



## Original Contribution

# Emergency medical services management of ST-segment elevation myocardial infarction in the United States—a report from the American Heart Association Mission: Lifeline Program



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## ABSTRACT

**Objective:** ST-segment elevation myocardial infarction (STEMI) is a major cause of morbidity and mortality in the United States. Emergency medical services (EMS) agencies play a critical role in its initial identification and treatment. We conducted this study to assess EMS management of STEMI care in the United States.

**Methods:** A structured questionnaire was administered to leaders of EMS agencies to define the elements of STEMI care related to 4 core measures: (1) electrocardiogram (ECG) capability at the scene, (2) destination protocols, (3) catheterization laboratory activation before hospital arrival, and (4) 12-lead ECG quality review. Geographic areas were grouped into large metropolitan, small metropolitan, micropolitan, and noncore (or rural) by using Urban Influence Codes, with a stratified analysis.

**Results:** Data were included based on responses from 5296 EMS agencies (36% of those in the United States) serving 91% of the US population, with at least 1 valid response from each of the 50 states and the District of Columbia. Approximately 63% of agencies obtained ECGs at the scene using providers trained in ECG acquisition and interpretation. A total of 46% of EMS systems used protocols to determine hospital destination, cardiac catheterization laboratory activation, and communications with the receiving hospital. More than 75% of EMS systems used their own agency funds to purchase equipment, train personnel, and provide administrative oversight. A total of 49% of agencies have quality review programs in place. In general, EMS systems covering higher population densities had easier access to resources needed to maintain STEMI systems of care. Emergency medical services systems that have adopted all 4 core elements cover 14% of the US population.

**Conclusions:** There are large differences in EMS systems of STEMI care in the United States. Most EMS agencies have implemented at least 1 of the 4 core elements of STEMI care, with many having implemented multiple elements.

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## 1. Introduction

ST-segment elevation myocardial infarction (STEMI) is a significant health problem in the United States, with 400,000 to 500,000 events per year, representing 30% of patients with acute coronary syndrome [1]. With the reliance of acute care hospitals on primary

percutaneous coronary intervention (PCI) or fibrinolysis, increased emphasis has been placed on developing systems of care to integrate emergency medical services (EMS) activation, evaluation, treatment, and transport of patients with STEMI [2,3].

Widely disseminated national guidelines describe the integration of EMS into STEMI systems of care [4–8]. Identification of STEMI on the prehospital electrocardiogram (ECG) allows for transport of the patient to a PCI-capable center (if appropriate) and prehospital activation of the cardiac catheterization laboratory [9]. Some 80% of the US population lives within the 90-minute window of a PCI center, and three-fourths of the remaining 20% live within 120 minutes, making prompt identification and transport imperative [8]. Prehospital identification of STEMI leads to an approximate 10-minute decrease in door-to-drug time for patients receiving fibrinolysis and an 18-minute decrease in door-to-balloon time for primary PCI [2,10].

In 2007, the American Heart Association (AHA) introduced *Mission: Lifeline*, a national, community-based initiative to improve the quality of care and outcomes for patients with STEMI and to increase the health care system readiness and response to STEMI. The initial implementation of *Mission: Lifeline* was based on recommendations for programs, policy, and research published in the *Development of Systems of Care for STEMI* [11].

We conducted this study to assess the level of EMS involvement in state and regional STEMI systems of care using a nationwide sample stratified by population density. Our hypothesis was that significant variability exists in the adoption of selected components of STEMI systems of care in the United States.

## 2. Methods

### 2.1. Study design

The survey was developed by volunteers from the AHA *Mission: Lifeline* Emergency Cardiac Care Task Force. Instrument development started in summer 2007. The survey was validated by *Mission: Lifeline* committee members who were not part of the research team. Validation consisted of identification of objects of measurement, defining relevant survey elements, and developing questions for each element. The survey was pilot tested for 4 weeks in 8 states and was then modified based on feedback from those pilot tests. The instrument was organized into the following question topic areas: 13 general, 22 specific for STEMI, and 6 specific for stroke (see Appendix A for actual survey). The survey elicited information on EMS protocols, equipment, staffing, funding, training, existing process measures, and treatment decisions. Survey questions were answered by respondents at the director level or above in order to understand specific agency characteristics. The survey was designed to require approximately 20 minutes to complete. It was distributed using online survey software (Vovici Corporation, Dulles, VA) and written formats. The stroke data were reported separately [11].

### 2.2. Population and setting

The survey was distributed to state or county lead agencies or regional EMS organizations. The AHA staff worked with local volunteers, state EMS offices, and state representatives from the National Association of State EMS Officials in all 50 states and the District of Columbia to identify the appropriate organizational leaders for survey completion. Respondents were asked to list all of the counties in which they provide EMS services.

