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Early Results of Massachusetts Health Care Reform on Racial, Ethnic and Socioeconomic Disparities in Cardiovascular Care

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Abstract

Background—Insured adults receive invasive cardiovascular procedures more frequently than uninsured adults. We examined the impact of Massachusetts's healthcare reform on use of coronary revascularization procedures, in–hospital and 1-year mortality by race/ethnicity, education, and sex.

Methods and Results—Using hospital claims data, we compared differences in coronary revascularization rates [coronary artery bypass grafting or percutaneous coronary intervention] and in-hospital mortality by race/ethnicity, education, and sex among Massachusetts residents age 21–64 hospitalized with a principal discharge diagnosis of ischemic heart disease pre (November 1, 2004 to July 31, 2006) and post (December 1, 2006 to September 30, 2008) reform; 1-year mortality was calculated for those undergoing revascularization. Adjusted-logistic regression assessed 24,216 discharges pre-reform and 20,721 discharges post-reform. Blacks had 30% lower odds of receiving coronary revascularization than whites in the pre-reform period. Compared to whites in the post-reform period, blacks (OR=0.73, 95%CI 0.63–0.84) and Hispanics (OR= 0.84, 95%CI 0.74–0.97) were less likely and Asians (OR=1.29, 95%CI 1.01–1.65) more likely to receive coronary revascularization. Patients living in more educated communities, males, and persons with private insurance were more likely to receive coronary revascularization pre and post-reform. Compared to pre-reform, the adjusted odds of in-hospital mortality were higher in patients living in less educated communities in the post-reform period. No differences in 1-year mortality by race/ethnicity, education, or sex for revascularized patients were observed pre- or post-reform.

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Disclosures

None.

Conclusion—Reducing insurance barriers to receipt of coronary revascularization procedures has not yet eliminated pre-existing demographic and educational disparities in access to these procedures.

Keywords

Coronary artery bypass grafting; Percutaneous Coronary Intervention; Health Care Reform; Race; Ethnicity; Socioeconomic; Gender

Introduction

African-Americans (blacks) are disproportionately affected by cardiovascular disease (CVD) and have worse cardiovascular health outcomes compared to other racial and ethnic groups in the United States[1]. Potential reasons for these differences include differences in CVD risk factors, socioeconomic status, chronic stress, suboptimal interactions with health care providers, and access to appropriate health care[1, 2]. Non-white Americans may also present with more severe CVD because of lack of adequate insurance coverage[2]. Prior research has demonstrated that blacks are less likely to receive potentially life-saving cardiovascular procedures such as coronary artery bypass grafting (CABG) and percutaneous coronary interventions (PCI)[3–4]. For example, in the National Registry of Myocardial Infarction, insurance status was positively associated with the receipt of invasive cardiovascular procedures[5].

In 2009, 50.7 million Americans lacked health insurance, with the highest rates of un-insurance among Hispanic (32.4%) followed by black (21.0%), Asian (17.0%), and white (12.0%) Americans[6–7]. In Massachusetts rates of un-insurance have been lower than national rates but with similar relative differences by race and ethnicity[8]. In April 2006 Massachusetts enacted legislation requiring all residents to have health insurance, expanding MassHealth (Medicaid), providing health insurance subsidies based on income, and requiring that employers with more than 11 employees offer health insurance or pay financial penalties if they fail to do so[9]. Emerging data suggest that since health insurance reform in Massachusetts, significant reductions in rates of un-insurance occurred according to race, sex, and income level from 2002–2006 to 2008. Specifically, un-insurance rates declined from 11.1 to 5.1 % for men, 6.2 to 2.0 % for women, 6.9 to 2.4 % for whites, 12.8 to 7.6% for blacks and 13.3% to 10.1% for Hispanics; these declines were statistically significant for all groups except blacks[10]. There were also statistically significant reductions in prevalent un-insurance according to income level during this period. However, whether the decline in the number of uninsured Massachusetts residents has translated into narrowed disparities in use of cardiovascular procedures and cardiovascular mortality is unknown.

We evaluated the impact of Massachusetts health insurance reform on racial, ethnic, and socioeconomic disparities in cardiovascular care by determining whether, for Massachusetts' residents aged 21–64 years with a diagnosis of ischemic heart disease, 1) the rates of in-hospital coronary revascularization procedures (PCI and CABG) have increased for blacks, Hispanics, and Asian adults relative to whites from pre to post reform; 2) the relative rates of these coronary procedures have increased for adults according to education level and sex pre

to post reform; and 3) health insurance reform has been associated with changes in relative in-hospital and 1-year mortality by these socio-demographic factors.

Methods

Data Sources

We used data from four sources: Billing data from Hospital Case-Mix and Charge datasets collected by the Massachusetts Division of Health Care Finance and Policy, clinical registry data for adults undergoing percutaneous coronary interventions or cardiovascular surgery in all Massachusetts' non-federal acute care hospitals collected by the Massachusetts Data Analysis Center [Mass-DAC][11], 2000 US Census data (US Census Bureau, 2000 Census of Population and Housing, Summary File 3: Technical Documentation, 2002), and information from the Massachusetts Registry of Vital Records and Statistics. The billing data consisted of patient-level diagnostic and procedural information, socio-demographic information, charge data, discharge status, and a Unique Health Identification Number (UHIN) which is an encrypted Social Security number. The Mass-DAC data contains detailed clinical data, including patient information linkable to determine vital status after hospital discharge for the subset of patients undergoing either PCI or cardiac surgery. For these patients, detailed clinical information regarding patient risk, cardiovascular history, and presenting symptoms are available at the time of their procedure. The Census data included zip-code-level high school educational information linkable to the billing data. IRB approval was attained for use of all records.

Study Cohort

All Massachusetts residents age 21–64 years discharged alive or dead from acute non-federal Massachusetts hospitals with a principal discharge diagnosis code of ischemic heart disease (IHD) [*International Classification of Diseases*, ICD-9 codes 410–414] between November 1, 2004 and September 30, 2008 were identified and ICD-9 procedure codes were used to identify CABG (36.10–36.19) or PCI (36.01–36.07) procedures during the admission (Supplemental Material 1). Non-Massachusetts residents and patients with zip codes that could not be linked to Census data were excluded.

Patients were classified by discharge date as pre-reform (November 1, 2004 to July 31, 2006) or post-reform (December 1, 2006 to September 30, 2008). Because Massachusetts Health reform was enacted in April 2006, but not implemented until July 2006, we selected the 22 month period prior to July 31, 2006 as pre-reform and a similar time frame after the initiation of the program. This permitted a four-month period to elapse in order to minimize misclassification by reform status. We also selected time frames that were similar according to season of the year.

Primary Covariates

We categorized patients into 5 racial/ethnic groups [non-Hispanic white, non-Hispanic black (black), Hispanic, Asian and Other/Missing]. Prior to October 1, 2006, race was coded as White, Black, Hispanic, Asian, or Other in the Massachusetts billing data. Beginning on October 1, 2006, Hispanic was separated from race in a distinct ethnic category. We coded a

patient as “Hispanic” if Hispanic is coded as Yes; if Hispanic is coded as No, then we coded the patient using one of the race options (White, Black, Asian, or Other/Missing) for discharges observed after October 1, 2006. Patients were classified as residing in low, medium, or high education area based on tertiles determined by the percentage of Massachusetts residents aged 25 years or older graduating high school across zip codes: if the percentage was less than 79.6% the zip code was classified as a low education area; zip codes with between 79.6% and 88.6% as medium; and zip codes with more than 88.6% of residents 25 or older completing high school were categorized as high education areas. Thus, we categorized participants by neighborhood level education attainment. We grouped insurance status as self-pay (uninsured), free care, public (Medicare and Medicaid), or private (commercial insurance and managed care plans).

