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Association Between Public Reporting of Outcomes With Procedural Management and Mortality for Patients With Acute Myocardial Infarction

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ABSTRACT

BACKGROUND Public reporting of procedural outcomes may create disincentives to provide percutaneous coronary intervention (PCI) for critically ill patients.

OBJECTIVES This study evaluated the association between public reporting with procedural management and outcomes among patients with acute myocardial infarction (AMI).

METHODS Using the Nationwide Inpatient Sample, we identified all patients with a primary diagnosis of AMI in states with public reporting (Massachusetts and New York) and regionally comparable states without public reporting (Connecticut, Maine, Maryland, New Hampshire, Rhode Island, and Vermont) between 2005 and 2011. Procedural management and in-hospital outcomes were stratified by public reporting.

RESULTS Among 84,121 patients hospitalized with AMI, 57,629 (69%) underwent treatment in a public reporting state. After multivariate adjustment, percutaneous revascularization was performed less often in public reporting states than in nonreporting states (odds ratio [OR]: 0.81, 95% confidence interval [CI]: 0.67 to 0.96), especially among older patients (OR: 0.75, 95% CI: 0.62 to 0.91), those with Medicare insurance (OR: 0.75, 95% CI: 0.62 to 0.91), and those presenting with ST-segment elevation myocardial infarction (OR: 0.63, 95% CI: 0.56 to 0.71) or concomitant cardiac arrest or cardiogenic shock (OR: 0.58, 95% CI: 0.47 to 0.70). Overall, patients with AMI in public reporting states had higher adjusted in-hospital mortality rates (OR: 1.21, 95% CI: 1.06 to 1.37) than those in nonreporting states. This was observed predominantly in patients who did not receive percutaneous revascularization in public reporting states (adjusted OR: 1.30, 95% CI: 1.13 to 1.50), whereas those undergoing the procedure had lower mortality (OR: 0.71, 95% CI: 0.62 to 0.83).

CONCLUSIONS Public reporting is associated with reduced percutaneous revascularization and increased in-hospital mortality among patients with AMI, particularly among patients not selected for PCI. (J Am Coll Cardiol 2015;65:1119–26)

Primary percutaneous coronary intervention (PCI) is a widely accepted treatment for acute myocardial infarction (AMI) (1,2). Public reporting of hospital outcomes associated with this procedure has been implemented in several states (Massachusetts [2003 to the present], New York [1991 to the present], and Pennsylvania [2002 to 2010]) over the past 2 decades. Additional states are

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ABBREVIATIONS AND ACRONYMS

AMI = acute myocardial infarction

CI = confidence interval

ICD-9-CM = International Classification of Diseases-Ninth Revision-Clinical Modification

IQR = interquartile range

NIS = nationwide inpatient sample

NSTEMI = non-ST-segment elevation myocardial infarction

OR = odds ratio

PCI = percutaneous coronary intervention

STEMI = ST-segment elevation myocardial infarction

currently considering or have recently implemented public reporting programs, with the intent of improving clinical performance for patients receiving this therapy (3). Evidence suggests that public reporting of outcomes may lead to improvements in the quality of care for cardiovascular procedures (4). However, it may also create disincentives for physicians to provide care for the most critically ill patients, as mortality in such individuals remains high despite treatment with appropriate guideline-based care (5–9).

SEE PAGE 1127

Prior investigations have demonstrated that Medicare patients presenting with AMI are less likely to undergo percutaneous revascularization in a state that participates in public reporting of hospital outcomes, despite a consensus that such therapy is indicated (1,2,10). The decreased rate of PCI observed in public reporting states was not associated with an increase in overall mortality, leading to speculation that public reporting of risk-adjusted mortality primarily reduced futile or otherwise unnecessary procedures. Subgroup analysis of the same cohort, however, demonstrated a greater likelihood of death following a ST-segment elevation myocardial infarction (STEMI) for Medicare patients treated in public reporting states than for those in nonreporting states (10). Whether this phenomenon is occurring across all ages and insurance payers is unknown.