### 2.3. Experimental protocol

Emergency medical services structure and financing were characterized as fire-based, volunteer-staffed, or third-service as well as not-for-profit, hospital-based, or for-profit. Staffing models were characterized as

including 1 or more of EMT-basic, EMT-intermediate, paramedic, first responder, or helicopter-based. Demographic characteristics were obtained relating to finance, training, and legislation for prehospital STEMI care.

The Federal Information Processing Standard (FIPS) codes were used to assign a unique 5-digit number to each county within the 50 states and the US territories [12]. The FIPS codes were used to derive the population coverage counts and to determine the type of area (eg, rural vs metro) covered by the survey. Agencies were also grouped by US Census definition of regions (eg, Northeast, Midwest, South, and West) [13]. County population counts were derived from 2008 Environmental Services Research Institute, Inc, population estimates [14]. Duplicate responses from the same agency or those missing county designation were excluded.

The population density of participating counties was classified using Urban Influence Codes (UICs) [15]. The UICs were categorized into 4 broad population density categories for analysis: large metropolitan ( $\geq 1$  million residents), small metropolitan ( $< 1$  million residents), micropolitan ( $\geq 1$  urban cluster of at least 10000 residents), and noncore or rural (without an urban cluster of at least 10000 residents) [16].

Planned EMS response to STEMI was characterized whether or not the system had landline-enhanced 911 or wireless-enhanced 911. The 4 core elements for STEMI systems are listed in Table 3. Transfer capabilities were assessed by examining (1) the use of interfacility transport protocols, (2) whether interfacility transfers for STEMI were given the same priority as 911 calls, (3) the use of expedited transfer from non-PCI to PCI-capable centers keeping patient on EMS stretchers, (4) fibrinolysis inclusion/exclusion protocols for EMS, and (5) prehospital fibrinolysis protocols.

Respondents described the proportion of their EMS vehicles with 12-lead ECG, proportion of responders trained to interpret 12-lead ECG for STEMI, and estimate of false-positive 12-lead ECG readings.

### 2.4. Analytical methods

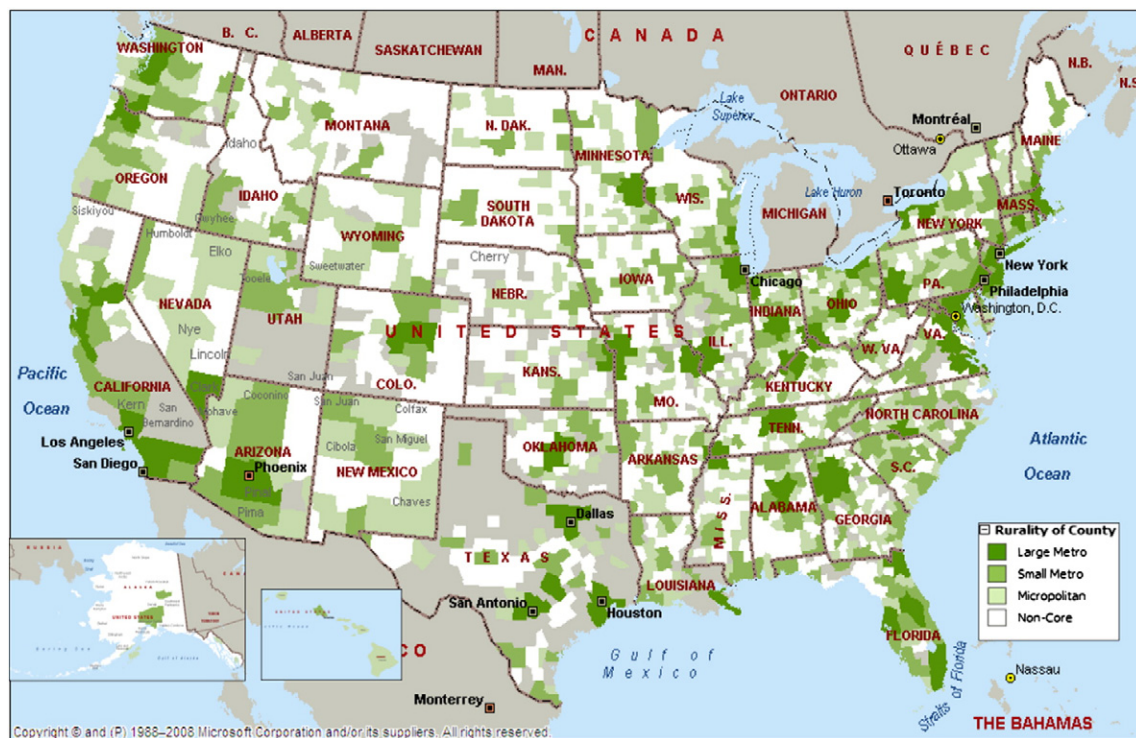
Survey responses were aggregated with FIPS codes, county name, state, the 2008 population estimate, and the UIC code. A subset of the survey data was created to include the agency's unique identification number, all the counties served by the agency, and the corresponding state. Survey subset responses were matched to the vertical data set through use of the agency's unique identifier using SAS 9.2.1 (SAS Institute, Cary, NC).

