Original Investigation

Geographic Variation in Cardiovascular Procedure Use Among Medicare Fee-for-Service vs Medicare Advantage Beneficiaries

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IMPORTANCE Little is known about how different financial incentives between Medicare Advantage and Medicare fee-for-service (FFS) reimbursement structures influence use of cardiovascular procedures.

OBJECTIVE To compare regional cardiovascular procedure rates between Medicare Advantage and Medicare FFS beneficiaries.

DESIGN, SETTING, AND PARTICIPANTS Cross-sectional study of Medicare beneficiaries older than 65 years between 2003-2007 comparing rates of coronary angiography, percutaneous coronary intervention (PCI), and coronary artery bypass graft (CABG) surgery across 32 hospital referral regions in 12 states.

MAIN OUTCOMES AND MEASURES Rates of coronary angiography, PCI, and CABG surgery.

RESULTS We evaluated a total of 878 339 Medicare Advantage patients and 5 013 650 Medicare FFS patients. Compared with Medicare FFS patients, Medicare Advantage patients had lower age-, sex-, race-, and income-adjusted procedure rates per 1000 person-years for angiography (16.5 [95% CI, 14.8-18.2] vs 25.9 [95% CI, 24.0-27.9]; $P < .001$) and PCI (6.8 [95% CI, 6.0-7.6] vs 9.8 [95% CI, 9.0-10.6]; $P < .001$) but similar rates for CABG surgery (3.1 [95% CI, 2.8-3.5] vs 3.4 [95% CI, 3.1-3.7]; $P = .33$). There were no significant differences between Medicare Advantage and Medicare FFS patients in the rates per 1000 person-years of urgent angiography (3.9 [95% CI, 3.6-4.2] vs 4.3 [95% CI, 4.0-4.6]; $P = .24$) or PCI (2.4 [95% CI, 2.2-2.7] vs 2.7 [95% CI, 2.5-2.9]; $P = .16$). Procedure rates varied widely across hospital referral regions among Medicare Advantage and Medicare FFS patients. For angiography, the rates per 1000 person-years ranged from 9.8 to 40.6 for Medicare Advantage beneficiaries and from 15.7 to 44.3 for Medicare FFS beneficiaries. For PCI, the rates ranged from 3.5 to 16.8 for Medicare Advantage and from 4.7 to 16.1 for Medicare FFS. The rates for CABG surgery ranged from 1.5 to 6.1 for Medicare Advantage and from 2.5 to 6.0 for Medicare FFS. Across regions, we found no statistically significant correlation between Medicare Advantage and Medicare FFS beneficiary utilization for angiography (Spearman $r = 0.19$, $P = .29$) and modest correlations for PCI (Spearman $r = 0.33$, $P = .06$) and CABG surgery (Spearman $r = 0.35$, $P = .05$). Among Medicare Advantage beneficiaries, adjustment for additional cardiac risk factors had little influence on procedure rates.

CONCLUSIONS AND RELEVANCE Although Medicare beneficiaries enrolled in capitated Medicare Advantage programs had lower angiography and PCI procedure rates than those enrolled in Medicare FFS, the degree of geographic variation in procedure rates was substantial among Medicare Advantage beneficiaries and was similar in magnitude to that observed among Medicare FFS beneficiaries.

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Treatment of cardiovascular disease is one of the largest drivers of health care cost in the United States, accounting for $273 billion annually.[1] Cardiovascular procedures are major contributors to this high cost. Studies consistently demonstrate several-fold geographic variation in rates of cardiovascular procedures across the United States.[2-5] For example, the 2007 rate of coronary angiography varied nearly 6-fold from 6.8 per 1000 Medicare fee-for-service (FFS) beneficiaries in Honolulu, Hawaii, to 39.8 per 1000 in Gulfport, Mississippi.

The vast majority of the studies of geographic variation in clinical practice have been performed among the Medicare FFS population.[6] In contrast, relatively little is known about variation in the rates of health care utilization among the 23% of Medicare beneficiaries covered under capitated plans via the Medicare Advantage program.[7] Under the Medicare FFS reimbursement structure, physicians are paid more for doing more procedures. In contrast, integrated delivery systems that provide care for Medicare Advantage beneficiaries receive a capitated payment, and physicians working in these settings are not paid more for doing more procedures. If the primary reason for geographic variation in health care utilization is varying financial incentives for physicians, one would expect that overall cardiovascular procedure rates and variation in procedure rates would be lower for Medicare Advantage patients than for Medicare FFS patients. On the other hand, if factors such as differences in patient clinical characteristics,[8,9] patient preferences for treatment, or local practice culture[10] are the central drivers of variation, one would expect that overall cardiovascular procedure rates and variation in procedure rates would be similar for Medicare Advantage patients and Medicare FFS patients.

