed care enrollees and traditional Medicare beneficiaries

Table 1: Sample descriptive statistics

	All	Medicare FFS	Medicare MC	Blue Cross FFS	Blue Cross MC	Commercial FFS	Commercial MC
Age (years)	64.7	72.9	72.9	56.2	56.5	56.2	56.8
Male	64.6	55.6	58.6	75.7	74.2	75.6	73.9
Hispanic or Latino ethnicity	1.3	1.0	1.1	0.8	1.2	1.0	1.2
White race	85.2	86.9	86.7	87.3	85.5	83.1	84.7
Black race	4.9	4.0	6.0	2.4	5.2	4.5	4.9
Neighboring state	9.0	10.4	1.8	7.7	3.6	20.7	11.1
Non-neighboring state	0.7	0.7	0.1	0.6	0.3	2.2	0.5
Afterhours presentation	36.0	34.6	37.5	35.9	37.9	34.9	36.6
Weekend presentation	11.9	11.7	11.8	11.9	12.0	11.8	11.3
AMI on admission	34.9	32.7	30.8	37.1	35.1	39.0	35.3
MD referral	38.1	39.6	40.4	38.6	40.4	32.4	35.1
ER referral	29.3	28.6	31.8	27.1	31.6	24.4	28.3
Hospital transfer	18.0	18.8	11.1	19.7	13.2	26.6	17.7
Diabetes (type II) without complications	20.3	21.5	24.2	16.7	20.3	15.5	19.2
Old myocardial infarct	14.1	14.0	13.2	15.0	13.7	14.8	14.0
Congestive heart failure	11.7	16.1	15.5	6.0	6.4	6.5	7.0
Chronic obstructive pulmonary disease	8.2	10.4	11.0	4.9	5.3	5.2	5.4
History of tobacco use	6.8	6.1	6.1	8.2	7.7	7.2	8.5
Primary cancer history	6.5	8.8	9.8	3.9	4.1	3.9	4.4
Prior CABG	4.6	6.0	5.4	3.4	3.5	2.9	3.1
Family history of ischemic heart disease	4.2	2.7	1.9	7.0	6.0	4.5	5.7
Diabetes with complications	4.1	4.7	4.3	3.1	3.4	2.8	3.0
Peripheral vascular disease	4.0	5.1	5.4	2.4	2.8	2.5	2.9
Stroke, not acute	3.9	5.3	6.3	1.9	2.7	1.5	2.4
Cardiac dysrhythmiae	3.1	3.3	2.8	3.3	2.7	3.6	3.0
Renal and uteric disease	3.1	4.5	4.3	1.4	1.6	1.3	1.4
Diabetes (type I) without complications	2.8	3.2	1.7	2.9	1.8	3.4	2.5
Knee replacement in situ	0.8	1.1	1.2	0.3	0.4	0.3	0.4
Hip replacement in situ	0.5	0.7	0.8	0.2	0.3	0.2	0.3
DRG: No stent, no AMI	1.6	1.6	2.4	1.0	2.2	0.6	1.6
DRG: No stent, MCV or AMI	6.0	5.4	6.8	4.5	8.7	3.3	6.6
DRG: BMS stent, no MCV or AMI	9.4	9.6	12.8	6.4	13.6	4.1	9.8
DRG: DES stent, no MCV or AMI	14.4	13.2	21.0	9.8	23.1	4.8	16.5
DRG: DES stent, MCV or AMI	7.3	6.2	9.6	4.8	11.0	2.9	8.2
Received PTCA	90.5	89.4	90.0	91.3	92.5	91.3	92.2
Multi-vessel PTCA	8.8	9.2	8.4	8.8	8.8	8.2	8.5
Received CABG	4.3	4.0	3.6	5.3	4.1	5.2	4.5
Received BMS	42.4	40.9	41.2	42.6	44.8	42.2	49.9
Received DES	22.9	20.6	32.7	15.2	35.5	7.9	25.7
In-hospital death	2.4	3.6	3.4	1.0	1.0	1.3	1.0
Length of stay (days)	4.1	4.7	4.2	3.5	3.1	3.8	3.2
MediQual Admission Severity (probability)	0.038	0.055	0.047	0.020	0.019	0.024	0.021
MediQual observations	509,504	208,037	51,172	67,021	55,864	24,778	50,212
Observations (except MediQual)	538,308	221,213	52,774	71,586	57,348	27,073	52,528

Note: Patient-level means in % (unless otherwise noted). DRG = diagnosis related grouper. DES = drug eluting, BMS = bare metal stent. MCV = major cardiovascular diagnosis. AMI = acute myocardial infarction. PTCA = percutaneous transluminal coronary angioplasty.CABG = coronary artery bypass graft. FFS = fee for service. MC = managed care (HMO, PPO, or POS).

