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Patient and Hospital Characteristics Associated With Inappropriate Percutaneous Coronary Interventions

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Objectives This study sought to examine whether rates of inappropriate percutaneous coronary intervention (PCI) differ by demographic characteristics and insurance status.

Background Prior studies have found that blacks, women, and those who have public or no health insurance are less likely to undergo PCI. Whether this reflects potential overuse in whites, men, and privately insured patients, in addition to underuse in disadvantaged populations, is unknown.

Methods Within the National Cardiovascular Data Registry CathPCI Registry, we identified 221,254 nonacute PCIs performed between July 2009 and March 2011. The appropriateness of PCI was determined using the Appropriate Use Criteria for coronary revascularization. Multivariable hierarchical regression was used to evaluate the association between patient demographics and insurance status and inappropriate PCI, as defined by the Appropriate Use Criteria.

Results Of 211,254 nonacute PCIs, 25,749 (12.2%) were classified as inappropriate. After multivariable adjustment, men (adjusted odd ratio [OR]: 1.08 [95% CI: 1.05 to 1.11]; $p < 0.001$) and whites (adjusted OR: 1.09 [95% CI: 1.05 to 1.14]; $p < 0.001$) were more likely to undergo an inappropriate PCI in comparison with women and nonwhites. Compared with privately insured patients, those who had Medicare (adjusted OR: 0.85 [95% CI: 0.83 to 0.88]), other public insurance (adjusted OR: 0.78 [95% CI: 0.73 to 0.83]), and no insurance (adjusted OR: 0.56 [95% CI: 0.50 to 0.61]) were less likely to undergo an inappropriate PCI ($p < 0.001$). In addition, compared with urban hospitals, those admitted at rural hospitals were less likely to undergo inappropriate PCI, whereas those at suburban hospitals were more likely.

Conclusions For nonacute indications, PCIs categorized as inappropriate were more commonly performed in men, whites, and those who had private insurance. Higher rates of PCI in these patient populations may, in part, be due to procedural overuse. (J Am Coll Cardiol 2013;62:2274–81) © 2013 by the American College of Cardiology Foundation

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Percutaneous coronary intervention (PCI) improves survival in patients with acute myocardial infarction and has the potential to reduce morbidity and improve quality of life in other settings. The use of PCI accounts for approximately 600,000 procedures (1) and $12 billion in healthcare spending annually in the United States (2). However, prior studies have reported lower rates of PCI among blacks, women, and those who have public or no health insurance (3, 4). Whether these differences are due to underuse in these traditionally vulnerable populations, or overuse in whites, men, and those who have private health insurance, or both, is unknown.

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Now, with the development of the Appropriate Use Criteria by national cardiovascular societies (5), there exists a standardized approach to systematically assess the clinical appropriateness of PCI. Recent studies applying these criteria have found that rates of inappropriate PCI in the United States range from 12% to 17% for stable patients without acute coronary syndromes, but these studies did not examine the patients or hospital characteristics associated with procedures categorized as inappropriate (6–9). Illuminating whether some of the observed differences in rates of PCI by race, sex, or insurance status of the patients may be due to PCIs considered by the Appropriate Use Criteria to be inappropriate, can provide information to improve equity in health care (10,11). This would suggest that efforts to reduce healthcare differences will not simply mean raising procedural rates for vulnerable populations, but also improving its use in whites, men, and privately insured patients. Thus, complex efforts would be required to address both procedural underuse and overuse.

To address this current gap in knowledge, we analyzed data from a large national PCI registry to examine whether certain patient demographics and insurance status are associated with inappropriate PCIs for nonacute indications. In addition, we examined whether certain hospital factors, such as location of hospital, hospital for-profit status, academic affiliation, and annual PCI volume, are associated with higher rates of inappropriate PCIs.

Methods

Data source. The CathPCI Registry is an initiative of the American College of Cardiology Foundation and The Society for Cardiovascular Angiography and Interventions. There are more than 1,500 participants submitting data from diagnostic cardiac catheterization and PCI procedures to the national registry. The design and salient characteristics of the registry have been previously described (12–14). Detailed information on patient characteristics, coronary angiography, PCIs, and in-hospital outcomes is collected by trained staff at participating hospitals using standardized data elements. For CathPCI Registry, all submissions of reported procedural data must meet predetermined levels of completeness and consistency for data fields and internal quality assurance protocols before the information is entered into the registry (14). In addition, the National Cardiovascular Data Registry has a robust data quality program that conducts annual audits of data variables at 25 randomly selected sites. In 2010, the CathPCI Registry found that the accuracy rate of audited sites was 93.1% (range, 89.4% minimum and 97.4% maximum) for 58 target variables (14).

