Relation Between Statewide Hospital Performance Reports on Myocardial Infarction and Cardiovascular Outcomes

Georgia Barbayannis, BA[a], I-Ming Chiu, PhD[a,b], Davit Sargsyan, MS[a,c], Javier Cabrera, PhD[a], Traymon E. Beavers, MS[a], John B. Kostis, MD[a,*], Nora M. Cosgrove, RN[a], Noah E. Michel, MS[a], and William J. Kostis, PhD, MD[a], for the Myocardial Infarction Data Acquisition System (MIDAS 32) Study Group

Healthcare systems may be judged on quality of care and access to health services. Studies on the association of hospital quality of care scores and clinical outcomes have yielded mixed results. With the help of a richer and more representative database, the aim of our study was to shed light on these inconsistencies. We examined the association of 4 process of care scores (prescription of aspirin, β blocker, angiotensin-converting enzyme inhibitor or angiotensin receptor blocker used for left ventricular systolic dysfunction, and an overall composite score) for acute myocardial infarction (AMI), reported in the Hospital Performance Reports, with 30-day and 1-year rates of readmission for AMI and cardiovascular (CV) death. Clinical outcomes were from the Myocardial Infarction Data Acquisition System, an administrative database that comprises all patient CV disease admissions to acute care hospitals in New Jersey. CV death was related with overall score (adjusted odds ratio [OR] 0.821, 95% confidence interval [CI] 0.726 to 0.930, p = 0.002) at 30 days and with all 4 scores at 1 year (OR ranging from 0.829 to 0.997, p <0.01). Readmission due to AMI was associated with the overall score (OR 0.789, 95% CI 0.691 to 0.902, p <0.0001) and the aspirin score (OR 0.995, 95% CI 0.990 to 1, p = 0.046) at 30 days. Low hospital performance scores for AMI were associated with increased CV death and readmission for AMI. In conclusion, healthcare providers should allocate their resources to improving hospital performance to decrease AMI case fatality, AMI readmissions, and CV-related healthcare spending. **(Am J Cardiol 2019;123:1587−1594)**

In 2004, the Centers for Medicare and Medicaid Services and the Joint Commission on Accreditation of Healthcare Organizations began to publicly report hospital performance on core process measures for acute myocardial infarction (AMI).[1,2] Public reports of hospital quality of care and safety scores influence patients' choices about their hospital care.[3−5] Studies on the associations of hospital performance on quality of care measures and clinical outcomes have yielded mixed results.[6−15] Previous studies found an association of higher scores with better clinical outcomes, others observed no relation and some reported that higher scores were associated with worse outcomes.[6−15] Most of these studies included only older patients, had a short duration of follow-up, and were published more than 5 years ago.[2,6−15] The Myocardial Infarction Data Acquisition System (MIDAS), a longitudinal statewide database of all hospital admissions in New Jersey, was used to examine the association between the New Jersey Hospital Performance Report process of care scores for AMI with the occurrence of fatal or nonfatal AMI.

Methods

We assessed the process of care (recommended care) scores reported in the New Jersey Hospital Performance Reports from 2004 through 2013. The process of care scores for AMI were developed by the Joint Commission on Accreditation of Healthcare Organizations and the Centers for Medicare and Medicaid Services.[16] The New Jersey Hospital Performance Reports are published annually by the New Jersey Department of Health and Senior Services.[16] We obtained the publicly available scores from the State of New Jersey Department of Health's website.[17] All New Jersey general care hospitals and 1 specialized heart hospital collected and submitted information from patient medical records for AMI to the New Jersey Department of Health and Senior Services, for a total of 80 hospitals.[16] Thirty-six of the 80 hospitals were teaching hospitals. Vendors from the New Jersey Department of Health and Senior Services and Joint Commission on Accreditation of Healthcare Organizations subsequently processed the hospital

[a]Cardiovascular Institute, Rutgers Robert Wood Johnson Medical School, New Brunswick, New Jersey; [b]Department of Economics, Rutgers University, Camden, Camden, New Jersey; and [c]Rutgers University Ernest Mario School of Pharmacy, Piscataway, New Jersey. Manuscript received December 12, 2018; revised manuscript received and accepted February 11, 2019.

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*Corresponding author: Tel: 732-235-7685; fax: 732-235-7039.
E-mail address: kostis@rwjms.rutgers.edu (J.B. Kostis).

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data and produced process of care scores published in the Hospital Performance Reports.[16] Although the data collection and reporting were the responsibility of the individual hospitals, both state and federal authorities audited the data for accuracy and completeness.[16]

We employed 3 individual process of care scores as well as a standardized overall process of care score as independent variables. The individual process of care scores indicate the percentage of patients aged 18 or older without contraindications who received the appropriate treatment at hospital discharge. These include prescription at discharge of aspirin, β blocker, angiotensin-converting enzyme inhibitor or angiotensin receptor blocker (ACEI/ARB) used for left ventricular systolic dysfunction (LVSD),[17] and the overall score. Because of the introduction of new measures and changes in measure definitions, overall scores are not necessarily comparable from year to year.[16] To account for this, we generated standardized overall scores on a 0 to 1 scale based on hospital rankings within each year.