We used ICD-9-CM codes to determine the presence of common conditions related to the use of revascularization strategies and in-hospital mortality. For each discharge, we identified the presence of a history of myocardial infarction (MI), congestive heart failure (CHF), previous CABG or PCI, peripheral vascular disease, chronic lung disease, neoplasm, chronic renal insufficiency, diabetes mellitus status, hypertension, hyperlipidemia, current smoking, cardiogenic shock, history of and gastrointestinal bleeding (Supplemental Material 1). Admission type is a state-specific field coded as emergency, urgent, elective, or unknown in the billing data.

Study Outcomes

The primary outcome was in-hospital use of CABG or PCI in patients discharged with a principal diagnosis of IHD in the pre-reform and post-reform periods. The secondary outcomes are all-cause in-hospital mortality based on discharge status in the Massachusetts hospital billing data for all IHD discharges and 1-year mortality for those undergoing CABG or PCI.

For 1-year mortality, we calculated rates for PCI and CABG patients separately. We linked Mass-DAC data to the Massachusetts Registry of Vital Records and Statistics to determine vital status; we also conducted searches using the Social Security Death Index Interactive Search tool. Risk-factors included in the 1-year mortality models were assembled from the Mass-DAC registry and included adjustors utilized in the state’s public reports. For the 1-year mortality models following CABG surgery, risk-factors included diabetes, peripheral vascular disease, prior PCI, ejection fraction < 30%, preoperative cardiac status (cardiogenic shock, MI within 6 hours, MI between 7 and 24 hours, MI more than a day), and operative status (urgent, emergent salvage); for 1-year mortality following PCI, risk-factors were renal failure, ejection fraction < 30%, left-main disease, cardiogenic shock, and operative status (emergent salvage).

Statistical Analysis

Continuous and categorical variables are reported as mean ± standard deviation and percentage respectively. Logistic regression models were fitted separately for each outcome [CABG, PCI with or without stenting, in-hospital mortality among IHD patients, and 1-year mortality among PCI or CABG patients] to estimate odds ratios for the primary covariates.

Models first controlled for race/ethnicity, age, sex, co-morbid conditions, and admission type (Model 1). For the 1-year mortality models, we used the risk-factors from Mass-DAC, eliminating the claims-based billing admission type variable. We next added Census-based education, using patients residing in areas where more than 88.6% of residents are high school graduates as the reference category (Model 2). Lastly, we added insurance status to determine if observed disparities were reduced or eliminated (Model 3). We fitted models separately to the pre-reform and post-reform periods to permit different relationships between risk-factors and outcomes in the two time periods. Testing to determine whether race/ethnicity, education, or sex modified the effect of health care reform on outcomes was accomplished through the inclusion of interaction terms of the pre-reform indicator with the respective variables. A positive coefficient of the interaction term implies a higher relative likelihood of the event in the pre-reform period compared to the post-reform period. We combined patients with acute ST-elevation myocardial infarction (STEMI) and non-STEMI because of low event rates.

We also evaluated interactions of race with sex and with education on the primary outcomes, but none of these interactions were statistically significant so we present odds ratios from models without these interaction terms. All p-values are 2-tailed. Analyses were conducted using SAS version 9.2 (SAS Institute Inc, Cary, NC).

Results

Race/ethnicity, Education, and Insurance

Between October 1, 2004 and September 30, 2008 (excluding the period between August 1, 2006 – November 30, 2006), 44937 discharges with the principal diagnosis of IHD were recorded for non-elderly Massachusetts adults (Table 1), including 82.0% white, 4.1% black, 4.8% Hispanic, 1.3% Asian, and 7.8% patients with missing or other race/ethnicity. Women comprised 25.4 % of the entire cohort. The mean age at admission was 54.4 ± 7.3 years. Most patients were admitted on an emergent/urgent basis with black and Hispanic patients more often represented in this category.

Compared to pre-reform, the prevalence of most co-morbid conditions increased in the post-reform period. Decreasing rates of hypertension, smoking, CHF, chronic lung disease, chronic renal insufficiency and emergent/urgent procedures were noted with increasing education level in both time periods (Table 2). Generally, the percentage of blacks and Hispanics decreased whereas the opposite was true for whites as education categories increased. As expected, insurance rates increased in all socio-demographic categories with larger increases observed for minority patients (Table 1) and patients residing in less educated areas (Table 2).

Primary Outcome: Coronary Revascularization

Compared to the pre-reform period, the likelihood of PCI among patients hospitalized for IHD decreased in the post-reform period (27.2% to 22.3%, $p<0.001$). A similar decline was noted for CABG procedures (6.3% versus 5.8%; pre vs. post reform, $p=0.013$).

In the post-reform period no significant changes were noted in racial/ethnic or socioeconomic disparities in use of CABG and PCI that had been observed in the pre-reform period. Post-reform, in models that included education, black and Hispanic patients were 27% and 16% less likely respectively, whereas Asian patients were 29% more likely to undergo CABG/PCI than white patients (Table 3a; CABG or PCI[b]). Although persons in the "other/missing" category had a higher likelihood of receiving revascularization procedures pre-reform and post-reform, the prevalence of risk factors or clinical conditions that would be associated with ischemic heart disease are similar when compared to those persons with a defined race/ethnicity of white, black or Hispanic (Supplemental Table 2). Compared to residents living in zip codes with larger proportions of high school graduates, lower education areas in both periods were associated with a lower likelihood of having CABG/PCI (Table 3b). Women were almost half as likely as men to receive CABG/PCI in either period (Table 3c). After adjusting for insurance status, no significant reduction or elimination of the differences was observed (Table 3d).

Because co-morbidities and other factors might influence receipt of CABG/PCI, we also assessed predictors of CABG/PCI. In the pre-reform period, the significant predictors of decreased likelihood of having coronary revascularization included previous history of CABG/PCI or MI, CHF history, female gender, chronic lung disease, neoplasm, black race and low education. Significant predictors of an increased likelihood of receiving CABG/PCI included the presence of hyperlipidemia, diabetes mellitus, smoking, cardiogenic shock, elective admissions, other/missing (all p values < 0.001). Similar factors were noted in the pre and post reform periods to predict receipt of CABG/PCI.

In terms of statistically significant differences between the pre- and post-reform periods, measured using interaction terms, patients living in low education areas (versus high education areas), females (versus males), and other/missing race (versus white) were more likely to undergo PCI or CABG in the pre-reform than in the post-reform period (Supplemental Table 3).

Secondary Outcomes: In-Hospital Mortality and One-Year Mortality

Figure 1 shows the adjusted odds of receipt of CABG/PCI and unadjusted odds of in-hospital mortality based on race/ethnicity, neighborhood level education and sex. Pre-reform, adjusted in-hospital mortality was significantly lower in blacks compared to whites (referent) [black: OR=0.36, 95% CI 0.14, 0.90; Hispanic: OR=0.62, 95%CI 0.31, 1.26; Asian: OR=0.28, 95% CI 0.03, 2.63]. Post-reform, no statistically significant associations were observed by race/ethnicity (black: OR=0.58, 95% CI 0.26, 1.29; Hispanic: OR=1.16, 95%CI 0.63, 2.12; Asian: OR=0.91, 95% CI 0.35, 2.42). In-hospital mortality was higher for women (OR= 1.46, 95%CI 1.07, 2.00) than men pre-reform, but not different in the post-reform period (OR= 1.02, 95%CI 0.74, 1.41). Finally, in both time frames, in-hospital mortality was higher for patients residing in zip codes where <79.6% residents graduated high school [low education: pre: OR=1.53, 1.05, 2.24; post: OR=1.62, 95%CI 1.13, 2.31) compared to those who lived where >88.6% of residents were high school graduates. However, no statistically significant interaction terms between reform period and sex, or between reform period and neighborhood/area education were observed.