CABG *coronary artery bypass graft surgery*

FFS *fee-for-service*

HRR *hospital referral region*

PCI *percutaneous coronary intervention*

Therefore, the objective of this study was to compare the overall rates and local area rates of coronary angiography, percutaneous coronary intervention (PCI), and coronary artery bypass graft (CABG) surgery between Medicare Advantage and Medicare FFS beneficiaries living in the same communities. We hypothesized that compared with Medicare FFS, overall rates and the degree of geographic variation of cardiovascular procedure use would be lower within the Medicare Advantage program.

Methods

Study Design

We conducted a cross-sectional study comparing rates of coronary angiography, PCI, and CABG surgery among Medicare Advantage and Medicare FFS beneficiaries over the 5-year period spanning 2003-2007.

Data Sources

Medicare FFS Patients

The study sample of Medicare FFS patients was drawn from the Medicare enrollment database (ie, "denominator" files). This database includes monthly indicators of whether beneficiaries are enrolled in a Medicare FFS or Medicare Advantage plan, as well as demographic information including dates of birth and death, sex, race, and residential zip codes.

Medicare Advantage Patients

The study sample of beneficiaries with Medicare Advantage plans was drawn from a population of approximately 11 million patients served by integrated delivery systems within the Cardiovascular Research Network (CVRN).[11-13] The CVRN is a National Heart, Lung, and Blood Institute–sponsored consortium of 15 health systems with dedicated research divisions. The research divisions compile their data, consisting of administrative, claims, and clinical electronic health record data, into standardized research repositories called the Virtual Data Warehouse to facilitate collaborative research.[12] Twelve CVRN sites participated in this study.

Geographic Area

We used the hospital referral region (HRR) as the geographic unit of analysis. Hospital referral regions have been defined by the Dartmouth Atlas project based on referral patterns for tertiary care[6] and are designed to approximate health care markets, in which practice patterns may be similar. Patients were assigned to HRRs by their zip code of residence.

Procedure Identification

Procedures were identified among Medicare FFS patients via inpatient, outpatient, and physician claims. The use of outpatient claims was necessary because angiography and PCI are increasingly performed on an outpatient basis.[14] Procedures were identified among Medicare Advantage patients via administrative claims or the electronic health record within participating CVRN health plans.[12] Medicare Advantage patients with health plans not participating within the CVRN are not included in this analysis. Physician and facility claims for the same procedure for the same patient on approximately the same date were assumed to be redundant.

For both Medicare FFS and Medicare Advantage data, coronary angiography was identified by *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes 37.22, 37.23, 88.55, 88.56, and 88.57 or *Current Procedural Terminology* (*CPT*) codes 93508, 93539, 93540, 93545, and 93556. Percutaneous coronary intervention was identified by *ICD-9* codes 00.66, 36.01, 36.02, 36.05, 36.06, 36.07, and 36.09 or *CPT* codes 92980-92984, 92995, 92996, G0290, and G0291. Coronary artery bypass graft surgery was identified by *ICD-9* codes 36.1X and *CPT* codes 33510-33536. We classified procedures that occurred during a hospitalization for an acute myocardial infarction (*ICD-9* code 410.X) as "urgent" and all others as "nonurgent."

Geographic Analysis

The study was restricted to patients living in HRRs (n = 32) with a minimum of 6000 CVRN Medicare Advantage beneficiaries to ensure precision and stability of the HRR-level procedure rates. We included only Medicare Advantage or Medicare FFS patients between the ages of 65 and 99 years, because Medicare coverage is nearly universal after age 65 years. Rates per

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Table 1. Populations of Medicare Patients Within and Surrounding Each Cardiovascular Research Network (CVRN) Delivery System (Average for 2003-2007)

CVRN Delivery System	Hospital Referral Regions	No. Medicare Advantage (n = 878 339)[a]	No. Medicare FSS (n = 5 013 650)	CVRN Total, %
Kaiser Permanente				
Colorado	Denver, Boulder	61 807	189 088	25
Northern California	Santa Rosa, San Francisco, Sacramento, Fresno, Napa, San Jose, Alameda County, Stockton, San Mateo County, Contra Costa County	325 337	823 606	28
Southern California	Orange County, Los Angeles, San Bernadino, San Diego, Ventura	164 248	1 205 717	12
Northwest	Portland, Salem (Oregon)	56 980	206 586	22
Georgia	Atlanta	16 576	510 073	3
Hawaii	Honolulu	27 153	110 313	20
Group Health Cooperative	Seattle, Tacoma, Olympia, Everett (Washington)	67 986	415 784	14
HealthPartners	Minneapolis, St Paul (Minnesota)	50 794	460 492	10
Henry Ford	Detroit, Dearborn (Michigan)	21 196	319 143	6
Harvard Pilgrim	Boston (Massachusetts)	47 612	554 760	8
Lovelace Sandia	Albuquerque (New Mexico)	30 702	156 805	16
Marshfield	Marshfield Clinic (Wisconsin)	14 665	61 283	19

[a] The number of Medicare Advantage patients enrolled in a CVRN health care delivery system; this does not include Medicare beneficiaries enrolled in other Medicare Advantage plans located in these regions.