The outcomes and additional independent variables were obtained from the MIDAS database from January 1, 2004 to December 31, 2015.[19−24] MIDAS is an ongoing, statewide administrative database that comprises all cardiovascular (CV) disease admissions to nonfederal acute care hospitals from March 1985 to December 2015. MIDAS includes the reason for admission and other discharge data, as well as demographic variables and 8 additional diagnoses (gender, age, commercial insurance, Medicaid/other insurance, black race, other race, Hispanic ethnicity, other ethnicity, acute heart failure, chronic heart failure, hypertension, diabetes, chronic liver disease, chronic kidney disease, chronic obstructive pulmonary disease (COPD), and dyslipidemia).[18] The data were obtained from the New Jersey Department of Health using the New Jersey Discharge Data Collection System and the New Jersey Statewide Hospital Uniform Billing System.[18] MIDAS data were also merged with the New Jersey death registration files for both cause and date of death.[18] The confidentiality of hospital records was maintained. Although the data collection was the responsibility of the individual hospitals, both state and federal authorities audited it for accuracy and completeness. The accuracy of this database was verified through a previous audit using a random sample of charts.[19] The Rutgers Institutional Review Board approved this study.

From the years 2004 to 2015, the data from the New Jersey Hospital Performance Reports were merged with the MIDAS data by hospital and division number. We used a subset of 160,755 patients, aged 18 years or older for whom hospital information was recorded. The New Jersey Hospital Performance Reports excluded patients transferred to another acute care hospital or federal hospital, patients who expired, patients who left against medical advice, and patients discharged to hospice. All diagnoses were encoded using the International Classification of Disease 9th Revision (ICD-9) billing codes. Patients who were admitted with the AMI codes of transmural AMI (anterior, ICD-9 410.0x, 410.1x; inferior, ICD-9 410.2x, 410.4x; lateral, ICD-9 410.3x, 410.5x; posterior, ICD-9 410.6x), subendocardial AMI (ICD-9 410.7x), and other/unspecified AMI (ICD-9 410.8x, 410.9x) were included in the study. Covariates were hospital characteristic (teaching/nonteaching), patient demographics (sex, age, race, and insurance type) and co-morbidities of acute and chronic heart failure (ICD-9 428.xx), hypertension (ICD-9 401.xx to 405.xx), diabetes (ICD-9 250.xx), chronic liver disease (ICD-9 571.xx), chronic kidney disease (ICD-9 585.xx), COPD (ICD-9 490.xx to 496.xx), and dyslipidemia (ICD-9 272.x). The patient demographic characteristics and medical history at index admission are shown in Table 1.

We examined the association of hospital readmission, defined as percentage of patients who were readmitted for AMI within a fixed period of time (30 days and 1 year) after their initial AMI discharge, and CV death after the first AMI discharge with hospital process of care scores for overall score, aspirin prescribed at discharge, β blocker prescribed at discharge, and ACEI/ARB used for LVSD at 30 days and 1 year. The top panel of Figure 1 displays the trends of patients with a first AMI from the year 2003 to 2015. The bottom panel of Figure 1 shows the trends of CV death over the same period. The incidence of AMI decreased from 2003 to 2009 and remained stable thereafter. However, the incidence of CV death increased between 2003 and 2009, and stabilized after 2009.

Logistic modeling was applied to explore the association of hospital performance scores including the standardized overall score with the clinical outcomes of AMI readmission and CV death. The odds ratios (ORs) for each response after the first AMI discharge were estimated at 30 days and 1 year, adjusted for sex, age, race, type of insurance, teaching/nonteaching hospital, history of heart failure, hypertension, diabetes, chronic liver disease, COPD, chronic kidney disease, and dyslipidemia. Statistical analyses were performed using R version 3.4.4 software.

Table 1
Demographics of acute myocardial infarction patients

Patient demographic characteristics	Mean/SD
Age at first AMI (years)	68 ± 14.8
Admission (mean ± SD)	
Women	40.8%
White	77.1%
Black	10.1%
Hispanic	8.2%
Non-Hispanic	82.3%
Insurance	
Commercial	42.6%
Medicare	50.4%
Medicaid/self-pay/other	7.0%
Medical history	
Acute heart failure	33.0%
Chronic heart failure	2.7%
Hypertension	75.8%
Diabetes mellitus	34.8%
Chronic liver disease	1.4%
Chronic kidney disease	12.0%
Chronic obstructive pulmonary disease	24.8%
Dyslipidemia	58.7%

AMI = acute myocardial infarction.

Dyslipidemia = ICD-9 code 272.1-4 (includes hypercholesterolemias, hypertriglyceridemias, hyperchylomicronemia, and other unspecified hyperlipidemias).