Abbreviations and Acronyms

CI = confidence interval

OR = odds ratio

PCI = percutaneous coronary intervention

Appropriate use criteria. The methodology for developing the Appropriate Use Criteria for coronary revascularization that reflects a synthesis of contemporary clinical trial evidence, clinical practice guidelines, and expert opinion, has been previously described (5). Using a modified Delphi approach, a 17-member expert panel adjudicated the appropriateness of coronary revascularization compared with medical therapy for 198 distinct clinical indications. From the individual ratings of the technical panel members, each clinical indication was classified as appropriate, uncertain, or inappropriate. An "appropriate" rating denotes coronary revascularization, as compared with medical therapy, would likely improve a patient's health status (symptoms, function, or quality of life) or survival. An "uncertain" rating implies that more research and/or patient information is needed to further classify the indication. An "inappropriate" rating indicates that the benefits of coronary revascularization, compared with medical therapy, may not outweigh the risks of treatment (5). Each of these ratings were intended to evaluate care of populations of patients with the understanding that any single patient case may have unmeasured variables affecting clinical decision making. For this study, we focused on the appropriateness of coronary revascularization with PCI, as the CathPCI Registry does not collect information on coronary artery bypass surgery.

In our prior work, we developed algorithms for matching PCI procedures from the CathPCI Registry to appropriateness ratings from the Appropriate Use Criteria for coronary revascularization (6). Although the Appropriate Use Criteria have recently been updated, we used the original criteria from 2009 (5) because these were operative at the time that the majority of cases from this study were conducted, and also because this approach is consistent with the methodology we used in our original work (6).

Study population of stable ischemic heart disease patients undergoing PCI. We examined 1,087,995 PCI procedures between July 1, 2009 and March 31, 2011. Our prior work had demonstrated that the vast majority of PCIs that were rated inappropriate were performed for nonacute indications. Based on that work, we excluded acute PCIs (i.e., those performed for myocardial infarction and high-risk unstable angina) and restricted our study cohort to the 426,880 patients who underwent a nonacute PCI during this

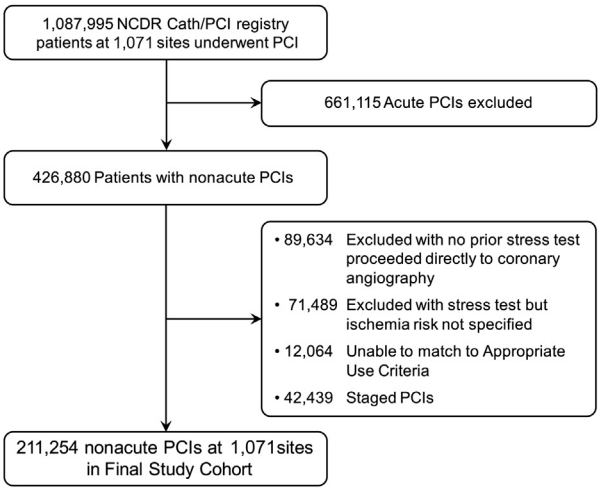

Figure 1 Study Cohort

Patients excluded from the study cohort are depicted. NCDR = National Cardiovascular Data Registry; PCI = percutaneous coronary intervention.

study period (Fig. 1). We further excluded 173,187 PCIs in which the requisite data for mapping patients to the Appropriate Use Criteria were not available, primarily due to the absence of noninvasive stress test results (89,634 who proceeded to PCI without a stress test, 71,489 with a stress test but without information on ischemia severity, and 12,064 unable to be matched to the Appropriate Use Criteria). We also excluded 42,439 staged nonacute PCIs, so that the analyses would reflect the practice patterns at the time of an initial decision to proceed with PCI. Our final study cohort comprised 211,254 nonacute PCIs from 1,071 hospitals. Importantly, except for age, there were no significant differences in patient and hospital characteristics between those who were excluded and those who were included in the study cohort (Online Table 1).