For counties served by more than 1 EMS agency, questions with dichotomous responses were scored as "yes" if at least 1 agency serving the county answered "yes" to a given question. For questions with multiple allowable responses, multiple response set variables were analyzed using Stata 10.0 (StataCorp LP, College Station, TX) for  $\chi^2$  analysis of geographic differences using methods described by Jenn [17] for managing surveys with multiple response sets. In order to assess differences, we conducted an overall Bonferroni-adjusted Pearson  $\chi^2$  on an expanded table of the frequencies of response "patterns" by geographic service type. The characteristics of EMS agencies' structure, function, legislative support, processes of care, and quality assurance related to patients with STEMI were compared by degree of population density using Pearson  $\chi^2$  test for trend.

All analyses were performed with commercial software including SPSS 17.0 (SPSS Inc, Chicago, IL), Stata 10.0 (StataCorp LP), or SAS 9.2.1 (SAS Institute, Cary, NC). Significance was declared at the .05 level.

## 3. Results

Between October 6, 2008, and December 31, 2008, responses were obtained from 5410 agencies, representing 2602 counties. There were 114 (2.1%) agencies excluded due to missing service area information, leaving 5296 EMS agencies (85% of those in the United States),



**Figure.** All respondents classified at the county level according to whether EMS covers a population that is large metro, small metro, micropolitan, or rural.

representing 91% of the population. [18,19] At 1 one valid response was received from each of the 50 states and the District of Columbia, with a mean of 108 (range, 1–423) responses per state (Figure).

Multiple EMS agencies often covered 1 county. Some agencies ( $n = 763$ ) covered large geographic areas, thereby crossing 2 or more

of the 4 UIC aggregate groups with service to both rural and urban areas. Most agencies (4533) served areas with a single type of rurality (ie, single type of UIC group.) The other EMS agencies served 2 ( $n = 611$ ), 3 ( $n = 115$ ), or all 4 UIC types ( $n = 37$ ), and 114 could not be categorized because of missing county information. Of the single UIC-

**Table 1**  
EMS agency structure and administration by region

| Characteristic                                | Large metropolitan | Small metropolitan | Micropolitan | Rural    | All       | P     |
|---|--------------------|--------------------|--------------|----------|-----------|-------|
| Description of EMS Agency (n)                 | 1160               | 1258               | 826          | 1092     | 4336      |       |
| Fire-based (%)                                | 61                 | 48                 | 44           | 24       | 44        | <.001 |
| Paid (%)                                      | 88                 | 82                 | 81           | 70       | 19        | <.001 |
| Third service (%)                             | 14                 | 17                 | 19           | 22       | 18        | <.001 |
| Not-for-profit (%)                            | 12                 | 17                 | 15           | 17       | 15        | .007  |
| Hospital-based (%)                            | 6                  | 7                  | 9            | 15       | 9         | <.001 |
| For-profit (%)                                | 7                  | 6                  | 8            | 7        | 7         | NS    |
| Ambulance staffing (n)                        | 1184               | 1305               | 852          | 1147     | 4488      |       |
| EMT-basic (%)                                 | 61                 | 66                 | 65           | 73       | 66        | <.001 |
| EMT-intermediate (%)                          | 27                 | 34                 | 40           | 42       | 36        | <.001 |
| EMT-paramedic (%)                             | 82                 | 73                 | 68           | 58       | 71        | <.001 |
| First responder (%)                           | 14                 | 20                 | 19           | 16       | 17        | <.001 |
| Helicopter (%)                                | 4                  | 8                  | 8            | 9        | 7         | <.001 |
| EMS medical record (n)                        | 1195               | 1306               | 857          | 1152     | 4510      |       |
| Paper (%)                                     | 61                 | 59                 | 65           | 75       | 65        | <.001 |
| Electronic (%)                                | 60                 | 61                 | 58           | 45       | 56        | <.001 |
| Funding for ECG machines (n)                  | 927                | 848                | 516          | 519      | 2810      |       |
| EMS agency (%)                                | 78                 | 77                 | 75           | 66       | 75        | <.001 |
| Grants and gifts (%)                          | 22                 | 21                 | 25           | 30       | 24        | .004  |
| Hospital (%)                                  | 6                  | 7                  | 6            | 3        | 6         | .084  |
| County (%)                                    | 7                  | 9                  | 10           | 15       | 10        | <.001 |
| City (%)                                      | 10                 | 11                 | 10           | 5        | 9         | .016  |
| State (%)                                     | 1                  | 2                  | 1            | 1        | 1         | NS    |
| 12-Lead ECG training for EMS personnel (n)    | 1099               | 1132               | 743          | 884      | 3858      |       |
| (%)   | 73                 | 64                 | 55           | 41       | 59        | <.001 |
| Enabling legislation for EMS (n)              | 249                | 166                | 99           | 131      | 645       |       |
| City (%)                                      | 12                 | 9                  | 10           | 9        | 11        | NS    |
| County (%)                                    | 31                 | 39                 | 29           | 28       | 32        | NS    |
| State (%)                                     | 66                 | 63                 | 72           | 74       | 68        | NS    |
| Legislative protocols for prehospital ECG (%) | 640 (26)           | 577 (17)           | 312 (17)     | 443 (17) | 1917 (19) | <.001 |