Table 2: Regression results

Ordinary least squares estimation: marginal effect of managed care on admission severity for PCI admissions insured by any Medicare type, and without past history of acute myocardial infarction, past PCI or past coronary artery bypass grafts, 1995-2006.

Controls included:										
Demographics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Related directly to PCI		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Related to general health status			Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Possibly related to insurance choice				Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographical region controls					Yes	Yes	Yes	No	Yes	No
Calendar year controls						Yes	Yes	Yes	Yes	Yes
County-level Medicare MC penetration							Yes	Yes	Yes	Yes
Hospital fixed effects								Yes	No	Yes
Treating physician fixed effects									Yes	Yes
Coefficient on Managed Care	(0.007) ***	(0.006) ***	(0.004) ***	(0.004) ***	(0.003) ***	(0.002) **	(0.002) *	(0.002) **	(0.002) **	(0.002) **
(Standard error)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
R^2	10.1%	17.1%	18.7%	19.5%	19.5%	19.8%	19.8%	20.4%	28.9%	29.2%
Observations	180,980								174,696	
F	1,566 ***	1,333 ***	943 ***	672 ***	602 ***	531 ***	525 ***	552 ***	419 ***	147

Notes: Ordinary least squares regressions excluding admissions from 1994 and 2007, exclude past history of acute myocardial infarction or coronary artery bypass graft, exclude out of state patients, and exclude those not enrolled in Medicare fee for service or Medicare managed care. Estimates significant at (***) = p<.001, (**) = p<.010, (*) = p<.050 and (¶) = p<.100. Hospital and treating physician fixed effects modeled using least squares dummy variable regression. Difference in records in last two columns due to missing physician identifiers.

Table 3: Regression results

Difference-in-difference estimation: marginal effect of (managed care*leading year) on admission severity for all admissions insured by Medicare managed care and a varying control group over varying consecutive pairs of years

	Columns: models with different control payor groups				
Rows: models with different Year $_t$ - Year $_{t-1}$	Blue Cross MC	Commercial MC	Commercial FFS	Blue Cross FFS	Medicare FFS
1996 - 1995	(0.0175)	(0.0106)	(0.0107)	(0.0114)	(0.0141)
	0.0240	0.0313	0.0240	0.0207	0.0413
1997 - 1996	0.0056	0.0019	(0.0044)	(0.0001)	0.0014
	0.0134	0.0131	0.0126	0.0102	0.0177
1998 - 1997	0.0017	0.0022	0.0045	0.0013	(0.0016)
	0.0047	0.0041	0.0044	0.0034	0.0048
1999 - 1998	0.0031	0.0029	0.0075 ¶	0.0041	0.0006
	0.0043	0.0037	0.0043	0.0033	0.0041
2000 - 1999	(0.0159) ***	(0.0088) **	(0.0180) ***	(0.0149) ***	0.0004
	0.0027	0.0027	0.0038	0.0026	0.0028
2001 - 2000	0.0020	0.0034	0.0012	0.0020	(0.0014)
	0.0022	0.0023	0.0039	0.0024	0.0023
2002 - 2001	0.0044	0.0033	0.0004	0.0065 *	0.0034
	0.0023	0.0025	0.0046	0.0026	0.0025
2003 - 2002	(0.0009)	(0.0036)	0.0007	(0.0041)	(0.0024)
	0.0022	0.0026	0.0050	0.0026	0.0024
2004 - 2003	0.0013	0.0025	0.0031	0.0013	0.0016
	0.0021	0.0025	0.0053	0.0027	0.0024
2005 - 2004	(0.0052) *	(0.0052) *	(0.0046)	(0.0059) *	(0.0005)
	0.0020	0.0023	0.0052	0.0025	0.0022
2006 - 2005	(0.0002)	0.0011	(0.0087) ¶	0.0018	(0.0030)
	0.0019	0.0021	0.0051	0.0024	0.0019

Note: Dependent variable is admission severity (probability). Model sample includes all Medicare managed care, and respectively, those insured with the control group payor. Double difference estimate on indicator for Medicare MC*leading year, and standard error below. Estimates significant at (***) = p<.001, (**) = p<.010, (*) = p<.050 and (¶) = p<.100. Not shown: constant, leading year indicator, Medicare Managed Care indicator. MC = managed care, FFS = fee for service. Commercial refers to non-Blue Cross affiliated commercial insurers.