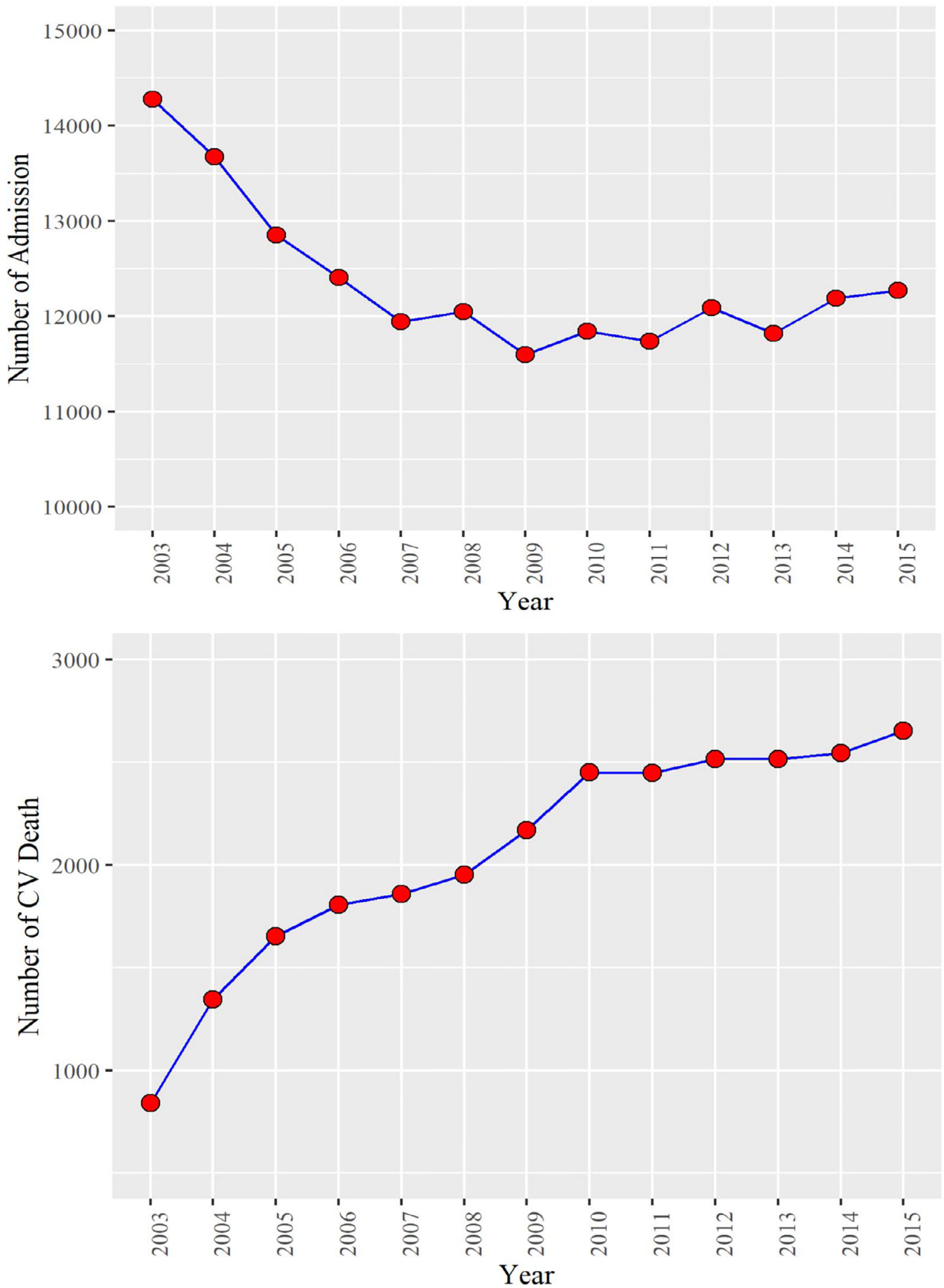

Figure 1. Top panel: annual trends in incidence of acute myocardial infarction admission. Bottom panel: annual trends in incidence of cardiovascular death.

Results

The OR estimates for both short-term (30 days) and long-term (1 year) results are reported in Figures 2 to 5, and the logistic regression results are reported in Table 2. The clinical score data were available at the hospital level rather than at the patient level. Not every hospital reported every score each year. Of the 105,994 patients who were hospitalized for a first AMI to hospitals that reported aspirin score that year, 101,730 (96%) were advised to take aspirin. Similarly, of 96,939 patients who were admitted to hospitals that reported β-blocker scores, 93,293 (96%) were advised to take a β blocker. Finally, of 83,688 patients admitted to hospitals that reported ACEI/ARB scores, 77,430 patients