Participants were allowed multiple responses to questions resulting in fluctuation in sample sizes. In order to assess differences, we conducted an overall Bonferroni-adjusted Pearson  $\chi^2$  on an expanded table of the frequencies of response patterns by geographic service type.

type agencies, 1199 (26%) covered large metro areas, 1317 (29%) served small metro areas, 861 (19%) covered micropolitan areas, and 1156 (26%) served rural areas.

The structure and administration of EMS agencies that participated in the survey was significantly associated with the population density (Table 1). Emergency medical services agencies in metropolitan areas were more likely than those in rural areas to be fire based (61% vs 24%), whereas rural systems tended to have more volunteers (30% vs 12%). Rural agencies were more likely to be staffed by basic EMTs (73% vs 61%) and less likely to be staffed by paramedics (58% vs 82%). Agencies in metropolitan areas were more likely than those in rural areas to use electronic medical records (73% vs 61%), more likely to use agency funds to obtain 12-lead ECG machines (78% vs 66%), and more likely to provide 12-lead ECG training for EMS personnel (73% vs 41%). Population density was not associated with differences in enabling legislation (Table 2).

Obtaining 12-lead ECGs at the scene, using protocols defining hospital destination, using protocols for prehospital activation of the catheterization laboratory, and the use of quality review programs for 12-lead ECGs differed significantly between the 4 categories (Table 3). Emergency medical services care delivery and quality assurance related to patients with STEMI were also significantly associated with population density.

Mode of communication differed significantly among communities in the following areas: ECGs were more likely to be communicated to the base hospital in metropolitan areas compared with rural and smaller communities (25% vs 12%). In contrast, there were no significant differences in the use of radio or landline to send interpretations of ECGs or computer interpretation of ECGs based on size of the community.

Emergency medical services agencies provision of interfacility transport for patients with STEMI, the urgency of such transport, and use of fibrinolysis inclusion/exclusion protocols for EMS or prehospital fibrinolysis protocols were not significantly associated with the degree of rurality.

Quality assurance of prehospital care of patients with STEMI was significantly associated with the population density, including review of the quality of 12-lead ECG interpretation and performance measures for patients with suspected STEMI. Agencies were more likely to examine the accuracy of 12-lead ECG interpretation (false positives and negatives) in large metro and small metro areas.

Table 3 shows the proportion of the population covered by an EMS agency using 1 or more of the 4 core elements, namely, scene ECG, destination protocols, prehospital catheterization laboratory activation, and ECG quality review.

