Impact of Regionalization of ST-Segment–Elevation Myocardial Infarction Care on Treatment Times and Outcomes for Emergency Medical Services–Transported Patients Presenting to Hospitals With Percutaneous Coronary Intervention

Mission: Lifeline Accelerator-2

BACKGROUND: Regional variations in reperfusion times and mortality in patients with ST-segment–elevation myocardial infarction are influenced by differences in coordinating care between emergency medical services (EMS) and hospitals. Building on the Accelerator-1 Project, we hypothesized that time to reperfusion could be further reduced with enhanced regional efforts.

METHODS: Between April 2015 and March 2017, we worked with 12 metropolitan regions across the United States with 132 percutaneous coronary intervention–capable hospitals and 946 EMS agencies. Data were collected in the ACTION (Acute Coronary Treatment and Intervention Outcomes Network)-Get With The Guidelines Registry for quarterly Mission: Lifeline reports. The primary end point was the change in the proportion of EMS-transported patients with first medical contact to device time ≤90 minutes from baseline to final quarter. We also compared treatment times and mortality with patients treated in hospitals not participating in the project during the corresponding time period.

RESULTS: During the study period, 10730 patients were transported to percutaneous coronary intervention–capable hospitals, including 974 in the baseline quarter and 972 in the final quarter who met inclusion criteria. Median age was 61 years; 27% were women, 6% had cardiac arrest, and 6% had shock on admission; 10% were black, 12% were Latino, and 10% were uninsured. By the end of the intervention, all process measures reflecting coordination between EMS and hospitals had improved, including the proportion of patients with a first medical contact to device time of ≤90 minutes (67%–74%; $P<0.002$), a first medical contact to device time to catheterization laboratory activation of ≤20 minutes (38%–56%; $P<0.0001$), and emergency department dwell time of ≤20 minutes (33%–43%; $P<0.0001$). Of the 12 regions, 9 regions reduced first medical contact to device time, and 8 met or exceeded the national goal of 75% of patients treated in ≤90 minutes. Improvements in treatment times corresponded with a significant reduction in mortality (in-hospital death, 4.4%–2.3%; $P=0.001$) that was not apparent in hospitals not participating in the project during the same time period.

CONCLUSIONS: Organization of care among EMS and hospitals in 12 regions was associated with significant reductions in time to reperfusion in patients with ST-segment–elevation myocardial infarction as well as in in-hospital mortality. These findings support a more intensive regional approach to emergency care for patients with ST-segment–elevation myocardial infarction.

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Clinical Perspective

What Is New?

- The Accelerator-2 project organized ST-segment–elevation myocardial infarction care, with systematic implementation of processes outlined in the American Heart Association Mission: Lifeline program, in 12 metropolitan regions across the United States.
- In comparison with prior efforts, dedicated regional coordinators and mentoring faculty were engaged throughout the intervention. Like prior US regionalization programs, the intervention was associated with improved treatment times for emergency medical system–transported patients (first medical contact to device ≤90 minutes increasing from 67% to 74% with 8 of the 12 regions exceeding this guideline goal by the end of the study).
- A new finding in this program was that the intervention was associated with a significant decline in mortality, which was not seen in patients treated in reference regions during the same time period.

What Are the Clinical Implications?

- The approach to coordinating the care of patients with ST-segment–elevation myocardial infarction on a regional basis, engaging all hospitals and emergency medical systems and using a common data structure for measurement and feedback, can reduce the time to reperfusion.
- These improved reperfusion times along with enhanced organization correspond with reductions in morbidity and mortality.
- This supports the class I recommendation in the American College of Cardiology/American Heart Association ST-segment–elevation myocardial infarction guidelines that "all communities should create and maintain a regional system of STEMI care that includes assessment and continuous quality improvement of EMS and hospital-based activities."
- This study provides specific guidance on how this engagement can be successfully accomplished.

There is significant variability across the United States in the timely reperfusion and mortality of patients with ST-segment–elevation myocardial infarction (STEMI) (Figure 1). Most of this variation is related to differences in the organization and delivery of emergency cardiovascular care. The most successful regional systems have implemented processes in which emergency medical service (EMS) providers obtain prehospital ECGs and activate cardiac catheterization laboratories before hospital arrival, bypass the emergency department (ED) when appropriate, and provide ongoing quality review and feedback.[1–8] In the STEMI Accelerator-1 project, we demonstrated modest improvements in the frequency and speed of coronary reperfusion by organizing STEMI care in 16 regions in which 23 809 patients were treated during the intervention by using evidence-based care and the Mission: Lifeline plan.[6,9,10] However, at the end of the intervention, not all regions had implemented processes necessary to allow EMS providers to obtain prehospital ECGs, activate catheterization laboratories, and bypass the ED when the laboratory was available. Hospitals that implemented key care processes reduced time to reperfusion and had shorter time to reperfusion than hospitals that did not implement these processes.[11] Building on our experience from this intervention, we launched the Mission: Lifeline Accelerator-2 project to test our hypothesis that time to reperfusion could be further reduced with the addition of full-time regional coordinators supported by the study and ongoing engagement of national faculty.

