

EXHIBIT 18(c)

Trends in Coronary Revascularization Procedures Among Medicare Beneficiaries Between 2008 and 2012

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Background—This study reports on the trends in the volume and outcomes of coronary revascularization procedures performed on Medicare beneficiaries between 2008 and 2012.

Methods and Results—This retrospective study identifies all Medicare beneficiaries undergoing a coronary revascularization procedure: coronary artery bypass graft surgery or percutaneous coronary intervention (PCI) performed in either the nonadmission or inpatient setting. *International Classification of Diseases, 9th Revision, Clinical Modification* procedure codes (inpatient setting) and Current Procedural Terminology and Ambulatory Payment Classification codes (nonadmission) were used to identify revascularizations. The study population consists of 2 768 007 records. This study finds that the rapid growth in nonadmission PCIs performed on Medicare beneficiaries (60 405–106 495) has been more than offset by the decrease in PCI admissions (363 384–295 434) during the study period. There also were >18 000 fewer coronary artery bypass graft admissions in 2012 than in 2008. This study finds lower observed mortality rates (3.7%–3.2%) among Medicare beneficiaries undergoing any coronary artery bypass graft surgery and higher observed mortality rates (1.7%–1.9%) for Medicare beneficiaries undergoing any PCI encounter. This study also finds a growth in the number of facilities performing revascularization procedures during the study period: 268 (20.2%) more sites were performing nonadmission PCIs; 136 (8.2%) more sites were performing inpatient PCIs; and 19 (1.6%) more sites were performing coronary artery bypass graft surgery.

Conclusions—The total number of revascularization procedures performed on Medicare beneficiaries peaked in 2010 and declined by >4% per year in 2011 and 2012. Observed mortality rates among all Medicare beneficiaries undergoing any coronary revascularization remained between 2.1% and 2.2% annually during the study period. (*Circulation*. 2015;131:362–370. DOI: 10.1161/CIRCULATIONAHA.114.012485.)

Key Words: coronary artery bypass ■ mortality ■ myocardial revascularization
■ percutaneous coronary intervention

Patients with coronary artery disease are treated either with medical management or they undergo a coronary revascularization procedure including coronary artery bypass graft (CABG) surgery and percutaneous coronary intervention (PCI).^{1–3} The choice of treatment options has changed over time as a result of innovation in revascularization techniques such as drug-eluting stents,^{4,5} off-pump CABG surgery,⁶ thrombectomy,⁷ and advancements in diagnosing lesion significance with intravascular ultrasound and fractional flow reserve.^{8–11} In addition to adding clinical site options,¹² the US healthcare delivery system's recent focus on quality improvement efforts and cost containment has increased attention on reducing procedure complications and the overall length of stay associated with coronary revascularizations. Furthermore, public and private payers have embraced outpatient PCI, which has dramatically increased the number of nonadmission PCIs among Medicare beneficiaries.^{13,14} The changes in treatment options and changes in the Medicare program has resulted in confusion concerning

the true trend in the volume and outcomes of coronary revascularizations in the Medicare program over time.¹⁵

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The purpose of this study is to report on the trends in coronary revascularization procedures being performed on Medicare beneficiaries from 2008 to 2012. This study provides an overview of the change in the volume of each type of coronary revascularization procedure overall, and adjusts for changes in the number of Medicare beneficiaries in both the nonadmission and inpatient setting over the study period, as well. Second, we report the annual trend in procedure volume and observed mortality rates for each revascularization procedure. Finally, this article reports the trends in the number of facilities performing PCI procedures or CABG surgery annually on Medicare beneficiaries and the resulting procedure

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volume distribution across all hospitals by type of revascularization procedure.

Methods

Data Source

This retrospective study used 2 administrative data sets: the Medicare Provider Analysis and Review (MedPAR) file and the Medicare Outpatient Payment file. The MedPAR file is an administrative database maintained by the Centers for Medicare and Medicaid Services containing all inpatient claims (both fee for service and managed care) submitted by hospitals for services provided to Medicare beneficiaries. For each hospitalization, the MedPAR record includes selected patient information, quarter of admission and discharge, *International Classification of Diseases, 9th Revision, Clinical Modification* diagnosis and procedure codes, discharge status, total charges, Medicare reimbursement, and days from admission to death if the beneficiaries died before the administrative cutoff date for the final versions of the MedPAR file. For Fiscal Year 2008 and 2009, our MedPAR files contained up to 9 diagnosis and 6 procedure codes per admission, whereas the 2010 through 2012 MedPAR files contained up to 25 diagnosis and 25 procedure codes per admission.

The Medicare Outpatient Payment file is an administrative database maintained by the Centers for Medicare and Medicaid Services that contains all (both fee-for-service and managed-care) claims submitted and paid as nonadmission (outpatient) services provided to Medicare beneficiaries. For each outpatient visit, the file includes demographic information, date of service, discharge status, 10 physician Current Procedural Terminology codes and 10 Ambulatory Payment Classification codes (all years), and 9 *International Classification of Diseases, 9th Revision, Clinical Modification* diagnosis codes (2008 and 2009) and 25 diagnosis codes (2010–2012).