1000 enrollee-years were determined by dividing the total number of procedures among the population within a given HRR over the time frame by the population within that region, accounting for partial-year enrollees. Crude rates were then adjusted for age, sex, race, and income using the indirect adjustment method with the national Medicare FFS rates as the standard rates.[15] We used 2000 US census per capita income data mapped to ZIP codes to estimate the mean income for Medicare Advantage and Medicare FFS patients.

To compare procedure rates across HRRs and between Medicare Advantage and Medicare FFS beneficiaries, we used generalized linear models with a Poisson distribution and a deviance scale parameter to adjust for overdispersion. Outcome variables were the age-, sex-, race-, and income-adjusted procedure counts, and person-year denominators were included as a logged offset term. Medicare Advantage vs Medicare FFS insurance status and HRR location were added to these models. We calculated the variation reduction attributable to the addition of a variable using overdispersion parameters estimated in Poisson models. The overdispersion of count data are caused by unmeasured variables, and an overdispersion parameter is used in Poisson models to account for the fact that the variance is not equal to the mean. If a variable is associated with outcome and is added in a Poisson model, the overdispersion of count data are lessened and its parameter decreases. We used the decrease of the overdispersion parameters as a measure of variation reduction in this analysis.

We explored the degree of regional variation between Medicare Advantage and Medicare FFS beneficiaries in 2 ways: we calculated the degree of variation between the maximum and minimum adjusted HRR-level procedure rates, and we performed a Levene test to compare variances.

We used a Spearman rank-order correlation coefficient to assess the correlations between the HRR rates for (1) Medicare Advantage and Medicare FFS beneficiary populations for each procedure; (2) angiography and PCI in both populations; and (3) PCI and CABG surgery in both populations.

Within the CVRN only, we additionally adjusted for the presence of coronary heart disease and cardiovascular risk factors (hypertension, hyperlipidemia, and diabetes)[16] using *ICD-9* codes 272.0-272.4 for hyperlipidemia, 401.XX-404.XX for hypertension, 250.XX for diabetes, and 410.XX, 412.XX, and 414.0 for prior coronary heart disease. We used a Spearman correlation coefficient to determine the correlation between the demographics-adjusted (age, sex, and race only) procedure rates and demographics-adjusted and disease (coronary heart disease) risk factor-adjusted procedure rates at the HRR level.

Statistical analyses were conducted using SAS version 9.3 (SAS Institute Inc). $P < .05$ (2-sided) was considered statistically significant. The institutional review boards at the University of Pennsylvania and each CVRN site either approved or ceded to the Kaiser Permanente Northern California institutional review board.

Results

This study included 12 CVRN integrated health care delivery systems representing 32 distinct HRRs. Within these HRRs were 878 339 Medicare Advantage patients and 5 013 650 Medicare FFS patients. The proportion of study patients enrolled in a Medicare Advantage plan varied across HRRs from 3% in the Georgia HRRs to 28% in the Northern California HRRs (**Table 1**). Medicare Advantage and Medicare FFS patients were demographically similar, but the Medicare Advantage pa-

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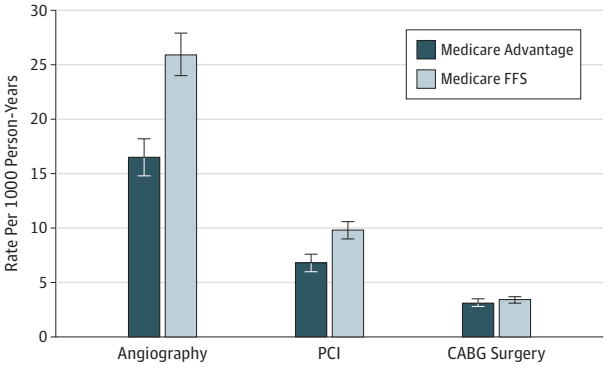
Table 2. Comparison of Cardiovascular Research Network Medicare Advantage Patients and Colocated Medicare Fee-for-Service Patients

Characteristic	%[a]	
	Medicare Advantage (n = 838 347)	Medicare FSS (n = 4 751 241)
Age, y		
65-69	30	34
70-74	24	20
75-79	20	18
80-84	15	14
85-99	12	13
Women	55	57
Nonblack race	94	93
Diabetes	21	24
Hypertension	62	61
Hyperlipidemia	44	50
Prior coronary artery disease	13	19
Proportion of angiographies performed as outpatients	28	36
Proportion of PCIs performed as outpatients	9	7

Abbreviations: FSS, fee for service; PCI, percutaneous coronary intervention.

[a] All differences are statistically significant at $P < .01$.

Figure 1. Comparison of Cardiovascular Procedure Rates Between Medicare Advantage Beneficiaries and Medicare FFS Beneficiaries



Error bars indicate 95% CIs. CABG indicates coronary artery bypass graft; FFS, fee for service; PCI, percutaneous coronary intervention.

tients did have slightly lower rates of diabetes (21% vs 24%), hyperlipidemia (44% vs 50%), and prior coronary artery disease (13% vs 19%) (**Table 2**). Because of the large sample sizes, differences between the groups were significant ($P < .01$ for all).