METHODS

The data, analytic methods, and study materials may be provided to other researchers for purposes of reproducing the results through direct contractual agreements with the participating hospital, the American Heart Association, and the American College of Cardiology.

The Accelerator-2 project was conducted between April 2015 and March 2017. Twelve regions that met 1 of 2 sets of criteria were selected. The first set of criteria was for regions that had not fully implemented regional STEMI plans but had the potential to do so based on (1) willingness to participate in the National Cardiovascular Data Registry's ACTION (Acute Coronary Treatment and Intervention Outcomes Network) Registry-Get With The Guidelines (AR-G) program; (2) engagement of recognized regional leadership; (3) willingness to develop and ratify common protocols across the region for the diagnosis and treatment of patients with STEMI; (4) formal agreement to enter patients into AR-G during the study period; and (5) commitment of regional leadership to participate in a 2-day national training session directed by study faculty reviewing current evidence, guidelines, and best practice approaches to regional STEMI care. The second set of criteria was for regions that had participated in the STEMI Accelerator-1 program or had potential for expansion and further improvement with continued participation.

The primary analysis was the change in the proportion of patients meeting the goal of first medical contact (FMC) to device between the baseline and final quarters. Secondary analyses included changes in additional processes of care evaluated each quarter, including FMC to cardiac catheterization laboratory arrival, ED dwell time, and changes in in-hospital complications and death. Baseline and final quarters were prospectively specified at the hospital level, with baseline defined as the first full quarter of data collection before study intervention, and final defined as the last full quarter of data collection under project coordination. The project was conducted in a fashion similar to STEMI Accelerator-1, with development of regional leadership, common protocols, and data measurement and

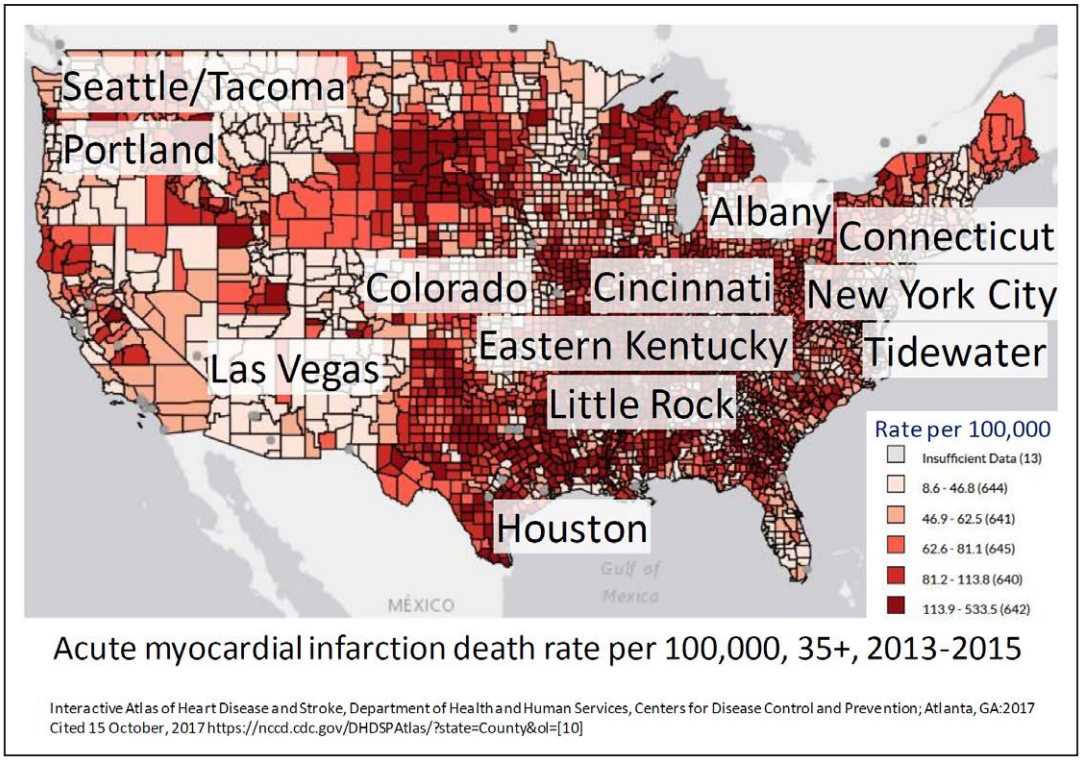

Figure 1. Accelerator-2 regions.

feedback in quarterly reports to identify variances from protocol or systematic barriers and hasten the diagnosis and reperfusion of patients with STEMI.[9] A number of enhancements were designed to improve implementation over that achieved in STEMI Accelerator-1. Grant funds were allocated to hire a full-time coordinator for each region who was not affiliated with any individual hospital. These coordinators had a variety of backgrounds in public health, quality improvement, nursing and paramedic experience, and statistics. Coordinators were selected and used by the local American Heart Association (AHA) affiliate according to experience in public health or emergency cardiovascular care, strong interpersonal skills, enthusiastic leadership, and ability to understand data and implement process improvement in collaboration with regional health care professionals and the Duke Clinical Research Institute study team. Funds were also allocated to provide at least 2 faculty mentors for each region throughout the project. Faculty mentors included nurses, paramedics, and physicians with expertise in organizing regional STEMI care. The mentorship pair conducted an on-site strategic assessment of current STEMI care in each region before the study intervention.