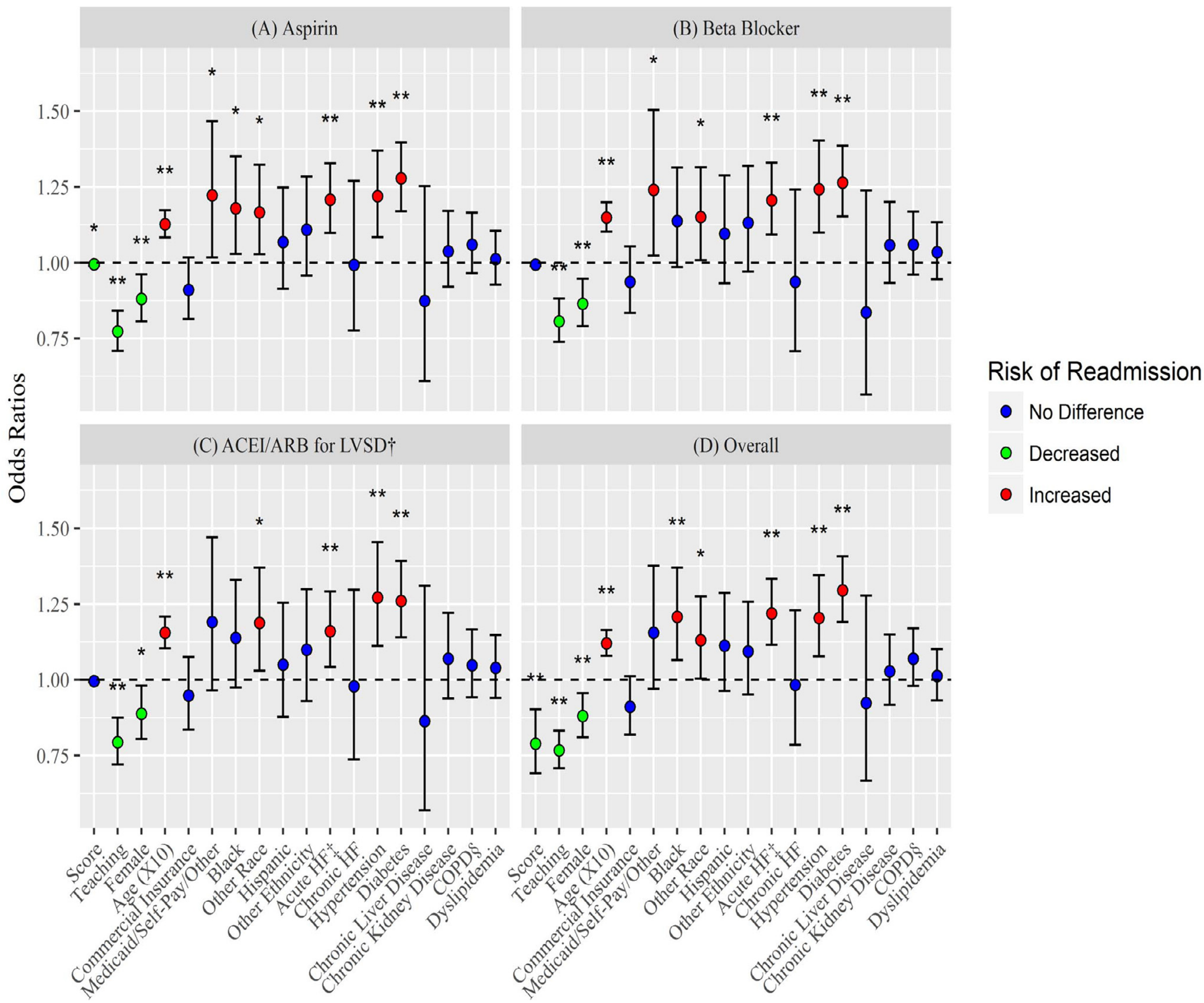

Figure 2. Odds ratios (ORs) of readmission for acute myocardial infarction at 30 days. Panel *(A) (left upper)* pertains to aspirin, panel *(B) (right upper)* pertains to β blocker, panel *(C) (left lower)* pertains to ACEI/ARB for left ventricular dysfunction, and panel *(D) (right lower)* pertains to the overall score. Asterisks indicate statistical significance of the estimated ORs. *p Value <0.05, **p value <0.01. †Angiotensin-converting enzyme inhibitor/angiotensin receptor blocker for left ventricular systolic dysfunction; ‡heart failure; §chronic obstructive pulmonary disease.

(93%) were advised to take an ACEI/ARB. Of the total 160,755 AMI patients studied, 4,743 (3.0%) had readmission within 30 days, 21,394 (13.3%) had readmission within 1 year, 4,359 (2.7%) had CV mortality within 30 days, and 12,285 (7.6%) had CV mortality within 1 year of their first AMI admission. Additionally, 313 patients (0.2%) had a readmission followed by CV death within 30 days of their first AMI admission, and 2,223 patients (1.4%) had a readmission followed by CV death within 1 year of their first AMI admission.

At 1 month, readmission for AMI was associated with the use of aspirin (OR 0.995, confidence interval [CI] 0.990 to 1, p = 0.046) and with overall score (OR 0.789, CI 0.691 to 0.902, p <0.001). At 12 months, CV death was associated with aspirin (OR 0.992, CI 0.989 to 0.995, p <0.001), β-blocker use (OR 0.992, CI 0.989 to 0.996, p <0.001), ACEI/ARB (OR 0.997, CI 0.994 to 0.999, p = 0.008), and the overall score (OR 0.829, CI 0.767 to 0.896, p <0.001). In addition, co-morbidities (i.e., acute heart failure, hypertension, COPD, and so on) increased the risk of both AMI readmission and CV death, whereas admission to teaching hospital decreased the risk (Figure 3).