The present study sought to evaluate the association between public reporting with procedural management and outcomes among a diverse population of patients with AMI. To do so, we used the Nationwide Inpatient Sample (NIS) to identify a representative sample of myocardial infarction patients that included all ages and multiple payers.

METHODS

POPULATION. The NIS is an annual database derived from a sample of all nonrehabilitation hospital stays in the United States. The population within this database was stratified based on the presence or absence of public reporting of PCI outcomes. Subjects hospitalized in Massachusetts and New York comprised the public reporting group, whereas those hospitalized in Connecticut, Maine, Maryland, Rhode Island, and Vermont served as the control cohort of regional states that do not publicly report PCI outcomes, consistent with prior analyses (10). Pennsylvania and New Jersey were excluded from this analysis as they have been collecting but inconsistently reporting outcomes to the public during the period under investigation. Furthermore, Pennsylvania has been inconsistently contributing data to the NIS during the study period. Among hospitalizations identified in these states, we identified all patients with a primary discharge diagnosis of AMI from 2005 to 2011, using the International Classification of Diseases - Ninth Revision - Clinical Modification (ICD-9-CM) codes. Acute myocardial infarction was defined as a primary discharge diagnosis of non-ST-segment elevation myocardial infarction (NSTEMI; codes 410.71 and 410.91) or STEMI (codes 410.11 to 410.61 and 410.81). Subjects who were hospitalized at facilities that did not offer PCI were excluded from analysis. Furthermore, patients transferred out of a given facility also were excluded to ensure an accurate assessment of in-hospital outcomes.

MEASUREMENTS. Demographic characteristics, including patient age, sex, and race, were derived from the dataset. High-risk features that could complicate procedural management such as cardiac arrest (code 427.5) and cardiogenic shock (code 785.51) were also assessed. To evaluate procedural management of patients with this diagnosis, the dataset was queried for procedural codes for percutaneous coronary intervention (ICD-9-CM codes 00.66, 17.55, 36.01, 36.02, 36.05, 36.06, and 36.07) and surgical revascularization via coronary artery bypass grafting (ICD-9-CM codes 36.10 to 36.19).

ANALYSIS. Summary statistics were reported as mean ± SD for continuous variables or medians and interquartile ranges (IQR) for non-normally distributed continuous data. To account for variation due to sampling, discharge weights were applied to the dataset based on methods established by the Healthcare Cost and Utilization Project (11). Unadjusted comparisons were made using the Proc Survey Logistic feature, which accounts for the complex survey design of NIS data. Adjusted logistic regression models with clustering by hospital were subsequently created that included age, sex, race, and 29 comorbid medical conditions identified by the risk adjustment model developed by the Agency for Healthcare Research and Quality (Online Table 1). This model was then used to assess the relationship between public reporting and percutaneous revascularization, which represents the most common modality for revascularization in myocardial infarction patients. To determine whether the association between public reporting and likelihood of percutaneous revascularization differed based on the risk profile of patients, we introduced interaction terms

for selected characteristics including age, primary insurance, and presentation with a concomitant STEMI, cardiac arrest, or cardiogenic shock. We also evaluated the association between public reporting and in-hospital mortality, using logistic regression models adjusted for the same set of demographic and clinical characteristics. To assess whether the association between public reporting and mortality differed based on the performance of percutaneous revascularization, we introduced an interaction term for PCI. Because coronary artery bypass graft surgery represents an alternative revascularization procedure for myocardial infarction, we also examined the association between public reporting and surgical revascularization. Finally, a sensitivity analysis was performed comparing the individual reporting states (Massachusetts or New York) to the nonreporting states to evaluate differences in procedural management and in-hospital outcomes between the two public reporting states included in this analysis. For these analyses, a 3-level categorical variable (New York versus Massachusetts versus all other nonreporting states) was included in logistic regression models for all outcomes. All statistical analyses were performed using SAS version 9.3 software (SAS Corp., Cary, North Carolina). A p value of <0.05 was considered statistically significant.