Study Population

The population in this study consists of any Medicare beneficiaries undergoing a coronary revascularization procedure (CABG surgery or PCI) in a US hospital during an episode of care during the study period. The study population was derived as follows. For each year, the MedPAR file was searched for all hospital admissions with an *International Classification of Diseases, 9th Revision, Clinical Modification* procedure code of 36.10 through 36.19, or 36.2 indicating that the patient underwent a primary or secondary CABG procedure or an *International Classification of Diseases, 9th Revision, Clinical Modification* procedure code of 00.66, 36.01, 36.02, 36.05, 36.06, or 36.07 indicating that the patient underwent a primary or secondary PCI procedure during that admission. Second, for each year the Medicare Outpatient file was searched for all episodes of care with a Current Procedural Terminology code of 92980, 92981, 92982, 92984, 92995, or 92996 or an Ambulatory Payment Classification code of 00082, 00083, 00104, or 00656 with appropriate Current Procedural Terminology codes to indicate that the Medicare beneficiary underwent a primary or secondary PCI procedure in a nonadmission setting. No Medicare beneficiary having either an inpatient or nonadmission coronary revascularization procedure in any year was excluded from the study population. The final study population consists of 2 768 007 patients who underwent revascularization.

Definition of Study Variables

In this study a Medicare beneficiary's episode of care involving coronary revascularization procedures was classified as follows. First, all nonadmission revascularization procedures were classified as nonadmission PCIs. Nonadmission PCI includes both patients who were outpatients and those patients who did not qualify for admission status under Medicare payment rules, such as observational patients who might have stayed overnight, but were not admitted. Second, all inpatient episodes of care involving a PCI procedure code but no CABG codes were classified as PCI admissions. Third, all episodes of admissions involving CABG surgery were reported under 1 of the following

categories: (1) only CABG if the data record includes a CABG code, but no PCI codes or valve surgery codes; (2) both CABG and PCI if the inpatient data record includes both a PCI and a CABG procedure code but no valve surgery during the admission; (3) both CABG and valve if the data record indicated the beneficiary underwent both CABG surgery and valve surgery during a hospitalization but not PCI; and (4) CABG, PCI, and valve if the data record indicated that the beneficiary underwent both a CABG and PCI revascularization procedure in addition to valve surgery all during the hospitalization. Fourth, any revascularization is defined as any nonadmission PCI or any hospitalization in which a Medicare beneficiary underwent at least 1 coronary revascularization procedure. This final category is the total number of revascularization episodes billed to the Medicare program (beneficiary records found in either data set) during the study period. For each major category of revascularization category (nonadmission PCI, PCI-only admission, CABG surgery admission, and any revascularization) we also categorized every Medicare beneficiary into 1 of 3 patient presentation groups: (1) ST-elevation myocardial infarction (STEMI); (2) non-ST-elevation myocardial infarction (NSTEMI); and (3) patients with no diagnostic code for acute myocardial infarction (no AMI).

Analytical Methods

All tables report standard descriptive statistics means, medians, counts, or proportions. In all but the last table of this article, the unit of analysis is a Medicare beneficiary's episode of care. In the last table, the unit of analysis is the individual Medicare facility providing revascularization procedures. All annual growth rates reported in tables are calculated as the compounded annual growth rate from 1 year to the next year. The annual number of Medicare enrollees was obtained from the Center of Medicare and Medicaid Services, Medicare Enrollment for selected years and rounded to the nearest thousand members.¹⁶

Results

Figure 1 summarizes the change in shares of total revascularization episodes for the 3 major types of revascularization procedure types: CABG surgery, PCI-only admissions, and PCI nonadmissions. First, Figure 1 indicates that the proportion of CABG surgery as a share of total revascularization procedures performed on Medicare beneficiaries declined from 24.9% in 2008 to 23.2% in 2012. Second, by 2012, PCI nonadmissions accounted for 20.4% of all revascularizations performed on Medicare beneficiaries, up from 10.7% in 2008. The share of PCI-only admissions declined each year from 64.4% to 56.4% during the study period.

Table 1 reports the numbers of coronary revascularizations by type performed on Medicare beneficiaries; key demographic characteristics by type of procedure, revascularization episodes per 1000 Medicare beneficiaries, and annual growth rates of coronary revascularization procedures over the 5-year study period. This table reports 3 major trends concerning revascularization use. First, among Medicare beneficiaries undergoing a PCI only, there was a significant increase in the number of nonadmission PCIs from 60 405 in 2008 to 109 064 in 2011, before declining to 106 495 in 2012. However, the growth in nonadmission PCIs was more than offset by a decrease of ≈68 000 Medicare beneficiaries undergoing a PCI only in the inpatient setting between 2008 and 2012. Overall, the total number of PCIs without CABG surgery in the Medicare program increased from 2008 to 2010 before declining by >3.7% per year (32 205 procedures) during 2011 and 2012. As a result, the number of PCI only per 1000 Medicare beneficiaries declined annually during the study period from 9.3 to 7.9.