In the pre-reform period, the 1-year post PCI mortality rate was 2.9%, whereas it was 2.6% in the post-reform setting which was not statistically significant. For CABG, 1-year mortality rates were 2.5% and 2.0% in the pre and post reform periods respectively. There were no significant differences in 1-year mortality post-PCI or post-CABG in the pre or post reform periods based on sex or socioeconomic status. Relative to private insurance, only those publicly insured were significantly different (OR = 2.45 [95% CI: 1.90, 3.17]) pre-reform, whereas post-reform, both self-pay (OR =5.89 [2.45,14.1]) and public (OR=2.32 [1.76,3.07]) PCI discharges had higher odds of dying relative to privately-insured.

Discussion

In April 2006 Massachusetts extended health insurance coverage to many uninsured residents, particularly those in racial/ethnic minority groups and individuals below the Federal poverty level[12]. Despite expansion of insurance coverage in these underserved groups, our data indicate that the use of coronary revascularization procedures, an important component of cardiovascular care, did not change meaningfully by race, ethnicity, sex, or neighborhood education level. Compared to white patients, black and Hispanic patients had lower adjusted odds of receiving CABG/PCI, whereas Asians were more likely to receive either procedure. These results suggest that the initial implementation of health insurance reform in Massachusetts has not reduced barriers to the receipt of coronary revascularization related to race/ethnicity, sex, and socioeconomic status.

Our data are consistent with previous work documenting significant racial/ethnic, sex and socioeconomic disparities related to the performance of coronary procedures[13–15]. A systematic review of studies related to racial differences in the use of invasive cardiovascular procedures demonstrated that blacks and Hispanics consistently received fewer procedures than whites despite adjustment for co-morbidities, whereas studies about receipt of coronary procedures by Asians compared to whites were conflicting[16]. Disparities in the performance of invasive coronary procedures by race/ethnicity and sex could relate to patient, physician or system level factors. Some work has focused on patient and physician decision making regarding cardiovascular procedures based on race. Physician processing of racial/ethnic and socioeconomic information affects clinical decision making in a manner that may contribute to observed disparities in care[17–20], but data about discrimination and cardiac outcome are scant[21]. Health care system factors not currently addressed by insurance reform such as referral patterns, accessibility and availability of cardiovascular specialists may play a role in disparities[22].

Our findings are timely and important for several reasons. First, our study examines the effect of “a natural experiment,” implementation of a new state law intended to improve access to care and quality of care by enhancing health insurance affordability and coverage. To our knowledge, this is the first U.S based study to evaluate the effect of insurance reform on well established disparities in invasive cardiovascular procedures, an important component of cardiovascular care.

Second, our findings are consistent with other reports demonstrating that elimination of lack of insurance as a financial barrier does not erase racial, ethnic and socioeconomic disparities

in revascularization rates[23–24]. This suggests that other determinants of health might be operative such as discrimination or other unmeasured patient and system level factors and is consistent with the framework outlined by the Institute of Medicine's Unequal Treatment report on health care disparities[25]. Indeed, Zhu et al noted that while health coverage improved by 3% from 2006 to 2008, no improvement was noted in disparities in access to primary care doctors or in self-reported health status[26]. These authors and an accompanying editorial suggest that addressing social determinants of health remains a crucial complimentary element to insurance coverage[27]. For example, despite relative improvement in coverage among minorities and women in particular, under-insurance may still be a prominent issue for these subgroups if insured patients still face substantial out-of-pocket costs for their health care. Under-insurance is further compounded by increasing health care costs and higher relative rates of inability to meet basic expenses, factors likely compounded by the ongoing economic recession which has more severely affected blacks and Hispanics who have roughly double the unemployment rates of whites. Indeed, data from Clark C et al indicate that while affordability of care improved in the post-reform period compared to the pre-reform setting, reductions that were previously noted in the numbers of adults with medical debt vanished by the fall of 2009[10]. Additionally, little is known about patient refusal of procedures or adherence to recommended medical therapies by race/ethnicity, gender or SES. Moreover, the threshold for intervention might be higher in underserved groups in general compared to potential overuse in whites, a factor that does not entirely explain observed race/ethnic disparities in revascularization rates[28–29].

Third, no change in the disparity in procedure rates by sex was observed despite gains in health insurance coverage (97.1% of women) and having a usual source of care (92.8% of women), as well as a 5.7% decrease in overall unmet need for care among women in Massachusetts from 2006 to 2009[30]. The lack of narrowing of the sex disparity might relate to a number of factors including differences in disease presentation by sex and higher out-of-pocket expenses for health care in women, a group that typically has lower wages and greater health needs than men in general. Previous work about gender disparities in CABG and PCI performance has been mixed with some data showing minimal gender disparity in the performance of coronary angiography[4] and other work indicating opposite findings[31].

Fourth, our finding that blacks had lower in-hospital mortality pre-reform than other racial groups is consistent with some[32] but not all studies following coronary revascularization[33]. Moreover, because black patients tend to have more co-morbidities suggesting greater severity of illness on presentation, they are probably more apt to have more clinically appropriate procedures, and thus derive greater short-term benefit from coronary revascularization. Another possibility is that the sickest of black patients are not offered intervention, thereby removing this group from the population undergoing coronary revascularization, a procedure that in the short-term likely increases the mortality risk of extremely sick patients. In this study, 1-year mortality did not differ significantly by demographic characteristics or insurance type in the pre compared to post-reform, a finding that is inconsistent with other work demonstrating higher long-term mortality in blacks compared to other racial and ethnic groups[34–35].

We also observed higher in-hospital mortality among those patients who lived in geographic areas where residents had lower levels of education compared to those areas where residents had higher levels of education. These results suggest that socioeconomic status, such as neighborhood environment is a contributor to cardiovascular disease outcome, a factor that can affect presenting patient co-morbidities and thus risk and benefit of revascularization procedures. Certainly, research indicates that persons who reside in neighborhoods of higher socioeconomic status have lower MI and CVD mortality rates[36], as well as that neighborhood deprivation is positively associated with higher odds of coronary artery calcification[37].

Fifth, our data are consistent with longstanding observations of higher likelihood of receiving coronary interventions among persons who are privately insured. Notably, these data indicate no significant differences in receipt of CABG or PCI in the pre or post reform period among free care, self-pay or publically insured compared to private insurance. Indeed utilizing registry data, Chan and colleagues found that among 211, 254 non-acute PCIs, privately insured patients were significantly more likely than Medicare, other public insurance or uninsured patients to receive PCI[38]. Similar findings were noted in a an analysis of private insurance and Medicaid patients who presented with STEMI in New York from January 2008 to December 2009; compared to private insurance patients, Medicaid enrollees were less likely to be admitted to a PCI certified hospital and to undergo PCI after control of confounders[39]. A majority of evidence demonstrates that private insurance is associated with lower mortality[31–33]. For example, data from New York State teaching hospitals demonstrate an independent relationship 5- fold increase in mortality among the uninsured or Medicaid compared to privately insured patients[40]. In our results, we also observed consistently higher mortality after PCI among publically insured patients in both the pre-reform and post-reform periods. These differences may reflect the impact of disability on mortality among non-elderly Medicare beneficiaries and of individual socioeconomic factors among Medicaid enrollees that were not captured by our neighborhood measure of education. We also found significantly increased mortality among self-pay patients in the post-reform period; this group included only 209 patients (<2% of the post-reform cohort) who may have been particularly disadvantaged (e.g. undocumented immigrants) if they were not eligible for any insurance coverage or free care in the post-reform period.