Statistics

Descriptive statistics for continuous and categorical variables were summarized as medians (25th, 75th percentiles) and numbers (percentages), respectively. Patient characteristics and process measures were compared by using the Wilcoxon rank-sum test for 2-group comparisons (the Kruskal-Wallis test was used for comparisons of >2 groups) for continuous variables and Pearson χ^2 or Fisher exact tests, as appropriate, for categorical variables. Baseline versus final quarter in-hospital mortality was analyzed by using a multivariable logistic regression model using generalized estimating equations with an exchangeable working correlation matrix to account for clustering within hospitals. This correlation structure assumes that hospitals are independent and patients within hospitals are equally correlated. Adjusted and unadjusted odds ratios and 95% confidence intervals were estimated from the logistics model. Covariates included in the adjusted model were age, creatinine, systolic blood pressure, troponin ratio, heart failure, heart rate, cardiac arrest, cardiogenic shock, and peripheral artery disease.[12] Only hospitals with a minimum of 4 quarters of data collection were included in the analysis. All patients with ischemic symptoms lasting >10 minutes within 12 hours before arrival and an ECG with diagnostic ST-segment elevation were included in the analyses. In cases when the first ECG did not have diagnostic ST-segment elevation, FMC time was reset to the first diagnostic ECG. Treatment times and mortality in hospitals not participating in the Accelerator-2 project that contributed data to AR-G as part of Mission: Lifeline during the corresponding time period, quarter 4 2015 through quarter 4 2016, were used for comparisons. All analyses were 2-sided and tested at the nominal 0.05 significance level, and no adjustment was made for multiple testing. Statistical analyses were performed with SAS version 9.4 (SAS Institute Inc). The project was reviewed by the Duke Institutional Review Board and classified as exempt from oversight.

RESULTS

Patient Characteristics and Presentation

Between April 2015 and March 2017, 21 160 patients presented with acute STEMI to 132 hospitals in the 12 US re-

gions (Tables I and II in the online-only Data Supplement). This included 10730 patients transported by EMS providers directly to hospitals with percutaneous coronary intervention (PCI) capabilities, 5884 patients who were self-transported directly to PCI-capable hospitals, and 4546 patients who were transferred from hospitals without PCI capability to PCI-capable hospitals. This analysis primarily includes the 6695 patients transported by EMS providers directly to PCI-capable hospitals who met AHA criteria for inclusion. Patients with nonsystem reasons for delay were excluded from Mission: Lifeline reports.[13] The reasons and percentage of overall exclusions per reason included cardiac arrest and intubation before PCI (35%), delays in consent (6%), difficulty with vascular access (9%) or crossing the lesion (18%), and other (33%). The proportion of patients excluded in each quarter varied, with ≈3% fewer patients excluded in the first quarter in comparison with subsequent quarters (quarter 4 2015, 36.7%; quarter 1 2016, 39.7%; quarter 2 2016, 37.6%; quarter 3 2016, 39.1%; and quarter 4 2016, 39.4%). The demographic and clinical characteristics of patients transported by EMS are presented in Table 1. The median age of patients in the overall cohort was 62 years; 30% were women, ST-segment elevation was apparent on the initial ECG for 84% of patients, and 97% of patients were thought to be appropriate candidates for reperfusion based on medical record review. Of patients eligible for reperfusion, 93% received reperfusion therapy. After excluding patients with nonsystem reasons for delay from regional reports, the proportion of patients with cardiac arrest and shock on presentation fell from 11% and 10% to 6% and 6%, respectively. Patients treated in hospitals not participating in the Accelerator-2 project contributing data to AR-G Mission: Lifeline from quarter 4 2015 through quarter 4 2016 were similar in age, had fewer blacks (9.6% versus 10.3%, $P<0.0001$), patients of Latino ethnicity (5.4% versus 10.6%, $P<0.0001$), and patients with Medicaid insurance (12.0% versus 19.6%, $P<0.0001$), and similar illness severity measures (shock, 6.5% versus 6.5%, $P=0.93$; cardiac arrest, 5.8% versus 5.9%, $P=0.85$; heart failure on presentation, 4.5% versus 4.9%, $P=0.31$).

Changes in Treatment Times From Baseline to Postintervention

During the baseline quarter of the project, 974 patients were treated at 132 participating PCI-capable hospitals; in the final quarter, 972 patients were treated in these same hospitals. Demographic and clinical characteristics were similar between the 2 quarters, with the exception of a slightly lower heart rate in the final quarter (78 versus 75 beats/min; $P=0.038$). Symptom onset to FMC was 50 minutes in both the baseline and final quarters. There were significant reductions in time to treatment, including the proportion of patients with FMC to catheterization laboratory activation time ≤20 minutes (38% baseline, 56% final; $P<0.0001$), the proportion spending ≤20 minutes in the ED (33% baseline, 43% final; $P<0.0001$) (Figure 2), and the proportion of patients treated within 90 minutes of FMC (67% baseline, 74% final; $P<0.002$) (Figure 3; Table 2). Nine of the 12 regions had an increase in the proportion of patients treated within 90 minutes, and 8 regions achieved the national Mission: Lifeline[11] goal of at least 75% of patients treated within 90 minutes by the end of the study. Of the 3 regions that did not improve, 2 were already meeting the Mission: Lifeline goal of 75% treated within 90 minutes of FMC in the baseline quarter, and 1 region had a decline in performance in this measure. With the use of quarter 4 2015 and quarter 4 2016 as baseline and final quarters, patients treated in hospitals not participating in the Accelerator-2 project had no change in the proportion of patients treated within 90 minutes of FMC (72.2%–72.1%, $P=0.91$).