Selected Procedure Share of all Revascularization Procedures

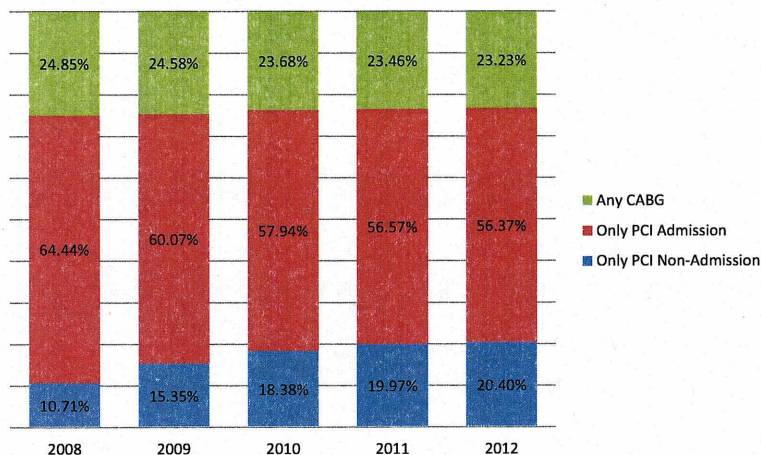


Figure 1. Major types of procedures as a share of all revascularizations by year. CABG indicates coronary artery bypass graft; and PCI, percutaneous coronary intervention.

Second, Table 1 indicates that the well-documented decline in the number of Medicare beneficiaries undergoing any CABG surgery continues, with the annual average rate of decline exceeding 4.8% in each of the last 2 years of the study period. By 2012, there were only 2.4 CABG surgeries per 1000 Medicare beneficiaries in US hospitals in comparison with nearly 3.1 per 1000 Medicare beneficiaries in 2008. Third, Table 1 indicates that the number of total revascularizations in the Medicare program, either inpatient or nonadmission, was relatively stable between 2008 and 2010, before the number of revascularizations declined by >4.0% per year ($\approx 45\,000$ total revascularization procedures) during 2011 and 2012. As a result, the number of total revascularizations per 1000 Medicare beneficiaries declined to 10.3 per 1000 Medicare beneficiaries during 2012.

Table 1 also reports on 2 demographic trends among Medicare beneficiaries undergoing revascularization procedures. First, males are more likely than females to undergo each type of revascularization procedure. In 2012, males accounted for 69.3% of the CABG admissions, 64.7% of nonadmission PCI, and 60.8% of PCI-only admissions. Second, the age distribution across study years remained very stable within a given procedure type. However, there were very different age distributions observed across the varying revascularization procedures reported in Table 1. For example, >80% of nonadmission PCI-only beneficiaries were <70 years of age, whereas only $\approx 35\%$ of CABG surgery beneficiaries were <70 years of age. In addition, slightly >60% of Medicare beneficiaries undergoing admission PCI only were >70 years of age in comparison with $\approx 53\%$ of beneficiaries undergoing any CABG surgery.

Table 2 reports detailed revascularizations and observed mortality rates among Medicare beneficiaries for revascularization procedures during each year of the study. In addition, following the summary row for each revascularization type (nonadmission PCI, PCI admission, CABG surgery, and any revascularization), Table 2 reports the volume (proportion) of patients undergoing revascularization and the observed mortality rates for 3 patient groups (STEMI, NSTEMI, or no AMI). An examination of combined observed mortality rates by revascularization procedure indicates that observed mortality rates among Medicare beneficiaries undergoing

nonadmission PCI declined from 0.32% in 2008 to 0.20% in 2010, before increasing to 0.24% and 0.27% during the last 2 years of the study, respectively. Next, the observed mortality rate among Medicare beneficiaries undergoing PCI admissions increased annually during the study period from 1.9% in 2008 to 2.5% in 2012. Combining all Medicare beneficiaries undergoing PCI only, with or without an admission, results in a relatively stable observed mortality rate of $\approx 1.7\%$ during the first 3 years of the study period before increasing by 0.1% per year during each of the last 2 years of the study.

An examination of the different categories of CABG admissions indicates that the vast majority of the annual decline in the total number of CABG surgery among Medicare beneficiaries between 2008 and 2012 is the result of a reduction in CABG-only surgery. In fact, the number of CABG and valve surgery admissions among Medicare beneficiaries was higher in 3 of the last 4 years of the study period than in 2008, although the number of admissions in this category peaked in 2009. The observed inpatient mortality rate for each of the CABG surgery categories reported in Table 2 was smaller in 2012 than in 2008. As a result, the in-hospital observed mortality rate among Medicare beneficiaries undergoing any CABG surgery declined from 3.7% in 2008 to 3.2% in 2012. Finally, the summary row reporting any revascularization by year indicates that the observed mortality rate among Medicare beneficiaries having any type of revascularization, with or without an admission, varied annually, but remained between 2.2% and 2.1% each year during the entire study period.

An examination of the patient presentation by type of AMI indicates that, during the study period, Medicare beneficiaries undergoing all types of revascularization procedures were much more likely to present with an AMI (STEMI or NSTEMI) in 2012 than in 2008. For example, across all revascularization, the percentage of beneficiaries presenting without an AMI declined from 70.8% to 65.7% during the study period, whereas beneficiaries presenting with an AMI increased (STEMI, 12.6%–13.6%) and (NSTEMI, 16.6%–20.7%). The largest change in patient presentation occurred among the PCI admission revascularization group where the proportion on Medicare beneficiaries presenting without an AMI declined from 64.7% in 2008 to

Table 1. Number of Revascularizations and Demographic Information of Medicare Beneficiaries by Year

