

## Taking the Reins on Systems of Care for ST-Segment–Elevation Myocardial Infarction Patients

### A Report From the American Heart Association Mission: Lifeline Program

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**Background**—Early success with regionalization of ST-segment–elevation myocardial infarction (STEMI) care has led many states to adopt statewide prehospital STEMI hospital destination policies, allowing emergency medical services to bypass non–percutaneous coronary intervention–capable hospitals. The association between adoption of these policies and patterns of care among STEMI patients is unknown.

**Methods and Results**—Using data from January 1, 2013, to December 31, 2014, from the National Cardiovascular Data Registry and Acute Coronary Treatment and Intervention Outcomes Network Registry, 6 states with bypass policies (cases included Delaware, Iowa, Maryland, North Carolina, Pennsylvania, and Massachusetts) were matched to 6 states without bypass policies (controls included South Carolina, Minnesota, Virginia, Texas, New York, and Connecticut) a priori on region, hospital density, and percent state participation in the registry. Using the matched sample, logistic regression models were adjusted for patient- and state-level characteristics. Outcomes were receipt of reperfusion and receipt of timely percutaneous coronary intervention. Our study cohort included 19 287 patients at 379 sites across 12 states. Patients from states with hospital destination policies were similar in age, sex, and comorbidities to patients from states without such policies. After adjustment for patient- and state-level characteristics, 57.9% (95% confidence intervals, 53.2%–62.5%) of patients living in states with hospital destination policies when compared with 47.5% (95% confidence intervals, 43.4%–51.7%) living in states without hospital destination policies received primary percutaneous coronary intervention within their relevant guideline–recommended time from first medical contact.

**Conclusions**—Statewide adoption of STEMI hospital destination policies allowing emergency medical services to bypass non–percutaneous coronary intervention–capable facilities is associated with significantly faster treatment times for patients with STEMI. (*Circ Cardiovasc Interv.* 2018;11:e005706. DOI: 10.1161/CIRCINTERVENTIONS.117.005706.)

**Key Words:** comorbidity ■ emergency medical services ■ hospitals  
■ percutaneous coronary intervention ■ registries

Heart disease remains the leading cause of death in the United States<sup>1</sup> and, in 2013, accounted for \$96.4 billion in total healthcare expenditures.<sup>2</sup> Every year >750 000 Americans suffer a myocardial infarction, and 30% of these are ST-segment–elevation myocardial infarctions (STEMI).<sup>3</sup> The time from first medical contact (FMC) to treatment in STEMI is a critical determinant of patient outcomes.<sup>4</sup> Emergency medical services (EMS) systems that can take patients directly to a hospital capable of performing immediate percutaneous coronary intervention (PCI) may dramatically shorten delays by bypassing other hospitals that do not provide such services. When a patient initially is taken to a non-PCI–capable hospital, considerable treatment delays are introduced as the patient must be evaluated, triaged, and wait for a second EMS

transport to be called, arrive, and take the patient from the initial hospital to the PCI hospital. However, not all EMS providers have the ability or authority to diagnose a STEMI and drive past the nearest hospital to a PCI-capable hospital.

#### See Editorial by Fiorilli and Kolansky

States differ greatly in their policies for EMS, and hospital bypass for time-critical conditions such as heart attack or trauma is far from universal in the United States.<sup>5</sup> Although 28 states have mandatory hospital destination policies for trauma patients, only 9 states currently have such policies for STEMI.<sup>6</sup> A recent survey of 381 unique systems across 47 states identified market competition between providers as the primary barrier to the establishment of statewide hospital destination policies for

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### WHAT IS KNOWN

- Time to treatment in ST-segment–elevation myocardial infarctions (STEMI) is a critical determinant of patient outcomes.
- Reducing delays relies on a robust emergency medical system (EMS) that can transport a patient directly to a percutaneous coronary intervention–capable hospital, even if it means driving past a closer hospital.
- Competition between hospitals, physician groups, and EMS agencies presents substantial barriers to the establishment and implementation of successful EMS systems of care for STEMI.

