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## Factors Associated With Longer Time to Treatment for Patients With Suspected Acute Coronary Syndromes A Cohort Study

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**Background**—Rapid treatment of acute coronary syndromes (ACS) is important; causes of delay in emergency medical services care of ACS are poorly understood.

**Methods and Results**—We performed an analysis of data from IMMEDIATE (Immediate Myocardial Metabolic Enhancement during Initial Assessment and Treatment in Emergency Care), a randomized controlled trial of emergency medical services treatment of people with symptoms suggesting ACS, using hierarchical multiple regression of elapsed time. Out-of-hospital ECGs were performed on 54 230 adults calling 9-1-1; 871 had presumed ACS, 303 of whom had ST-segment elevation myocardial infarction and underwent percutaneous coronary intervention. Women, participants with diabetes mellitus, and participants without previous cardiovascular disease waited longer to call 9-1-1 (by 28 minutes,  $P<0.01$ ; 10 minutes,  $P=0.03$ ; and 6 minutes,  $P=0.02$ , respectively), compared with their counterparts. Time from emergency medical services arrival to ECG was longer for women (1.5 minutes;  $P<0.01$ ), older individuals (1.3 minutes;  $P<0.01$ ), and those without a primary complaint of chest pain (3.5 minutes;  $P<0.01$ ). On-scene times were longer for women (2 minutes;  $P<0.01$ ) and older individuals (2 minutes;  $P<0.01$ ). Older individuals and participants presenting on weekends and nights had longer door-to-balloon times (by 10, 14, and 11 minutes, respectively;  $P<0.01$ ). Women and older individuals had longer total times (medical contact to balloon inflation: 16 minutes,  $P=0.01$ , and 9 minutes,  $P<0.01$ , respectively; symptom onset to balloon inflation: 31.5 minutes for women;  $P=0.02$ ).

**Conclusions**—We found delays throughout ACS care, resulting in substantial differences in total times for women and older individuals. These delays may impact outcomes; a comprehensive approach to reduce delay is needed. (*Circ Cardiovasc Qual Outcomes*. 2014;7:00-00.)

**Key Words:** acute coronary syndrome ■ emergency medical services ■ women

Acute coronary syndromes (ACS) are a major cause of death in the United States.<sup>1,2</sup> A majority of these deaths occur in the first hours after symptom onset, approximately half from ischemia-induced arrhythmias.<sup>2-5</sup> Therefore, reducing delays in treatment of patients with ACS should reduce morbidity and mortality.<sup>6-14</sup>

Over half of patients hospitalized for ACS arrive via emergency medical services (EMS).<sup>15</sup> Thus, quantifying the time that patients with possible ACS spend in the sequence of EMS care through initiating care at the receiving hospital and determining the causes of longer durations are important for developing strategies to reduce delays and thereby improve clinical outcomes. Yet, few studies have described time that patients with ACS spend in EMS care or factors associated with longer time in EMS care,<sup>16,17</sup> and no previous studies have examined all patients who have out-of-hospital ECGs performed.

We conducted an exploratory analysis of data from IMMEDIATE (Immediate Myocardial Metabolic Enhancement during Initial Assessment and Treatment in Emergency Care),

a randomized controlled trial of EMS treatment of patients for symptoms suggestive of ACS.<sup>18</sup> The goals were to ascertain durations of time that patients with potential ACS spend in the entire sequence of care from initial EMS contact until initiation of definitive treatment at the receiving hospital (eg, inflation of a percutaneous coronary intervention [PCI] balloon) and to determine which patient characteristics are associated with longer times. We hypothesized that female sex, older age, minority race/ethnicity, presence of diabetes mellitus, lack of history of cardiovascular disease (CVD), and occurrence of events on weekends and nights would be associated with longer times.

### Methods

#### Study Design and Setting

This was a retrospective analysis of data from IMMEDIATE.<sup>18</sup> IMMEDIATE was a multicenter, double-blinded, randomized, placebo-controlled clinical effectiveness trial evaluating whether intravenous glucose–insulin–potassium reduced the progression of unstable angina pectoris to myocardial infarction, and whether it

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**WHAT IS KNOWN**

- Prior studies have found delays in hospital care of acute coronary syndrome for certain categories of patients including women, elderly, and those without chest pain.
- Little is known about the time intervals in early ACS care that contribute to these delays.