SUPPLEMENTAL MATERIAL

Appendix 1. Dataset construction

We requested index percutaneous coronary interventions (PCI) admissions and subsequent non-PCI admissions from PHC4 records from the universe of state-regulated hospital and other healthcare facility patient admissions between Q1 1994 and Q4 2007.

Index PCI admissions comprised records in which the principal procedure code and/or any one of five secondary procedure codes contained the ICD9 procedure codes (3601, 3602, 3605, 3606, 3607 as well as 0040, 0041, 0042, 0043, 0045, 0046, 0047, 0048 and 0066). Any readmissions for repeat percutaneous coronary interventions on the same patient were included as index admissions, and identified separately through a unique patient identifier (<*pseudoid*>) provided by PHC4.

Subsequent non-PCI admissions comprised records within twelve months of discharge by any of the index patients discharged in 1/1/1994 through 12/31/2006 meeting any of the following criteria: acute myocardial infarction (AMI), cardiac event leading to death or coronary artery bypass graft (CABG). These follow-up admissions therefore comprised:

(i) a principal diagnosis code or any one of eight secondary diagnosis codes containing ICD9 diagnostic codes for AMI (410.xx), or

(ii) discharge status code 20 together with ICD9 diagnostic codes for major cardiac events leading: AMI (410) or other acute/sub acute ischemic heart disease (411) or angina (413) or conduction disorders (426) or dysrhythmiae (427), heart failure (428), or ill-defined descriptions and complications of heart disease (429), or

(iii) a principal procedure code and/or any one of five secondary procedure codes contained the ICD9 procedure codes for CABG (3610, 3611, 3612, 3613, 3614, 3615, 3616, 3617, and 3619).

A unique patient may therefore appear only once in the entire dataset for a PCI admission, or may appear more than once. Multiple appearances may be for repeated PCI admissions, or for at least one PCI and a subsequent CABG, or for at least one PCI and a subsequent major cardiac event leading to death, or for at least one PCI and a subsequent admission for a survived AMI. The following presentation and re-presentation patterns were observed in the final dataset:

Appendix 2. Dataset validation

PHC4 supplied index and subsequent admissions in one combined file containing 565,506 records (PHC4, 2007). We identified and removed 27,198 records in which either the entire record had been duplicated, or the records were logical duplicates. These latter represented cases in which a patient had been counted both as an index and a subsequent admission in the same admission (for example, a PCI and CABG performed on the same unique patient identifier with identical patient demographic and co morbidity data in the same admission by the same physicians for the same costs). We also used physician identity files and facility identity files supplied by PHC4 and merged these data with the 538,308 records remaining in our data.

Where <*paytype1*> code and <*healthplanid1*> agreed, we coded the relevant payor type. For example, 45 and 95109 in combination represent the Aetna's Commercial HMO plans. Where these disagree, we conservatively coded the payor type as unknown. For example, 12 and 9999999 conflict as the former codes for a Medicare PPO plan, while the latter codes for Medicare FFS. Where one of these was missing, we coded for the other's payor type.

PHC4 changed managed care codes over Q3 1999 – Q1 2000 to reflect plan diversity (see Table A6). For example, Commercial managed care plans were uniformly coded with <*paytype1*> code 45 before Q1 2000, after which 45 was retained for Commercial HMO, and POS were coded as 43 and PPO as 42. A two quarter period of permitted hospital coding overlap in Q3-Q4 1999 presented interpretation difficulties. For example, continuing the example, 45 could represent generic managed care or specifically HMO. To be conservative, we coded all such ambiguities as belonging to the previous coding regime of generic managed care, rather than assuming hospitals had expedited the changes.

Finally, we identified and cleaned records in which the hospital-claimed diagnostic related group differed from that assigned by PHC4, favoring the latter codes in conflicts.

Appendix 3. Dataset restriction

Our identification strategy focuses on Medicare insured patients, in particular for the difference-in-difference analyses. We wished to use a more fine-grained subset of the data for our main analyses and thus restricted patients as follows.