### WHAT THE STUDY ADDS

- State-level EMS policies improve quality of care for STEMI patients.
- STEMI patients who live in a state with a state-level policy that allows EMS to take them directly to a hospital with the ability to immediately perform percutaneous coronary intervention receive guideline-recommended care faster than STEMI patients who live in states without a state policy.

STEMI.<sup>7</sup> Thus, states may be best suited to lead regionalization efforts through regulatory mandates by acting as a neutral broker and directing resources toward this goal,<sup>8</sup> but few states have taken on this responsibility and some lack the regulatory authority to establish such systems.<sup>6</sup> Recently, state governments such as Illinois and Colorado have considered legislation to promote this process for STEMI, but these bills were ultimately tabled. As additional state governments grapple with the administrative and financial commitment to regionalize STEMI systems of care, they need data on the impact of state government participation in this process. In this study, we sought to answer the following question: are patients who live in states that have adopted mandatory statewide hospital destination policies for STEMI more likely to receive reperfusion therapy or immediate PCI within guideline-recommended time frames than patients living in similar states without such policies?

### Methods

We identified all patients with STEMI who arrived at the final destination hospital Acute Coronary Treatment and Intervention Outcomes Network (ACTION PCI center) by EMS using ACTION Registry–Get With The Guidelines (ACTION Registry–GWTG) data from January 1, 2013, to December 31, 2014 (Figure 1). The registry is a large quality improvement registry with voluntary participation from hospitals in the United States.<sup>9</sup> ACTION Registry–GWTG serves as the hospital data collection and evaluation mechanism for American Heart Association Mission: Lifeline. The Duke Clinical Research Institute serves as the data analysis center and has an agreement to analyze the aggregate deidentified data for research purposes. Several authors of this article are part of the Duke Clinical Research Institute and had full access to all the data in the study and take responsibility for its integrity and the data analysis. The data, analytic methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure. The registry has been granted a waiver of informed consent by the designated internal review board for

the National Cardiovascular Data Registry, which oversees the ACTION Registry–GWTG. Hospitals participating in the registry submit clinical information on the medical history, hospital care, and outcomes of consecutive patients hospitalized for acute coronary syndrome using an online, interactive case report form supplied by ACTION Registry–GWTG.

In 2013, Kupas et al<sup>6</sup> conducted a survey of all state EMS directors or EMS medical directors to define current characteristics of statewide policies for EMS in the United States. Fifty states responded to the survey, which identified 9 states as having mandatory statewide hospital destination policies used by all EMS providers within the state that guide EMS transport of patients with STEMI directly to a PCI-capable hospital if appropriate. Each of these states' EMS offices was contacted, and the date of policy adoption and full implementation was confirmed. States that had implemented their policies by 2013 were selected as case states in our analysis. Using a greedy matching algorithm, 6 states with hospital destination policies (cases) were matched to 6 states without hospital destination policies (controls) a priori on region, hospital density, and percent state participation in the registry.

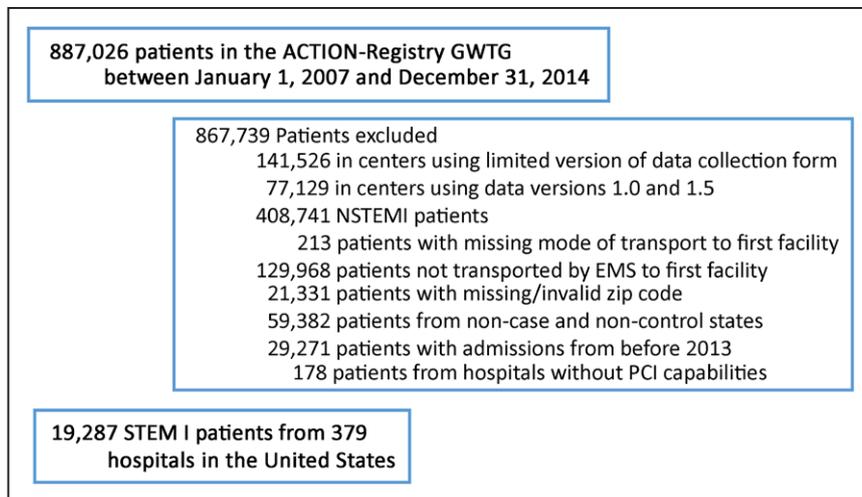
We constructed several regression models to isolate the effects of living in states that have adopted hospital destination policies. Our key outcomes were (1) primary PCI within 90 minutes and (2) 120 minutes from FMC and (3) overall receipt of reperfusion therapy. Using the matched sample, logistic regression models adjusted for patient- and state-level characteristics and accounting for case–control match were fitted for receipt of any reperfusion therapy and PCI within guideline-recommended time frames. To account for the case–control match, indicator variables for each case–control match were included in the logistic regression models.