**Table 2**  
EMS care delivery and quality assurance by region

| Characteristic  | Large metropolitan | Small metropolitan | Micropolitan | Rural    | Total     | P     |
|---|--------------------|--------------------|--------------|----------|-----------|-------|
| Total number  | 1194               | 1306               | 849          | 1146     | 4495      |       |
| Landline E-911 (%)  | 99                 | 99                 | 97           | 93       | 97        | <.001 |
| Wireless E-911 (%)  | 91                 | 90                 | 86           | 79       | 87        | <.001 |
| Prehospital 12-lead ECG capabilities for at least 80% of patients (%)                       | 1098 (70)          | 1125 (64)          | 739 (56)     | 884 (45) | 3846 (60) | <.001 |
| Communication mode (n)  | 745                | 719                | 367          | 352      | 2183      |       |
| EMS staff interpretation sent by radio/telephone (%)  | 74                 | 75                 | 78           | 80       | 76        | NS    |
| Computer interpretation sent by radio/telephone (%)   | 27                 | 28                 | 31           | 24       | 27        | NS    |
| ECG communicated to base hospital (%)   | 25                 | 19                 | 17           | 12       | 20        | <.001 |
| ECG communicated by Bluetooth (%)   | 17                 | 15                 | 13           | 9        | 14        | <.001 |
| ECG communicated by cell phone (%)  | 38                 | 37                 | 27           | 27       | 34        | <.001 |
| ECG communicated by radio (%)   | 12                 | 13                 | 13           | 16       | 13        | NS    |
| Communication receipt (n)   | 1098               | 1125               | 739          | 884      | 3846      |       |
| PCI hospital (%)  | 40                 | 37                 | 18           | 12       | 28        | <.001 |
| Non-PCI hospital (%)  | 23                 | 21                 | 32           | 26       | 25        | <.001 |
| Other hospital (%)  | 8                  | 7                  | 4            | 7        | 7         | .02   |
| Medical control facility (%)  | 22                 | 17                 | 17           | 11       | 17        | <.001 |
| No communication (%)  | 30                 | 36                 | 44           | 55       | 40        | <.001 |
| Interfacility transport (%)   | 269 (37)           | 352 (38)           | 321 (41)     | 503 (40) | 1445 (39) | NS    |
| Interfacility transfers for STEMI given same priority as 911 calls (%)                      | 410 (74)           | 462 (80)           | 398 (76)     | 615 (81) | 1885 (78) | NS    |
| Expedited transfer from non-PCI to PCI-capable centers keeping patient on EMS stretcher (%) | 404 (31)           | 431 (32)           | 406 (27)     | 616 (27) | 1857 (29) | NS    |
| Fibrinolysis inclusion/exclusion protocols for EMS (%)                                      | 641 (24)           | 675 (25)           | 504 (24)     | 718 (22) | 2538 (24) | NS    |
| Prehospital fibrinolysis protocols (%)  | 978 (6)            | 1001 (6)           | 646 (6)      | 893 (7)  | 3518 (6)  | NS    |
| STEMI data collection (n)   | 1085               | 1152               | 749          | 1007     | 3993      |       |
| State agency (%)  | 52                 | 53                 | 52           | 55       | 53        | NS    |
| Other organization (%)  | 23                 | 21                 | 21           | 13       | 20        | <.001 |
| Not reported (%)  | 35                 | 35                 | 35           | 36       | 35        | NS    |
| Review of EMS ECG interpretations (n)   | 770                | 818                | 509          | 634      | 2731      |       |
| Non-PCI hospital agency (%)   | 8                  | 6                  | 7            | 6        | 7         | NS    |
| PCI hospital (%)  | 28                 | 24                 | 17           | 9        | 21        | <.001 |
| Emergency medicine (%)  | 27                 | 26                 | 30           | 21       | 26        | .019  |
| Cardiology (%)  | 12                 | 15                 | 6            | 3        | 10        | <.001 |
| EMS agency (%)  | 17                 | 18                 | 21           | 19       | 18        | <.001 |
| Medical director (%)  | 79                 | 79                 | 76           | 80       | 79        | NS    |
| Performance measures  | 888                | 908                | 598          | 783      | 3177      |       |
| False-positive ECG data collected (%)   | 33                 | 29                 | 20           | 12       | 24        | <.001 |
| False-negative ECG data collected (%)   | 27                 | 24                 | 15           | 11       | 20        | <.001 |
| Complications during transport (%)  | 48                 | 45                 | 46           | 45       | 46        | NS    |
| EMS dispatch time (%)   | 71                 | 71                 | 69           | 69       | 70        | NS    |
| EMS arrival time (on scene) (%)   | 65                 | 67                 | 63           | 57       | 63        | <.001 |
| EMS arrival time at hospital (%)  | 61                 | 60                 | 57           | 52       | 58        | .008  |
| Scene to hospital interval (%)  | 56                 | 57                 | 52           | 46       | 53        | <.001 |
| None (%)  | 20                 | 19                 | 20           | 22       | 20        | NS    |
| Time of symptom onset (%)   | 34                 | 35                 | 36           | 30       | 34        | NS    |

Participants were allowed multiple responses to questions resulting in fluctuation in sample sizes. In order to assess differences, we conducted an overall Bonferroni-adjusted Pearson  $\chi^2$  on an expanded table of the frequencies of response patterns by geographic service type.



**Table 3**  
Planned EMS response to STEMI: core elements

| Core element   | Large metropolitan | Small metropolitan | Micropolitan | Rural     | All       | P     |
|--|--------------------|--------------------|--------------|-----------|-----------|-------|
| ECG capability at the scene (%)  | 1190 (80)          | 1304 (67)          | 851 (62)     | 1151 (42) | 4496 (63) | <.001 |
| Destination protocols (%)  | 1101 (60)          | 1011 (52)          | 648 (36)     | 898 (30)  | 3568 (46) | <.001 |
| Prehospital 12-lead ECG triggers catheterization laboratory activation before hospital arrival (%) | 1009 (67)          | 1117 (59)          | 720 (35)     | 943 (21)  | 3789 (47) | <.001 |
| 12-Lead ECG quality review (%)   | 881 (59)           | 923 (56)           | 551 (41)     | 663 (31)  | 3018 (49) | <.001 |

Participants were allowed multiple responses to questions resulting in fluctuation in sample sizes. In order to assess differences, we conducted an overall Bonferroni-adjusted Pearson  $\chi^2$  on an expanded table of the frequencies of response patterns by geographic service type.