To characterize and approximate the full potential of the project, we identified a subset of hospitals that were not meeting goals at baseline and were able to implement the systematic processes as identified by improvement in care processes. For this subset of 57 hospitals, 441 patients were treated in the baseline quarter and 429 were treated in the final quarter. The treatment times were improved, with the proportion of patients spending ≤20 minutes in the ED increasing from 27% to 52% ($P<0.0001$) and the proportion of patients treated within 90 minutes of FMC increasing from 66% to 78% ($P<0.0001$), and a decline in median FMC to device time from 84 to 76 minutes ($P<0.0001$). This subset illustrates the potential of the intervention with full implementation.

Changes in Clinical Outcomes From Baseline to Postintervention

Among patients brought to PCI-capable centers by EMS, in-hospital mortality fell from 4.4% to 2.3% ($P=0.001$) and heart failure as a complication fell from 7.4% to 5.0% ($P=0.031$) between the baseline and final quarters (Table 2). Other complications developing after admission, including stroke, cardiogenic shock, and major bleeding, were unchanged. After adjusting for demographic and clinical characteristics, the mortality improvement remained statistically significant (adjusted odds ratio, 2.16; 95% confidence interval, 1.17–3.99; $P=0.013$). To further understand the possibility for the observed mortality changes to be related to secular trend rather than the intervention, we examined mortality by quarter for patients in the Accelerator-2 project versus patients in other Mission: Lifeline hospitals collecting data in AR-G during the same period from quarter 4 2015 through quarter 4 2016, the 5 quarters with full participation by Accelerator regions. This demonstrated a statistically significant trend for declining mortality for

Table 1. Patients Transported to Primary PCI-Capable Hospitals by Emergency Medical Service Providers, Demographic and Clinical Characteristics

	All Patients	After AHA Exclusions	Baseline Quarter	Final Quarter	*P* Value Comparing Baseline and Final Quarters
No.	10730	6695	974	972	
Age, y, median (25, 75th percentiles)	62 (54, 71)	61 (53, 69)	61 (54, 70)	61 (53, 70)	0.477
Male, %	70.1	73.1	70.6	73.7	0.137
Female, %	29.9	26.9	29.4	26.3	
Race, %					0.985
White	80.2	81.4	80.7	80.6	
Black	11.5	10.2	10.1	10.0	
Other	8.3	8.5	9.2	9.5	
Latino ethnicity					0.511
n	10641	6636	969	959	
%	11.4	11.5	10.8	11.8	
Insurance					
Private/HMO, %					0.391
n	9723	6049	885	884	
%	63.1	63.4	64.7	62.8	
Medicaid, %					0.305
n	9723	6049	885	884	
%	19.0	19.4	18.9	20.8	
None, %	9.4	9.6	9.1	9.1	0.949
Other, %	19.3	18.4	18.4	18.4	0.983
Prior myocardial infarction					0.204
n	6546	4031	572	590	
%	19.6	18.2	16.8	19.7	
Prior heart failure					0.095
n	6542	4030	571	590	
%	6.8	4.5	3.7	5.8	
Prior PCI					0.122
n	6548	4031	571	590	
%	20.3	20.0	18.4	22.0	
Prior coronary bypass surgery					0.082
n	6540	4031	572	590	
%	4.9	3.3	2.8	4.7	
Diabetes mellitus					0.509
No.	10720	6691	973	972	
%	27.0	24.4	26.4	25.1	
Symptom onset to first medical contact					0.751
No.	9189	6037	864	887	
Median, min (25, 75th percentiles)	50 (25, 126)	49 (26, 118)	50 (26, 113)	50 (26, 120)	
Shock on presentation					0.676
n	10712	6685	973	968	
%	10.3	6.2	5.5	6.0	

(*Continued*)

Table 1. Continued

	All Patients	After AHA Exclusions	Baseline Quarter	Final Quarter	*P* Value Comparing Baseline and Final Quarters
Cardiac arrest on presentation					0.324
n	10706	6681	973	969	
%	10.8	5.9	5.9	4.9	
Heart failure on presentation					0.983
n	10714	6684	972	968	
%	8.8	5.0	5.0	5.1	
Reperfusion candidate					0.500
n	10704	6687	972	971	
%	97.1	99.8	100.0	99.9	
Heart rate on presentation, bpm					0.038
n	10640	6654	971	964	
Median	77	76	78	75	
Systolic BP, mm Hg					0.713
n	10633	6649	971	963	
Median	136	137	139	138	
STEMI diagnosed on first ECG					1.000
n	10710	6682	972	970	
%	83.9	100.0	100.0	100.0	

AHA exclusions are nonsystem reasons for delay listed in ACTION (Acute Coronary Treatment and Intervention Outcomes Network) Registry-Get With The Guidelines and Mission: Lifeline instructions. AHA indicates American Heart Association; BP, blood pressure; HMO, health maintenance organization; PCI, percutaneous coronary intervention; and STEMI, ST-segment–elevation myocardial infarction.

patients in the Accelerator-2 project, and no difference in mortality over time for other patients in Mission: Lifeline (quarter 4 2015 to quarter 4 2016, Accelerator-2, *P* value for trend=0.019; Mission: Lifeline not in Accelerator-2, *P* value for trend=0.706) (Figure 4).