TABLE 1 Characteristics of Patients With Acute Myocardial Infarction, 2005 to 2011

	Public Reporting (n = 57,629)	Nonreporting (n = 26,492)	p Value
Age, yrs	68.0 ± 14.7	67.4 ± 14.6	0.200
Female	22,786 (40)	10,758 (41)	0.078
White	40,935 (71)	20,137 (76)	0.032
Presentation			0.689
Non-ST-segment elevation MI	40,388 (70)	18,726 (71)	
ST-segment elevation MI	17,241 (30)	7,766 (29)	
Complications			
Cardiac arrest	1,237 (2)	731 (3)	<0.001
Cardiogenic shock	2,431 (4)	1,279 (5)	0.025
Primary insurance			<0.001
Medicare	33,075 (57)	14,983 (57)	
Medicaid	4,961 (9)	1,691 (6)	
Private insurance	16,330 (28)	8,373 (32)	
Self-pay	1,823 (3)	957 (4)	
Other	1,029 (2)	303 (1)	
Comorbid conditions			
Anemia (blood loss)	499 (1)	404 (2)	<0.001
Anemia (deficiency)	6,928 (12)	4,132 (16)	<0.001
Diabetes (uncomplicated)	16,398 (29)	7,522 (28)	0.910
Diabetes (chronic complications)	2,974 (5)	1,535 (6)	0.052
Hypertension	39,240 (68)	18,026 (68)	0.935
Peripheral vascular disorders	5,260 (9)	3,305 (13)	<0.001
Renal failure	8,876 (15)	4,287 (16)	0.326

Values are mean ± SD or n (%). Reporting states include Massachusetts and New York. Nonreporting states include Connecticut, Maine, Maryland, New Hampshire, Rhode Island, and Vermont.