Compared with Medicare FFS patients, Medicare Advantage patients had lower age-, sex-, race-, and income-adjusted procedure rates per 1000 person-years for angiography (16.5 [95% CI, 14.8-18.2] vs 25.9 [95% CI, 24.0-27.9]; $P < .001$; rate ratio (RR), 0.64 [95% CI, 0.54-0.75]) and PCI (6.8 [95% CI, 6.0-7.6] vs 9.8 [95% CI, 9.0-10.6]; $P < .001$; RR, 0.70 [95% CI, 0.59-0.83]) but similar rates for CABG surgery (3.1 [95% CI, 2.8-3.5] vs 3.4 [95% CI, 3.1-3.7]; $P = .33$; RR, 0.93 [95% CI, 0.80-1.08]) (**Figure 1**). There were no differences between Medicare Advantage and Medicare FFS patients in the rates per 1000 person-years of urgent angiography (3.9 [95% CI, 3.6-4.2] vs 4.3 [95% CI, 4.0-4.6]; $P = .24$) or PCI (2.4 [95% CI, 2.2-2.7] vs 2.7 [95% CI, 2.5-2.9]; $P = .16$).

When exploring procedure rates across HRRs, we found wide geographic variation among Medicare Advantage patients and among Medicare FFS patients. For angiography, the rates per 1000 person-years among Medicare Advantage beneficiaries ranged from 9.8 to 40.6, whereas the rates among Medicare FFS beneficiaries ranged from 15.7 to 44.3, with no statistically significant difference in the variances (37.1 vs 49.9; $P = .56$). For PCI, the rates per 1000 person-years among Medicare Advantage beneficiaries ranged from 3.5 to 16.8, whereas the rates among Medicare FFS beneficiaries ranged from 4.7 to 16.1, with no statistically significant difference in the variances (7.0 vs 8.0; $P = .77$). For CABG surgery, the rates per 1000 person-years among Medicare Advantage beneficiaries ranged from 1.5 to 6.1, whereas the rates among Medicare FFS beneficiaries ranged from 2.5 to 6.0, with no statistically significant difference in the variance (1.2 vs 0.68; $P = .14$). For angiography and PCI, the variation between regions was largely driven by variations in nonurgent procedures (**Figure 2**).

We found no statistically significant Spearman rank correlation between Medicare Advantage and Medicare FFS beneficiary utilization for angiography ($r = 0.19$, $P = .29$) and modest correlations for PCI ($r = 0.33$, $P = .06$) and CABG surgery ($r = 0.35$, $P = .05$) (**Figure 3**). In our Poisson analysis, the variation in the rates of angiography was reduced by 19% when payment structure (Medicare Advantage vs Medicare FFS) was added to the model and was further reduced to a total of 50% when region (HRR) was added to the model. For PCI, the variation was reduced by 11% when payment structure only was added to the model and by a total of 47% when region was added. For CABG surgery, the variation was reduced by 1% with payment structure only and by a total of 36% when region was added to the model.

When exploring the correlation of procedures at the HRR level, we found that rates of coronary angiography were highly correlated with rates of PCI ($r = 0.88$, $P < .01$), and rates of PCI were modestly correlated with rates of CABG surgery ($r = 0.54$, $P < .01$).

Within the CVRN only, the demographics-adjusted (age, sex, race, and income only) rates for angiography, PCI, and CABG surgery were highly correlated with the demographics-adjusted and disease (coronary heart disease) risk factor-adjusted procedure rates ($r = 0.82$ to 0.94, $P < .01$ for all) (**Figure 4**), confirming minimal change in the ranking of communities with the additional adjustments. More importantly, disease adjustments did not decrease the range of rates, and variances increased slightly (variance with no disease vs disease adjustment: angiography, 38.3 vs 38.5; PCI, 7.9 vs 8.6; CABG surgery, 38.3 vs 38.5).

Discussion

We compared overall rates of and geographic variation in the use of major cardiovascular procedures between Medicare Advantage and Medicare FFS beneficiaries across 32 HRRs. We