	2008	2009	2010	2011	2012
PCI only					
Nonadmission	60 405	86 807	104 566	109 064	106 495
Male, %	62.7	63.1	63.8	64.1	64.7
Age distribution					
Age <65, %	62.0	62.3	62.1	62.9	63.0
Age 65–69, %	20.0	19.5	19.5	19.0	18.7
Age 70–79, %	18.0	18.2	18.4	18.1	18.3
Age ≥80, %	0.0	0.0	0.0	0.0	0.0
Admission (PCI only)	363 245	339 534	329 327	308 680	295 055
Male, %	59.6	59.7	60.1	60.3	60.8
Age distribution					
Age <65, %	13.8	14.0	14.4	14.7	15.1
Age 65–69, %	22.3	22.5	22.6	22.5	22.8
Age 70–79, %	40.3	39.3	38.6	38.2	37.7
Age ≥80, %	23.6	24.2	24.4	25.6	24.4
Admission (PCI and valve)	139	177	241	219	379
Male, %	61.2	55.4	58.9	57.5	55.9
Age distribution					
Age <65, %	8.6	5.1	7.5	7.3	6.9
Age 65–69, %	24.5	15.8	19.9	15.1	12.4
Age 70–79, %	41.0	44.6	29.9	38.8	29.8
Age ≥80, %	25.9	34.5	42.7	38.8	50.9
Total MBs undergoing PCI only*	423 789	426 518	434 134	417 963	401 929
PCI only per 1000 MBs	9.33	9.17	9.11	8.56	7.91
Annual growth rate of PCI volume	NA	+0.64%	+1.79%	–3.72%	–3.84%
CABG surgery					
CABG with or without PCI or valve surgery	140 124	138 976	134 701	128 129	121 744
Male, %	67.4	67.7	68.6	68.9	69.3
Age distribution					
Age <65, %	10.1	10.3	10.6	10.7	10.9
Age 65–69, %	24.1	24.7	25.3	25.3	25.5
Age 70–79, %	46.4	45.4	44.9	44.5	44.4
Age ≥80, %	19.4	19.6	19.2	19.5	19.2
CABG surgery per 1000 MBs	3.09	2.99	2.83	2.62	2.40
Annual growth rate of CABG volume	NA	–0.82%	–3.08%	–4.88%	–4.98%
Total revascularizations†	563 913	565 494	568 835	546 092	523 673
Male, %	61.9	62.2	62.8	63.1	63.6
Age distribution					
Age <65, %	17.8	20.5	22.3	23.4	23.9
Age 65–69, %	22.5	22.6	22.7	22.5	22.5
Age 70–79, %	39.3	37.6	36.3	35.7	35.3
Age ≥80, %	20.2	19.3	18.7	18.5	18.3
Total revascularizations per 1000 MBs	12.42	12.16	11.93	11.18	10.30
Annual growth rate of procedure volume	NA	+0.28%	+0.59%	–4.00%	–4.11%
Total Medicare beneficiaries (1000 MBs)‡	45 412	46 521	46 521	47 664	50 829

CABG indicates coronary artery bypass graft; MB, Medicare beneficiary; NA, not applicable; and PCI, percutaneous coronary intervention.

*This row reports the total number of Medicare beneficiaries that had at least 1 PCI procedure performed during a nonadmission or during an inpatient hospitalization, without any CABG surgery during that admission.

†MBs that underwent both a PCI and CABG surgery in the same hospitalization are only counted as 1 admission.

‡Medicare Enrollment as of July 1 of each year in Hospital Insurance or Supplementary Medical Insurance Programs for both Fee-for-Service and Medicare Advantage.

Table 2. Revascularizations and Observed Mortality Rates Among Medicare Beneficiaries Undergoing Selected Types of Revascularizations by Year