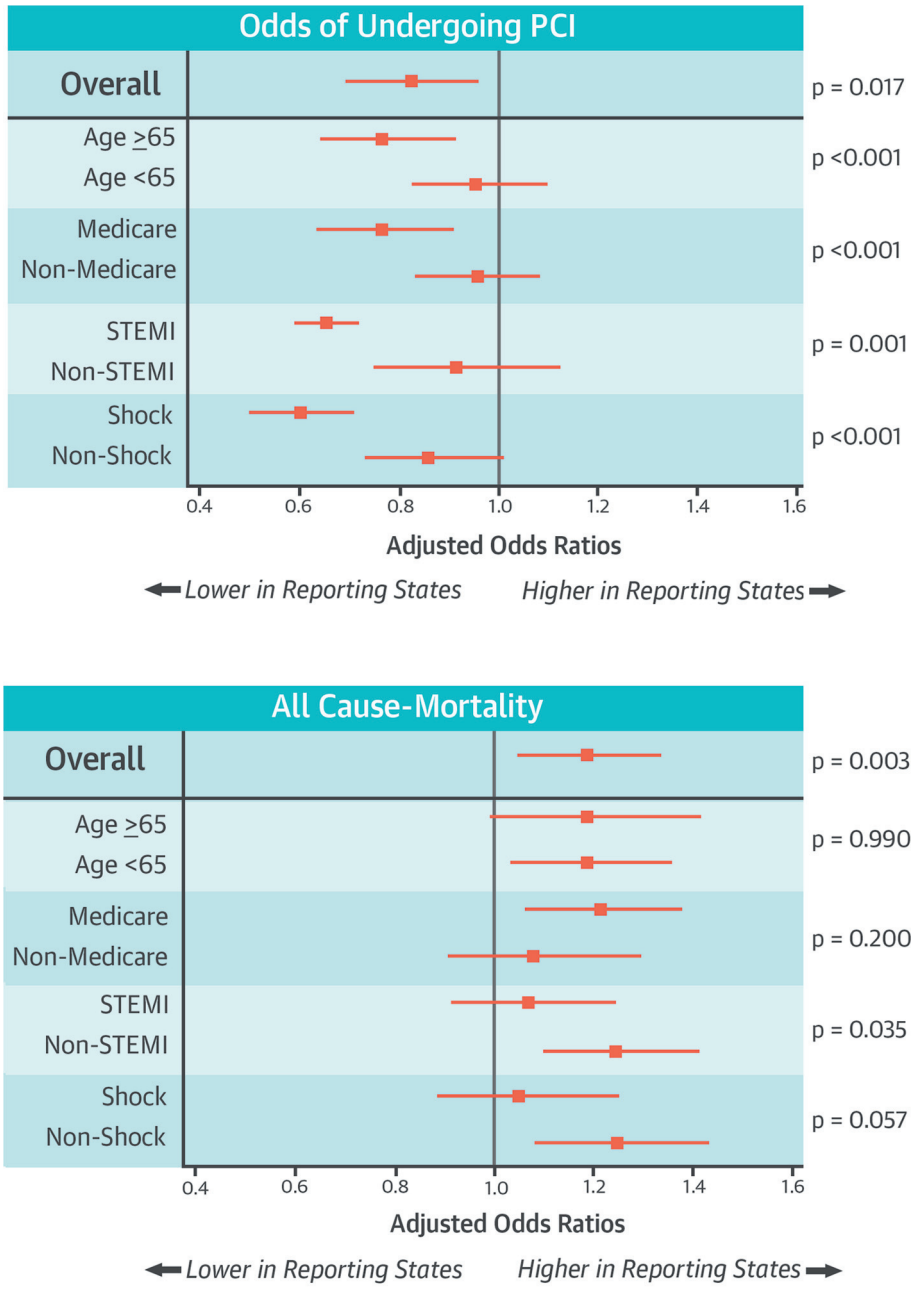
MI = myocardial infarction.

RESULTS

POPULATION. From 2005 to 2011, 84,121 patients were hospitalized with AMI in the selected states, and 57,629 of these patients (69%) received treatment in a facility that publicly reported hospital outcomes for PCI. The demographic characteristics of the population stratified by the presence or absence of public reporting are presented in **Table 1**. Compared with those in nonreporting states, patients presenting with AMI in a public reporting state were similar with respect to age and sex but were significantly less likely to have concomitant cardiac arrest ($p < 0.001$) or cardiogenic shock ($p = 0.025$). Medical comorbidities of the analyzed patient population are summarized in **Table 1** and Online Table 2. The median length of stay in days was longer for those treated in a public reporting state (4 days, IQR: 2 to 6 days) than for those treated in a nonreporting state (3 days, IQR: 2 to 7 days; $p < 0.001$).

PERCUTANEOUS REVASCULARIZATION. Percutaneous revascularization was performed in 48% of myocardial infarction patients in reporting states compared with 51% in nonreporting states ($p = 0.209$), as shown in the **Central Illustration** and Online Table 3. After multivariate adjustment, percutaneous revascularization was performed significantly less often in public reporting states than in nonreporting states among all patients (odds ratio [OR]: 0.81, 95% confidence interval [CI]: 0.67 to 0.96). These findings were specifically pronounced among patients with older age (0.75, 95% CI: 0.62 to 0.91), those with Medicare insurance (OR: 0.75, 95% CI: 0.62 to 0.91), and those presenting with STEMI (OR: 0.63, 95% CI: 0.56 to 0.71) or concomitant cardiac arrest or cardiogenic shock (OR: 0.58, 95% CI: 0.47 to 0.70) in public reporting states compared with those in nonreporting states (interaction: $p < 0.001$ for each comparison). A sensitivity analysis demonstrated similarly reduced odds of undergoing percutaneous revascularization in Massachusetts (OR: 0.88, 95% CI: 0.70 to 1.11) and New York (OR: 0.77, 95% CI: 0.64 to 0.93) compared with those in regional nonreporting states. Differences between the odds of undergoing percutaneous revascularization in the 2 reporting states did not reach statistical significance ($p = 0.192$). Of note, the adjusted rate of surgical revascularization for patients in reporting states was