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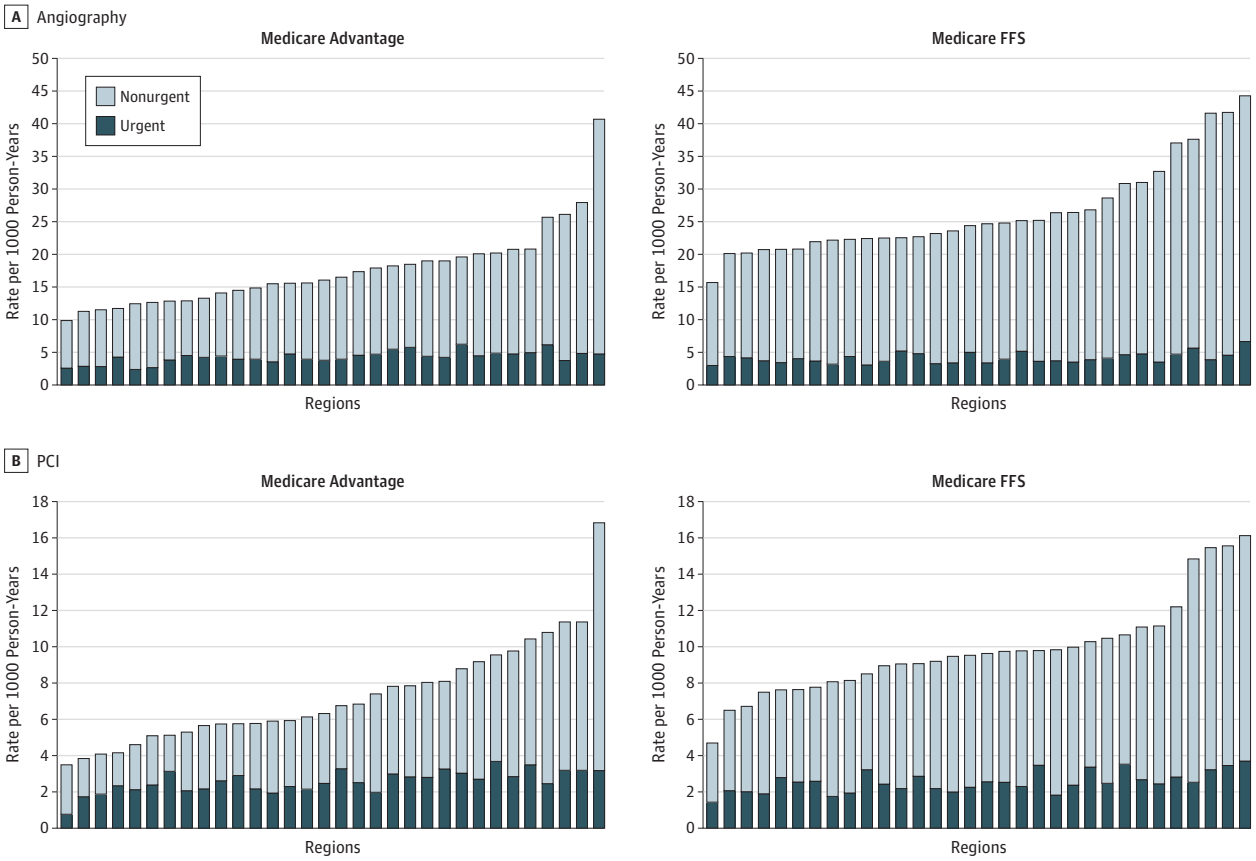
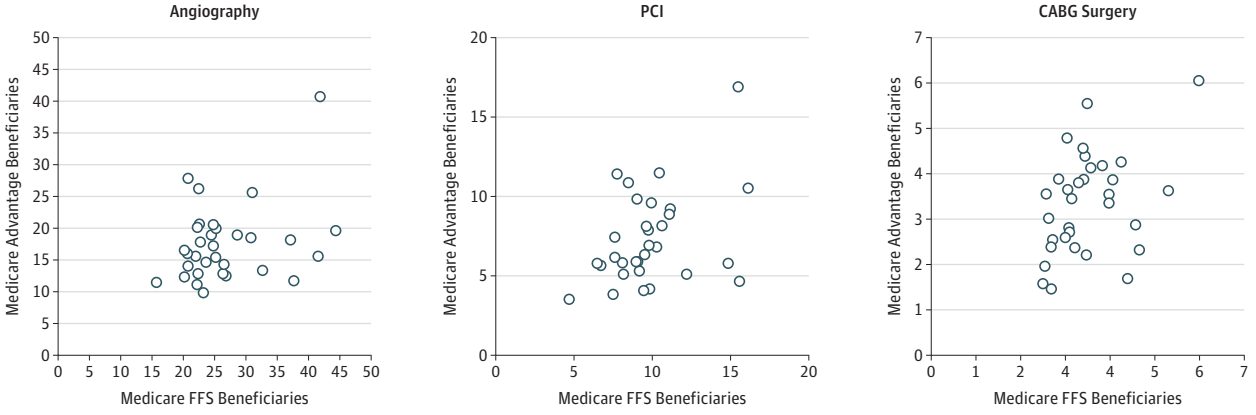
Figure 2. Rates of Urgent and Nonurgent Angiography and PCI per 1000 Person-Years for Medicare Advantage and Medicare FFS Beneficiaries From 2003-2007 Across 32 Hospital Referral Regions



FFS indicates fee for service; PCI, percutaneous coronary intervention.