**WHAT THE STUDY ADDS**

- This study identified factors associated with longer pre-hospital care steps (eg, emergency medical services arrival to electrocardiogram) for patients with suspected acute coronary syndrome.
- The results support cumulative delays over the span of early ACS care steps for women.

reduced mortality, cardiac arrest, development of heart failure, and infarct size in patients with a high suspicion of ACS. The methods of IMMEDIATE trial have been previously published.<sup>18,19</sup> The study was conducted between 2006 and 2011 and enrolled participants from 13 US cities. The identification of participants with ACS by the paramedics was aided by the ECG-based acute cardiac ischemia time-insensitive predictive instrument and thrombolytic predictive instrument, using a threshold of 75% or higher predicted probability of having ACS by the acute cardiac ischemia time-insensitive predictive instrument, detection of suspected ST-segment myocardial infarction (STEMI) by the thrombolytic predictive instrument, or both.<sup>20</sup> This resulted in a population of participants with a high rate of ACS.

**Selection of Participants**

We analyzed the data from 3 cohorts from IMMEDIATE: all participants aged ≥18 years with a 12-lead out-of-hospital ECG who were screened to determine the eligibility for inclusion; participants with high risk of ACS who met the trial eligibility criteria, agreed to have the study drug started in the ambulance, and provided written informed consent; and participants who had an adjudicated diagnosis of STEMI and underwent PCI <12 hours of their initial presentation to EMS. For each outcome measure, we analyzed the largest sample for which we had data available.

This study was reviewed and approved by the Tufts Medical Center institutional review board. All participants with out-of-hospital ECG

performed had deidentified the data collected as part of the screening process to determine the eligibility for enrollment into IMMEDIATE. All participants provided written informed consent that allows for the analyses of data presented.

**Independent Variables**

We assessed for differences in time intervals by sex, age, past medical history of CVD, history of diabetes mellitus, minority ethnicity or race, day of week, and time of day. Age was entered into the model as a categorical variable, whereas all other independent predictors were entered as binary variables (day of week was entered as weekend, and weekday and time of day as overnight or daytime). Ethnicity and race were combined into a single variable for the purpose of analyses. Non-Hispanic whites were defined as participants of white race and were not of Hispanic ethnicity. Minorities were defined as all participants of nonwhite race (including black, Native American, Asian, and Hawaiian) and those of Hispanic ethnicity.

**Outcome Measures**

We analyzed the time interval (in minutes) from symptom onset through PCI balloon inflation (Figure 1). Each time interval was analyzed as a continuous outcome. Time of symptom onset was obtained via patient recall at the time of transport. All times in EMS care were obtained from EMS runsheets with the exception of the ECG time, which was taken from the ECG timestamp. Hospital times, including time of arrival at hospital and time of PCI balloon inflation, were obtained from medical records. All time interval definitions were agreed upon before conducting the study.

**Measured Time Intervals**

**Time From Symptom Onset to 9-1-1 Call**

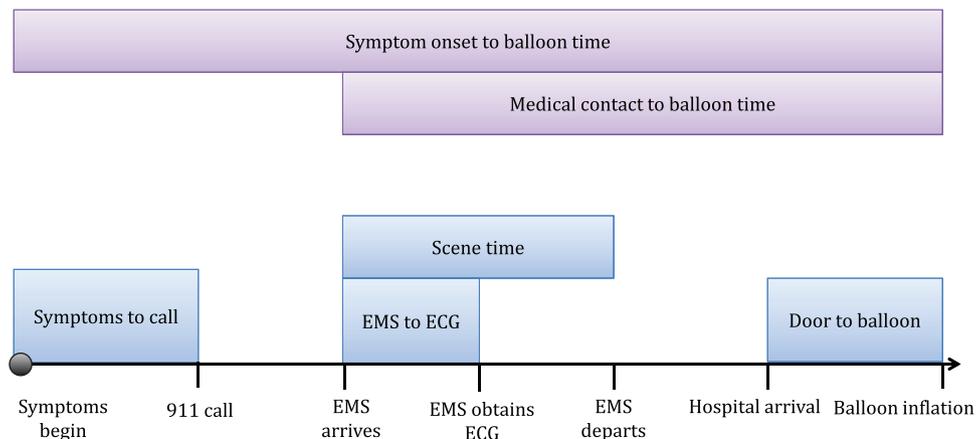
Time from symptom onset to 9-1-1 call was defined as the time from the onset of symptoms concerning for ACS until the participant called 9-1-1. Data for this time interval were analyzed for participants with a high risk of ACS.

**Time From EMS Arrival to Out-of-Hospital ECG**

Time from EMS arrival to out-of-hospital ECG was defined as the time from EMS arrival on scene and out-of-hospital ECG timestamp. Data for this time interval were analyzed for all participants receiving an out-of-hospital ECG.

**Scene Time**

Scene time was defined as the time between EMS arrival on scene and EMS departure from scene. Data for this time interval were analyzed for participants with a high risk of ACS.