Interestingly, we observed lower coronary revascularization rates post-reform compared to the pre-reform period. It is possible that health care reform in Massachusetts has coincided with a secular trend of reductions in rates of coronary revascularization, particularly CABG procedures from 2001 through 2008[41]. Although, national trends indicate stability of the PCI rate over time, these investigators note that the need for repeat revascularization after PCI with drug eluting stents has decreased and may contribute to the decline in CABG procedures. It is also possible that increased usage of statin therapy and physician behavior contribute to the decrement in coronary revascularizations post-reform.

Limitations of our study merit consideration. Our results are based on observational administrative data which do not permit adjustment of physician or system level decisions regarding patient care; moreover some comorbidities may reflect consequences of care and

not conditions present at admission. We cannot adjust for unmeasured confounders such as ability to obtain a specialist appointment that might affect patient referral for cardiovascular procedures; other factors, such as changes in referral patterns that may well have coincided with health insurance reform, could impact the results. We do include patient admission status and comorbidities, both factors which are highly relevant in physician clinical decision making. Additionally, the impact of expanded insurance coverage on procedure rates may have been blunted by the relatively high rates of insurance coverage in the pre-reform period and the pre-existing "free care pool" in Massachusetts that covered hospital care for eligible low-income residents who were uninsured during this period before insurance coverage expanded. We did not have patient anatomy based on angiography, but a majority of procedures in our analysis were deemed emergent/urgent thereby reducing the effect of inappropriate procedures on our findings.

Demographic characteristics such as race/ethnicity could have been self-reported or assigned based on phenotypic characteristics which could result in race/ethnic misclassification. A new state regulation implemented in April 2007 requires Massachusetts hospitals to collect self-reported race/ethnicity from patients. This regulation may have increased the accuracy of race/ethnicity data during the post-reform period[42]. Because our analysis only involved Massachusetts, it is unclear whether our findings are generalizable to the U.S population. Nonetheless, several key points are noteworthy: 1) the race/ethnic and socioeconomic disparities we observed parallel findings from other U.S databases about this topic, even the observation that the disparity related to CABG is greater than that related to PCI in blacks and women; 2) observations related to health insurance reform in Massachusetts may serve as a harbinger for what might occur nationwide with the federal Patient Protection and Affordable Care Act of 2010. Finally, while we presented the data for the "other/missing" category, we are unable to make comparative assessments with the other race/ethnicity categories except to note that the associated co-morbidities and magnitude of results are not similar to those found in blacks and Hispanics.

In summary, although near universal insurance has been achieved in Massachusetts, disparities in the performance of coronary revascularization procedures persist according to certain demographic characteristics. Our findings support previous work in the Veterans Affairs health system and others that show a limited effect of insurance status on coronary procedure performance. In addition, since the change in the number of persons who were uninsured in Massachusetts pre-reform compared to post-reform was relatively small among adults hospitalized for coronary heart disease, we may not have observed an effect. Nonetheless, our results underscore the need for continued work that focuses on residual factors related to health disparities and implementation of interventions aimed at assessing and addressing *specific* needs of vulnerable subgroups as part of the health care reform process.

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References

1. American Heart Association. 2013 Heart Disease and Stroke Statistics-2013 Update. Circulation. 2013; 127:e6–e245. [PubMed: 23239837]
2. Mensah GA, Mokdad AH, Ford ES, Greenlund KJ, Croft JB. State of disparities in cardiovascular health in the United States. Circulation. 2005; 111:1233–1241. [PubMed: 15769763]
3. Brown CP, Ross L, Lopez I, Thornton A, Kiros GE. Disparities in the receipt of cardiac revascularization procedures between blacks and whites: An analysis of secular trends. Ethnicity & Disease. 2008; 18(Suppl 2):111–117.
4. Vaccarino V, Rathore SS, Wenger NK, Fredrick PD, Abramson JL, Barron HV, Manhapra A, Mallik S, Krumholz HM, The National Registry of Myocardial Infarction Investigators. Sex and racial differences in the management of acute myocardial infarction, 1994 through 2002. New Eng J Med. 2005; 353:671–82. [PubMed: 16107620]
5. Sada MJ, French WJ, Carlisle DM, Chandra NC, Gore JM, Rogers WJ. Influence of payor on use of invasive cardiac procedures and patient outcome after myocardial infarction in the United States. J of American Coll Card. 1998; 31:1474–1480.
6. US Census Bureau. Current Population Survey, 2000 to 2007 Annual Social and Economic Supplements. Historical Health Insurance Tables. www.census.gov/hhes/ww/hlthins/historic/hihistt2.html
7. US Census Bureau 2010 Report. http://www.census.gov/hhes/www/hlthins/hlthins.html
8. Cruz AC, Hager CL. Eliminating racial and ethnic health disparities: Opportunities and challenges for the Commonwealth. Issue Brief (The Massachusetts Health Policy Forum). 2001; 11:1–26.
9. Massachusetts Health Care Reform Law of 2006, Chapter 58 of the Acts of 2006: An Act Providing Access to Affordable, Quality, Accountable Health Care. April 12, 2006
10. Clark CR, Soukup J, Govindarajulu U, Riden HE, Tovar DA, Johnson PA. Health Affairs. 2011; 30:247–255. [PubMed: 21289346]
11. Shahian DM, Silverstein T, Lovett AF, Wolf RE, Normand SL. Comparison of clinical and administrative data sources for hospital coronary artery bypass graft surgery report cards. Circulation. 2007; 115:1518–1527. [PubMed: 17353447]
12. Long SK, Stockley K, Health reform in Massachusetts. Massachusetts health reform survey Fall 2006 to Fall 2009. Health Aff (Millwood). 2010; 29:1234–41. [PubMed: 20530362]
13. Steingart RM, Packer M, Hamm P, Coglinese ME, Gersh B, Geltman EM, Sollano J, Katz S, Moye L, Basta LL. Sex differences in the management of coronary artery disease. Survival and Ventricular Enlargement Investigators. N Engl J Med. 1991; 325:274–6. [PubMed: 2057027]
14. Ayanian JZ, Udvarhelyi IS, Gatsonis CA, Pashos CL, Epstein AM. Racial differences in the use of revascularization procedures after coronary angiography. JAMA. 1993; 269:2642–6. [PubMed: 8487447]
15. Ayanian JZ, Epstein AM. Differences in the use of procedures between women and men hospitalized for coronary heart disease. New Eng J Med. 1991; 325:221–5. [PubMed: 2057022]
16. Kressin NR, Petersen LA. Racial differences in the use of invasive cardiovascular procedures: review of the literature and prescription for future research. Ann Intern Med. 2001; 135:352–366. [PubMed: 11529699]
17. Taylor SL, Fremont A, Jain AK, Mclaughlin R, Peterson E, Ferguson TB Jr, Lurie N. Racial and ethnic disparities in care: the perspectives of cardiovascular surgeons. Ann Thorac Surg. 2006; 81:531–6. [PubMed: 16427845]