	2008		2009		2010		2011		2012	
	Medicare Beneficiaries	Mortality Rate	Medicare Beneficiaries	Mortality Rate	Medicare Beneficiaries	Mortality Rate	Medicare Beneficiaries	Mortality Rate	Medicare Beneficiaries	Mortality Rate
Nonadmission PCI										
All PCI procedures*	60 405	0.32%	86 807	0.22%	104 566	0.20%	109 064	0.24%	106 495	0.27%
Patient presentation all nonadmission PCIs										
STEMI	202 (0.3%)	50.00%	496 (0.6%)	25.81%	568 (0.5%)	24.47%	840 (0.8%)	25.48%	884 (0.8%)	27.15%
NSTEMI	62 (0.1%)	0.00%	767 (0.9%)	0.52%	967 (0.9%)	0.41%	1451 (1.3%)	0.41%	1529 (1.4%)	0.72%
No AMI	60 141 (99.6%)	0.15%	85 544 (98.5%)	0.07%	103 031 (98.5%)	0.07%	106 773 (97.9%)	0.04%	104 082 (97.7%)	0.03%
PCI admissions										
All PCI procedures†	363 384	1.90%	339 711	2.06%	329 568	2.16%	308 899	2.39%	295 434	2.55%
Patient presentation all PCI admissions										
STEMI	58 180 (16.0%)	7.82%	54 039 (15.9%)	7.78%	56 840 (17.2%)	7.58%	57 805 (18.7%)	8.67%	60 198 (20.4%)	8.80%
NSTEMI	70 152 (19.3%)	2.14%	69 234 (20.4%)	1.82%	74 669 (22.7%)	1.76%	78 895 (25.5%)	1.46%	84 028 (28.4%)	1.35%
No AMI	235 052 (64.7%)	0.36%	216 438 (63.7%)	0.71%	198 059 (60.1%)	0.75%	172 199 (55.8%)	0.70%	151 208 (51.2%)	0.73%
All PCI episodes	423 789	1.67%	426 518	1.69%	434 134	1.69%	417 963	1.83%	401 929	1.94%
CABG surgery admissions										
CABG surgery only	107 296	2.56%	105 355	2.44%	101 570	2.30%	95 572	2.36%	90 288	2.27%
Both CABG and PCI	3689	7.37%	3565	6.28%	3525	6.44%	3385	6.79%	3273	6.97%
Both CABG and valve surgery	28 888	7.35%	29 816	6.95%	29 364	6.35%	28 907	6.10%	27 927	5.70%
CABG, PCI, and valve	251	16.33%	240	14.58%	242	15.29%	265	16.23%	256	15.63%
Total CABG surgery	140 124	3.70%	138 976	3.53%	134 701	3.32%	128 129	3.35%	121 744	3.22%
Patient presentation all CABG surgery										
STEMI	12 592 (9.0%)	9.54%	10 690 (7.7%)	8.85%	10 278 (7.6%)	8.55%	10 154 (7.9%)	12.00%	9944 (8.2%)	13.20%
NSTEMI	23 181 (16.5%)	4.77%	21 868 (15.7%)	4.19%	22 220 (16.5%)	3.87%	22 496 (17.6%)	3.63%	23 132 (19.0%)	3.33%
No AMI	104 351 (74.5%)	2.76%	106 418 (76.6%)	2.86%	102 203 (75.9%)	2.67%	95 479 (74.5%)	2.36%	88 668 (72.8%)	2.07%
Any revascularization among Medicare beneficiaries										
Total procedure	563 913	2.18%	565 494	2.14%	568 835	2.07%	546 092	2.18%	523 673	2.24%
Patient presentation any revascularization										
STEMI	70 974 (12.6%)	8.24%	65 225 (11.5%)	8.09%	67 866 (11.9%)	7.87%	68 799 (12.6%)	9.37%	71 026 (13.6%)	9.64%
NSTEMI	93 395 (16.6%)	2.79%	91 869 (16.3%)	2.37%	97 856 (17.2%)	2.23%	102 842 (18.8%)	1.92%	108 689 (20.7%)	1.76%
No AMI	399 544 (70.8%)	0.96%	408 400 (72.2%)	1.14%	403 293 (70.9%)	1.06%	374 451 (68.6%)	0.94%	343 958 (65.7%)	0.86%

AMI indicates acute myocardial infarction; CABG, coronary artery bypass graft; NSTEMI, non-ST-elevation myocardial infarction; PCI, percutaneous coronary intervention; and STEMI, ST-elevation myocardial infarction.

*All PCI procedures include both balloon angioplasty and stent in the nonadmission setting.

†All PCI procedures include Medicare beneficiaries undergoing PCI only or PCI with valve surgery.

51.2% by 2012, whereas the proportion of Medicare beneficiaries presenting with any AMI increased to 48.8% by 2012 up from 35.3% in 2008. Table 2 also reports the observed mortality rates by patient presentation and revascularization type for each study year. Three major trends are worth noting. First, as expected, the highest observed mortality rates are among beneficiaries presenting with a STEMI, and during the study period the observed mortality rate for STEMI patients increased for all inpatient revascularization procedures. For example, among all CABG surgery admissions the observed mortality rate for STEMI patients increased from 9.5% in 2008 to 13.2% in 2012. Second, the observed mortality rate among beneficiaries presenting with NSTEMI declined for each revascularization type over the study period. For example, the NSTEMI observed mortality rate declined overall from 2.8% in 2008 to <1.8% in 2012.

Third, the observed mortality rates among beneficiaries presenting without an AMI declined among CABG surgery patients (2.8%–2.1%) and nonadmission PCI patients (0.15%–0.03%) during the study period, but the observed mortality rate for PCI admission patients without an AMI increased from a low of 0.36% (2008) to >0.7% for the remainder of the study period.

Figure 2A shows all-cause postdischarge mortality rates, by patient presentation, during the first 90 days postdischarge for Medicare beneficiaries separately for 2 summary categories: PCI only with admission and any CABG surgery. Figure 2B reports all-cause mortality rates, by patient presentation, from admission to 90 days postdischarge for the same 2 categories of revascularization. Figure 2A indicates that the 90-day postdischarge all-cause mortality rate for Medicare beneficiaries undergoing CABG surgery declined during the study period,