Statistical analysis. The proportion of PCIs classified as appropriate, uncertain, and inappropriate was determined using a previously validated algorithm (6). Baseline demographics, clinical characteristics, and hospital factors of patients undergoing PCI were then compared by appropriateness category. Continuous variables were evaluated using analysis of variance and categorical variables with the chi-square test.

To examine whether patient demographics, insurance status, and hospital factors were associated with inappropriate PCI, we constructed a 2-level multivariable hierarchical logistic regression model, which allowed us to account for patients from the same hospitals (15). In this model, all patient and hospital characteristics were modeled as fixed effects, and each hospital site was modeled as a random effect. Our primary independent variables of interest in the model were age, sex, race (categorized as white, black, or other), and insurance type (private, Medicare, other public [e.g., Veterans Affairs, Medicaid, Indian Health Service], and none). In addition to these 4 characteristics, in our models, we included the following patient variables to minimize potential confounding: active smoking, heart failure exacerbation within the past 2 weeks, hypertension, dyslipidemia, diabetes mellitus, chronic hemodialysis, family history of coronary artery disease, left ventricular systolic dysfunction (ejection fraction <40%), and a history of myocardial infarction, PCI, coronary artery bypass surgery, cardiac valve surgery, heart failure, peripheral arterial disease, cerebrovascular disease, and chronic lung disease. In addition, we included certain hospital factors as fixed effects in the model, including location (rural, suburban, urban), teaching status, public versus private hospital, hospital type (private/community, university, or government), availability of onsite cardiothoracic surgery backup, mean door-to-balloon time for ST-segment elevation myocardial infarction, and annual nonacute PCI volume.

All tests for statistical significance were 2-tailed and evaluated at a significance level of 0.05. All statistical analyses were performed with the use of SAS 9.2 (SAS Institute, Inc., Cary, North Carolina) or R version 2.10.0 (Vienna, Austria).

Results

Of 211,254 nonacute PCIs, 105,121 (49.8%) were classified by the Appropriate Use Criteria as appropriate, 80,384 (38.1%) as uncertain, and 25,749 (12.2%) as inappropriate. Table 1 summarizes baseline characteristics of patients undergoing PCI, stratified by appropriateness category. Compared with patients who had appropriate PCIs, patients who had inappropriate PCIs were more frequently men, white, and privately insured. There were modest differences by age. In addition, patients who underwent inappropriate PCIs less likely had a prior myocardial infarction, PCI, coronary artery bypass surgery, or valve surgery, a pre-existing or recent heart failure, other cardiac comorbidities, and/or left ventricular systolic dysfunction. They were also more likely to have a pre-operative evaluation for noncardiac surgery than patients who had PCIs that were categorized as appropriate (8.9% vs. 2.6%; $p < 0.001$).

Table 2 summarizes the characteristics of hospitals at which patients underwent PCIs that were stratified by appropriateness. A greater proportion of patients undergoing PCI at suburban hospitals were classified as having an inappropriate PCI, as compared with patients at urban and rural hospitals. Compared with patients who had PCIs that were uncertain or appropriate, patients who had inappropriate PCIs were more commonly treated at hospitals that performed fewer nonacute PCIs annually. Finally, there were small differences observed across appropriateness categories for teaching status, public hospital status, for-profit status, and the presence of onsite cardiothoracic surgery.

Factors associated with inappropriate PCI. After multivariable adjustment, we found that men (adjusted odds ratio

Table 1 Characteristics of Patients Undergoing PCI, Stratified by Appropriateness