DISCUSSION

The most important finding of this study is that coordinated care between EMS and hospitals on the regional level led to statistically significant reductions in treatment times for patients with STEMI transported by 946 EMS agencies to 132 PCI-capable hospitals in 12 diverse regions. There were reductions in every time interval analyzed, reflecting increased coordination between EMS providers, ED physicians, cardiologists, and catheterization laboratory staff. The improvements in treatment times were accompanied by statistically significant reductions in hospital mortality and development of heart failure.

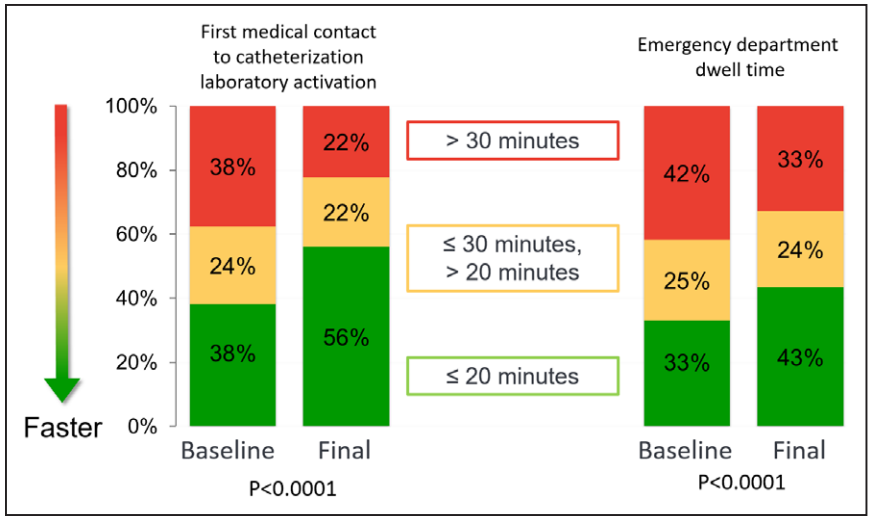

Figure 2. First medical contact to catheterization laboratory activation and emergency department dwell time, baseline and final quarters.

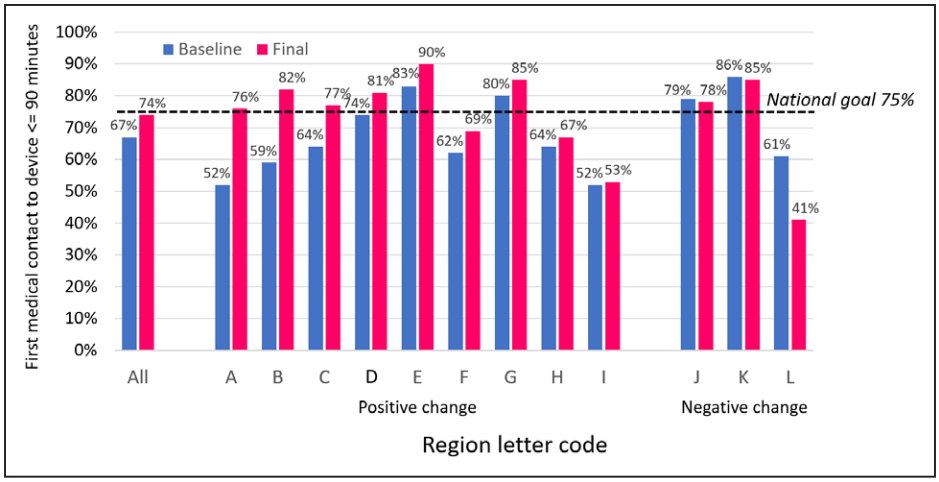

Figure 3. First medical contact to device ≤90 minutes by region, baseline and final quarters, sorted by descending order of change.

Over the past decade, improving the treatment of patients with STEMI by coordinating their care at a regional level has gained support and has been incorporated into national guidelines.[6] However, there has been skepticism about whether efforts to achieve these goals would be successful, and furthermore, whether reductions in time to treatment of such individuals would be followed by reductions in mortality.[14–19] Over a span of <18 months, using established methods to organize emergency cardiac care, hundreds of healthcare professionals across the United States collaborated to successfully improve the care of patients with STEMI.[1–4,11,20] We attribute the success of this intervention to their hard work and the addition of full-time regional coordinators supported by the local AHA affiliates and ongoing engagement by national faculty mentors in supporting regional leaders throughout the process (Table III in the online-only Data Supplement).