## 4. Discussion

### 4.1. Emergency medical services structure

Emergency medical services agencies rely on a variety of organizational structures to provide service to the public. Survey respondents were most likely to represent a fire-based service, with volunteers, third service, not-for-profits, hospital-based, and for-profit equally represented in the remainder. Of note, fire-based service is disproportionately represented in large metropolitan areas as opposed to smaller metropolitan and rural areas. Volunteer agencies are much more common in rural areas.

### 4.2. Prehospital 12 leads

National guidelines and other consensus and scientific statements have recommended the use of prehospital ECGs during the initial evaluation of patients with symptoms suggestive of acute coronary syndrome [1–12,20–22]. Our results show that 80% of EMS agencies in large metropolitan areas reported performing ECGs, and 67% of metropolitan agencies with ECG capabilities use this information to activate the cardiac catheterization laboratory, compared with 21% of rural agencies.

Most EMS agencies were responsible for purchasing their 12-lead ECG devices. In rural EMS agencies, there was a greater reliance on grants or donations. Governmental agencies and hospitals provided funding in less than 20% of all EMS agencies. Startup funding borne by the EMS agency thus represents one potential barrier to developing the prehospital component of STEMI systems in the United States [23].

Agencies that did not transmit or communicate ECG findings were more likely to be rural than urban, a difference that may be due to the increased proportion of EMS personnel at the EMT-basic level or may be due to problems with transmission. In rural settings, more than one-half did not transmit. In major metropolitan areas, approximately one-third of agencies did not transmit or communicate their 12-lead ECG findings.

Without transmission or verbal reporting, it is difficult or impossible to modify destination decisions or to activate cardiac catheterization laboratory in advance of patient arrival. It should be emphasized that transmission may not be required if paramedics are trained to interpret and verbally report ECG findings. Accuracy of paramedic interpretation of STEMI is high, although, in one study, transmission to the emergency department for physician interpretation improved the positive predictive value of the prehospital 12-lead ECG for triage and therapeutic decision making [24].

### 4.3. Regional systems

The rationale for establishing regional ST-elevation myocardial infarction receiving center networks has been reviewed previously [25]. Prehospital ECG programs may reduce the time from EMS arrival at the scene to arrival at the PCI center because of expedited scene and transport time, and direct transport protocols, thus bypassing non-PCI-capable hospitals, if necessary [12,26–28]. Of note, in rural

systems, more than one-half of all patients with STEMI do not have access to prehospital ECG or bypass protocols.

Large metropolitan areas have more destination choices and use destination and bypass protocols more frequently. Rural EMS has fewer choices for destination hospital and makes greater use of secondary transfer. Even with the need for secondary transfer to a PCI facility, only 29% of receiving hospitals specifically instructed EMS to remain with the patient while kept on the EMS gurney during non-PCI center evaluation in anticipation of subsequent transfer to a PCI center.

### 4.4. Staffing

Emergency medical services staffing levels demonstrate a greater proportion of EMT-paramedic in more populous EMS service areas and a greater proportion of EMT-basic and EMT-intermediate in the smaller population centers. Because of the larger proportion of EMT-basic providers in rural areas, programs must accommodate providers who are capable of ECG acquisition and transmission instead of interpretation. Systems with a higher proportion of EMT-paramedic should consider training these advanced providers in ECG interpretation to facilitate system activation for patients with STEMI [24,29].

### 4.5. Quality

Most EMS agencies rely on the agency medical director to review ECG interpretation quality. From our survey data, it appears that some EMS systems use contemporaneous review of interpretation quality in addition to retrospective agency medical director review.

Although most EMS Systems measure response and transport intervals, it is notable that approximately 1 in 4 does not. Increasing the use of an electronic health record may help agencies with data collection. Of the agencies that record and report STEMI data, more than one-half of all EMS systems report to a state agency, usually the state EMS office. Others report to some other external organization such as regional or local EMS agencies.

### 4.6. Legislation

Most respondents cited state law as the source of enabling EMS legislation for STEMI protocols, with a smaller proportion relying on county- or city-level legislation. Most STEMI system legislation enables development and maintenance of the program but does not provide funding. It is likely that this lack of funding is preventing the development of prehospital STEMI programs in many EMS regions.

## 5. Limitations

This survey reflects data collected at a single point in time and is several years old at this point. As a single data point, the results are not reflective of changes over time, where arguably, there have been significant advances in STEMI system of care, specifically in rural settings.

The data collected in this survey describe observations only and cannot be used to infer association or causation. The observations are based on responses from personnel at individual EMS agencies and may

not reflect the opinions of the majority. Responses were not vetted with the represented agencies and thus reflect the opinions of the respondent.