We follow exclusions informed by those of the Stent Anticoagulation Restenosis Trial Study (Malenka et al, 2008). These criteria included restricting observations to those patients in whom an unobserved prior PCI is less likely (by 'washing out' patients from the 1994 calendar year), to those without an acute myocardial infarction on admission, and to those not presenting emergently.

To avoid a similar bias towards unobservably sicker patients, we also exclude admissions from all other states or all except the six neighboring states of Delaware, Maryland, West Virginia, Ohio, New York or New Jersey in some specifications. Finally, in some specifications we attempted to mitigate potential bias due to compositional differences by further restricting observations to patients' first appearance in the panel and discarding subsequent admissions.

In appendix Table A1 we report additional summary statistics for progressively restricted samples. In the first column are shown the unrestricted patient-level means for the entire dataset of 538,308 records from 1/1/94 through 12/31/2007. Of these, the second column reports only those records up to 12/31/2006 (dropping 1,955 records), so that all possible re-admissions in the subsequent twelve months were observable.

The third column focuses additionally only on in-state Pennsylvania residents, and those in whom an unobserved prior PCI is less likely (by 'washing out' patients from the 1994 calendar year), in whom no evidence of a prior CABG exists (coded by the absence of ICD9 code 41402) and in whom no evidence of a prior myocardial infarction exists (coded by the absence of ICD9 code 412). These changes lead to us dropping a further 157,170 records.

The fourth column of appendix Table A1 further restricts the panel to those patients enrolled in Medicare of any type, dropping 187,016 records belonging to patients not insured by any type of Medicare. This column corresponds to the subset of 192,167 records on which most of our analyses are based.

The fifth column focuses additionally on those without an acute myocardial infarction on admission (coded by the absence of ICD9 codes 410.X0 and 410.X1), and to those not presenting emergently. Note that this definition includes sub-endocardial infarcts (ICD9 410.7) in contrast to Malenka et al (2008) and also includes all unspecified infarct diagnoses (ICD9 410.X0) like Malenka et al (2008), but unlike the more narrow inclusion for acute myocardial infarction followed by the Agency for Healthcare Quality and Research (AHRQ Quality Indicators, 2008).

This focus causes us to drop a further 150,729 records. The final column only reports patients' first presentation, discarding all 24,133 repeat presentations for further PCI or surgical revascularization, for myocardial infarction or for major cardiac event leading to death.

Appendix 4. Control variable inclusion and coding

First, to control for co morbid *conditions directly related to admission for PCI* we included co morbidities used by Malenka et al (2008) and coded for a history of a previous myocardial infarction (ICD9 code 412), chronic obstructive pulmonary disease (4168), congestive heart failure (4280), peripheral vascular disease (4439), long-term use of insulin (V5867), diabetes type 1 (25001) or type II (25000) without complications, diabetes with complications (CCS code 50), liver disease (150 and 151), dementia (653), renal disease of nephritis, nephrosis and renal sclerosis (156) and chronic renal failure (158), primary cancer (11-41), and metastatic cancer (42). We also included non-acute stroke (110 -113) used by Ryan et al (2009), cardiac dysrhythmiae (ICD9 code 42789) used by Hannan et al (2005) and the following additional co morbid conditions: paroxysmal ventricular tachycardiae (4271) and prior coronary artery bypass graft (41402).

We considered, but did not include diagnostic codes for conditions which are likely to be ex interim complications sustained during the hospitalization. These comprised acute renal failure (ICD9 code 4414), acute respiratory failure (5849), and cardiogenic shock (78551).

Next, to control for general post-enrollment health status *not directly related to ischemic heart disease*, we coded the presence of asthma (ICD9 code 49390), presence of an abdominal aortic aneurysm (4414), esophageal reflux (53081), chronic diverticulitis (56210), history of replaced knee (V4365) or hip (V4364), hypothyroidism (2449), anemia (2859) and iron deficient anemia (2809), atrial fibrillation (42731), benign (4011) and not otherwise specified hypertension (4019), hypertrophic heart disease (40290), primary cardiomyopathy (4254), sleep apnea (78057) and depressive disorder (code 311).