	Entire Cohort (N = 211,254)	Appropriate (n = 105,121)	Uncertain (n = 80,384)	Inappropriate (n = 25,749)	p Value*
Demographics					
Age	65.3 ± 11.2	65.4 ± 11.4	65.2 ± 11.0	65.5 ± 10.6	<0.001
Men	66.6%	66.6%	66.2%	68.3%	<0.001
Race					
White	88.9%	88.4%	89.1%	90.0%	<0.001
Black	7.6%	7.7%	7.6%	7.2%	0.02
Other	3.5%	3.9%	3.3%	2.8%	<0.001
Health Insurance					<0.001
Medicare	67.5%	66.0%	68.0%	71.8%	
Private	24.3%	24.9%	24.3%	22.1%	
Other	5.4%	5.8%	5.1%	4.3%	
None	2.9%	3.3%	2.6%	1.7%	
Comorbidities					
Current or recent smoker	22.0%	22.2%	22.1%	21.2%	0.002
Family history of CAD	25.1%	25.1%	25.8%	22.8%	<0.001
Hypertension	86.3%	87.3%	85.6%	84.1%	<0.001
Dyslipidemia	86.0%	86.4%	85.9%	84.9%	<0.001
Diabetes mellitus	38.0%	39.5%	36.8%	35.4%	<0.001
Prior heart failure	11.1%	12.8%	9.7%	8.3%	<0.001
Heart failure in past 2 weeks	7.5%	8.5%	6.5%	6.3%	<0.001
LVEF <40%	9.8%	11.0%	8.6%	8.5%	<0.001
Prior myocardial infarction	28.8%	31.4%	27.3%	22.7%	<0.001
Prior PCI	44.3%	47.0%	43.6%	35.4%	<0.001
Prior CABG	13.9%	14.8%	13.5%	10.9%	<0.001
Prior valve surgery	1.3%	1.3%	1.4%	1.4%	0.009
Cerebrovascular disease	12.6%	13.4%	11.8%	11.7%	<0.001
Peripheral arterial disease	13.4%	14.0%	12.9%	12.7%	<0.001
Chronic lung disease	14.9%	15.6%	14.5%	13.3%	<0.001
Hemodialysis	2.1%	2.3%	1.9%	2.3%	<0.001
Pre-operative evaluation	3.9%	2.6%	4.1%	8.9%	<0.001

Values are mean ± SD or %. *p values denote significant differences across the 3 categories of appropriateness.

CABG = coronary artery bypass graft surgery; CAD = coronary artery disease; LVEF = left ventricular ejection fraction; PCI = percutaneous coronary intervention.

[OR]: 1.08; 95% confidence interval [CI]: 1.05 to 1.11; $p < 0.001$) and white patients (adjusted OR: 1.09; 95% CI: 1.05 to 1.14; $p < 0.001$) were more likely to undergo an inappropriate PCI than women and nonwhites, respectively. Compared with patients having private health insurance, those who had Medicare (adjusted OR: 0.85; 95% CI: 0.83 to 0.88), other public insurance (adjusted OR: 0.78; 95% CI: 0.73 to 0.83), and no insurance (adjusted OR: 0.56; 95% CI: 0.50 to 0.61) were less likely to undergo an inappropriate PCI ($p < 0.001$). There were no differences in rates of inappropriate PCI by age ($p = 0.32$). Notably, patients with a family history of premature coronary artery disease, known heart failure, left ventricular systolic dysfunction, and a history of myocardial infarction or coronary revascularization were less likely to undergo an inappropriate PCI (Table 3), whereas patients with a pre-operative evaluation for noncardiac surgery were more likely to undergo an inappropriate PCI (adjusted OR: 2.84; 95% CI: 2.69 to 2.99).

Several hospital characteristics were also associated with inappropriate PCI after adjusting for patient characteristics. Compared with patients admitted at urban hospitals, those admitted at rural hospitals (adjusted OR: 0.92; 95% CI: 0.88 to 0.96) were less likely to undergo an inappropriate PCI, whereas those treated at suburban hospitals were more likely to undergo inappropriate PCI (adjusted OR: 1.10; 95% CI: 1.07 to 1.13; $p < 0.001$). There was no association between treatment at a teaching, public, or for-profit hospital, and onsite cardiothoracic surgery and rates of inappropriate PCI. Although we found a statistically significant association between the annual elective PCI volume (per 100 cases) of a hospital and inappropriate PCI, the adjusted OR was 0.99, suggesting that these differences were not clinically significant. Notably, there were no significant interactions between a patient's demographics or insurance status and hospital factors (all $p > 0.10$).