**Figure 1.** Time intervals and goals for each time interval. Blue boxes display individual time intervals, purple boxes depict comprehensive time intervals. Goal times are derived from American College of Cardiology/American Heart Association guidelines.

### Hospital Arrival to Balloon Inflation

Hospital arrival to balloon inflation was defined as the time between arrival at hospital and PCI balloon inflation. Data for this time interval were analyzed for the STEMI cohort.

### Cumulative Time Intervals

In addition to the analysis of individual time intervals defined above, 2 cumulative time intervals were analyzed.

### Medical Contact to Balloon Inflation

First medical contact to balloon inflation was defined as the time between EMS arrival on scene and time of PCI balloon inflation.

### Symptom Onset to Balloon Inflation

Symptom onset to balloon inflation was defined as the time between the onset of symptoms and PCI balloon inflation.

### Data Handling

Each time interval was calculated from the collected date and time information using Excel. For the largest data set (all participants receiving out-of-hospital ECGs), some times were improbable (546 times between 0 and 1 minute, 1790 times <0 minute, 866 times >60 minutes). Where a reporting error is likely (ie, around daylight saving times), these times were corrected by hand to the likely value. This resulted in 2084 of 51 975(4%) data points being corrected. The remaining 1118 improbable times were excluded. A sensitivity analysis was conducted without this data, but resulted in little impact on model coefficients. One door-to-balloon time was recorded as 1 minute and was also removed from the analysis.

Missing data were excluded from the analysis. Data were missing for 194 of 871 (22%) participants for time from symptom onset to 9-1-1 call; 2838 of 51 975 participants for EMS arrival to out-of-hospital ECG (5.4%); 12 of 871 participants (1.4%) for on-scene time; 1 of 303 (0.3%) for door-to-balloon time; 5 of 303 (1.7%) for medical contact to balloon time; and 51 of 303 (17%) for symptom onset to balloon time.

### Statistical Analysis

Descriptive statistics were used to report median times for each time interval. We then assessed the association of each time interval with study site. There were significant associations between study site and time; therefore, hierarchical multiple regression models were used for all analyses. All *P* values are the product of hierarchical multiple regression models, adjusting for all other variables in the model. Hierarchical multiple regressions were used to assess differences in times by sex, age, primary complaint of chest pain, day of week, time of day, medical history of CVD (including history of myocardial infarction, PCI, coronary artery bypass grafting, congestive heart failure, and previous stroke), and participant race and ethnicity, while controlling for clustering of outcomes at the site level. Patient factors were forced into the models as fixed effects, and study site was forced into the models as a random effect. Log transformations of time were performed before regression analysis because of right-skewed distributions. Linear regressions were used to model elapsed time (in log minutes). For time intervals with outliers, sensitivity analyses were performed with truncated times. All analyses were conducted using R statistical software, version 2.13.1.