Our efforts focused on patients transported by EMS providers to PCI-capable hospitals, and the key elements of our intervention included prehospital activation of catheterization laboratories (Table IV in the online-only Data Supplement) and bypassing EDs whenever appropriate, prespecified treatment protocols, measurement and feedback in regional reports, broad regional leadership to support these activities, and ongoing implementation and quality improvement efforts by a dedicated regional coordinator. Based on the findings of the Prehospital Study Group that paramedics could identify patients with STEMI before hospital arrival, the cornerstone of our intervention involved prehospital diagnosis and cardiac catheterization laboratory activation.[20,21] Our intervention relied on EMS providers' interpretation of ECGs, assisted by computer algorithm interpretation, and transmission in cases of uncertainty. In 2007, Diercks and colleagues[22] found that the 27% of patients with prehospital ECGs in the AR-G were treated 14 minutes faster according to door-to-balloon metrics, and there was a trend toward lower mortality. Prehospital ECGs and EMS provider diagnosis has become a guideline-supported standard of care, yet many hospitals and EMS agencies continue to be challenged in implementing such systems. In our experience, some interventional cardiologists and hospital administrators are reluctant to rely on EMS provider diagnosis, primarily because of concerns about specificity and the potential overtriage of patients, resulting in unnecessary laboratory activation with resultant wasted time and resources.[23–25] Our approach to increase the acceptance of prehospital activation included dedicated training of EMS providers in ECG interpretation and identification of STEMI to improve accuracy, establishing agreed-on criteria for obvious STEMI diagnosis within each region, support from machine interpretation algorithms and transmission when ECGs were questionable, ongoing case review between physicians and EMS providers, and encouragement of prehospital activation by interventional cardiology leadership. We monitored the performance of hospitals in preactivation by using time from ED arrival to arrival in the catheterization laboratory (ED dwell times), with shorter times indicating catheterization laboratories were activating before patient hospital arrival. In prior work, we saw a strong association between shorter ED dwell times and lower mortality.[9] With the collection of a new catheterization laboratory activation time data element, we identified a corresponding strong association between activating the laboratory within 20 minutes and lower mortality, further supporting the case for prehospital diagnosis of STEMI and immediate (prehospital) activation of the catheterization laboratory team (Figure 5).

The value of defining common regional treatment protocols is based on experience in randomized clinical trials where such protocols encourage optimal and systematic treatment defined by study investigators. We first codified this approach in a statewide operations manual that allowed front-line healthcare professionals to provide care according to protocols without concern

Table 2. Patients Transported to Primary PCI-Capable Hospitals by Emergency Medical Service Providers, Treatment Times, and In-Hospital Outcomes

	All Patients	After AHA Exclusions	Baseline Quarter	Final Quarter	*P* Value
PCI during hospitalization					1.000
n	10729	6695	974	972	
%	90.3	100.0	100.0	100.0	
CABG during hospitalization					0.166
n	10716	6685	972	971	
%	3.8	2.1	2.7	1.8	
First medical contact to catheterization laboratory activation					<0.0001
n	8858	5898	821	866	
Median, min (25, 75th percentiles)	26 (15, 41)	22 (13, 34)	25 (15, 38)	18 (12, 28)	
Emergency department dwell time					<0.0001
n	9661	6686	974	970	
Median, min (25, 75th percentiles)	30 (18, 46)	25 (15, 37)	28 (17, 39)	23 (14, 34)	
First medical contact to device ≤90 min					0.002
n	9493	6695	974	972	
%	53.8	70.3	67.2	73.8	
First medical contact to device					<0.0001
n	9493	6695	974	972	
Median, min (25, 75th percentiles)	88 (72, 109)	80 (68, 94)	82.5 (70, 96)	78.5 (66, 91)	
In-hospital death					0.008
n	10730	6695	974	972	
%	8.3	3.4	4.4	2.3	
Stroke					0.131
n	10711	6685	973	971	
%	1.0	0.7	0.8	0.3	
Hemorrhagic stroke					1.000
n	109	44	7	3	
%	15.6	9.1	14.3	0.0	
Cardiogenic shock					0.937
n	10717	6690	973	972	
%	10.5	7.4	7.7	7.6	
Congestive heart failure					0.031
n	10715	6687	972	971	
%	7.5	5.7	7.4	5.0	
Major bleeding					0.341
n	10716	6689	972	971	
%	5.1	3.5	3.4	4.2	
Reinfarction					0.679
n	10713	6687	972	971	
%	1.1	1.0	1.1	1.3	

AHA indicates American Heart Association; CABG, coronary artery bypass graft; and PCI, percutaneous coronary intervention.

or delay for the preferences of individual physicians or hospitals that may become involved in a patient's care.[2] These protocols differ from typical guidelines in that they provide practical standards for systematic coordination that go beyond treatment comparisons or evidence consolidation, and are based on processes that have been successful in overcoming systematic barriers to implementation of trial-proven therapies. The

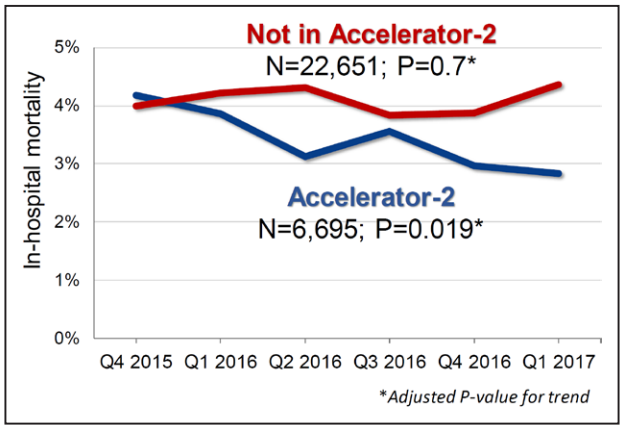

Figure 4. In-hospital mortality according to hospital participation in Accelerator-2.