Figure 3. Comparison of the Average Angiography, PCI, and CABG Surgery Age-, Sex-, and Race-Adjusted Rates per 1000 Person-Years Between Medicare Advantage Beneficiaries and Medicare FFS Beneficiaries From 2003-2007 Across Hospital Referral Regions



CABG indicates coronary artery bypass graft surgery; FFS, fee for service; PCI, percutaneous coronary intervention.

found that rates of angiography and PCI were significantly lower among Medicare Advantage beneficiaries, whereas the rates for CABG surgery were not significantly different. We also found that cardiovascular procedure rates varied widely at the HRR level among Medicare Advantage beneficiaries and among Medicare FFS beneficiaries. In the case of angiography and PCI, this variation was driven by nonurgent procedures. The HRR-level procedure rates were modestly correlated between Medi-

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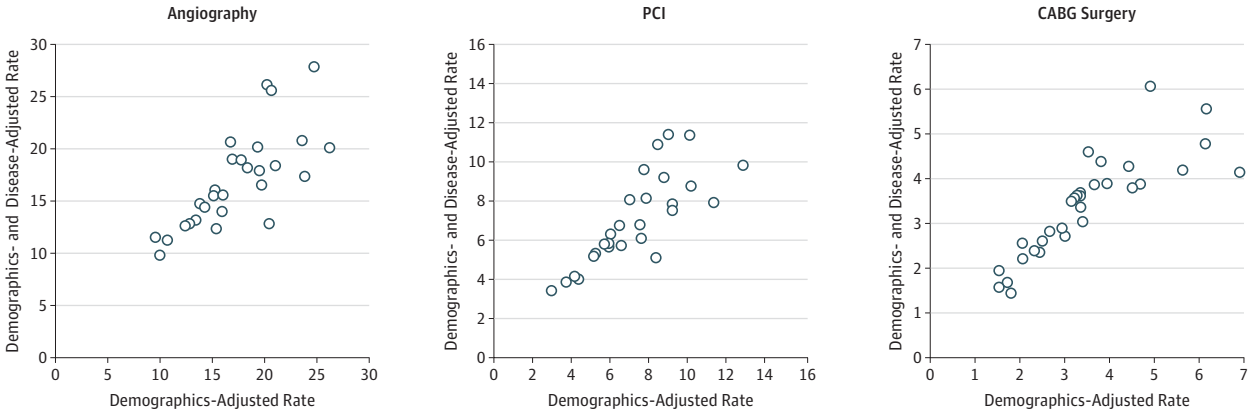
Figure 4. Comparison of Rates per 1000 Person-Years Adjusted for Age, Sex, and Race With Rates Additionally Adjusted for Presence of Diabetes, Hypertension, Hyperlipidemia, and Prior Coronary Artery Disease Within the Medicare Advantage Population Across Hospital Referral Regions



CABG indicates coronary artery bypass graft surgery; PCI, percutaneous coronary intervention.

care Advantage and Medicare FFS beneficiaries for PCI and CABG surgery but not for angiography. Last, demographics-adjusted procedure rates were highly correlated with demographics-adjusted and disease-adjusted rates.

This study has several strengths. First, we directly compared rates between Medicare Advantage and Medicare FFS beneficiaries. Few studies have done this, because comprehensive administrative claims data for Medicare Advantage patients have not been readily available. Data sources such as the CVRN are among the few ways to capture procedure rates within Medicare Advantage systems. Because evolving payment policy including accountable care organizations[17] emphasizes capitation, it is critical that the effects of capitation on health care utilization be better understood. Second, the CVRN is large and geographically diverse, with patients comparable to those in the surrounding populations.[13] Third, we include both inpatient and outpatient rates. Prior reports documenting geographic variation of procedures generally only include inpatient rates.[6] Although this is appropriate for procedures like CABG surgery that are always performed in the hospital, counting inpatient rates alone underestimates rates for procedures, including angiography and PCI, performed on large numbers of outpatients. Fourth, most geographic variation studies have not adjusted for differences in population clinical characteristics.[8,9] In this study we adjusted not only for patient demographics but also for preexisting coronary heart disease as well as risk factors for coronary heart disease.

The finding that Medicare Advantage patients have lower rates of angiography and PCI underscores the need for additional research to determine the extent to which this is attributable to differences in population characteristics, more efficient utilization of procedures among Medicare Advantage patients (ie, overutilization in Medicare FFS), or harmfully restrictive management of utilization among Medicare Advantage patients (ie, underutilization in Medicare Advantage). One explanation for the differences in rates seen in this report could be that Medicare Advantage beneficiaries are healthier and require fewer cardiovascular procedures than Medicare FFS beneficiaries.[18] We partially address this by showing that demographics-adjusted and disease-adjusted rates are highly correlated with the demographics-adjusted rates. The fact that the difference in rates between Medicare Advantage and Medicare FFS was attributable to nonurgent procedures provides some evidence that necessary procedures are not being withheld from Medicare Advantage beneficiaries. Future research should explore if the differences in procedure rates between Medicare Advantage and Medicare FFS patients are associated with differences in appropriateness and in clinical outcomes.