Finally, the 7 most common indications for an inappropriate PCI from the 2009 Appropriate Use Criteria are described (Online Fig. 1), with each indication comprising >500 PCI cases in the study cohort. The most frequent indications for an inappropriate PCI were indications 12 and 14, in which PCIs were performed in patients who had no

Table 2 Characteristics of Hospitals for Patients Undergoing PCI, Stratified by Appropriateness

	Entire Cohort (N = 211,254)	Appropriate (N = 211,254)	Uncertain (n = 80,384)	Inappropriate (n = 25,749)	p Value*
Hospital location					<0.001
Rural	10.2%	10.2%	10.3%	9.7%	
Suburban	30.8%	29.4%	31.8%	33.0%	
Urban	59.0%	60.4%	57.8%	57.2%	
Teaching hospital	50.4%	51.0%	50.0%	49.1%	<0.001
Public hospital	58.4%	59.3%	57.1%	58.4%	<0.001
For-profit status					<0.001
Government	0.7%	0.8%	0.7%	0.6%	
Private	87.4%	86.8%	87.9%	87.9%	
Nonprofit	11.9%	12.4%	11.5%	11.5%	
Onsite cardiothoracic surgery	88.4%	89.0%	87.4%	88.5%	
Elective PCI volume, no. per year	843 ± 706	872 ± 702	836 ± 740	748 ± 592	<0.001
Door-to-balloon time for STEMI	74.4 ± 21.5	74.1 ± 22.5	74.9 ± 20.9	74.3 ± 18.6	<0.001

Values are % or mean ± SD. *p values denote significant differences across the 3 categories of appropriateness.
STEMI = ST-segment elevation myocardial infarction; other abbreviations as in Table 1.

prior history of coronary artery bypass surgery, single to 2-vessel non–high-risk CAD, minimal to no anti-anginal therapy, and either a low-risk or intermediate-risk study for ischemia. Among these 7 most common indications for an inappropriate PCI, those with higher rates among men, whites, privately-insured patients, and suburban patients are described in Table 4.

Discussion

Although prior studies have described differences in use of medical procedures by race and sex, it has not been clear whether these treatment differences were solely attributable to underuse in vulnerable populations or also overuse in others (10). In this large, national PCI registry, we found that men, whites, and those with private health insurance were more likely to undergo a PCI for stable coronary artery disease that was classified by consensus-based criteria as inappropriate. There were also differences in a patient's likelihood of receiving an inappropriate PCI based on whether their treating hospital was located in a suburban, urban, or rural area. Finally, we found that patients without heart failure, left ventricular dysfunction, or known coronary artery disease, as well as patients undergoing pre-operative evaluation for noncardiac surgery, were more likely to undergo a PCI categorized as inappropriate. Collectively, these findings provide important insights into which patient and hospital characteristics are associated with a PCI for stable coronary artery disease in whom the risks of the procedure may exceed its benefits.

By leveraging the recently developed Appropriate Use Criteria for coronary revascularization, we were able to extend the existing literature that has documented less PCI use in women and blacks by showing that, in the setting of stable ischemic heart disease, these patients are less likely to undergo inappropriate procedures. Men were 8% more likely to have an inappropriate PCI than women, and whites were 9% more likely to have an inappropriate PCI than blacks. Although the clinical magnitude of these differences was modest, it represents more than 2,000 additional procedures per year in which men and white patients may be exposed to procedural and long-term bleeding risks without clear clinical benefit in comparison to that of medical therapy (Online Table 2). Importantly, these data suggest that prior reports of racial and sex differences in PCI rates may not be solely due to underuse (i.e., disparities), but also overuse (10).

In contrast to the modest differences by patient demographic characteristics, we found substantially larger differences in inappropriate PCI by insurance status and treatment location. Compared with patients who have private health insurance, those who have Medicare and other public insurance were 15% and 22% less likely to undergo a nonacute PCI classified as inappropriate, respectively, and uninsured patients were nearly half as likely to undergo such procedures. We also found that the location of the hospital was associated with large differences in the rates of inappropriate PCI, even after adjusting for patient demographics, insurance, and clinical characteristics. Patients admitted to rural hospitals were the least likely to undergo a PCI without clear clinical benefit, whereas patients admitted at suburban hospitals were the most likely. The reason for this treatment pattern is unknown but may be related to decreased availability of interventional cardiologists at rural hospitals or different cultures of practice and patient preferences within different hospital settings. Interestingly, we did not find an association between a hospital's for-profit or teaching status and a patient's likelihood of undergoing an inappropriate PCI, nor did we find a clinically meaningful relationship with a hospital's nonacute PCI case volume.