CENTRAL ILLUSTRATION **Public Reporting and PCI for AMI: Rates of Percutaneous Intervention and In-Hospital Mortality for AMI in States With and Without Public Reporting**



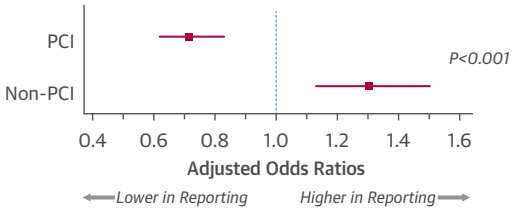
Waldo, S.W. et al. J Am Coll Cardiol. 2015; 65(11):1119–26.

(Top) Adjusted odds of undergoing percutaneous revascularization among patients with AMI was significantly lower in public reporting states than in nonreporting states ($p = 0.017$). These findings were specifically pronounced among older patients, those with Medicare insurance, and those presenting with STEMI or concomitant cardiac arrest or cardiogenic shock (interaction $p < 0.001$ for each comparison). **(Bottom)** Adjusted odds of in-hospital mortality among patients with AMI were significantly higher in public reporting states than in nonreporting states ($p = 0.003$). This finding was consistent across all ages and insurance carriers, although slightly more prominent among those with a non-STEMI (interaction: $p = 0.035$). AMI = acute myocardial infarction; PCI = percutaneous coronary intervention; STEMI = ST-segment elevation myocardial infarction.

similar to that for patients in nonreporting states (OR: 1.13, 95% CI: 0.88 to 1.45) (Online Table 4). The association between public reporting and any revascularization procedure, that is, percutaneous or surgical, was attenuated compared with the rate of PCI alone (OR: 0.88, 95% CI: 0.69 to 1.12 for any revascularization), although rates of any revascularization continued to be significantly lower for those with STEMI or cardiac arrest/shock in public reporting states (Online Table 5).

IN-HOSPITAL MORTALITY. The overall in-hospital mortality of those presenting with AMI was 6%. Stratifying the population by public reporting, the mortality rate was 6% of patients in public reporting states compared with 5% of patients in nonpublic reporting states. Both the unadjusted (OR: 1.13, 95% CI: 1.02 to 1.25) and adjusted (OR: 1.21, 95% CI: 1.06 to 1.37) in-hospital mortality rates were significantly greater among patients presenting with AMI in a public reporting state than for those admitted to a facility in a nonreporting state (**Central Illustration**, Online Table 6). This finding was consistent across all ages and insurance carriers, although slightly more prominent among those with a non-STEMI (interaction: $p = 0.035$). When patients were stratified by PCI, the adjusted odds of mortality was significantly lower in public reporting states among myocardial infarction patients undergoing intervention (OR: 0.71, 95% CI: 0.62 to 0.83) but significantly higher in public reporting states for patients who did not undergo percutaneous revascularization (OR: 1.30, 95% CI: 1.13 to 1.50, interaction: $p < 0.001$), as shown in **Figure 1** and Online Table 7. A sensitivity analysis demonstrated similarly increased in-hospital mortality in Massachusetts (OR: 1.21, 95% CI: 1.02 to 1.42) and New York (OR: 1.21, 95% CI: 1.04 to 1.39) compared with regional nonreporting states.

FIGURE 1 Rate of In-Hospital Mortality for AMI Stratified by Public Reporting and PCI, 2005 to 2011



The adjusted odds of mortality were significantly lower in public reporting states among myocardial infarction patients undergoing intervention but significantly higher in public reporting states for patients who did not undergo percutaneous revascularization (interaction: $p < 0.001$). AMI = acute myocardial infarction; PCI = percutaneous coronary intervention.