### Results

Our case states were Delaware, Iowa, Maryland, North Carolina, Pennsylvania, and Massachusetts and were matched to the respective control states: South Carolina, Minnesota, Virginia, Texas, New York, and Connecticut, with 19287 patients at 379 sites (Table 1). The number of patients and number of sites varied greatly between individual states, but overall contributed to 2 well-balanced groups of patients (Table 2). Patients from states with hospital destination policies were similar in age, sex, and comorbidities to patients from states without hospital destination policies (Table 2). They were more likely to be white, have private insurance, and reside in rural areas in unadjusted analysis.

Hospital-level characteristics between the 2 groups were similar, with more than three quarters (78%) of patients admitted to hospitals having on-site cardiothoracic surgery available, 77% classifying as nonacademic, and a mean number of hospital beds of 448. States without hospital destination policies tended to have a lower hospital density and population density than states with hospital destination policies. State-level median household income, race, and percent participation in the registry were comparable between groups (Table 3).

When we examined intermediate steps in the process of STEMI care, we noticed interesting trends. Rates of prehospital ECG utilization were high, and patients in states with hospital destination policies were more likely to have a prehospital ECG obtained (74.7%) than patients in states without hospital destination policies (68.7%). The time of symptom onset to hospital arrival was no different between the 2 groups, even though patients in states with hospital destination policies received treatment faster from the time of FMC. However, there was a >10% missing rate for the variable symptom onset to reperfusion time. Finally, the median time from symptom onset to hospital arrival was quite lengthy in both groups, 1.5 hours overall with a 25th quartile of 1 hour and a 75th quartile of 2.7 hours (Table 2).



**Figure 1.** Selection of study population. ACTION indicates Acute Coronary Treatment and Intervention Outcomes Network; EMS, emergency medical services; GWTG, Get With The Guidelines; NSTEMI, non-ST-segment-elevation myocardial infarction; and PCI, percutaneous coronary intervention.

Several important observations are demonstrated in Figure 2. First, patients living in states that have adopted hospital destination policies were significantly more likely to receive timely primary PCI. This time advantage persisted at 90 and 120 minutes from FMC, respectively (odds ratio [OR], 1.59; 95% confidence interval [CI], 1.19–2.12 and OR, 1.44; 95% CI, 1.06–1.95). Second, overall unadjusted rates of receipt of any reperfusion therapy were high at 96.8%, with a trend toward higher use for patients in states with hospital destination policies in the adjusted analysis (OR, 1.77; 95% CI, 0.96–3.24). In summary, living in a state with a statewide prehospital plan for EMS transport of STEMI patients is associated with faster treatment times.

Some patients in our study (13%) were transported by EMS to a non-PCI-capable hospital first and subsequently were transferred to a PCI-capable hospital. The American College of Cardiology/ American Heart Association treatment guidelines for STEMI care recommend that patients who arrive directly to a PCI-capable hospital receive PCI in <90 minutes and patients who are transferred into a PCI-capable hospital receive PCI in <120 minutes from FMC.<sup>3</sup> Therefore, we examined if patients were more likely to receive PCI within the relevant guideline time recommendation, taking into account their mode of arrival to the PCI-capable hospital (direct arrival versus transfer-in). Figure 3 demonstrates that after adjustment for patient- and state-level characteristics, 57.9% (95% CIs, 53.2%–62.5%)

of patients living in states with hospital destination policies when compared with 47.5% (95% CIs, (43.4%–51.7%)) living in states without hospital destination policies received primary PCI within their relevant guideline-recommended time from FMC. This analysis reinforces our conclusion that living in a state with a statewide prehospital plan for EMS transport of STEMI patients is associated with faster treatment times.