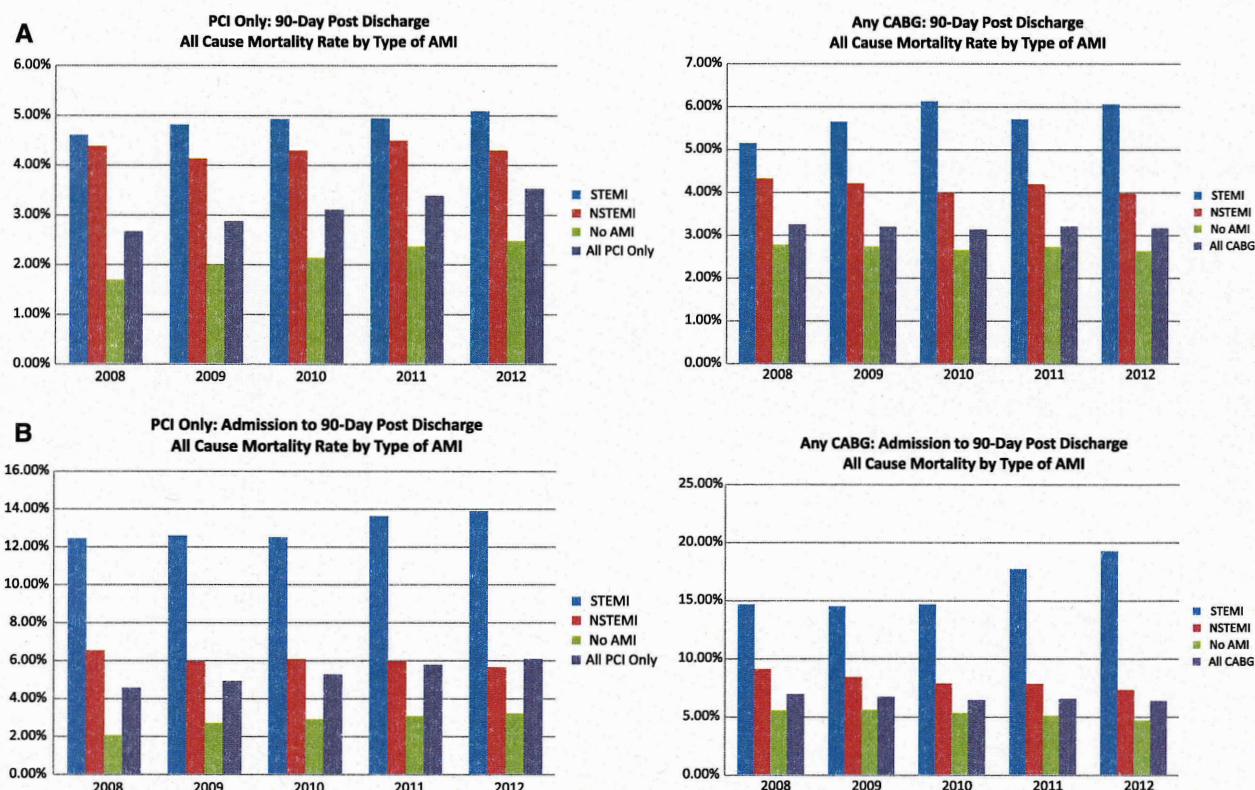


Figure 2. A, All-cause mortality rate for the first 90 days postdischarge for all PCI only and any CABG by patient AMI presentation. B, All-cause mortality rates from admission to 90-day postdischarge for all PCI only and any CABG by patient AMI presentation. AMI indicates acute myocardial infarction; CABG, coronary artery bypass graft; NSTEMI, non-ST-elevation myocardial infarction; PCI, percutaneous coronary intervention; and STEMI, ST-elevation myocardial infarction.

for all Medicare beneficiaries (3.25%–3.17%), for those beneficiaries presenting with NSTEMI (4.32%–3.98%), and for patients presenting with no AMI (2.78%–2.63%). However, 90-day postdischarge mortality rates increased during the study period for Medicare beneficiaries undergoing CABG surgery with STEMI from 5.15% to 6.06%. Among Medicare beneficiaries undergoing an admission with a PCI only, the 90-day postdischarge all-cause mortality rate increased each year (2.67%–3.35%), those presenting with STEMI (4.61%–5.09%), and those presenting with no AMI (1.69%–2.48%). The 90-day postdischarge mortality rates varied during the study period between 4.13% and 4.49% for Medicare beneficiaries undergoing PCI only with NSTEMI.

Figure 2B indicates that the all-cause mortality rate from admission to 90 days postdischarge has increased since 2008 for PCI-only admissions from 4.57% to 6.08% in 2012. Within the PCI-only category, nearly 14% of all Medicare beneficiaries presenting with STEMI die within 90 days of their PCI inpatient admission, in comparison with 3.2% of all Medicare beneficiaries undergoing a PCI without an AMI. Figure 2B indicates that the all-cause mortality rate from admission to 90 days postdischarge for any CABG surgery declined during the study period for all CABG patients and those Medicare beneficiaries presenting with NSTEMI (9.09%–7.31%) and for beneficiaries with no AMI (5.55%–4.69%). On the other hand, >19% of Medicare beneficiaries presenting with STEMI died within 90 days postdischarge in 2012, up from ≈14.7% of the patients presenting with STEMI and undergoing CABG surgery in 2008.

Table 3 summarizes the information concerning trends in the number of facilities performing PCI, both nonadmission and admission, and CABG surgery on Medicare beneficiaries by year. In addition, Table 3 provides information on the number of facilities performing PCI or CABG within selected volume intervals each year. Table 3 indicates that there has been an annual increase in the number of facilities performing both types of revascularization procedures and that the annual compounded growth rate of facilities performing any inpatient PCIs (2.0%, 136 facilities) is greater than the growth of new CABG surgery facilities (0.4%, 19 facilities). In addition, during our study period, the number of nonadmission PCI facilities increased by 268 facilities. Table 3 also indicates that the mean and median number of PCIs or CABG surgeries performed per facility declined between 2008 and 2012. The mean volumes of PCI per facility declined by ≈32 PCIs per facility (median declined by 5 PCIs per facility) during the study period, whereas the mean number of CABG surgeries declined by ≈17 per facility (median declined by 14 CABG surgeries per facility).