Last, we controlled for *personal or family health information* that might plausibly be associated with the patient's choice of particular insurance. Accordingly, we coded for history of non-compliance (V1581), history of tobacco use (V1582), tobacco use disorder (3051) or history of alcohol abuse (305), family history of ischemic heart disease (V173), history of past circulatory disease (V1259), chronic heart disease (4148), heart disease not otherwise specified (4299), obesity (ICD9 code 27800) and morbid obesity (27801),

past history of heart valve replacement (V433), current mitral (4240), aortic (4241), and triscuspid (3971) valve disorder, chronic pulmonary heart disease (4168), hyperlipidemia (2724) and hypercholesterolemia (2720), long-term use of antiplatelets (V5863), anticoagulants (V5861) or aspirin (V5866), previously implanted and currently in-situ automatic cardiac defibrillator (V4502) or cardiac pacemaker (V4501).

Our presentation of these covariates in distinct categories is for presentational purposes only. We used all in our analyses. We did not observe other independent predictors of post-enrollment disease severity such as previous physician or hospital outpatient treatment or diagnoses (Pope et al, 2004). We also did not observe directly the clinical or chart data variables such as creatinine level used by other investigators (Moscucci et al, 1999).

For exclusion restrictions and subset analyses we generated indicators for treatment received. These dummies included CABG, PCI, multi-vessel PCI, bare metal stent (BMS), and for drug eluting stent (DES). Finally, in some specifications we used indicators for key diagnosis related groupers (DRG) including PCI without stent and without AMI (518), PCI without stent but with AMI (516 and 555), BMS stent without AMI or major cardiovascular (MCV) diagnosis (517 or 556), DES stent without AMI or MCV diagnosis (527 or 558), and for DES stent with AMI or MCV diagnosis (526 or 557).

Table A1: Patient-level means for unrestricted and restricted panels

Variable	All	Excludes, progressively				
		2007 admissions	Out of state, 1994, prior CABG, prior AMI	Not enrolled in Medicare	AMI or emergent admissions	Subsequent admissions
Age (years)	64.7	64.7	64.7	73.2	73.2	73.2
Male	64.6	64.6	62.9	54.1	52.2	51.2
Hispanic or Latino ethnicity	1.3	1.3	1.3	1.1	1.2	1.2
White race	85.2	85.2	85.5	87.2	87.0	85.9
Black race	4.9	4.8	5.1	4.6	6.9	7.3
AMI on admission	34.9	34.8	37.1	33.7	0.0	0.0
Weekend	11.9	11.9	12.5	12.1	17.2	15.6
Afterhours presentation	36.0	36.0	36.3	35.5	33.7	31.9
Acuity urgent	28.3	28.3	27.4	26.7	0.0	0.0
Acuity elective	30.0	30.1	29.3	30.9	0.0	0.0
Neighboring state	9.0	9.0				
Non-neighboring state	0.7	0.7				
MD referral	38.1	38.1	37.7	39.7	20.4	21.9
Hospital transfer	18.0	18.1	15.7	14.7	8.5	9.8
ER referral	29.3	29.2	32.0	31.7	58.5	53.9
Diabetes (II) without complications	20.3	20.3	20.2	21.9	22.2	21.6
Old myocardial infarct	14.1	14.1	0.0	0.0	0.0	0.0
Congestive heart failure	11.7	11.6	11.6	16.0	14.9	12.4
Chronic obstructive pulmonary disea	8.2	8.2	8.5	10.9	12.0	11.5
Primary cancer	6.5	6.5	6.6	9.1	9.5	9.8
Prior CABG	4.6	4.6	0.0	0.0	0.0	0.0
Paroxysmal ventricular tachycardia	4.1	4.1	4.3	4.3	3.5	3.3
Diabetes with complications	4.1	4.0	4.3	4.9	6.1	5.8
Peripheral vascular disease	4.0	4.0	3.8	5.0	4.9	4.8
Stroke, not acute	3.9	3.9	4.2	5.9	4.8	5.5
Cardiac dysrhythmiae	3.1	3.1	3.2	3.3	3.2	3.5
Renal and uteric disease	3.1	3.0	3.2	4.7	6.4	6.0
Diabetes (I) without complications	2.8	2.8	2.5	2.6	2.9	2.6
Dementia	0.7	0.7	0.8	1.3	1.5	1.5
Liver disease	0.7	0.6	0.7	0.7	0.9	0.8
Long-term insulin user	0.4	0.4	0.4	0.5	0.5	0.5
Secondary cancer	0.3	0.3	0.3	0.5	0.7	0.6
Hypertension	48.6	48.7	48.7	50.3	50.2	52.1
Atrial fibrillation	9.2	9.2	9.6	14.0	15.1	13.6
Esopahageal reflux	7.8	7.8	8.2	8.1	9.6	9.6
Hypothyroidism	5.8	5.8	6.1	7.9	8.4	8.9
Anemia	3.5	3.5	3.6	4.8	5.3	5.1
Beign hypertension	2.5	2.5	2.1	2.2	1.2	1.1
Depressive disorder	2.2	2.2	2.3	2.1	2.4	2.4
Primary cardiomyopathy	2.1	2.1	2.1	2.6	3.1	3.1
Asthma	1.8	1.8	1.9	1.6	1.6	1.8
Sleep apnea	1.3	1.3	1.4	1.0	1.1	1.1
Hypertrophic heart disease	1.0	1.0	1.1	1.3	1.6	1.7
Knee replaced	0.8	0.8	0.8	1.2	1.2	1.4
Abdominal aortic aneurysm	0.6	0.6	0.6	0.9	0.9	1.0