The degree of regional variation was similar for Medicare Advantage and Medicare FFS beneficiaries, suggesting that factors beyond payment mechanisms influence practice variations. For some medical interventions, regional variation has been strongly associated with supply; for example, length of stay in an intensive care unit is associated with the regional number of intensive care beds.[19] Similarly, the rate of cardiac catheterization is associated with the regional supply of cardiac catheterization laboratories.[20] The variation seen in this study may be a function of the availability of the procedures. In other research, patient-level factors including patient preferences and disease variability have had a minimal influence on variations in utilization.[21-26] That the variation did not diminish with disease adjustment in our analysis further supports this point. Prior research exploring appropriateness in angiography at the regional level suggests that regions with higher rates perform a higher number of both appropriate and inappropriate procedures.[5] Last, other research suggests that the central drivers of practice variation are implicit professional norms or the local practice culture.[10,27] To better understand each of these potential factors, future research should explore the influences of physician supply, procedure capacity, social norms, practice culture, and appropriateness of procedure use.

The finding that the regional rates for PCI and CABG surgery are correlated between the Medicare Advantage and the

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Medicare FFS beneficiaries is consistent with prior studies comparing utilization between capitated and FFS reimbursement systems. Data from the California Office of Statewide Health Planning and Development demonstrated that patients enrolled in integrated health care delivery systems had similar patterns of geographic variation compared with FFS patients in the number and length of stay of their hospitalizations.[28] In the Kaiser Permanente health care system, more than 2-fold variations have been observed across regions in the average number of hospital days in the last 6 months of life. Although those numbers were lower than the number of hospital days seen in Medicare FFS patients in these same regions, the patterns of use were correlated at the region level.[29] Our report extends those findings by directly exploring patient-level utilization in procedure rates between a much larger population of Medicare Advantage and Medicare FFS patients and by demonstrating that the patterns persist even after adjusting for population clinical characteristics.

Several limitations should be considered when interpreting these findings. First, we were unable to assess the degree to which regional variations were influenced by procedural appropriateness or patient preferences. Second, these results were not linked to clinical outcomes, so we do not know if differential use of cardiovascular procedures within an HRR affects patient outcomes. Third, patients choosing a Medicare Advantage plan may be different than patients in Medicare FFS, and this implies that the "correct" rate of cardiovascular procedure use may be different in these populations.[30] Fourth, we were unable to adjust for smoking, one of the most important risk factors for coronary artery disease. Fifth, although all Medicare Advantage plans receive capitated payments from the government, there are different models of delivery. Examples are "staff" models, in which clinicians are salaried and work directly for the health management organization, and "group" or "network" models, in which clinicians are contracted by the health plan. Given that many of the organizations participating in the CVRN are a mixture of these models, we were unable to analyze this effect in this report, but the effect would be an important avenue for future research.

Conclusions and Implications

We demonstrated lower utilization of cardiac procedures for Medicare Advantage compared with Medicare FFS as well as wide geographic variation. Geographic variation in health services in the Medicare FFS population has fueled the perception of an inefficient, ineffective US health care system.[21,31] Until the causes of geographic variation are understood, shedding light on the sources of variability remains an important research and quality improvement endeavor. Indeed, comparing "the effectiveness of accountable care systems and usual care on costs, processes of care, and outcomes for geographically defined populations of patients" is one of the Institute of Medicine's 100 priorities for comparative effectiveness research.[32] Capitation in various forms is anticipated to be an effective means of reducing future health care cost growth, particularly cost growth resulting from unnecessary care. Although in this study capitation was associated with lower procedure rates for angiography and PCI, the substantial geographic variation that remained despite the reimbursement structure suggests that capitation alone may not lead to reductions in the wide variations seen in use of cardiovascular procedures.

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Study supervision: Matlock, Xu, Lieu, Gunter.

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REFERENCES

1. Heidenreich PA, Trogdon JG, Khavjou OA, et al. Forecasting the future of cardiovascular disease in the United States: a policy statement from the American Heart Association. *Circulation*. 2011;123(8):933-944.

2. Matlock DD, Peterson PN, Heidenreich PA, et al. Regional variation in the use of implantable cardioverter-defibrillators for primary prevention: results from the National Cardiovascular Data Registry. *Circ Cardiovasc Qual Outcomes*. 2011;4(1):114-121.

3. Lucas FL, Sirovich BE, Gallagher PM, Siewers AE, Wennberg DE. Variation in cardiologists' propensity to test and treat: is it associated with regional variation in utilization? *Circ Cardiovasc Qual Outcomes*. 2010;3(3):253-260.

4. Wennberg DE, Birkmeyer JD, Birkmeyer NJO. *The Dartmouth Atlas of Cardiovascular Health Care*. Chicago, IL: AHA Press; 1999.

5. Ko DT, Wang Y, Alter DA, et al. Regional variation in cardiac catheterization appropriateness and baseline risk after acute myocardial infarction. *J Am Coll Cardiol*. 2008;51(7):716-723.

6. Dartmouth Institute for Health Policy and Clinical Practice. *The Dartmouth Atlas of Health Care*. Dartmouth Atlas website. www.dartmouthatlas.org. Accessed July 1, 2012.

7. Zarabozo C, Harrison S. Payment policy and the growth of Medicare Advantage. *Health Aff (Millwood)*. 2009;28(1):w55-w67.