**Discussion**

Our study suggests that statewide hospital destination policies for STEMI organized by the state government allow EMS providers to more effectively triage patients to meet guideline recommendations. STEMI patients living in states with statewide hospital destination policies were more likely to receive any reperfusion therapy and were more likely to receive timely PCI than STEMI patients in states without such policies.

The implications of these findings are broad and important. There are several potential explanations for why a statewide plan for EMS transport of patients with time-critical conditions would be more effective than local or regional policies. Many EMS agencies provide services in multiple counties and health systems, so having a statewide hospital destination policy streamlines expectations for patient transport, data collection, and quality improvement. A statewide system of EMS care for STEMI can account for and

**Table 1. State Characteristics Used for Matching States With Hospital Destination Policies (Cases) and States Without Hospital Destination Policies (Controls)**

State		Region		Hospital Density		%Participation ACTION	
Case (n=8656, No. of Sites=206)	Control (n=10 631, No. of Sites=284)	Case	Control	Case	Control	Case	Control
Delaware	South Carolina	South	South	3.5	2.2	100	100
Iowa	Minnesota	Midwest	Midwest	2.1	1.6	57	56
Maryland	Virginia	South	South	4.8	2.3	96	87
Massachusetts	Connecticut	Northeast	Northeast	10.0	6.8	24	53
North Carolina	Texas	South	South	2.2	1.6	91	97
Pennsylvania	New York	Northeast	Northeast	4.2	3.6	79	64

ACTION indicates Acute Coronary Treatment and Intervention Outcomes Network Registry.

**Table 2. Demographic Characteristics of Patients Living in States With Hospital Destination Policies and Patients Living in States Without Hospital Destination Policies**

Characteristic	No Destination Policies (n=10 631)	Destination Policies (n=8656)
<b>Demographics</b>		
Age, y	62.6±13.4	63.5±13.5
Female, n (%)	3376 (31.8)	2857 (33.0)
BMI (kg/m <sup>2</sup> )	29.0±6.5	29.03±6.5
White, n (%)	7200 (67.7)	7092 (81.9)
<b>Insurance status, n (%)</b>		
HMO/private	5482 (51.6)	5009 (57.9)
Medicare	2503 (23.5)	2029 (23.4)
Military/VAMC	192 (1.8)	110 (1.3)
Medicaid	517 (4.9)	504 (5.8)
Self/none	1825 (17.2)	940 (10.9)
Rural status, n (%)	1587 (14.9)	1838 (21.2)
<b>Medical history, n (%)</b>		
Current/recent smoker (<1 yr)	4236 (39.9)	3517 (40.6)
Hypertension	7226 (68.0)	5845 (67.5)
Dyslipidemia	5684 (53.5)	4765 (55.1)
Diabetes mellitus	3124 (29.4)	2331 (26.9)
Prior MI	2039 (19.2)	1775 (20.5)
Prior CHF	692 (6.5)	483 (5.6)
Prior PCI	2200 (20.7)	1899 (22.0)
Prior CABG	661 (6.2)	537 (6.2)
<b>Signs and symptoms at presentation, n (%)</b>		
<b>Location patient first evaluated</b>		
ED	8629 (81.2)	6735 (77.8)
CathLab	1713 (16.1)	1618 (18.7)
First ECG obtained prehospital	7298 (68.7)	6467 (74.7)
Symptom onset to arrival, h*	1.4 (1.0, 2.7)	1.5 (1.0, 2.7)
First medical contact to balloon time, min	93 (74, 118)	89 (72, 114)
Door-to-balloon time, min	52 (38, 67)	48 (35, 62)
Heart rate on admission, bpm	80.3±26.1	78.4±26.8
Systolic blood pressure on admission (mm Hg)	133.8±38.0	132.8±39.8
Cardiac arrest	1177 (11.1)	915 (10.6)
Direct arrival to a PCI-capable hospital	9335 (87.8)	7514 (86.8)
Prehospital cardiac arrest	987 (83.9)	785 (85.8)
Outside facility cardiac arrest	117 (9.9)	111 (12.1)
Baseline creatinine, mg/dL	1.2±0.7	1.1±0.6