Table A1: (continued)

Variable	All	Excludes, progressively				
		2007 admissions	Out of state, 1994, prior CABG, prior AMI	Not enrolled in Medicare	AMI or emergent admissions	Subsequent admissions
Hyperlipidemia	26.6	26.6	26.8	25.1	23.8	23.3
Hypercholesterolemia	19.2	19.2	18.3	15.1	15.7	16.0
Tobacco use disorder	11.4	11.4	12.4	5.5	4.1	4.9
History of tobacco use	6.8	6.8	6.7	6.1	4.8	5.4
Mitral valve disorder	5.2	5.2	5.2	6.7	6.9	7.0
Family history ischemic heart disea	4.2	4.2	4.6	2.7	2.0	2.5
Ischemic heart disease	3.2	3.2	2.9	3.4	4.1	3.2
History of circulatory disease	2.5	2.5	2.5	3.3	3.3	3.6
Aortic valve disease	2.0	2.0	2.1	3.0	3.2	3.4
Pacemaker implant	1.6	1.6	1.6	2.6	3.3	3.0
Morbid obesity	0.9	0.9	1.0	0.7	0.7	0.8
Long-term anticoagulant user	0.9	0.9	0.9	1.3	1.3	1.2
Chronic pulmonary heart disease	0.8	0.8	0.8	1.2	1.3	1.4
Long-term aspirin useer	0.8	0.8	0.8	0.9	0.6	0.6
Heart valve replacement	0.7	0.7	0.7	0.9	1.0	1.1
ACD implant	0.5	0.5	0.3	0.5	0.6	0.4
Long-term antiplatelet user	0.3	0.3	0.3	0.4	0.2	0.1
MQ Admission Severity (probability)	0.038	0.037	0.040	0.056	0.038	0.028
In-hospital death	2.4	2.3	2.6	3.9	5.0	1.1
Length of stay (days)	4.1	4.1	4.1	4.7	5.4	5.3
DRG: No stent, no AMI	1.6	1.6	1.5	1.7	2.5	1.8
DRG: No stent, MCV or AMI	6.0	6.0	6.7	6.1	0.5	0.4
DRG: BMS stent, no MCV or AMI	9.4	9.5	9.6	10.4	14.0	16.2
DRG: DES stent, no MCV or AMI	14.4	14.5	15.1	15.4	18.1	20.2
DRG: DES stent, MCV or AMI	7.3	7.2	8.1	7.4	2.3	2.2
Received PTCA	90.5	90.7	90.1	88.8	85.2	100.0
Multi-vessel PCI	8.8	8.8	8.2	8.3	8.3	10.0
Received BMS	42.4	42.5	44.1	42.0	40.2	49.5
Received DES	22.9	22.9	24.5	24.4	22.0	24.2
Received CABG	4.3	4.2	3.9	3.7	3.7	1.0
Medicare FFS	41.1	41.1	39.5	77.9	76.9	77.2
Blue Cross FFS	13.3	13.3	12.9	0.0	0.0	0.0
Blue Cross MC	10.7	10.7	12.1	0.0	0.0	0.0
Medicare MC	9.8	9.8	11.2	22.1	23.1	22.8
Commercial MC	9.8	9.8	10.1			
Commercial FFS	5.0	5.0	4.0			
Medicaid MC	1.8	1.8	2.0			
Medicaid FFS	3.2	3.2	3.3			
Uninsured	1.0	1.0	0.9			
Observations (except MediQual)	538,308	536,353	379,183	192,167	41,438	24,133
MediQual observations	509,504	507,749	357,553	180,981	38,657	22,531

Note: Patient-level means in % (unless otherwise noted). DRG = diagnosis related grouper. DES = drug eluting, BMS = bare metal stent. MCV = major cardiovascular diagnosis. AMI = acute myocardial infarction. PTCA = percutaneous transluminal coronary angioplasty. CABG = coronary artery bypass graft. FFS = fee for service. MC = managed care (HMO, PPO, or POS).