18. Lurie N, Fremont A, Jain AK, Taylor SL, Mclaughlin R, Peterson E, Kong BW, Ferguson TB Jr. Racial and ethnic disparities in care: the perspectives of cardiologists. Circulation. 2005; 111:1264–9. [PubMed: 15769767]
19. Schulman KA, Berlin JA, Harless W, Kerner JF, Sistrunk S, Gersh BJ, Dube R, Taleghani CK, Burke JE, Williams S, Eisenberg JM, Escare JJ. The effect of race and sex on physicians' recommendations for cardiac catheterization. N Engl J Med. 1999; 340:618–26. [PubMed: 10029647]
20. van Ryn M, Burke J. The effect of patient race and socioeconomic status on physician perceptions of patients. Soc Sci Med. 2000; 50:613–828.
21. Albert MA, Cozier Y, Ridker PM, Palmer JR, Glynn RJ, Rose L, Halevy N, Rosenberg L. Perceptions of race/ethnic discrimination in relation to mortality among Black women: results from the Black Women's Health Study. Arch Intern Med. 2010; 170:896–904. [PubMed: 20498418]
22. Cook NL, Ayanian JZ, Orav EJ, Hicks LS. Differences in specialist consultations for cardiovascular disparities by race, ethnicity, gender, insurance status, and site of primary care. Circulation. 2009; 119:2463–70. [PubMed: 19398667]
23. Cram P, Bayman L, Popescu I, Vaughan-Sarrazin MS. Racial disparities in revascularization rates among patients with similar insurance coverage. J Natl Med Assoc. 2009; 101:1132–9. [PubMed: 19998642]
24. Parikh PB, Gruberg L, Jeremias A, Chen JJ, Naidu SS, Shlofmitz RA, Brener SJ, Pappas T, Marzo KP, Brown DL. Am Heart J. 2011; 162:512–7. [PubMed: 21884869]
25. Institute of Medicine of the National Academies. Unequal Treatment; Confronting Racial and Ethnic Disparities in Health care. National Academy of Sciences. 2003
26. Zhu J, Brawarsky P, Lipsitz S, Huskamp H, Haas J. Massachusetts health reform and disparities in coverage, access and health status. J Gen Intern Med. 25:1356–62.
27. Carrasquillo O, Betancourt J. Massachusetts health disparities: Key lessons for the nation. J Gen Intern Med. 25:1266–7.
28. Bertoni AG, Goonan KL, Bonds DE, Whitt MC, Goff DC Jr, Brancati FL. Racial and ethnic disparities in cardiac catheterization for acute myocardial infarction in the United States, 1995–2001. J Natl Med Assoc. 2005; 97:317–23. [PubMed: 15779495]
29. Schneider EC, Leape LL, Weissman JS, Piana RN, Gatsonis C, Epstein AM. Racial differences in Cardiac revascularization rates: does "overuse" explain higher rates among white patients. Ann Intern Med. 2001; 135:328–37. [PubMed: 11529696]
30. Long SK, Stockley K, Urban Institute. Health Reform in Massachusetts: An Update as of Fall 2009. Blue Cross and Blue Shield of Massachusetts. Jun.2010
31. Nguyen JT, Berger AK, Duval S, Luepker RV. Gender disparity in cardiac procedures and medication use for acute myocardial infarction. Am Heart J. 2008; 155:862–8. [PubMed: 18440333]
32. Williams ML, Hill G, Jackson M. Acute Myocardial infarction at a university hospital: effect of race on short-term mortality. J Assoc Acad Minor Phys. 2000; 11:50–4. [PubMed: 11852649]
33. Leborgne L, Cheneau E, Wolfram R, Pinnow EE, Canos DA, Pichard AD, Suddath WO, Satler LF, Lindsay J, Waksman R. Comparison of baseline characteristics and one-year outcomes between African-Americans and Caucasians undergoing percutaneous coronary intervention. Am J Cardiol. 2004; 93:389–93. [PubMed: 14969608]
34. Napan S, Kashinath R, Orig M, Kadri S, Khadra S. Racial difference in cardiovascular outcomes following percutaneous coronary intervention in a public health service patient population. J Invasive Cardiol. 2010; 4:168–73.
35. Melsop K, Brooks MM, Boothroyd DB, Hlatky MA. Effect of race on the clinical outcomes in the bypass angioplasty revascularization investigation trial. Circ Cardio Qual Outcomes. 2009; 3:186–90.
36. Wen M, Christakis NA. Neighborhood effects on posthospitalization mortality: a population- based cohort study of the elderly in Chicago. Health Serv Res. 2005; 40:1108–1127. [PubMed: 16033495]

37. Kim D, Diez Roux AV, Kiefe CI, Kawachi I, Liu K. Do neighborhood socioeconomic deprivation and low social cohesion predict coronary calcification?: the CARDIA study. Am J Epidemiol. 2010; 172:288–298. [PubMed: 20610467]

38. Chan PS, Rao SV, Bhatt DL, Rumsfeld JS, Gurm HS, Nallamothu BK, Cavender MA, Kennedy K, Spertus JA. Patient and hospital characteristics associated with inappropriate percutaneous coronary interventions. J Am Coll Cardiol. 2013; 62:2274–81. [PubMed: 24055743]

39. Hannan EL, Zhong Y, Walford G, Jacobs AK, Venditti FJ, Stamato NJ, Holmes DR Jr, Sharma S, Gesten F, King SB 3rd. Underutilization of percutaneous coronary intervention for ST-Elevation Myocardial Infarction in Medicaid patients relative to private insurance patients. J Interv Cardiol. 2013; 26:470–81. [PubMed: 23962131]

40. Parikh PB, Gruberg L, Jeremias A, Chen JJ, Naidu SS, Shlofmitz RA, Brener SJ, Pappas T, Marzo KP, Brown DL. Association of health insurance status with presentation and outcomes of coronary artery disease among nonelderly adults undergoing percutaneous coronary intervention. Am Heart J. 2011; 162:512–17. [PubMed: 21884869]

41. Epstein AJ, Polsky D, Yang F, Yang L, Groeneveld PW. Coronary revascularization trends in the United States, 2001–2008. JAMA. 2011; 305:1769–1776. [PubMed: 21540420]

42. Weinick RM, CAGLIA JM, Friedman E, Flaherty K. Measuring racial and ethnic health care disparities in Massachusetts. Health Affairs (Milwood). 2007; 26:1293–302.