Accelerator-2 Operations Manual was provided to all regions and was adopted in whole or in part, according to modifications that suited regional preferences and resources.[26]

The most challenging but critical element of our intervention involved the ongoing collection of common data elements that spanned the entire episode of care from EMS arrival to hospital discharge. Each participating hospital was asked to collect data into AR-G, and these data populated quarterly Mission: Lifeline regional reports. These reports were used to monitor hospital performance in comparison with regional competitors in a deidentified blinded fashion and to guide system improvement. An example of reports used in regional meetings is presented in Figure 6. Over the course of this and prior interventions, the concerns and costs of data collection and sharing were overcome by the value of receiving benchmarked measures of system performance that allowed healthcare professionals to focus resources, improve systems, and make the data case for resources and change. In our experience, systems can be neither built nor maintained without such regionally shared data, and performance begins to decline as soon as data measurement is interrupted.[2,27]

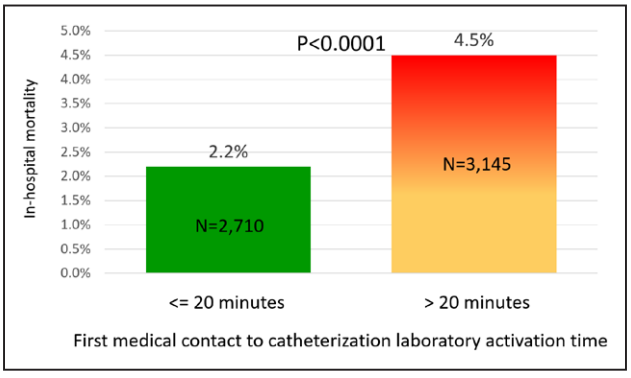

Figure 5. First medical contact to activation time and in-hospital mortality.

If other regions wish to implement systems similar to that described above for the Accelerator-2 project, the required elements beyond existing hospital and EMS resources include (1) a willingness of hospitals, physicians, and EMS agencies to collaborate, establish common protocols, and share data; (2) participation in a registry that measures processes and outcomes from initial system contact through hospital care; (3) local leadership that spans multiple institutions and healthcare disciplines willing to meet on a regular basis to design and direct the system (commonly 2–3 hours per month to support conference calls, quarterly data meetings, hospital visits, and focused EMS provider training programs); (4) a regional coordinator with funding shared by participating PCI-capable hospitals and health systems or grant mechanisms; and (5) meeting space provided by regional hospitals (Table V in the online-only Data Supplement) and EMS agencies on a rotating basis. This small infrastructure added to the significant resources dedicated to cardiovascular care at the individual hospital level has the potential to expedite care and improve outcomes for patients with acute coronary syndrome across entire regions.

In our project, when including all participating hospitals and regions, the overall improvements in time to reperfusion, although highly significant, were modest, and there were some regions that did not improve or showed relatively small improvement in the proportion of patients treated within 90 minutes. The modest effect can be attributed to at least 2 factors. First, for regions that were performing according to national standards at baseline, additional improvement was less likely as performance approached the upper boundaries of performance. A second reason was the inclusion of all hospitals and regions, regardless of their performance or their ability to implement coordinated care. By providing aggregate results, the absolute potential of the intervention may not be reflected because some hospitals were unable to implement systematic improvements. The subset of 57 hospitals with slower performance at baseline and full implementation during the project described likely represents the full potential of this intervention.

Limitations

Our study compared preintervention and postintervention time periods, and the improvements in reperfusion times and outcomes may have been related to unmeasured secular changes unrelated to the project interventions. Such secular changes were not evident when examining treatment times and mortality for hospitals not participating in the project during the time period as described above. Our study found a statistically significant decrease in mortality after implementation of the intervention. Even with adjustment for differences in baseline characteristics, we cannot be certain that