Table A2: Regression results

Ordinary least squares with hospital fixed effects estimation: progressively restricted samples

		Excludes, progressively				
Variable	Unrestricted	2007 admissions	Out of state, 1994, prior CABG, and prior AMI	Not enrolled in Medicare	AMI or emergent admissions	Subsequent admissions
Demographics controls			Included			
Co-morbidities related directly to PCI			Included			
Co-morbidities related to general health status			Included			
Co-morbidities possibly related to insurance choice			Included			
Calendar year controls			Included			
County-level Medicare managed care penetration			Included			
Hospital fixed effects			Included			
Coefficient on Managed Care	0.0000	0.0000	(0.0003)	(0.0020) **	(0.0004)	(0.0004)
(Standard error)	0.0003	0.0003	0.0003	0.0006	0.0011	0.0011
R^2	19.6%	19.4%	20.2%	20.4%	17.7%	14.6%
Observations	497,681	495,943	357,450	180,980	38,656	22,530
F	1,366 ***	1,361 ***	1,101 ***	525 ***	78 ***	39

Notes: Ordinary least squares regressions of progressively restricted pooled regressions. Estimates significant at (***) = p<.001, (**) = p<.010, (*) = p<.050 and (¶) = p<.100. An F test on the joint probability of all hospital fixed effects being zero was rejected for each model (p<.001).

Table A3: Summary statistics

Propensity score quintiles size and disease severity

	Quintiles of propensity score					Excluded from propensity model	All
	1	2	3	4	5		
Propensity score	5.5%	11.6%	23.8%	30.8%	38.7%	nm	nm
Actual Medicare managed care	5.9%	11.2%	23.2%	30.5%	39.6%	37.9%	32.2%
MediQual admission severity	6.7%	5.1%	6.4%	6.1%	3.8%	2.8%	3.8%
MediQual Observations	35,628	36,877	35,663	35,995	36,817	328,524	509,504
Medicare observations	38,436	38,432	38,432	38,449	38,416	346,143	538,308

Notes: Patient-level means. Propensity score is fitted value from probit regression of restricted pooled panel data on 'treatment' of having Medicare managed care insurance. Restricted panel excludes admissions from 1994 and 2007, excludes past history of acute myocardial infarction or coronary artery bypass graft, excludes out of state patients, and excludes those not enrolled in Medicare fee for service or Medicare managed care. "nm" = not meaningful.

Table A4: Regression results

Ordinary least squares by propensity score quintiles

		Quintiles of propensity score				
	Unstratified	1	2	3	4	5
Coefficient on Managed Care	(0.0016) *	(0.0003)	(0.0013)	0.0007	(0.0044) ***	(0.0019) *
(Standard error)	0.0006	0.0026	0.0017	0.0015	0.0013	0.0009
R^2	0.1978	20.0%	21.3%	18.6%	19.3%	19.5%
Observations	180,980	35,628	36,877	35,663	35,995	36,817
F	525 ***	111 ***	117 ***	97 ***	105 ***	108 ***

Notes: Ordinary least squares regressions of restricted panel, within strata defined by quintiles of propensity score. Propensity score is fitted value from probit regression of restricted panel data on 'treatment' of having Medicare managed care insurance. Restrictions exclude admissions from 1994 and 2007, excludes past history of acute myocardial infarction or coronary artery bypass graft, excludes out of state patients, and excludes those not enrolled in Medicare fee for service or Medicare managed care. Estimates significant at (***) = p<.001, (**) = p<.010, (*) = p<.050 and (¶) = p<.100.