The distribution of PCIs per facility indicates that the number of facilities and the percentage of total PCI procedure volume that was performed in facilities providing >500 PCIs per year declined each year during the study period from a high of 245 facilities (14.9% of facilities), accounting for 46.3% of all PCIs performed, to 196 facilities (11.0% of facilities) accounting for only 35.7% of all PCIs in 2012. At the low end of the volume distribution, the number of facilities performing <52 PCIs per year (one per week) in their facility also

Table 3. Selected Trends in the Number of Medicare Facilities, Revascularization Procedures, and the Distribution of Provider Volume for PCI and CABG by Year

	2008	2009	2010	2011	2012
All facilities treating at least 1 PCI patient in both the nonadmission and inpatient setting					
Number of facilities, any nonadmission PCI	1325	1410	1501	1568	1593
Number of facilities, any inpatient PCI	1650	1667	1722	1769	1786
Number of PCIs performed, mean (median)	259.2 (168)	258.1 (177)	254.3 (178)	238.3 (165)	227.3 (163)
Number of revascularizations among PCI facilities, mean (median)	341.8 (233)	339.2 (230)	330.3 (232)	308.7 (215)	293.5 (207)
Nonadmission share of total PCIs (PCI only)	13.0%	18.5%	22.4%	23.8%	24.2%
Distribution of PCI procedure volume for all facilities performing at least 1 PCI, No. of hospitals (% of total volume)					
<12	162 (0.1)	140 (0.1)	137 (0.1)	134 (0.1)	133 (0.1)
12–52	229 (1.6)	229 (1.6)	214 (1.6)	232 (1.8)	212 (1.7)
53–99	183 (3.2)	195 (3.4)	220 (3.7)	226 (4.0)	256 (4.8)
100–249	454 (17.9)	460 (17.9)	502 (19.4)	558 (22.1)	599 (24.7)
250–500	377 (30.8)	409 (32.9)	426 (34.4)	407 (33.7)	390 (33.0)
500+	245 (46.3)	234 (43.9)	223 (40.8)	212 (38.4)	196 (35.7)
All facilities performing at least 1 CABG surgery during a selected year					
Number of facilities performing CABG	1171	1172	1174	1187	1190
Number of CABG surgeries, mean (median)	119.7 (91)	118.6 (90)	114.7 (88.5)	107.9 (83)	102.3 (77)
Number of revascularizations among CABG hospitals, mean (median)	461.9 (356)	459.4 (365)	454.2 (359)	426.2 (340)	404.2 (325)
Distribution of CABG procedure volume for all facilities performing at least 1 CABG surgery, No. of hospitals (% of total volume)					
<12	48 (0.2)	40 (0.1)	46 (0.2)	57 (0.2)	61 (0.2)
12–52	289 (7.0)	290 (6.9)	303 (7.7)	322 (8.4)	346 (9.4)
52–99	303 (16.2)	303 (16.2)	308 (17.3)	320 (18.9)	324 (19.9)
100–249	412 (45.5)	422 (46.4)	407 (46.0)	391 (46.1)	383 (48.6)
250–500	108 (26.1)	107 (25.7)	101 (24.5)	90 (22.8)	70 (18.7)
500+	11 (5.1)	10 (4.7)	9 (4.3)	7 (3.5)	6 (3.2)

In the distribution reported for any PCI and any CABG we count patients who underwent both a PCI episode and a CABG surgery episode in both distributions. CABG indicates coronary artery bypass graft; and PCI, percutaneous coronary intervention.

declined by 46 facilities during the study period. Overall, in 2012, slightly <69% of all Medicare beneficiaries undergoing PCI had their procedure performed by a facility that performed >250 PCIs annually.

Only 76 facilities (6% of all CABG sites) performed >250 CABG surgeries per year on Medicare beneficiaries in 2012, down from 119 facilities (10% of all CABG sites) in 2008. In addition, Table 3 indicates that between 2008 and 2012, between 707 and 715 facilities per year performed between 52 and 249 CABG surgeries on Medicare beneficiaries, with the exception of 2009. Nevertheless, nearly one-third of all CABG surgery facilities (407) were performing <52 CABG surgeries per year on Medicare beneficiaries during 2012, but these facilities accounted for <10.0% of all CABG surgeries during 2012.

Discussion

This study documents 5 major volume trends among Medicare beneficiaries undergoing coronary revascularization procedures during our study period. First, we found a significant growth in the number of PCIs being performed in the nonadmission setting. The proportion of Medicare beneficiaries receiving PCI only treated in the nonadmission setting grew from 14.3% in 2008 to 26.5% by 2012. Second, we found that the annual

decline in the number of CABG surgeries continued during the study period such that there were 18 380 fewer admissions (–13.1% total change) involving any type of CABG surgery among Medicare beneficiaries in 2012 than in 2008. Third, we found that the total number of PCIs (both nonadmission and admission) among Medicare beneficiaries has decreased since 2010, and the number of PCIs only (with or without an admission) has declined by >15 000 procedures (–3.7%) per year. Fourth, we found an increase in the number of facilities performing revascularization procedures: 268 more sites were performing nonadmission PCIs, 136 more sites were performing inpatient PCI procedures, and 19 more facilities began providing CABG surgery during our study period. Fifth, we find that the volume (mean and median) of revascularizations performed per facility declined during the study period for both PCI (mean, 259–227; and median, 168–163) and CABG surgery (mean, 120–102; and median, 91–77).