DISCUSSION

The present study evaluated the association between state-mandated public reporting of hospital procedural outcomes with procedural management and in-hospital outcomes among patients presenting with a myocardial infarction. As shown, patients treated in a public reporting state are less likely to undergo percutaneous revascularization, particularly when they have high-risk features such as older age, cardiogenic shock, cardiac arrest, or STEMI. In contrast to previous studies, this is the first analysis that demonstrates increased overall in-hospital mortality after myocardial infarction among patients treated in public reporting states after multivariate adjustment for the severity of illness (**Central Illustration**). Furthermore, the increase in in-hospital mortality was predominantly isolated to patients who did not receive percutaneous revascularization, whereas those selected for the procedure had lower odds of mortality in public reporting states. Taken together, these data suggest that public reporting may improve PCI-related outcomes but may also have the unintended consequence of increasing risk aversion to the detriment of overall outcomes for patients with myocardial infarction.

Public reporting is intended to improve outcomes among patients undergoing percutaneous revascularization. The association between public reporting and mortality in this population, however, has not been completely elucidated (12). Previous research has suggested that unadjusted in-hospital mortality is lower among patients undergoing PCI in states with public reporting, a finding that does not reach numerical or statistical significance after adjustment for significant differences in comorbid conditions (13). Analysis of the Medicare population demonstrated similar findings with no differences in 1-month mortality between most myocardial infarction patients treated in public reporting and nonreporting states, apart from patients with STEMI (10). In contrast to these previous studies, the present analysis demonstrates increased in-hospital mortality for myocardial infarction patients treated in public reporting states overall. A sensitivity analysis demonstrated that these findings were consistent across both public reporting states included in this study. The stark differences in these observations may be a result of the time period investigated, differences in patient populations studied, or significant differences

between in-hospital and 1-month mortality among patients with acute infarction. Alternatively, the increased mortality observed in the present analysis may reflect differential patient selection in public reporting and nonreporting states, a difference that could not be detected in the more homogeneous Medicare population surveyed in previous studies.

Patient selection for percutaneous revascularization may differ in public reporting states compared with that in nonreporting states, resulting in significant differences in clinical outcomes. Myocardial infarction patients selected for percutaneous revascularization in public reporting states had a lower mortality rate than those in nonreporting states. These improved outcomes may reflect the intended effect of improvement in PCI quality in these states or a greater avoidance of futile cases, improving the observed mortality among those who were selected for the procedure. However, those who were not selected for revascularization in public reporting states had a marked increase in mortality, perhaps reflecting the avoidance of very high-risk cases that may have, in fact, benefited from revascularization. Some have argued that the highest risk cases may have the most to gain from revascularization and that overall outcomes could be improved if they too were treated aggressively (14). Regardless, our results suggest that the triage of AMI patients in public reporting states differed from the triage in nonreporting states, a finding with implications for health care policy. There is a significant need to develop strategies to combat risk aversion for percutaneous revascularization among critically ill patients with myocardial infarction while maintaining the important goals of transparency, accountability, and quality improvement supported by public reporting. Such strategies may include the continued refinement of risk adjustment models to include unmeasured markers of risk (15) or through the exclusion of the most critically ill patients from performance reports as has been attempted in Massachusetts (16). Our findings support the recently published statement from the American Heart Association suggesting that cardiac arrest patients should be excluded from public reporting of PCI outcomes, categorizing these cases as compassionate use of an appropriate treatment in exceptionally high-risk patients (17). The publicly reported 30-day outcomes for Medicare fee-for-service patients hospitalized with AMI may play a role in ensuring that patients receive optimal care, although the impact of this intervention is unclear. It is notable that the avoidance of PCI in high-risk patients that could improve PCI-specific publicly reported outcomes might result in worse hospital performance on this myocardial infarction–specific performance metric. Alternate strategies to monitor outcomes for patients who may be eligible but do not undergo percutaneous revascularization also should be considered to ensure that every patient has access to this therapy.