The Cox regression models identified the following significant predictors of CV mortality at 1 year: aspirin score over 90, HR 0.754, 95% CI 0.802 to 0.710, p <0.001; β-blocker score over 90, HR 0.816, 95% CI 0.873 to 0.763, p <0.001; ACEI/ARB score over 70, HR 0.789, 95% CI 0.878 to 0.709, p <0.001; and standardized overall score over 0.6, HR 0.814, 95% CI 0.848 to 0.782, p <0.001. These effects remained significant after adjusting for covariates.

The same predictors were also significant for the 30-day AMI readmission as follows: aspirin score over 90, HR 0.786, 95% CI 0.884 to 0.700, p <0.001; β-blocker score

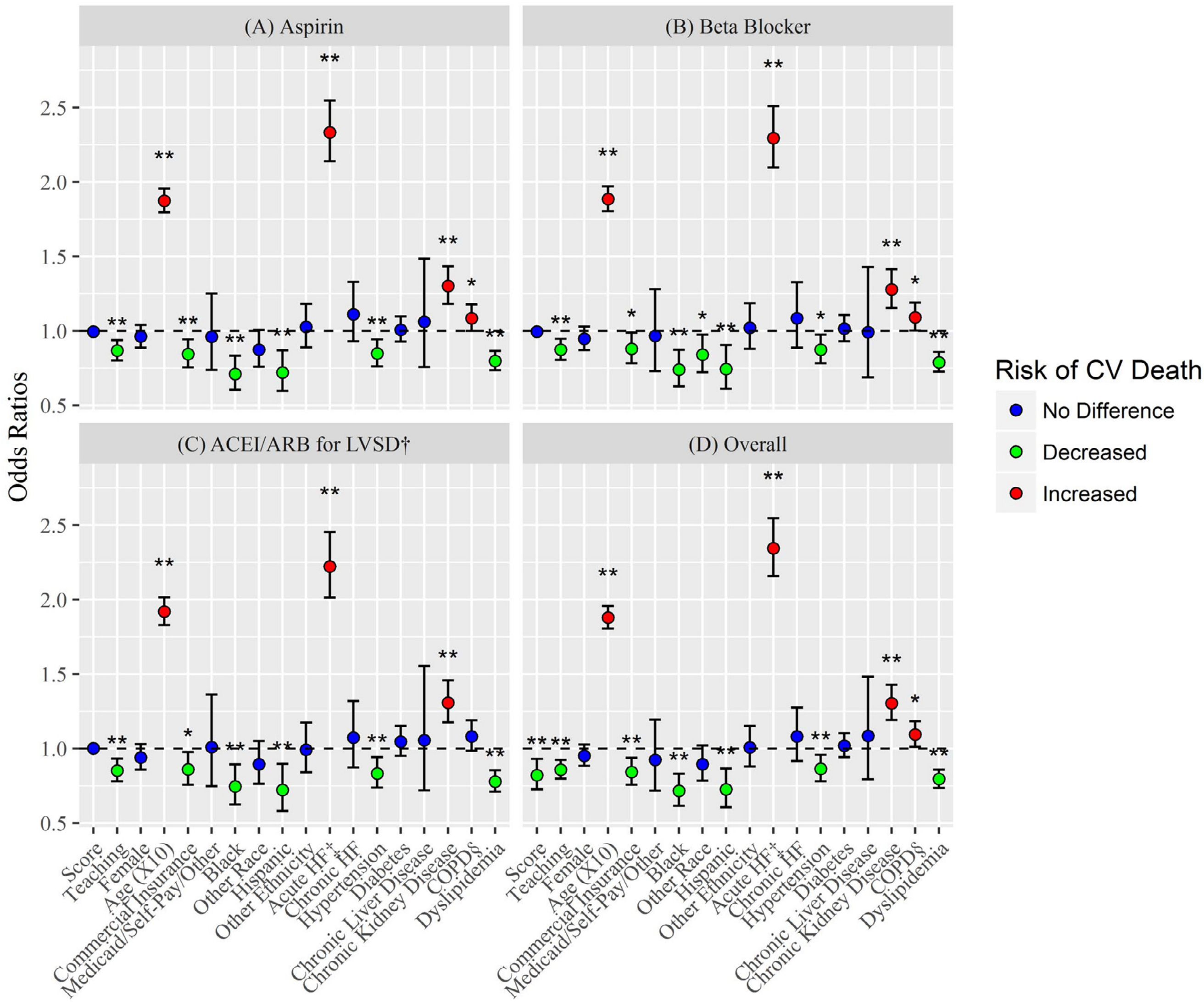

Figure 3. Odds ratios (ORs) of cardiovascular death at 30 days. Panel *(A) (left upper)* pertains to aspirin, panel *(B) (right upper)* pertains to β blocker, panel *(C) (left lower)* pertains to ACEI/ARB for left ventricular dysfunction, and panel *(D) (right lower)* pertains to the overall score. Asterisks indicate statistical significance of the estimated ORs. *p Value <0.05, **p value <0.01. †Angiotensin-converting enzyme inhibitor/angiotensin receptor blocker for left ventricular systolic dysfunction; ‡heart failure; §chronic obstructive pulmonary disease.

over 90, HR 0.761, 95% CI 0.862 to 0.672, p <0.002; ACEI/ARB score over 70, HR 0.813, 95% CI 0.996 to 0.664, p = 0.045; and standardized overall score over 0.6, HR 0.828, 95% CI 0.894 to 0.766, p <0.002. Only the aspirin score and the overall score effects remained statistically significant after adjusting for all covariates.