8. Bach PB. A map to bad policy—hospital efficiency measures in the Dartmouth Atlas. *N Engl J Med*. 2010;362(7):569-574.

9. Anderson HV. Regional variation: only moderately interesting: a word of caution. *Circ Cardiovasc Qual Outcomes*. 2010;3(1):6-7.

10. Barnato AE, Bost JE, Farrell MH, et al. Relationship between staff perceptions of hospital norms and hospital-level end-of-life treatment intensity. *J Palliat Med*. 2007;10(5):1093-1100.

11. HMO Research Network website. www.hmoresearchnetwork.org/. Accessed July 1, 2012.

12. Magid DJ, Gurwitz JH, Rumsfeld JS, Go AS. Creating a research data network for cardiovascular disease: the CVRN. *Expert Rev Cardiovasc Ther*. 2008;6(8):1043-1045.

13. Go AS, Magid DJ, Wells B, et al. The Cardiovascular Research Network: a new paradigm for cardiovascular quality and outcomes research. *Circ Cardiovasc Qual Outcomes*. 2008;1(2):138-147.

14. Epstein AJ, Polsky D, Yang F, Yang L, Groeneveld PW. Coronary revascularization trends in the United States, 2001-2008. *JAMA*. 2011;305(17):1769-1776.

15. Gordis L. *Epidemiology*. Amsterdam, the Netherlands: Elsevier Science; 2004.

16. Wilson PW, D'Agostino RB, Levy D, Belanger AM, Silbershatz H, Kannel WB. Prediction of coronary heart disease using risk factor categories. *Circulation*. 1998;97(18):1837-1847.

17. The Patient Protection and Affordable Care Act 2010. Pub L 111-148. US Government Printing Office website. www.gpo.gov/fdsys/pkg/PLAW-111publ148/content-detail.html. Accessed May 9, 2013.

18. Cooper AL, Trivedi AN. Fitness memberships and favorable selection in Medicare Advantage plans. *N Engl J Med*. 2012;366(2):150-157.

19. Fisher ES, Wennberg JE. Health care quality, geographic variations, and the challenge of supply-sensitive care. *Perspect Biol Med*. 2003;46(1):69-79.

20. Wennberg DE, Dickens J Jr, Soule DN, et al. The relationship between the supply of cardiac catheterization laboratories, cardiologists and the use of invasive cardiac procedures in northern New England. *J Health Serv Res Policy*. 1997;2(2):75-80.

21. Sutherland JM, Fisher ES, Skinner JS. Getting past denial—the high cost of health care in the United States. *N Engl J Med*. 2009;361(13):1227-1230.

22. Fisher ES, Wennberg DE, Stukel TA, Gottlieb DJ, Lucas FL, Pinder EL. The implications of regional variations in Medicare spending, part 1: the content, quality, and accessibility of care. *Ann Intern Med*. 2003;138(4):273-287.

23. Fisher ES, Wennberg DE, Stukel TA, Gottlieb DJ, Lucas FL, Pinder EL. The implications of regional variations in Medicare spending, part 2: health outcomes and satisfaction with care. *Ann Intern Med*. 2003;138(4):288-298.

24. Fowler FJ Jr, Gallagher PM, Anthony DL, Larsen K, Skinner JS. Relationship between regional per capita Medicare expenditures and patient perceptions of quality of care. *JAMA*. 2008;299(20):2406-2412.

25. Anthony DL, Herndon MB, Gallagher PM, et al. How much do patients' preferences contribute to resource use? *Health Aff (Millwood)*. 2009;28(3):864-873.

26. Matlock DD, Peterson PN, Wang Y, et al. Variation in use of dual-chamber implantable cardioverter-defibrillators: results from the National Cardiovascular Data Registry. *Arch Intern Med*. 2012;172(8):634-641.

27. Lin CY, Farrell MH, Lave JR, Angus DC, Barnato AE. Organizational determinants of hospital end-of-life treatment intensity. *Med Care*. 2009;47(5):524-530.

28. Baker LC, Fisher ES, Wennberg JE. Variations in hospital resource use for Medicare and privately insured populations in California. *Health Aff (Millwood)*. 2008;27(2):w123-w134.

29. Stiefel M, Feigenbaum P, Fisher ES. The Dartmouth Atlas applied to Kaiser Permanente: analysis of variation in care at the end of life. *Perm J*. 2008;12(1):4-9.

30. McGuire TG, Newhouse JP, Sinaiko AD. An economic history of Medicare part C. *Milbank Q*. 2011;89(2):289-332.

31. Institute of Medicine. *Clinical Practice Guidelines: Directions for a New Program*. Washington, DC: National Academies Press; 1990. www.nap.edu/openbook.php?record_id=1626. Accessed May 9, 2013.

32. Institute of Medicine. *Initial National Priorities for Comparative Effectiveness Research*. Washington, DC: National Academies Press; 2009. www.iom.edu/Reports/2009/ComparativeEffectivenessResearchPriorities.aspx. Accessed May 9, 2013.

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