Because the survey was sent to known EMS jurisdictions, specific regions of the country may be overrepresented if specific government jurisdictions such as cities, counties, or states were covered by multiple EMS agencies, with overlapping coverage.

The survey results allowed the authors to assess the characteristics of the responding EMS system. If a survey was not completed, the structure of EMS service remained unknown, making comparisons between responders and nonresponders impossible. Because of the high response rate, the authors believe that the survey is representative of EMS practices as they existed at the time of the survey.

## 6. Conclusions

We conclude that metropolitan areas have greater access to resources, including funding and/or access to content expertise, to support the key elements of prehospital STEMI care, whereas rural areas do not. Although most of the population is served in the metro area, the largest impact could arguably be made by improving programs in the rural areas where hospital distance is also a limiting factor to reaching time to treatment thresholds. Enhancement of systems of care in more rural areas should be a focus of future efforts to improve access to resources.

## Appendix A. EMS assessment for STEMI and stroke

Thank you for taking the time to complete the EMS Assessment. Your responses will provide valuable information to help the American Heart Association assess EMS needs for your area. The full assessment should take no longer than 20 minutes to complete. **Only one assessment should be filled on behalf of the designated lead agency(ies) or organizations who respond to 911 requests in your region with a complaint of chest pain or other potential AMI symptoms.** The assessment should be completed by the director or the medical director for the agency/organization or their designee.

### General Questions

- Q1 Your name:  
 Q2 EMS role or professional title:  
 Q3 Your agency's name:  
 Q3a You agency's contact phone number and address:  
 Q4 EMS agency/lead organization description?  
   Fire  
   Third service  
   Private agency  
     For profit  
     Not for profit  
   Hospital based  
 Q5 Your state:  
 Q6 Please list the county (ies) in which you operate.  
 Q7 Do you transport patients with high suspicion of acute myocardial infarction to a hospital?  
   Yes  
   No  
 Q8 What is the population in your service area?  
 Q9 How many square miles of area does your service cover?  
 Q10 Is 9-1-1 coverage available for your city or county?  
   E-911 for 100% of the population for landline  
   Wireless 911 coverage for at least 75% of the population  
   Landline E9-1-1 (include hyperlink)  
   Yes  
   No  
     Wireless 9-1-1  
   Yes  
   No

- Q11 How do your EMS units document patient information once the patient has been transported to the receiving hospital?  
 Check all that apply.

Documentation is on paper form

Documentation is entered onto an electronic health record

- Q12 How does your organization report the patient information data on STEMI? Check all that apply.

Data are reported to a state agency

Data are reported to another organization

Please name the organization (text box): \_\_\_\_\_

Data are not reported to an external organization

Don't know

- Q13 How does your organization report the patient information data on stroke? Check all that apply.

Data are reported to a state agency

Data are reported to another organization

Please name the organization (text box): \_\_\_\_\_

Data are not reported to an external organization

Don't know

### STEMI Questions

- Q14 Describe the staffing of the EMS or first-response vehicles that respond to treat patients with chest discomfort. Check all that apply.

EMT-basic

EMT-intermediate

EMT-paramedic

Nontransporting first responder agency

Helicopter transport

Don't know/not applicable

- Q15 What is the total number of staffed ambulances in your agency/organization that are typically available to respond to chest pain patients in your agency/organization's response area?

Number of staffed ground ambulances: \_\_\_\_\_

Number of staffed helicopters: \_\_\_\_\_

Don't know/not applicable

- Q16 In your agency/organization, is the field provider's 12-lead ECG information used to activate the catheterization laboratory prior to arrival at the receiving facility?

Yes, for all receiving facilities

Yes, sometimes or for some receiving facilities

No

Don't know

- Q17 Does your organization have 12-lead ECG devices available at the scene for at least 80% of the patients with chest pain?

Yes

No

- Q18 What percentage of your vehicles responding to suspected cardiac patients in your agency/organization have 12-lead ECG acquisition devices?

10% or less

11%-25%

26%-50%

51%-75%

76%-100%

Don't know

- Q19 Who provided the funding for the 12-lead ECG devices? Check all that apply.