Table A5: Regression results

Difference-in-differences estimation: marginal effect of (managed care*leading year) on probability of admission severity for all admissions insured by Medicare managed care and a varying control group using varying pairs of two years without intervening year

Rows: models with different $Year_t$ - $Year_{t-2}$	Columns: models with different control payor groups				
	Blue Cross MC	Commercial MC	Commercial FFS	Blue Cross FFS	Medicare FFS
1999 - 1997	0.0048	0.0051	0.0120 **	0.0054	(0.0010)
	0.0045	0.0039	0.0045	0.0034	0.0045
2000 - 1998	(0.0128) ***	(0.0059) *	(0.0104) **	(0.0108) ***	0.0010
	0.0031	0.0030	0.0038	0.0027	0.0033
2001 - 1999	(0.0140) ***	(0.0053) ¶	(0.0167) ***	(0.0129) ***	(0.0010)
	0.0030	0.0029	0.0043	0.0029	0.0030
…	…	…	…	…	…
2004 - 2002	0.0004	(0.0011)	0.0039	(0.0028)	(0.0007)
	0.0022	0.0026	0.0051	0.0027	0.0024
2005 - 2003	(0.0039) *	(0.0027)	(0.0015)	(0.0046) ¶	0.0012
	0.0020	0.0023	0.0050	0.0025	0.0022
2006 - 2004	(0.0053) **	(0.0041) ¶	(0.0133) *	(0.0041)	(0.0034) ¶
	0.0020	0.0023	0.0053	0.0025	0.0020

Note: Dependent variable is admission severity (probability). Model sample includes all Medicare managed care, and respectively, those insured with the control group payor. Double difference estimate on indicator for Medicare MC*leading year, and standard error below. Estimates significant at (***) = p<.001, (**) = p<.010, (*) = p<.050 and (¶) = p<.100. Not shown: constant, leading year indicator, Medicare Managed Care indicator. MC = managed care, FFS = fee for service. Commercial refers to non-Blue Cross affiliated commercial insurers.

Table A6: Billing data

PHC4 billing codes for payor type

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Uninsured	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Medicare FFS	10	10	10	10	10	10	14	14	14	14	14	14	14	14
Medicare non-FFS	15	15	15	15	15	15								
Medicare HMO						15	15	15	15	15	15	15	15	15
Medicare PPO						12	12	12	12	12	12	12	12	12
Medicare POS								13	13	13	13	13	13	13
Commercial Other	40	40	40	40	40	40								
Commercial FFS						44	44	44	44	44	44	44	44	44
Commercial HMO/PPO	45	45	45	45	45	45								
Commercial HMO						45	45	45	45	45	45	45	45	45
Commercial POS						43	43	43	43	43	43	43	43	43
Commercial PPO						42	42	42	42	42	42	42	42	42
Commercial Union	46	46	46	46	46	46								
Commercial WC	47	47	47	47	47	47	47	47	47	47	47	47	47	47
Commercial Auto	48	48	48	48	48	48	48	48	48	48	48	48	48	48
Commercial Unknown						49	49	49	49	49	49	49	49	49
Blue Cross Other	30	30	30	30	30	30								
Blue Cross FFS						34	34	34	34	34	34	34	34	34
Blue Cross Union	36	36	36	36	36	36								
Blue Cross Asociation	39	39	39	39	39	39								
Blue Cross HMO/PPO	35	35	35	35	35	35								
Blue Cross HMO						35	35	35	35	35	35	35	35	35
Blue Cross PPO						32	32	32	32	32	32	32	32	32
Blue Cross POS						33	33	33	33	33	33	33	33	33
Blue Cross Unknown									39	39	39	39	39	39
Government Other/Unknown	80	80	80	80	80									
Government Unknown						89	89	89	89	89	89	89	89	89
Government State Workers	87	87	87	87	87									
Government Catastrophic	88	88	88	88	88									
Government FFS						84	84	84	84	84	84	84	84	84
Government PPO						82	82	82	82	82	82	82	82	82
Government HMO						85	85	85	85	85	85	85	85	85
Medicaid Other	20	20	20	20	20	20								
Medicaid FFS						24	24	24	24	24	24	24	24	24
Medicaid HMO/PPO	25	25	25	25	25									
Medicaid PPO						22	22	22	22	22	22	22	22	22
Medicaid HMO						25	25	25	25	25	25	25	25	25
Other/Unknown	90	90	90	90	90									
Unknown						99	99	99	99	99	99	99	99	99

Note: Changeover at end of 1999 allowed hospitals to use new codes and former codes through Q3 and Q4 of 1999. From Q1 2000, all hospitals were mandated to report using new codes.