### Results

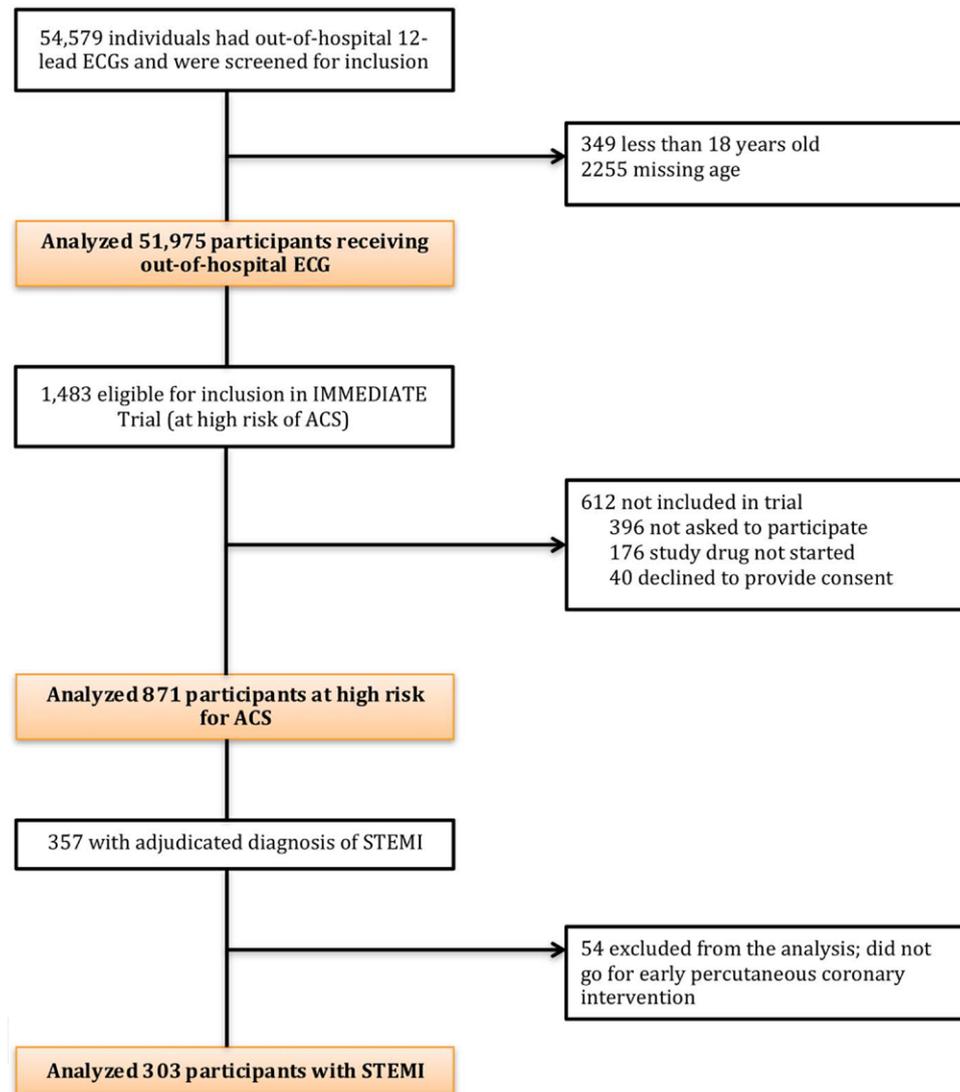
Table 1 presents the patient characteristics. Of 54 579 individuals with 12-lead, out-of-hospital ECGs performed, 51 975 were aged  $\geq 18$  years and were included in the analysis (Figure 2). A total of 871 of 51 975 were enrolled in IMMEDIATE<sup>18</sup> and were included in the analysis of participants with high risk of ACS. There were 303 of 871 who had an adjudicated diagnosis of STEMI and went for PCI <12 hours of starting the study drug. These participants were included in the analysis of participants with STEMI.

**Table 1. Baseline Characteristics of Study Participants**

	All Participants Receiving ECG* (N=51 975)	Participants at High Risk of ACS (N=871)	Participants With STEMI (N=303)
Age, mean (SD), y	63 (17.9)	63.6 (14)	61.3 (12.3)
Male sex	26 201 (50%)	618 (71%)	228 (75%)
Race			
White		724 (83%)	267 (89%)
Black		94 (11%)	17 (6%)
Native American		16 (2%)	7 (2%)
Asian		16 (2%)	4 (1%)
Native Hawaiian		3 (0.3%)	1 (0.3%)
Other		8 (1%)	3 (1%)
Hispanic ethnicity		102 (12%)	43 (14%)
Chest pain primary complaint	21 834 (44%)	749 (86%)	282 (93%)
Weekend	13 676 (26%)	243 (28%)	94 (31%)
Night	19 067 (37%)	323 (37%)	104 (34%)
Past medical history			
Myocardial infarction		311 (36%)	70 (23%)
Coronary artery bypass grafting		141 (16%)	11 (4%)
Congestive heart failure		145 (17%)	14 (5%)
Cerebrovascular accident		86 (10%)	18 (6%)
Percutaneous coronary intervention		264 (30%)	67 (22%)
Diabetes mellitus		242 (28%)	61 (20%)

ACS indicates acute coronary syndrome; and STEMI, ST-segment myocardial infarction.

\*Data on race, ethnicity, and past medical history not available for all participants receiving an out-of-hospital ECG.



**Figure 2.** Study population.

### Overall Median Times

Overall median time was 53 minutes for time from symptom onset to 9-1-1 call, 15.2 minutes from EMS arrival to out-of-hospital ECG, 20 minutes for on-scene time, and 62 minutes for door-to-balloon time. Six percent of participants received an out-of-hospital ECG <5 minutes and 27% <10 minutes. Participants with STEMI had median times of 94 minutes from medical contact to PCI balloon inflation, and 156 minutes from symptom onset to balloon inflation.

### Association of Sex With Time

Table 2 presents the median times for each time interval by sex, and Figure 3 displays the time intervals for participants with STEMI by sex. Figure 3 provides the breakdown of all time intervals from symptom onset until balloon inflation. Time from 9-1-1 call to EMS arrival and transport time were not separately analyzed because of concern for confounding by distance, which was unmeasured in this study.