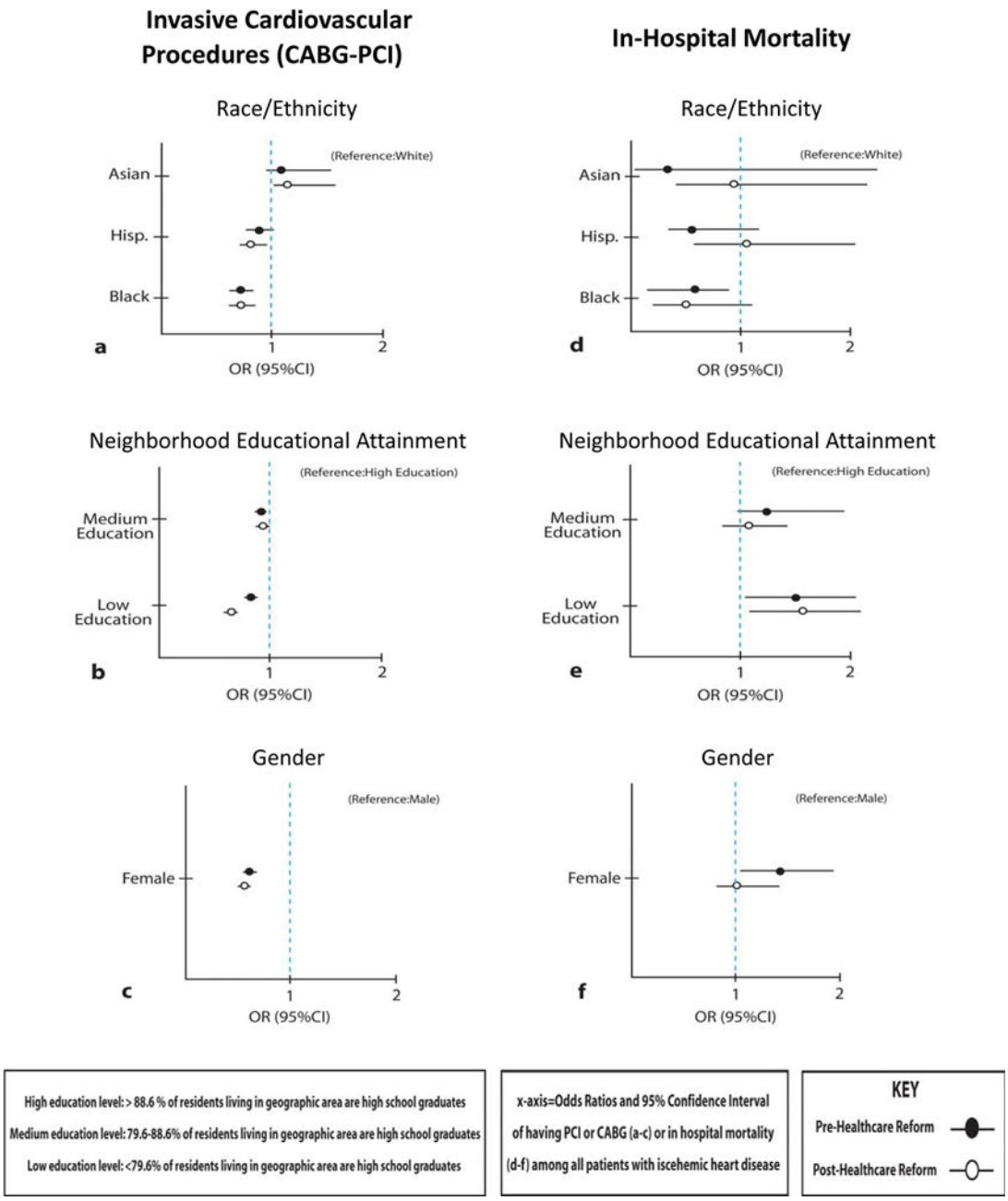

Figure 1.

Table 1

Baseline Characteristics According to Race/Ethnicity for Massachusetts Residents who underwent cardiovascular procedures for ischemic heart disease pre and post the implementation of the Massachusetts Health Care Reform Act

Whites (N=36,801)	**Pre-Reform (N=19,915)**	**Post-Reform (N=16,886)**	**p-value**
Age — yr	54.6 (7.2)	54.6 (7.1)	0.85
Female sex — no. (%)	4,838 (24.3)	4,101 (24.3)	0.99
Insurance — no. (%)			<0.001
Self-pay	301 (1.5)	148 (0.9)	
Free-care (uninsured) **	852 (4.3)	602 (3.6)	
Private ***	14,383 (72.2)	11,914 (70.6)	
Public ****	4,379 (22.0)	4222 (25.0)	
Diabetes mellitus — no. (%)	11,654 (58.5)	9,973 (59.1)	0.29
Hyperlipidemia — no. (%)	7,026 (35.3)	7,961 (47.2)	<0.001
Hypertension — no. (%)	12,348 (62.0)	10,984 (65.1)	<0.001
Smoker — no. (%)			
Current	7,469 (37.5)	7,481 (44.3)	<0.001
Previous myocardial infarction — no. (%)	3,223 (16.2)	2,908 (17.2)	0.008
Congestive heart failure — no. (%)	2,251 (11.3)	1,998 (11.8)	0.11
Chronic lung disease — no. (%)	491 (2.5)	541 (3.2)	<0.001
History of neoplasm — no. (%)‡	362 (1.8)	376 (2.2)	0.005
Chronic renal insufficiency — no. (%)	699 (3.5)	964 (5.7)	<0.001
Cardiogenic shock — no. (%)	280 (1.4)	277 (1.6)	0.07
Admission status — no. (%)			
Elective	NR	NR	<0.001
Emergency/urgent	17,541 (88.1)	15,122 (89.6)	
Blacks (N=1,857)	Pre-Reform (N=948)	Post-Reform (N=909)	p-value
Age — yr	52.6 (8.0)	52.8 (8.1)	0.56
Female sex — no. (%)	382 (40.3)	328 (36.1)	0.06
Insurance — no. (%)			0.007
Self-pay	27 (2.9)	15 (1.7)	
Free-care (uninsured) **	107 (11.3)	68 (7.5)	
Private ***	421 (44.4)	410 (45.1)	
Public ****	393 (41.5)	416 (45.8)	
Diabetes mellitus — no. (%)	613 (64.7)	568 (62.5)	0.33
Hyperlipidemia — no. (%)	278 (29.3)	371 (40.8)	<0.001
Hypertension — no. (%)	723 (76.3)	706 (77.7)	0.47
Smoker — no. (%)			
Current	337 (35.6)	367 (40.4)	0.03
Previous myocardial infarction — no. (%)	163 (17.2)	147 (16.2)	0.55
Congestive heart failure — no. (%)	175 (18.5)	149 (16.4)	0.24

Whites (N=36,801)	**Pre-Reform (N=19,915)**	**Post-Reform (N=16,886)**	**p-value**
Chronic lung disease — no. (%)	24 (2.5)	26 (2.9)	0.66
History of neoplasm — no. (%)‡	12 (1.3)	14 (1.5)	0.62
Chronic renal insufficiency — no. (%)	90 (9.5)	121 (13.3)	0.01
Cardiogenic shock — no. (%)	10 (1.1)	16 (1.8)	0.20
Admission status — no. (%)			
Emergency/Urgent	880 (92.8)	851 (93.6)	0.50
Elective	68 (7.2)	58 (6.4)	
Hispanics (N=2,173)	Pre-Reform (N=1,124)	Post-Reform (N=1,049)	p-value
Age — yr	52.6 (8.1)	52.7 (7.7)	0.78
Female sex — no. (%)	383 (34.1)	402 (38.3)	0.04
Insurance — no. (%)			<**0.001**
Self-pay	48 (4.3)	12 (1.1)	
Free-care (uninsured) **	138 (12.3)	90 (8.6)	
Private ***	282 (25.1)	299 (28.5)	
Public ****	656 (58.4)	648 (61.8)	
Diabetes mellitus — no. (%)	678 (60.3)	660 (62.9)	0.21
Hyperlipidemia — no. (%)	350 (31.1)	457 (43.6)	<0.001
Hypertension — no. (%)	785 (69.8)	772 (73.6)	0.05
Smoker — no. (%)			
Current	324 (28.8)	385 (36.7)	<0.001
Previous myocardial infarction — no. (%)	188 (16.7)	181 (17.3)	0.74
Congestive heart failure — no. (%)	163 (14.5)	141 (13.4)	0.48
Chronic lung disease — no. (%)	20 (1.8)	42 (4.0)	0.002
History of neoplasm — no. (%)‡	18 (1.6)	13 (1.2)	0.48
Chronic renal insufficiency — no. (%)	97 (8.6)	89 (8.5)	0.90
Cardiogenic shock — no. (%)	12 (1.1)	13 (1.2)	0.71
Admission status — no. (%)			
Elective	NR	NR	
Emergency/urgent	1,040 (92.5)	962 (91.7)	0.46
Asians (N=593)	Pre-Reform (N=260)	Post-Reform (N=333)	p-value
Age — yr	52.5 (8.4)	52.9 (8.0)	0.59
Female sex — no. (%)	51 (19.6)	69 (20.7)	0.74
Insurance — no. (%)			**0.02**
Self-pay	12 (4.6)	6 (1.8)	
Free-care (uninsured) **	34 (13.1)	25 (7.5)	
Private ***	151 (58.1)	216 (64.9)	
Public ****	63 (24.2)	86 (25.8)	
Diabetes mellitus — no. (%)	141 (54.2)	193 (58.0)	0.36
Hyperlipidemia — no. (%)	69 (26.5)	147 (44.1)	<0.001
Hypertension — no. (%)	158 (60.8)	221 (66.4)	0.16
Smoker — no. (%)			

