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State Variation in the Use of Non-Acute Coronary Angiograms and Coronary Revascularization Procedures

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In the United States, approximately 500,000 percutaneous coronary interventions (PCIs) are performed each year at an estimated cost of \$12 billion. Since publication of appropriate use criteria (AUC) for coronary revascularization, non-acute PCI use has declined, but little is known about recent state variation in non-acute PCI use (1,2). Given policymakers interest in curbing expenditures on high-cost procedures and recent debate regarding the role of PCI for non-acute indications (3), understanding variation in the use of non-acute PCI and other coronary procedures is important. We examined population rates of non-acute coronary angiograms, PCI, and coronary artery bypass graft surgery (CABG) surgery in 4 states from 2010 to 2014.

Using the Healthcare Cost and Utilization Project state inpatient and ambulatory surgery databases, we identified *all* individuals undergoing non-acute coronary angiograms and coronary revascularization procedures in New York, Florida, Michigan, and Maryland from 2010 to 2014. We selected these states due to their large populations and geographic dispersion. We included Maryland because its all-payer system, in which all insurers pay the same price for inpatient and outpatient hospital care, is distinct from all other states. Both inpatient and outpatient data were available for these states, allowing us to identify *all* coronary procedures. Procedures were classified as non-acute if they were not associated with unstable angina or myocardial infarction. State population denominators were obtained from the U.S. census. Procedure rates for each state were age- and sex-adjusted using Florida's 2014 population as a standard. SEs were calculated for adjusted procedure rates, and chi-square testing was used to compare procedure rates between years for each state.

We identified 1,189,423 non-acute coronary angiograms, 261,946 non-acute PCIs, and 93,763 non-acute CABGs performed from 2010 through 2014. From 2010 to 2014, the adjusted rate of coronary angiograms declined from 458 per 100,000 (SE: 3.2) to 362 per 100,000 (SE: 2.7) in Maryland, 465 (SE: 2.4) to 442 (SE: 2.2) per 100,000 in Michigan, and 658 (SE: 1.9) to 506 (SE: 1.6) per 100,000 in Florida, but increased from 470 (SE: 1.8) to 484 (SE: 1.7) per 100,000 in New York (Figure 1A) ($p < 0.001$ for all states). By 2014, the rate of coronary angiograms remained lowest in Maryland and was 40% higher in Florida ($p < 0.001$ for difference among states in 2014).

The adjusted rate of PCIs, from 2010 to 2014, declined from 93 (SE: 1.5) to 71 per 100,000 (SE: 1.2) in Maryland, 126 (SE: 1.3) to 80 (SE: 1.0) per 100,000 in Michigan, 135 (SE: 0.9) to 88 (SE: 0.7) per 100,000 in Florida, and 156 (SE: 1.0) to 115 (SE: 0.8) per 100,000 in New York (Figure 1B) ($p < 0.001$ for all states). By 2014, the rate of PCI remained lowest in Maryland, and was 62% higher in New York ($p < 0.001$ for difference among states in 2014). Adjusted rates of CABG also declined from 39 (SE: 1.0) to 33 (SE: 0.8) per 100,000 in Maryland, 51 (SE: 0.8) to 39 (SE: 0.7) in Michigan, 47 (SE: 0.5) to 36 (SE: 0.4) in Florida, and 47 (SE: 0.6) to 35 (SE: 0.5) in New York ($p < 0.001$ for all states).

Given rising health care expenditures, recent efforts have focused on the implementation of AUC for high-cost cardiac procedures (2). In this study, although we observed mixed trends in the use of non-acute coronary angiograms and steady reduction in non-acute PCI rates, we found that significant variations in age- and sex-adjusted rates of these procedures persisted between states.

In 2009, concerns regarding overuse of PCI prompted the release of AUC for coronary revascularization (2). These efforts led to declines in the use of non-acute PCIs (1). Our findings, however, show that despite this, there remains significant geographic variation in the use of these procedures. This is of particular relevance because, similar to the landmark COURAGE (Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation) trial (4), recent findings from the ORBITA (Objective Randomised Blinded Investigation With Optimal Medical Therapy of Angioplasty in Stable Angina) trial have reinvigorated the debate regarding the role of PCI for non-acute indications (3). It is possible that the heterogeneity we observed reflects the differential uptake of AUC of coronary angiography and PCI, with continued over use in certain areas of the United States that have lower adoption (1,5). It is also possible that the low rates of procedure use in Maryland reflect under use due to the influence of its unique all-payer system, which is designed to promote cost efficiency. Future investigations should seek to understand the extent to which observed variations among states may, in part, be explained by differences in patient case-mix, academic versus private institution penetrance in each state, or variations in state policies (i.e., public reporting, malpractice, payment models).

In summary, we observed persistent, substantial variation in the use of non-acute coronary angiograms and coronary revascularization procedures among 4 states. These data have implications for policy efforts that seek to ensure appropriate cardiac procedure use and provide insight regarding the potential influence of payment system structure on use.

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FIGURE 1. Temporal Trends in Population Rates of Cardiac Procedures

Adjusted rates reflect the number of non-acute coronary angiograms (A) and non-acute coronary revascularization procedures (B) per 100,000 residents by state and year, from 2010 to 2014. CABG = coronary artery bypass graft surgery; PCI = percutaneous coronary intervention.