Current iterations of public reporting may provide a disincentive for physicians to perform procedures on sicker patients with a higher likelihood of a poor outcome. Previous research has suggested that patients treated for AMI were significantly more likely to undergo coronary angiography and percutaneous revascularization in a nonreporting state (Michigan) than in a state with publicly reported outcomes (New York) (8,13). Furthermore, patients selected for PCI in the public reporting state had significantly lower rates of cardiogenic shock, congestive heart failure, or significant extracardiac vascular disease than those treated in a nonreporting state, suggesting physicians may have avoided higher risk cases when the outcomes were being monitored. This has been corroborated in a recent analysis of the Medicare population, again demonstrating decreased use of coronary angiography and percutaneous revascularization for patients with AMI treated in public reporting states (10). The present study adds to these data, demonstrating that the overall rates of percutaneous revascularization are lower in public reporting states than in nonreporting states among all ages and all insurance payers, particularly for those with more acute presentations. Interestingly, the in-hospital mortality differences between reporting and nonreporting states were more prominent among patients with less acute presentations. This could be explained by a higher proportion of patients who were too ill to benefit from percutaneous revascularization, classified as having shock or an arrest, whereas differential treatment among slightly lower risk patients may have been more influential to the overall difference in mortality (18). This explanation is speculative, however, and the limitations of the data do not allow for a more rigorous exploration of this finding.

STUDY LIMITATIONS. The present study should be interpreted in the context of several limitations. Patients were identified in an administrative dataset that samples hospitals from a given region each year. Billing codes were subsequently used to identify patients with the diagnoses of interest, an imperfect system that has nevertheless been widely used. The temporal association between presenting complaints and comorbid conditions, such as cardiogenic shock or cardiac arrest, is also ambiguous given the way

data are collated. Furthermore, the sampling scheme has been designed to be representative of acute care hospitals but does not necessarily represent all hospitals performing PCI (19). Analyzing temporal trends in procedural management and in-hospital outcomes would strengthen the association of our findings as well as allow investigation of changes in the public reporting system during the time period under study. Unfortunately, the regional sampling process used in this dataset ensures an adequate representation of similar hospitals across regions rather than states. Because of this, a given state could be over- or underrepresented in the sample during a given year, preventing the accurate analysis of temporal trends within a state. The primary findings of the study, however, average the data across several years, minimizing the effect of sampling (11). Furthermore, multivariate adjustment for the severity of illness could only be performed based on claims-based data. Because of this, it is possible that there are comorbidities that differ between reporting and nonreporting states that are not captured by the dataset but would explain the differences in procedural management and outcomes. Similarly, clinical outcomes within this dataset are limited to the inpatient setting, and thus a comparison of long-term mortality could not be performed. Finally, the observational analysis performed in the present study is only able to evaluate the association between public reporting and outcomes and cannot prove causality. Further studies in other datasets could be performed to overcome these limitations and corroborate our findings.

CONCLUSIONS

Public reporting of outcomes is associated with a lower rate of percutaneous revascularization and increased overall in-hospital mortality among patients with AMI, particularly among those who do not receive PCI. Public reporting of outcomes should balance the benefits of transparency and accountability against the potential influence of physician risk aversion.

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PERSPECTIVES

COMPETENCY IN SYSTEMS-BASED PRACTICE: Public reporting of the outcomes of primary PCI for patients with AMI is associated with lower likelihood of using PCI and higher in-hospital mortality.

TRANSLATIONAL OUTLOOK: Better reporting methods are needed to adequately balance transparency and accountability with the potential influence of risk aversion.

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KEY WORDS acute coronary syndromes(s), percutaneous coronary intervention, public reporting

APPENDIX For supplemental tables, please see the online version of this article.