Discussion

The study showed that low hospital performance scores for AMI were associated with increased CV death and readmission for AMI. These results generally agree with past studies that indicated higher quality of care measures were associated with improved patient outcomes. In the National Registry of Myocardial Infarction database, adherence to the American Heart Association/American College of Cardiology practice discharge therapy guidelines, a proxy for quality of care, for ACEI/ARB, aspirin, and β blockers were associated with decreased in-hospital mortality rates.[11] Also, Marciniak et al[15] reported lower 1-year mortality in Medicare patients for hospitals adhering to the Cooperative Cardiovascular Project quality measures compared with hospitals not adhering to those measures in 4 different states. Ryan et al[13] found no statistically significant decrease in AMI mortality after adjustment for preexisting secular trends. Also, Bradley et al[7] reported that hospital performance on the CMS/JCAHO process measures for AMI explained only 6% of the hospital-level variation in short-term, risk standardized mortality rates for patients with AMI. Glickman et al[8] reported that a modest improvement in American Heart Association/American College of Cardiology hospital AMI quality measures was not associated with appreciable changes in hospital outcomes or mortality. The divergent effects among the studies with respect to the associations between clinical outcomes and AMI process of care scores may be explained by

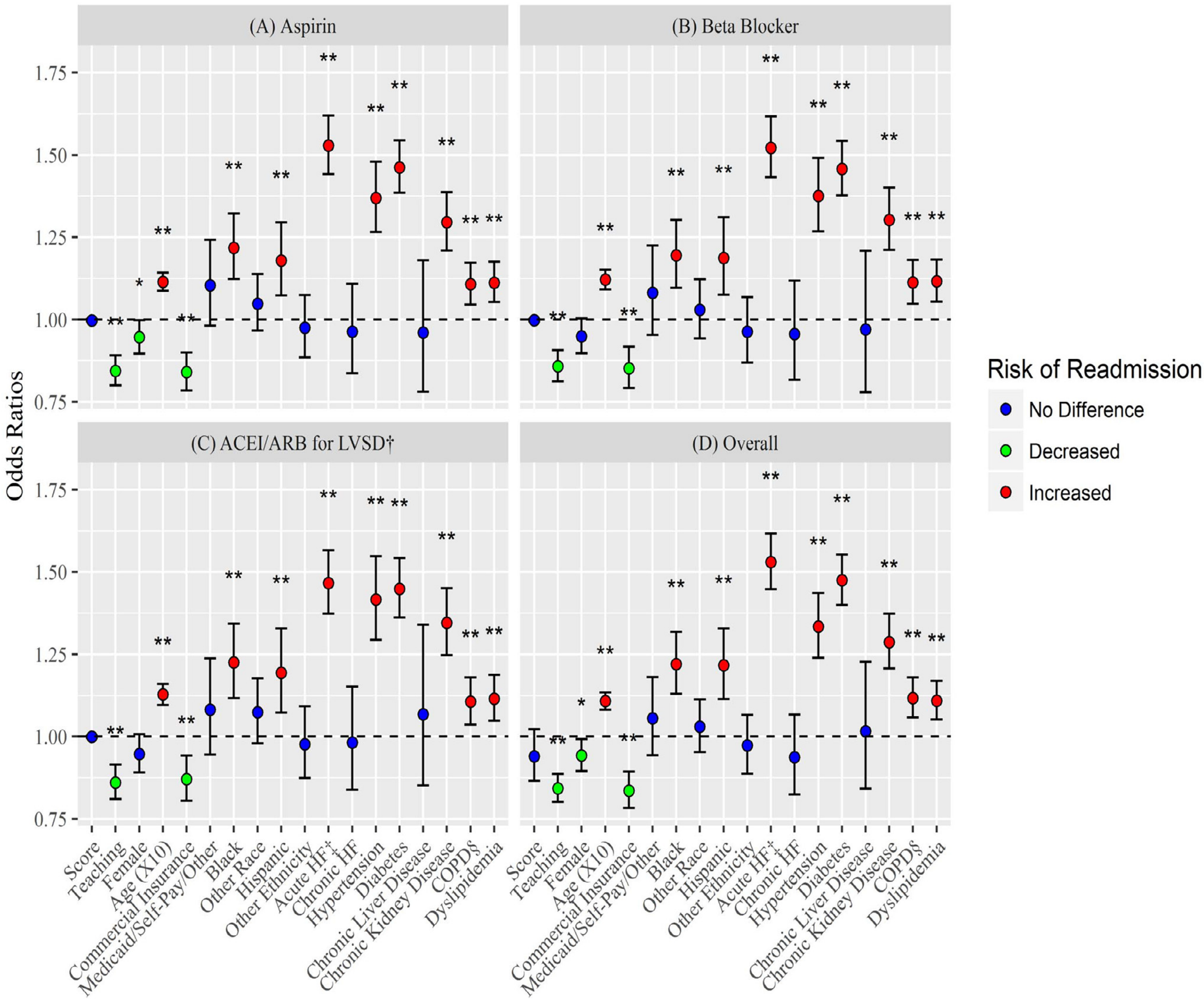

Figure 4. Odds ratios (ORs) of readmission for acute myocardial infarction at 1 year. Panel *(A) (left upper)* pertains to aspirin, panel *(B) (right upper)* pertains to β blocker, panel *(C) (left lower)* pertains to ACEI/ARB for left ventricular dysfunction, and panel *(D) (right lower)* pertains to the overall score. Asterisks indicate statistical significance of the estimated ORs. *p Value <0.05, **p value <0.01. †Angiotensin-converting enzyme inhibitor/angiotensin receptor blocker for left ventricular systolic dysfunction; ‡heart failure; §chronic obstructive pulmonary disease.

sample selection, differences in covariates and duration of the studies.

Hospital quality of care and safety scores do influence patients' choices about their hospital care. For instance, when respondents were given hypothetical scenarios requiring them to prioritize hospital cost or hospital safety, they preferred the safer hospital 97% of the time, regardless of cost.[1] A study by McConnell et al[3] found that patients with AMI were more likely to choose hospitals with better performance on hospital quality measures and Pope demonstrated that public hospital rankings by *U.S. News and World Reports* have a significant effect on consumers' hospital-choice decisions.[4] The policy implications of our work are several fold. (1) To reemphasize that the scores reported on the Internet have clinical importance. (2) Scores similar to those used in this study may be implemented in efforts to improve patient adherence to medication, for example, by phone call at 30 days. (3) These or similar metrics may be used to motivate appropriate therapy, for example, by widespread publicity or reimbursement rules.

Limitations of this study based on an administrative database include the lack of information on dose and long-term adherence to the medications included in the quality scores, data on ejection fraction, hospitalization for catheterization, and that the hospital scores include recommendations for ACE blocker/ARBs only for LVSD. The small number of deaths occurring outside the state within 1 year of AMI discharge (1.4% of the total deaths) and the exclusion of non-New Jersey residents who had an AMI (4.3%) did not affect the overall conclusions of this study.[19] Because this study does not include physician level data, we could not definitely separate the effects of better treatment versus superior physicians. However, the conclusions of the study do not change when the teaching hospital variable is included in the analysis.