Continuous variables are presented as mean±SD or median (25th percentile, 75th percentile). ACTION indicates Acute Coronary Treatment and Intervention Outcomes Network; BMI, body mass index; CABG, coronary artery bypass graft; CHF, congestive heart failure; GWTG, Get With The Guidelines; HMO, health maintenance organization; MI, myocardial infarction; PCI, percutaneous coronary intervention; and VAMC, Veterans Administration Medical Center.

\*Among patients who arrived directly to the ACTION Registry-GWTG hospital.

**Table 3. Hospital- and State-Level Characteristics of Patients Living in States With Hospital Destination Policies and Patients Living in States Without Hospital Destination Policies**

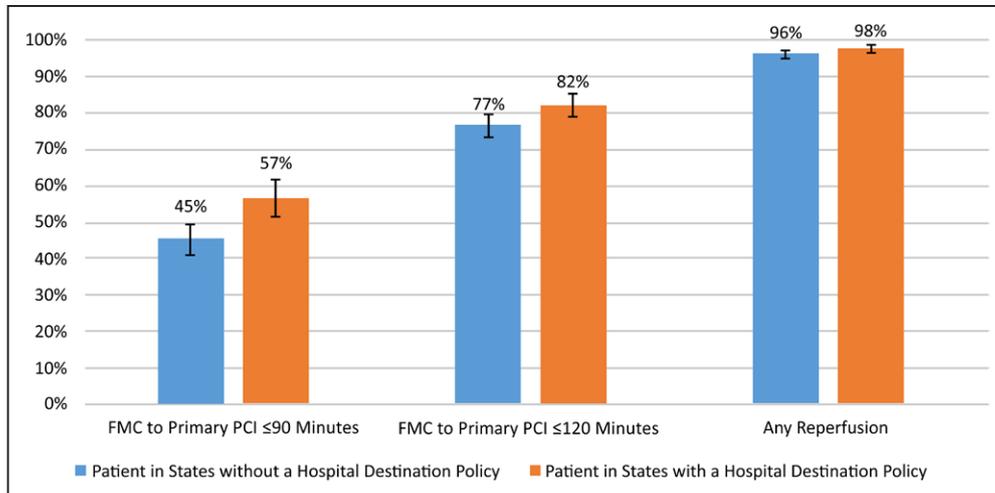
Characteristic	No Destination Policies (n=10631)	Destination Policies (n=8656)
<b>Hospital-level characteristics</b>		
Type of hospital		
PCI, no surgery	2291 (21.6)	1990 (23.0)
Surgery	8340 (78.5)	6666 (77.0)
Teaching hospital		
Nonacademic	8161 (76.8)	6658 (76.9)
Academic	2109 (19.8)	1760 (20.3)
Total hospital beds	444.3±306.5	453.5±227.0
<b>State-level characteristics</b>		
White (%)	72.3±7.7	74.9±11.9
Median household income (\$)	52 905±8883	53 585±7914
Hospital density (per 1000 land square miles)	3.0±2.0	4.5±2.9
Population density (per square mile of land area)	278.1±256.2	404.9±286.0
Percent participation in ACTION	76.2±21.0	74.5±29.2

ACTION indicates Acute Coronary Treatment and Intervention Outcomes Network; and PCI, percutaneous coronary intervention.

facilitate coordination with multiple involved agencies such as fire, law enforcement, EMS, hospitals, and public health to better ensure accountability and system integrity.<sup>5</sup> In addition, state governments currently license EMS and other healthcare providers, so policies developed by a state lead agency may better account for the training and qualifications of various healthcare providers caring for STEMI patients within a state. Finally, a state lead agency has the potential legal authority and resources to designate and recognize specialty receiving centers.