Whites (N=36,801)	**Pre-Reform (N=19,915)**	**Post-Reform (N=16,886)**	**p-value**
Current	72 (27.7)	101 (30.3)	0.48
Previous myocardial infarction — no. (%)	36 (13.9)	29 (8.7)	0.05
Congestive heart failure — no. (%)	24 (9.2)	38 (11.4)	0.39
Chronic lung disease — no. (%)	NR	NR	0.72
History of neoplasm — no. (%)‡	NR	NR	0.34
Chronic renal insufficiency — no. (%)	15 (5.8)	30 (9.0)	0.14
Cardiogenic shock — no. (%)	NR	NR	0.007
Admission status — no. (%)			
Elective	22 (8.5)	43 (12.9)	0.09
Emergency/urgent	238 (91.5)	290 (87.1)	
Other/Missing† (N=3,513)	Pre-Reform (N=1,969)	Post-Reform (N=1,544)	p-value
Age — yr	53.9 (7.3)	54.1 (7.0)	0.53
Female sex — no. (%)	441 (22.4)	398 (25.8)	0.02
Insurance — no. (%)			<**0.001**
Self-pay	50 (2.5)	28 (1.8)	
Free-care (uninsured) **	144 (7.3)	108 (7.0)	
Private ***	1,371 (69.6)	995 (64.4)	
Public ****	404 (20.5)	413 (26.8)	
Diabetes mellitus — no. (%)	1,231 (62.5)	945 (61.2)	0.43
Hyperlipidemia — no. (%)	688 (34.9)	692 (44.8)	<0.001
Hypertension — no. (%)	1,300 (66.0)	1,032 (66.8)	0.61
Smoker — no. (%)			
Current	695 (35.3)	627 (40.6)	0.001
Previous myocardial infarction — no. (%)	230 (11.7)	207 (13.4)	0.12
Congestive heart failure — no. (%)	219 (11.1)	192 (12.4)	0.23
Chronic lung disease — no. (%)	44 (2.2)	44 (2.9)	0.25
History of neoplasm — no. (%)‡	24 (1.2)	26 (1.7)	0.25
Chronic renal insufficiency — no. (%)	67 (3.4)	84 (5.4)	0.003
Cardiogenic shock — no. (%)	31 (1.6)	36 (2.3)	0.10
Admission status — no. (%)			
Elective	165 (8.4)	124 (8.0)	0.71
Emergency/urgent	1,804 (91.6)	1,420 (92.0)	

* Plus–minus values are means ±SD. Percentages may not sum to 100 because of rounding. CABG denotes coronary-artery bypass grafting, and PCI percutaneous coronary intervention.

** Free care refers to the uninsured but also persons who are eligible for the Massachusetts free care pool

*** Private insurance includes commercial insurance and managed care plans

**** Public insurance incudes Medicaid and Medicare insurance plans

† Race or ethnic group was self-assessed.

‡ A history of neoplasm was defined as the presence of any condition with a code of 140.0 through 239.9 of the *International Classification of Diseases, 9th Revision, Clinical Modification*

(ICD-9-CM), during the index admission.

[1]Of the 3513 with racial status as “other/missing”, 2322 are from categories unspecified or missing and 1191 are from other race categories such as Native American, Native Hawaiian/Pacific Islander, Other.

NR=not reported due to small cell size to protect patient confidentiality.

Table 2

Baseline Characteristics According to Census Level Education for Massachusetts Residents who underwent cardiovascular procedures for ischemic heart disease pre and post the implementation of the Massachusetts Health Care Reform Act

Pre-Reform (N=24,216)	**< 79.6% HS Grad (N=6,848)**	**79.6–88.6% HS Grad (N=8,371)**	**>88.6% HS Grad (N=8,997)**	**p-value**
Age — yr	53.8 (7.7)	54.3 (7.3)	54.9 (7.0)	<0.001
Female sex — no. (%)	2,099 (30.7)	2,112 (25.2)	1,884 (20.9)	<0.001
Race or ethnic group — no./total no. (%)†				
White	4,803 (70.1)	7,179 (85.8)	7,933 (88.2)	<0.001
Black	568 (8.3)	255 (3.1)	125 (1.4)	
Hispanic	836 (12.2)	227 (2.7)	61 (0.7)	
Asian	99 (1.5)	84 (1.0)	77 (0.9)	
Other/Missing	542 (7.9)	626 (7.5)	801 (8.9)	
Insurance — no. (%)				<0.001
Self-pay	163 (2.4)	140 (1.7)	135 (1.5)	
Free Care (uninsured)**	537 (7.8)	443 (5.3)	295 (3.3)	
Private***	3,561 (52.0)	5,873 (70.2)	7,174 (79.7)	
Public ****	2,587 (37.8)	1,915 (22.9)	1,393 (15.5)	
Diabetes mellitus — no. (%)	4,108 (60.0)	4,960 (59.3)	5,249 (58.3)	0.11
Hyperlipidemia — no. (%)	2,372 (34.6)	2,872 (34.3)	3,167 (35.2)	0.46
Hypertension — no. (%)	4,480 (65.4)	5,292 (63.2)	5,542 (61.6)	<0.001
Smoker — no. (%)				
Current	2,770 (40.5)	3,120 (37.3)	3,007 (33.4)	<0.001
Previous myocardial infarction — no. (%)	1,198 (17.5)	1,328 (15.9)	1,314 (14.6)	<0.001
Congestive heart failure — no. (%)	979 (14.3)	931 (11.1)	922 (10.3)	<0.001
Chronic lung disease — no. (%)	231 (3.4)	202 (2.4)	149 (1.7)	<0.001
History of neoplasm — no. (%)‡	115 (1.7)	158 (1.9)	147 (1.6)	0.41
Chronic renal insufficiency — no. (%)	345 (5.0)	319 (3.8)	304 (3.4)	<0.001
Cardiogenic shock — no. (%)	113 (1.7)	106 (1.3)	116 (1.3)	0.08
Admission status — no. (%)				
Elective	NR	NR	NR	<0.001
Emergency/urgent	6,216 (90.8)	7,447 (89.0)	7,840 (87.1)	
Post-Reform (N=20,721)	(N=5,843)	(N=7,163)	(N=7,715)	
Age — yr	53.5 (7.6)	54.3 (7.1)	55.1 (7.0)	<0.001
Female sex — no. (%)	1,855 (31.8)	1,790 (25.0)	1,653 (21.4)	<0.001
Race or ethnic group — no./total no. (%)†				
White	4,026 (68.9)	6,037 (84.3)	6,823 (88.4)	<.0001
Black	547 (9.4)	245 (3.4)	117 (1.5)	
Hispanic	732 (12.5)	232 (3.2)	85 (1.1)	
Asian	92 (1.6)	121 (1.7)	120 (1.6)	
Other/Missing	446 (7.6)	528 (7.4)	570 (7.4)	

Pre-Reform (N=24,216)	< 79.6% HS Grad (N=6,848)	79.6–88.6% HS Grad (N=8,371)	>88.6% HS Grad (N=8,997)	p-value
Insurance — no. (%)				<.0001
Self-pay	74 (1.3)	65 (0.9)	70 (0.9)	
Free Care (uninsured) **	365 (6.3)	301 (4.2)	227 (2.9)	
Private ***	2,926 (50.1)	4,864 (67.9)	6,044 (78.3)	
Public ****	2,478 (42.4)	1,933 (27.0)	1,374 (17.8)	
Diabetes mellitus — no. (%)	3,518 (60.2)	4,263 (59.5)	4,558 (59.1)	0.41
Hyperlipidemia — no. (%)	2,636 (45.1)	3,403 (47.5)	3,589 (46.5)	0.02
Hypertension — no. (%)	4,023 (68.9)	4,713 (65.8)	4,979 (64.5)	<0.001
Smoker — no. (%)				
Current	2,874 (49.2)	3,203 (44.7)	2,884 (37.4)	<0.001
Previous myocardial infarction — no. (%)	1,081 (18.5)	1,241 (17.3)	1,150 (14.9)	<0.001
Congestive heart failure — no. (%)	843 (14.4)	849 (11.9)	826 (10.7)	<0.001
Chronic lung disease — no. (%)	267 (4.6)	193 (2.7)	198 (2.6)	<0.001
History of neoplasm — no. (%)‡	124 (2.1)	143 (2.0)	171 (2.2)	0.65
Chronic renal insufficiency — no. (%)	431 (7.4)	435 (6.1)	422 (5.5)	<0.001
Cardiogenic shock — no. (%)	118 (2.0)	129 (1.8)	110 (1.4)	0.026
Admission status — no. (%)				
Elective	NR	NR	NR	<.0001
Emergency/urgent	5,385 (92.2)	6,390 (89.2)	6,870 (89.1)	

* Plus–minus values are means ±SD. Percentages may not sum to 100 because of rounding

** Free care refers to the uninsured but also persons who are eligible for the Massachusetts free care pool

*** Private insurance includes commercial insurance and managed care plans

**** Public insurance incudes Medicaid and Medicare insurance plans

† Race or ethnic group was self-assessed.