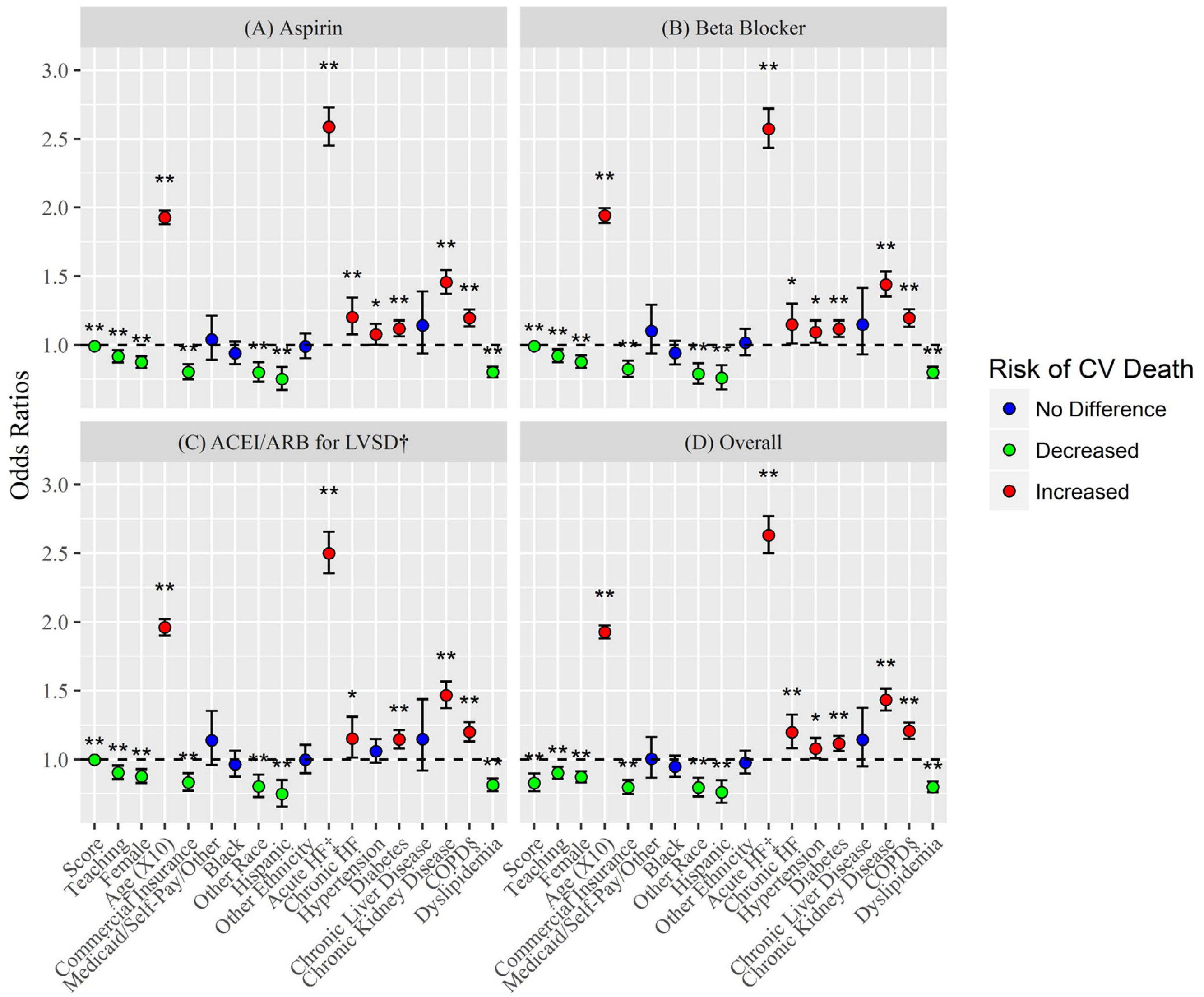

Figure 5. Odds ratios (ORs) of cardiovascular death at 1 year. Panel *(A) (left upper)* pertains to aspirin, panel *(B) (right upper)* pertains to β blocker, panel *(C) (left lower)* pertains to ACEI/ARB for left ventricular dysfunction, and panel *(D) (right lower)* pertains to the overall score. Asterisks indicate statistical significance of the estimated ORs. *p Value <0.05, **p value <0.01. †Angiotensin-converting enzyme inhibitor/angiotensin receptor blocker for left ventricular systolic dysfunction; ‡heart failure; §chronic obstructive pulmonary disease.

A strength of the study is that the diagnosis of AMI in MIDAS was validated by comparing the information in the hospital records of a randomly selected sample of MIDAS to the clinical charts using predefined criteria for the diagnosis of AMI.[20−23] Another strength is that the effect size was significant for the decrease in readmissions for AMI at 1 month (OR 0.789, 95% CI 0.691 to 0.902, p <0.001) associated with high hospital grades. CV death at 12 months was lower when hospital grades were high (OR 0.829, 95% CI 0.767 to 0.896, p <0.001). This is clinically meaningful because it pertains to mortality where the overall score was associated with 17% lower adjusted CV death. Extrapolated to the New Jersey population, this effect would result in 160 fewer CV deaths per year and extrapolated to the US 6800 fewer deaths per year.[24]

The inclusion of recent data from an unselected population with long-term follow-up up to 1 year is an additional strength. Previous studies examining the association of quality of care and clinical outcomes used data that was more than a decade old were performed on older patients or were of short duration.[2,7−10,12−15]