Still the question of governance<sup>10</sup> remains controversial in EMS systems of care, and despite these advantages to state leadership, many states have not created statewide systems of emergency care for time-critical conditions.<sup>6</sup> Some state EMS offices lack the statutory authority to recognize or designate specialty receiving centers or to enforce statewide hospital destination policies. A potential reason has been the lack of clear evidence for their benefit that has pushed for greater movement in this area. Other concerns have been raised that these policies may disadvantage non-PCI-capable hospitals, but evidence for this is lacking.<sup>11</sup> Our findings suggest that state EMS offices can be very effective in organizing systems of care for STEMI that enhance the quality of STEMI care, extending the reach of prior public policy directed toward in-hospital quality metrics for STEMI<sup>12</sup> to the out-of-hospital setting.

Our data show that STEMI patients receive primary PCI in a timelier manner in those states that facilitate direct EMS transport to PCI-capable hospitals (OR, 57.9%; 95% CIs, 53.2%–62.5% versus OR, 47.5%; 95% CI, 43.4%–51.7%,

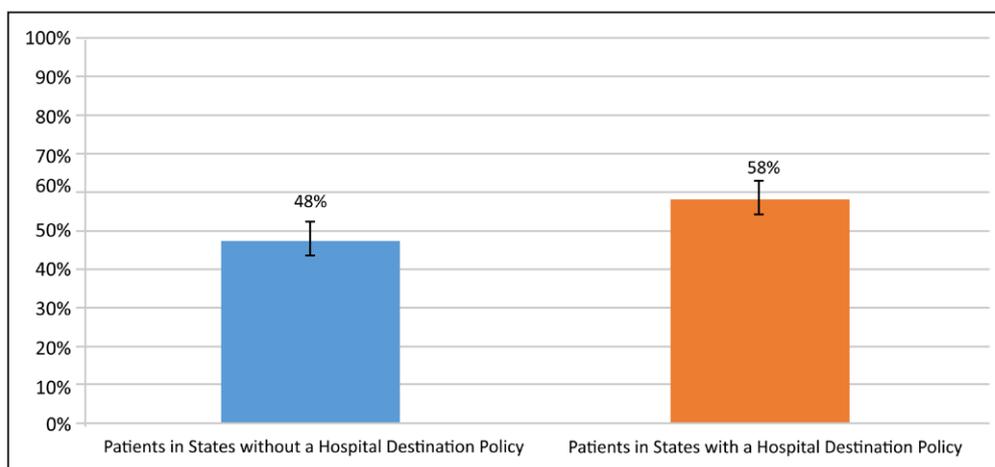


**Figure 2.** Adjusted proportion of ST-segment–elevation myocardial infarctions (STEMI) patients transported by emergency medical services who received treatment by state hospital destination policy. Adjusted for age, sex, white race, urban residence, insurance status, diabetes mellitus, prior myocardial infarction, prior percutaneous coronary intervention (PCI), prior stroke, prior coronary artery bypass graft, prior heart failure, dyslipidemia, cardiogenic shock/heart failure on presentation, prehospital cardiac arrest, creatinine clearance (mL/min), systolic blood pressure, heart rate, median household income (state level), and percent white (state level). Excluding patients with contraindications for any reperfusion outcome. The error bars represent 95% confidence limits. FMC indicates first medical contact.

respectively). It also is noteworthy that the overall reduction in time from both FMC to balloon and door to balloon seems rather modest at 4 minutes for patients living in states with hospital destination policies. Controversy remains over the potential clinical significance of reducing total ischemic time by a few minutes when times are already within guideline-recommended time frames. For example, Menees et al<sup>13</sup> did not find a significant reduction in in-hospital or unadjusted 30-day mortality associated with annual trends in improvements in door-to-balloon times by roughly 16 minutes on a population level. Nallamothu et al,<sup>14</sup> however, reanalyzed the same data after accounting for the potential of an ecological fallacy and demonstrated that effects at the individual level are important even if modest at the population level. The mean door-to-balloon times in our study, of 48 minutes for patients living in states with hospital destination policies and

52 minutes for patients living in states without hospital destination policies, were well within guideline-recommended time frames for both groups. Many mitigating factors affecting STEMI mortality continue to exist when considering both population- and individual-level effects, and most cardiologists still agree that minimizing total ischemic time improves patient outcomes.