This study also finds 4 major trends worth highlighting in the observed mortality rates among Medicare beneficiaries undergoing coronary revascularization procedures during the study period. First, we found that, despite the underlying changes in the type of revascularizations, the overall observed mortality rate for all revascularizations in the Medicare program remained

stable between 2.1% and 2.2% per year during the study period. Second, we found lower mortality rates for all Medicare beneficiaries undergoing CABG surgery in 2012 than in 2008 both during the inpatient admission (3.7%–3.2%) and from admission to 90 days postdischarge (6.9%–6.4%). The annual improvement in the overall CABG surgery mortality rate was the result of improved outcomes during the study period for both patients presenting with NSTEMI (inpatient mortality declined from 4.8% to 3.3%) and for patients presenting without an AMI (inpatient mortality rate declined from 2.8% to 2.1%). On the other hand, Medicare beneficiaries undergoing any CABG surgery and presenting with a STEMI (8%–9% of all CABG surgery) experienced observed mortality rates during the last 2 years of the study period that exceed 12% during the inpatient admission (12.0% in 2011 and 13.2% in 2012) and 17% from admission to 90 days postdischarge (17.7% in 2011 and 19.3% in 2012). Third, despite the rapid growth in the number of nonadmission revascularizations, the overall observed mortality rate among Medicare beneficiaries in this setting declined slightly during the study period (0.32%–0.27%). This decline in observed mortality rate reflects the decline in observed mortality among Medicare beneficiaries presenting without an AMI, which declined from 0.15% in 2008 to 0.027% in 2012. Fourth, among PCI admissions, only Medicare beneficiaries presenting with NSTEMI admission experienced decreased observed mortality rate during the study period. In fact, the observed mortality rate from admission to 90 days postdischarge among Medicare beneficiaries presenting with STEMI increased during the study period from 12.4% to 13.9%, whereas the same observed mortality rate for PCI admission without AMI increased from slightly >2.0% to 3.2% by 2012.

Looking forward, the well-documented demographic impact of the baby boom generation reaching Medicare age will result in a rapid growth in the number of Medicare beneficiaries during the next 15 years. Combining the current incidence of revascularization procedures by age and sex (see Table 1) with the expected growth in the number of Medicare beneficiaries implies that the total number of revascularizations performed on Medicare beneficiaries each year will likely begin to increase again in the near future, unless there are significant changes in Medicare beneficiaries' lifestyle and behavior, or new noninvasive treatments that delay or reduce the incidence of coronary artery disease. Fortunately, Table 3 indicates that the US delivery system already has the capacity to handle any expected increase in the demand for revascularization procedures from future Medicare beneficiaries based on recommend annual revascularization volume levels.^{17,18}

There are 2 limitations worth noting with this study. First, all mortality rates reported in this study are observed mortality rates, and any trends in mortality rates should be interpreted with care, because rates have not been adjusted for changes in the severity of illness among Medicare beneficiaries undergoing revascularization procedures over time. However, to the extent that this study represents the population of Medicare beneficiaries that physicians believed required specific types of revascularization procedures, the summary rates for all PCIs and CABG surgeries most likely are of interest in that they report what happened to all Medicare beneficiaries undergoing PCI or CABG surgery in a given year. Second, all facilities in this study are identified

by their Medicare provider number in the respective Medicare data set. To the extent that hospital mergers and acquisitions have resulted in multiple hospitals using the same provider number, then the number of providers performing revascularizations and the average number of revascularization procedures may not represent the true trend in the number of facilities, and the volume levels at individual sites may be different than reported in this article. On the other hand, there is little evidence in the research literature concerning whether the growing number of mergers and acquisitions have actually impacted the number of locations performing revascularization procedures.

Disclosures

None.

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CLINICAL PERSPECTIVE

This article provides 5-year trends in volume and outcomes for coronary revascularization procedures performed on all Medicare beneficiaries by 3 patient presentation groups: (1) patients with ST-elevation myocardial infarction; (2) patients with non-ST-elevation myocardial infarction; and (3) patients with no acute myocardial infarction. Increasingly, practicing physicians are being measured and monitored on a number of population-based statistics. For example, both the Medicare's shared saving and pay-for-performance programs reward/penalize provider organizations relative to a selected number of national performance and outcome measures. The information presented in this study provides practicing clinicians with a number of patient volume and clinical benchmarks that can be used to evaluate and monitor treatment choices and outcomes obtained in their own/group patient populations. First, practicing physicians can evaluate whether the patients presenting across acute myocardial infarction groups in their practice differ from the national distribution of patients with acute myocardial infarction for the revascularization procedures. Second, although the outcome measures reported are not risk adjusted, this article presents national benchmarks and trends in short-term mortality rates for the entire Medicare population by revascularization procedures for each acute myocardial infarction patient group. Third, the article presents 90-day postdischarge all-cause mortality rates for all patients undergoing percutaneous coronary intervention only and any patients undergoing coronary artery bypass graft surgery. These mortality rates provide practicing physicians with some important national benchmark outcome measures to report to patients, especially for those patients who may be deciding between the 2 revascularization procedures.