Organization purchased the devices

Organization purchased the devices through a grant/donation

PCI hospital(s) assisted in the purchased devices

County provided devices

City provided devices

- State provided devices  
Don't know/not applicable
- Q20- Q21 Did your organization's responders receive 12-lead ECG STEMI identification training?
- Yes  
No
- If yes, please list the course length and how the training was provided (ie. classroom, self taught, Internet, etc).
- Q22 What percentage of your organization's responders that see suspected cardiac patients are trained to read and interpret 12-lead ECGs for STEMI diagnosis?
- 10% or less  
11%-25%  
26%-50%  
51%-75%  
76%-100%  
Don't know
- Q23 Does your organization communicate prehospital 12-lead information? Check all that apply.
- Yes, to PCI hospital  
Yes, to base hospital  
Yes, in some ambulances and to some hospitals  
Yes, to a medical control facility  
No
- (Please note: if "No" skip questions 24-26)**
- Q24 How is the 12-Lead ECG information transmitted? Check all that apply.
- ECG read by EMS personnel and interpretation called by phone/radio  
ECG read by computer algorithm and called by phone/radio to base hospital  
ECG communicated to base hospital  
ECG communicated by blue tooth  
ECG communicated by cell phone  
ECG communicated by radio  
Don't know/not applicable
- Q25 What is your estimate of the false positive (ie, catheterization laboratory activated but ECG did not really show ST elevation) of 12-lead ECG readings? Check the answer that best applies.
- Greater than 50%  
26%-50%  
10%-25%  
Less than 10%  
Don't know
- Q26 Does your organization have a process for collecting and analyzing data related to 12-lead ECG acquisition and interpretation or quality review and improvement reasons?
- Yes  
No
- Q27 Is your organization's data review performed with: (Check all that apply)
- Non-PCI hospital  
PCI hospital  
ED  
Cardiologists  
State Agency or Department of EMS  
Agency medical director  
None of the above  
Don't know/not applicable
- Q28 Does your organization track and review any of the following performance measures for patients with suspected STEMI? Check all that apply.

- 12-Lead ECG interpretation accuracy including false-positive rate, if applicable  
12-Lead ECG interpretation accuracy including false-negative rate, if applicable  
Complications (including death) during transport  
Time ambulance dispatched to call  
EMS arrival on scene (first medical contact)  
EMS arrival at hospital door  
Medical transport unit's on scene time to hospital door arrival time  
No performance measures are captured  
Patient AMI symptom onset time  
Don't know/not applicable
- Q29 Are there destination protocols (ie, bypass non-PCI hospitals to go directly to PCI centers) for patients that have had a prehospital identification of a STEMI?
- Yes  
No  
Don't know/not applicable
- Q30 Was state, city or county legislation needed to implement the bypass protocols? (add hyperlink)
- Yes  
No  
Don't know/not applicable
- Q31 Please specify if the legislation/regulation was initiated at the (Check all that apply):
- City level  
County level  
State level  
Don't know/not applicable
- Q32 If your organization does not routinely transfer patients with AMI to a PCI center, do you utilize an inclusion/exclusion fibrinolytic criteria checklist completed on patients with suspected STEMI prior to ED arrival?
- Yes  
No  
Don't know/not applicable
- Q33 Is prehospital fibrinolysis used in your organization?
- Yes.  
No  
Sometimes  
Don't know/not applicable
- Q34 For interfacility transports from non-PCI to PCI hospitals, is there a transport time goal from departure of non-PCI center to arrival at the PCI hospital door.
- Yes and the expected response time is \_\_\_\_\_  
No  
Don't know/not applicable
- Q35 For non-PCI hospitals that use interfacility transfers to a PCI facility for patients with STEMI, do the patients with suspected STEMI stay on an ambulance stretcher for evaluation?
- Yes.  
Always  
Frequently  
Occasionally  
No  
Don't know/not applicable
- Q36 Do the interfacility STEMI patients need to be transferred to a PCI facility given the same priority as a 911 calls?
- Yes  
No  
Don't know/not applicable

#### Stroke Questions

- Q37 Does your organization's dispatch center utilize established standards for emergency medical dispatch (EMD) protocols for

stroke patients that meet national guidelines <sup>A</sup> established by AHA through emergency cardiovascular care or policy papers?

Yes

No

Don't know/not applicable

Q38 If yes, which one?

Emergency cardiac care

Policy papers

Don't know/not applicable

Q39 Do all emergency medical trained responders within your organization utilize a stroke triage assessment tool for every suspected stroke patient that meets AHA/ASA guidelines <sup>A</sup> (including Cincinnati Stroke Scale, LA, MENDS or other validated tool)?

Yes

No

Don't know/not applicable

Q40 Do all emergency medical responders within your organization utilize a stroke treatment protocol that meets (at a minimum) AHA/ASA guidelines <sup>A</sup> and emergency cardiovascular care ACLS standards?

Yes

No

Don't know/not applicable

Q41 Do all EMS responders within your organization utilize stroke transport protocols with the intent to transport qualified acute stroke patients to the most appropriate treatment facilities (ie, primary stroke center).

Yes

No

Don't know/not applicable

Q42 Do all emergency medical trained responders within your organization that care for stroke patients complete a minimum of 2 hours of stroke assessment education and care per year as a part of their certification or registration renewal requirements?

Yes

No

Don't know/not applicable

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