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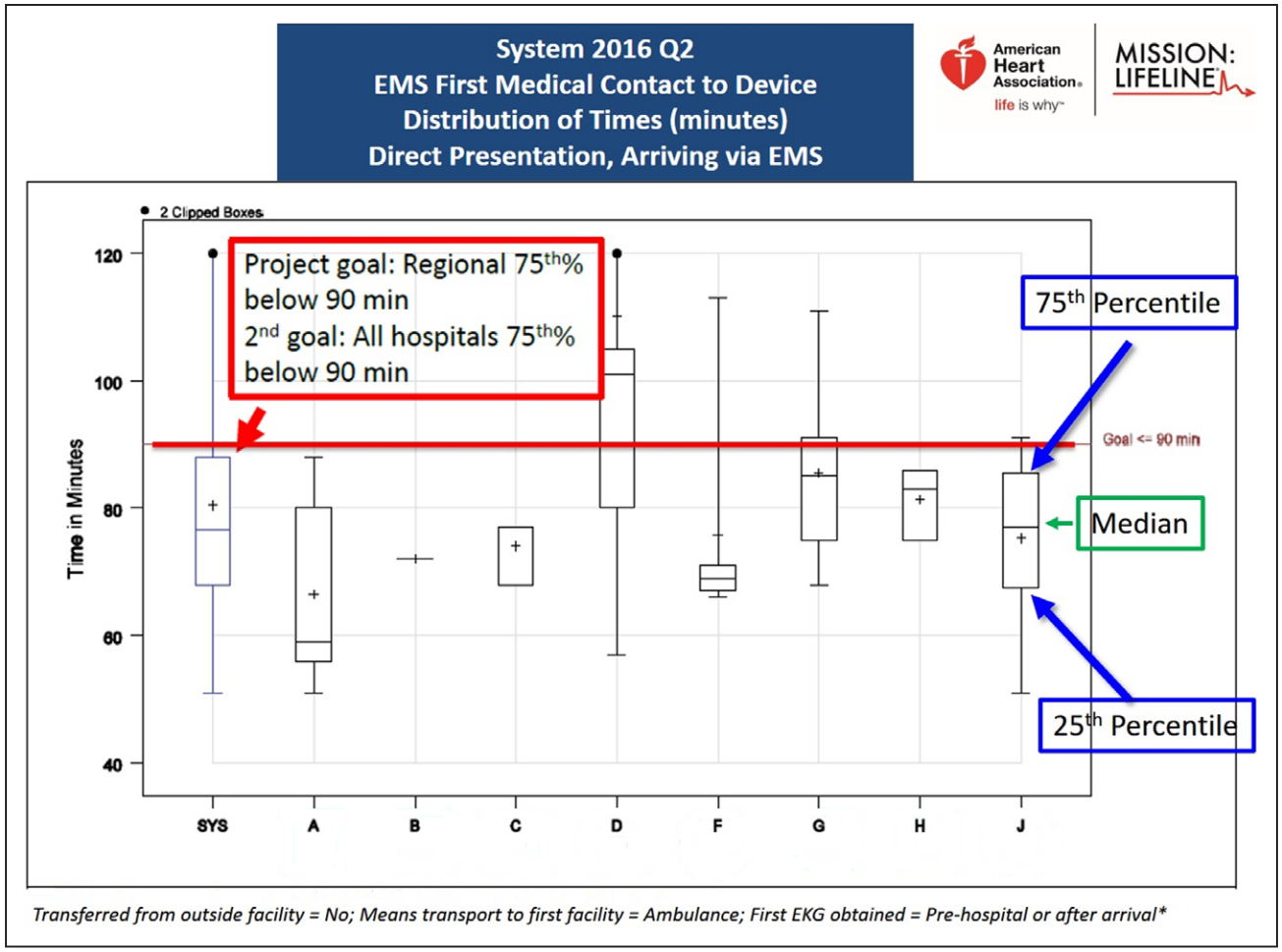

Figure 6. Mission: Lifeline regional report example.
EKG indicates electrocardiogram; EMS, emergency medical system.

this change was not attributable to confounding by some factor that influenced mortality other than the intervention. Nonetheless, the well-documented association of more consistent and faster reperfusion with better survival in patients with STEMI, reflected in recommendations in the American College of Cardiology/AHA guidelines and in the Mission: Lifeline program, strongly support our results and indicate the development of regional systems of care for STEMI represents an important opportunity to improve public health.

The improvements in treatment times were relatively modest and may not explain the degree of decline in mortality that we observed. Despite data indicating that the improved mortality could not be explained by patient characteristics or by secular trends among all hospitals, it is possible that some portion of the decline was attributable to chance variation. It is expected, however, that successful efforts to implement guidelines to provide more rapid and consistent reperfusion of acute myocardial infarction would improve outcome. It is also possible that some of the decline was related to the delivery of coordinated STEMI care beyond faster treatment, such as better training of paramedics or the enhanced ability of frontline emergency personnel to activate catheterization laboratories for patients they feel would most benefit.

Another important limitation of using cardiovascular registries to document quality care is the inconsistent application of criteria to exclude patients (with contraindications or with variables outside the control of the providers) from the denominator. We found some evidence for this occurrence with 3% fewer patients meeting exclusion criteria in the first quarter of data. Although this modest difference is unlikely to explain our findings, increased attention to exclusion can lead to apparent improvement in treatment that is actually related to more strict application of the exclusion process. In sensitivity analysis including all patients (including those with nonsystem delay), the time trend for adjusted mortality remained significantly lower $P<0.05$).

Conclusions

The Accelerator-2 program builds on early US regional models, Mission: Lifeline, and the Accelerator-1 Demonstration Project, and demonstrates that regionalizing emergency STEMI systems of care can reduce the time

to reperfusion. This enhanced organization corresponded with reductions in morbidity and mortality among patients with STEMI.

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FOOTNOTES

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