A key challenge we noted was that a substantial number of patients failed to access EMS or delayed accessing EMS. For example, 27% of potentially eligible (129 968/478 285) STEMI patients in our study (Figure 1) self-transported to a hospital, without using EMS. This finding is consistent with previous work.<sup>15</sup> Thus, failure to access EMS identifies yet another objective for process improvement. In our study, time from symptom onset to presentation remained a substantial barrier to timely care in both study groups. This



**Figure 3.** Adjusted proportion of ST-segment–elevation myocardial infarctions (STEMI) patients transported by emergency medical services who received primary percutaneous coronary intervention (PCI) within guideline-recommended time from first medical contact by state hospital destination policy. Patients were considered to have met guideline-recommended time frames if those patients transported directly to a PCI-capable hospital received primary PCI within 90 minutes of first medical contact and those patients who were transferred into a PCI-capable hospital received primary PCI within 120 minutes of first medical contact. The error bars represent 95% confidence limits.

factor is largely influenced by the time it takes for a patient to call EMS. Community health literacy about heart attack symptoms and the importance of calling 9-1-1 remain additional barriers to timely STEMI care. Although statewide EMS mandates for hospital transport of STEMI patients seem to expedite guideline-compliant STEMI care, delay or failure to access EMS remains an important objective for improvement.

Our finding that a state-level policy intervention focused on EMS processes improved STEMI care is consistent with prior studies,<sup>16</sup> showing that modifying EMS processes can improve STEMI care without increasing the number of PCI-providing centers. Despite an estimated increase in US PCI capacity of 44% between 2000 and 2006, with an estimated 521 new PCI programs, access increased only marginally at an estimated 1%, defined as 60 minutes or less ground transportation driving time.<sup>17</sup> Similarly between 2004 and 2008, a 16.5% increase in PCI capacity translated into only a modest 1.8% increase in access to timely PCI.<sup>18</sup> Thus, it is noteworthy that the improvements in STEMI care delivery seem to have been achieved without expanding the number of PCI-capable centers.

Our method for selecting control states used a reproducible and nonbiased approach to identify patients as similar as possible to the patients in case states. An unintended, but serendipitous consequence of this was the inclusion of several control states that have sophisticated systems of STEMI care championed by the private sector and without formal state government policies. Although inclusion of these states potentially diluted the strength of the associations observed in this study, it provides a unique counterbalance to the argument that local and regional solutions are as effective as state-led systems of EMS care for time-critical conditions.

Our study has a few limitations. First, we evaluated a state-level policy intervention in a cohort of voluntary hospitals with incomplete penetration of the registry in every state. For this reason, we used penetration of ACTION Registry-GWTG within each state as a criterion for state selection and matching. Second, some states without hospital destination policies have local and regional systems of care that are not accounted for in our analysis. The registry does not collect location of FMC by EMS in the field, and, therefore, we were unable to adjust for driving times to the nearest PCI-capable hospital. Third, patients had to survive to arrival at an ACTION hospital to be included in this analysis, and thus, we may have missed patients who died before evaluation within the healthcare system or en route to definitive therapy. Finally, our study is observational and cannot definitively determine a causal link between hospital destination policies and patterns of care for STEMI patients. Yet the study of state-level policy interventions is rarely assessed using randomized designs and, thus, frequently relies on natural experiments that compare interventions across similar communities.

## Conclusions

Statewide EMS policies directing transport of STEMI patients to hospitals for immediate PCI improve their timely receipt of guideline-recommended therapy.

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## Disclosures

Dr Mears serves as the Medical Director at Zoll. The other authors report no conflicts.

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## Taking the Reins on Systems of Care for ST-Segment–Elevation Myocardial Infarction Patients: A Report From the American Heart Association Mission: Lifeline Program

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