The lower rate of inappropriate PCIs in blacks, women, the uninsured, or those residing in rural locations may suggest that these patients are treated later in the course of their

Table 3 Patient and Hospital Predictors of Inappropriate PCI

	Adjusted OR (95% CI)	p Value
Demographics		
Age, per 10 yrs	1.01 (0.99–1.02)	0.32
Men	1.08 (1.05–1.11)	<0.001
White	1.09 (1.05–1.14)	<0.001
Health insurance (reference: private)		<0.001
Medicare	0.85 (0.83–0.88)	
Other public insurance	0.78 (0.73–0.83)	
None	0.56 (0.50–0.61)	
Clinical variables		
Smoker	1.00 (0.97–1.04)	0.99
Hypertension	0.90 (0.87–0.93)	<0.001
Dyslipidemia	1.05 (1.01–1.09)	0.02
Family history of CAD	0.89 (0.86–0.92)	<0.001
Prior myocardial infarction	0.84 (0.81–0.86)	<0.001
Prior heart failure	0.83 (0.79–0.87)	<0.001
Prior valve surgery	1.11 (0.99–1.25)	0.06
Prior PCI or CABG	0.73 (0.70–0.75)	<0.001
Hemodialysis	0.98 (0.90–1.08)	0.71
Cerebrovascular disease	0.96 (0.92–1.00)	0.05
Peripheral arterial disease	0.97 (0.93–1.01)	0.17
Chronic lung disease	0.93 (0.89–0.97)	<0.001
Diabetes mellitus	0.93 (0.90–0.96)	<0.001
Heart failure in past 2 weeks	0.95 (0.90–1.01)	0.12
Pre-operative evaluation	2.84 (2.69–2.99)	<0.001
Left ventricular systolic dysfunction	0.93 (0.89–0.98)	0.008
Hospital variables		
Hospital location (reference: urban)		<0.001
Rural	0.92 (0.88–0.96)	
Suburban	1.10 (1.07–1.13)	
Teaching hospital	0.98 (0.95–1.01)	0.11
Public hospital	1.02 (0.99–1.05)	0.25
For-profit status (reference: university)		0.28
Government	0.87 (0.74–1.04)	
Private	1.00 (0.96–1.05)	
Onsite cardiothoracic surgery	1.03 (0.99–1.08)	0.20
Annual elective PCI volume per 100 cases	0.99 (0.99–0.99)	<0.001
Mean door-to-balloon time for STEMI, per 10 min	0.99 (0.98–1.00)	0.002

CI = confidence interval; OR = odds ratio; other abbreviations as in Table 1 and 2.

coronary artery disease than those who had greater access to care. As a result, these patient groups may be more symptomatic or were given a more robust trial of anti-angina therapy prior to coronary angiography and PCI, thus leading to lower rates of inappropriate procedures. This pattern of care among traditionally vulnerable populations would not be intrinsically problematic, as it may simply reflect good clinical decision making, as long as it is also not accompanied by concurrent underuse of PCIs for appropriate indications. Moreover, for whites, men, privately insured patients, and those in suburban locations to have higher rates of inappropriate PCI, our findings suggest that these patient groups are undergoing PCI more frequently with only mild to no angina, low-risk stress tests, and/or insufficient trials of anti-angina therapy.

Finally, we found that patients evaluated for noncardiac surgery were more likely to undergo inappropriate PCIs. Use of PCIs in this setting is inconsistent with the findings of the CARP (Coronary Artery Revascularization Prophylaxis) trial, which demonstrated that coronary revascularization prior to even the highest risk noncardiac surgeries (i.e., vascular surgeries involving aortic aneurysms or femoral-popliteal artery bypasses) did not reduce rates of death or myocardial infarction (16). Given the common use of drug-eluting stents in contemporary practice and the requirements for dual antiplatelet therapy with any stent for 30 days or greater, the use of PCI in stable patients prior to noncardiac surgery may not only deviate from the findings of the CARP trial, but it may also increase bleeding risk. Nevertheless, avoiding PCIs that may not confer a clear clinical benefit in pre-operative patients can be complex and challenging, as it involves not only the cardiologist, but also the referring physicians and surgeon. Therefore, efforts to reduce inappropriate PCIs in pre-operative patients will require concerted efforts to provide educational outreach to