‡ A history of neoplasm was defined as the presence of any condition with a code of 140.0 through 239.9 of the *International Classification of Diseases, 9th Revision, Clinical Modification*

(ICD-9-CM), during the index admission.

NR=Not reported due to small cell sizes to protect patient confidentiality.

Table 3a

Odds Ratios (and 95% Confidence Intervals) for Cardiovascular Procedures based on Race/Ethnicity for Massachusetts Residents who underwent cardiovascular procedures for ischemic heart disease pre and post the implementation of the Massachusetts Health Care Reform Act

	White	Black	Hispanic	Asian	Other/Missing
Pre-reform					
PCI[a]	1.00	0.74 (0.64, 0.85)	0.80 (0.70, 0.91)	0.99 (0.77, 1.28)	1.80 (1.63, 1.98)
PCI[b]	1.00	0.79 (0.68, 0.91)	0.88 (0.77, 1.00)	1.02 (0.80, 1.32)	1.80 (1.63, 1.99)
CABG or PCI[a]	1.00	0.65 (0.57, 0.75)	0.81 (0.71, 0.92)	1.15 (0.88, 1.50)	2.20 (1.96, 2.47)
CABG or PCI[b]	1.00	0.70 (0.60, 0.80)	0.89 (0.78, 1.01)	1.19 (0.91, 1.55)	2.21 (1.97, 2.48)
Post-reform					
PCI [a]	1.00	0.72 (0.63, 0.84)	0.79 (0.69, 0.90)	1.06 (0.85, 1.33)	1.27 (1.14, 1.41)
PCI [b]	1.00	0.82 (0.71, 0.94)	0.92 (0.80, 1.05)	1.08 (0.87, 1.36)	1.29 (1.16, 1.44)
CABG or PCI [a]	1.00	0.66 (0.57, 0.76)	0.74 (0.64, 0.84)	1.27 (0.99, 1.62)	1.41 (1.25, 1.59)
CABG or PCI [b]	1.00	0.73 (0.63, 0.84)	0.84 (0.74, 0.97)	1.29 (1.01, 1.65)	1.44 (1.28, 1.62)

Note: PCI denotes percutaneous coronary intervention (with or without stenting); CABG denotes coronary-artery bypass grafting.

[a]Model 1 includes age, female, diabetes, hyperlipidemia, hypertension, smoker (current), previous MI, previous CABG, previous PCI, CHF, PVD, CLD, neoplasm, GI bleeding, renal failure, cardiogenic shock, and elective status.

[b]Model includes Model 1 covariates and education. Education = neighborhood educational attainment.

Table 3b

Odds Ratios (and 95% Confidence Intervals) for Cardiovascular Procedures based on Education for Massachusetts Residents who underwent cardiovascular procedures for ischemic heart disease pre and post the implementation of the Massachusetts Health Care Reform Act

	Adjusted Model 1[a]			Adjusted Additionally for Race/ethnicity[b]		
	>88.6% HS Graduates	79.6–88.6% HS Graduates	< 79.6% HS Graduates	>88.6% HS Graduates	79.6–88.6% HS Graduates	< 79.6% HS Graduates
Pre-reform						
PCI	1.00	0.87 (0.82, 0.93)	0.76 (0.72, 0.82)	1.00	0.88 (0.83, 0.94)	0.79 (0.74, 0.85)
CABG or PCI	1.00	0.88 (0.83, 0.94)	0.76 (0.71, 0.82)	1.00	0.90 (0.84, 0.96)	0.80 (0.74, 0.86)
Post-reform						
PCI	1.00	0.89 (0.84, 0.96)	0.67 (0.63, 0.73)	1.00	0.90 (0.84, 0.96)	0.69 (0.64, 0.74)
CABG or PCI	1.00	0.91 (0.85, 0.98)	0.69 (0.64, 0.74)	1.00	0.92 (0.85, 0.98)	0.71 (0.66, 0.77)

Note: PCI denotes percutaneous coronary intervention (with or without stenting); CABG denotes coronary-artery bypass grafting.

[a]Model 1 includes age, female, diabetes, hyperlipidemia, hypertension, smoker (current), previous MI, previous CABG, previous PCI, CHF, PVD, CLD, neoplasm, GI bleeding, renal failure, cardiogenic shock, and elective status.

[b]Model includes Model 1 covariates and race/ethnicity. Education = neighborhood educational attainment

Table 3c

Odds Ratios (and 95% Confidence Intervals) for Cardiovascular Procedures based on Sex for Massachusetts Residents who underwent cardiovascular procedures for ischemic heart disease pre and post the implementation of the Massachusetts Health Care Reform Act

	Adjusted Model 1[a]		Adjusted Additionally for Education [b]	
	Males	**Females**	**Males**	**Females**
Pre-reform				
PCI	1.00	0.71 (0.67, 0.76)	1.00	0.72 (0.68, 0.77)
CABG or PCI	1.00	0.58 (0.55, 0.62)	1.00	0.59 (0.55, 0.63)
Post-reform				
PCI	1.00	0.68 (0.64, 0.73)	1.00	0.70 (0.65, 0.74)
CABG or PCI	1.00	0.53 (0.50, 0.57)	1.00	0.54 (0.51, 0.58)

Note: PCI denotes percutaneous coronary intervention (with or without stenting); CABG denotes coronary-artery bypass grafting.

[a] Model 1 includes age, race/ethnicity, patient admission status and comorbidities listed in Table 1.

[b] Model includes Model 1 covariates and education. Education = neighborhood educational attainment

Table 3d

Odds Ratios and 95% Confidence Intervals) for Cardiovascular Procedures based on Insurance Type for Massachusetts Residents who underwent cardiovascular procedures for ischemic heart disease pre and post the implementation of the Massachusetts Health Care Reform Act

	Private	Public	Free Care	Self-Pay
Pre-reform				
PCI	1.00	0.65 (0.61, 0.70)	0.76 (0.67, 0.85)	0.78 (0.64, 0.95)
CABG or PCI	1.00	0.58 (0.54, 0.62)	0.73 (0.64, 0.82)	0.70 (0.57, 0.85)
Post-reform				
PCI	1.00	0.64 (0.60, 0.69)	0.82 (0.71, 0.95)	0.74 (0.56, 0.99)
CABG or PCI	1.00	0.56 (0.52, 0.60)	0.84 (0.73, 0.98)	0.56 (0.42, 0.75)

Note: PCI denotes percutaneous coronary intervention (with or without stenting); CABG denotes coronary-artery bypass grafting.

Model 1 includes age, race/ethnicity, female, diabetes, hyperlipidemia, hypertension, smoker (current), previous MI, previous CABG, previous PCI, CHF, PVD, CLD, neoplasm, GI bleeding, renal failure, cardiogenic shock, elective status and education. Education = neighborhood educational attainment