Our findings could be generalizable to other geographic areas in the United States. New Jersey has a large, diverse population with proportions of young and old as well as whites, African-Americans, and Hispanics similar (within 10%) to the overall United States.[25] In addition, the rate of uninsured patients in New Jersey was comparable to that reported in the United States overall (13.2% vs 14.5%).[26]

This study indicates that the overall composite score and the score for aspirin prescribed at discharge were positively and significantly associated with outcomes after 30 days, whereas all 4 AMI hospital process of care scores showed a reduced risk of CV death after 1 year.

Table 2
Logistic regression outcomes of hospital performance scores for acute myocardial infarction readmission or cardiovascular death at 30 days or 1 year

Duration (months)	Outcome	Process of care score	OR estimate	95% CI	p Value
1	Readmission for AMI	Aspirin	0.995	(0.990, 1)	0.046
		Beta blocker	0.994	(0.989, 1)	0.063
		ACEI/ARB for LVSD	0.996	(0.992, 1)	0.072
		Overall	0.789	(0.691, 0.902)	<0.001
	Cardiovascular death	Aspirin	0.996	(0.991, 1.001)	0.103
		Beta blocker	0.996	(0.991, 1.002)	0.196
		ACEI/ARB for LVSD	1.001	(0.997, 1.006)	0.525
		Overall	0.821	(0.726, 0.930)	0.002
12	Readmission for AMI	Aspirin	0.996	(0.994, 1.001)	0.114
		Beta blocker	0.998	(0.994, 1.001)	0.217
		ACEI/ARB for LVSD	0.999	(0.996, 1.002)	0.445
		Overall	0.940	(0.865, 1.022)	0.146
	Cardiovascular death	Aspirin	0.992	(0.989, 0.995)	<0.001
		Beta blocker	0.992	(0.989, 0.996)	<0.001
		ACEI/ARB for LVSD	0.997	(0.994, 0.999)	0.008
		Overall	0.829	(0.767, 0.896)	<0.001

ACEI = angiotensin-converting enzyme inhibitor; AMI = acute myocardial infarction; ARB = angiotensin receptor blockers; CI = confidence interval; LVSD = left ventricular systolic dysfunction; OR = odds ratio.

Disclosures

The authors have no conflicts of interest to disclose.

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