Table 4 Distribution of Inappropriate PCIs by Indication and Subgroup*

		Appropriate Use Criteria Indication Number						
	Proportion of Study Sample	12 (n = 14,824)	13 (n = 758)	14 (n = 5,999)	19 (n = 613)	48 (n = 686)	54 (n = 1,338)	56 (n = 688)
Demographics								
Sex								
Male	66.6%	65.9%	59.0%	**72.3%**	54.2%	**80.6%**	**77.1%**	**83.9%**
Female	33.4%	34.1%	41.0%	**27.7%**	45.8%	**19.4%**	**22.9%**	**16.1%**
Insurance								
Private	67.5%	**73.1%**	66.8%	**70.7%**	65.9%	**70.6%**	**71.2%**	**69.0%**
Medicare	24.4%	**20.6%**	27.2%	**24.3%**	22.0%	**26.1%**	**23.2%**	**27.0%**
Other	5.4%	**4.4%**	4.2%	**3.9%**	8.2%	**2.9%**	**4.4%**	**3.3%**
None	2.9%	**2.0%**	1.8%	**1.2%**	3.9%	**0.4%**	**1.2%**	**0.6%**
Race								
White	88.9%	**90.0%**	82.3%	**89.8%**	**90.5%**	**92.7%**	**91.7%**	**94.3%**
Black	7.6%	**7.0%**	14.8%	**7.4%**	**7.5%**	**4.7%**	**5.0%**	**3.6%**
Other	3.5%	**3.0%**	2.9%	**2.8%**	**2.0%**	**2.5%**	**3.3%**	**2.1%**
Hospital location								
Suburban	30.8%	**32.8%**	31.4%	**33.5%**	32.0%	**33.5%**	**35.4%**	**35.3%**
Urban	59.0%	**57.2%**	61.2%	**57.5%**	53.2%	**56.4%**	**55.4%**	**57.7%**
Rural	10.2%	**10.0%**	7.4%	**9.0%**	14.8%	**10.1%**	**9.3%**	**7.0%**

Values are %. *The most common indications for inappropriate PCI (>500 cases) in the study cohort are displayed by sex, race, insurance status, and hospital location. Values in **bold** show if the proportion of inappropriate PCI was higher for men, whites, privately insured patients, and those who were treated at suburban locations.

primary care physicians, cardiologists, and noncardiac surgeons alike.

Our study should be interpreted in the context of the following limitations. First, the results of the present analysis apply only to the stable PCI population, which represents ~40% of procedures in the CathPCI Registry; therefore, these results cannot be extrapolated to PCI of patients with acute coronary syndromes, in whom overall rates of inappropriate PCI are extremely low (~1%). Moreover, although our findings suggest potential overuse of PCI in men, whites, and those who had private health insurance, they do not diminish the critical importance of efforts to reduce previously documented underuse of PCIs in blacks, women, and those who had public or no insurance. However, the CathPCI Registry does not contain data on all patients potentially eligible for coronary revascularization. As a result, we could not assess for underuse of PCI (17,18) or determine what the "right rates" (avoiding overuse and reducing underuse) should be for coronary revascularization with PCI.

Although our analyses were conducted in a patient sample from more than 1,000 hospitals, not all hospitals that perform PCI in the United States participate in the National Cardiovascular Data Registry CathPCI Registry. Our study also excluded nonacute procedures without an assessment of ischemia risk, which is an inherent limitation in the design and application of the Appropriate Use Criteria. However, it is noteworthy that the Appropriate Use Criteria reflect a synthesis of contemporary clinical trial evidence, clinical practice guidelines, and expert opinion, and readily acknowledge that some inappropriate procedures may be considered uncertain or appropriate when considering unique clinical and patient factors (e.g., coronary anatomy) not covered by the indications. An additional potential concern is that we were unable to examine the failure of medical therapy or the influence of patient preferences in determining treatment with PCI. Finally, data in the CathPCI Registry are not 100% audited, so there is the possibility of miscoding of data elements, although data accuracy has been shown to be generally high (14).

Conclusion

We found that 1 in 8 PCIs in stable patients were classified as inappropriate by the Appropriate Use Criteria for Coronary Revascularization, and these procedures were more commonly performed in men, whites, those who had private insurance, and patients who were admitted to hospitals in suburban locations. Although underuse of treatment leads to disparities in care, our findings suggest potential overuse of PCI in these patient groups may also account for some of the previously observed differences in care.

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Key Words: disparities ■ overuse ■ PCI ■ quality of care.

APPENDIX

For supplemental tables and a figure, please see the online version of this article.