Compared with men, median times were longer for women for time from symptom onset to 9-1-1 call (unadjusted medians: 73 versus 45 minutes; multivariate adjusted  $P$  value <0.01), EMS arrival to out-of-hospital ECG (unadjusted medians: 16 versus 14.5 minutes; multivariate adjusted  $P$  value <0.01), and on-scene time (unadjusted medians: 21 versus 19 minutes; multivariate adjusted  $P$  value <0.01). A sensitivity analysis was conducted on time from hospital arrival to balloon inflation because of the presence of outliers, but removing the 4 points identified as outliers resulted in little impact on model coefficients (change in  $\beta$ -coefficient of 4%), so the original analysis is presented here.

Women had an unadjusted median time from medical contact to balloon inflation of 106.5 minutes compared with 90.5 minutes for men (multivariate adjusted  $P$  value=0.01). Time from symptom onset through balloon inflation was 180 minutes for women compared with 148.5 minutes for men (multivariate adjusted  $P$  value=0.02).

**Table 2. Association of Demographic Variables With Median Times**

Interval	Median Times, min*									
	Sex			Age Group, y				Race/Ethnicity		
	Men	Women	<i>P</i> Value†	<55	55–64	>64	<i>P</i> Value†	Non-Hispanic Whites	Minorities	<i>P</i> Value†
Symptom onset to 9-1-1 call (n=677)	45	73	<0.01	41	54	56	0.4	50	58	0.99
EMS arrival to out-of-hospital ECG (n=49 061)‡	14.5	16	<0.01	14.1	14.9	16.2	<0.01	n/a*	n/a*	
Scene time (n=859)	19	21	<0.01	19	18	21	<0.01	19	22	0.26
Hospital arrival to balloon inflation (n=301)	59	67	0.05	63.5	56	66	<0.01	60.5	65.5	0.53
Medical contact to balloon inflation (n=298)	90.5	106.5	0.01	95.5	88	97	<0.01	91	97	0.62
Symptom onset to balloon inflation (N=252)	148.5	180	0.02	144	157	167.5	0.09	150	162.5	0.61

EMS indicates emergency medical service; and n/a, not available.

\*Median times are unadjusted.

†*P* values are adjusted for age, race/ethnicity, presence of chest pain as the primary complaint, day of week, time of day, and past medical history of cardiovascular disease and diabetes mellitus.

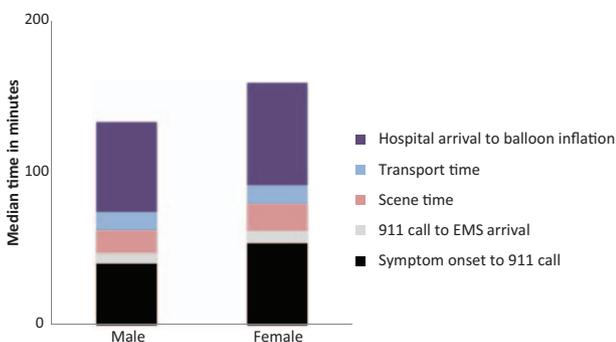
‡Data on race, ethnicity, and past medical history not available for all participants receiving an out-of-hospital ECG.

### Association of Age With Time

Table 2 shows the median times by age. There was no association of age with time from symptom onset to 9-1-1 call. Older age was associated with longer time to ECG (unadjusted median times: 14.1 minutes for individuals aged <55 years, 14.9 minutes for individuals aged 55–64 years, and 16.2 minutes for individuals aged >64 years; multivariate adjusted *P* value <0.01), on-scene time (unadjusted median times: 19 minutes for individuals aged <55 years, 18 minutes for individuals aged 55–64 years, and 21 minutes for individuals aged >64 years; multivariate adjusted *P* value <0.01), and hospital arrival to balloon inflation (unadjusted median times: 63.5 minutes for individuals aged <55 years, 56 minutes for individuals aged 55–64 years, and 66 minutes for individuals aged >64 years; multivariate adjusted *P* value <0.01). A sensitivity analysis was conducted for time from hospital arrival to balloon inflation because of the presence of outliers, but removing the 4 points identified as outliers had little impact on model coefficients (change of 1% in  $\beta$ -coefficient for the eldest group and 15% for the middle-aged group).

### Comprehensive Time Intervals

After adjusting for covariates, there was a significant association of age with longer time from medical contact to balloon



**Figure 3.** Participants with ST-segment myocardial infarction time intervals. \*\*Times presented are unadjusted and are separated into intervals. Time from 9-1-1 call to EMS arrival and transport time were not separately analyzed in this study.

inflation (unadjusted median times: 95.5 minutes for individuals aged <55 years, 88 minutes for individuals aged 55–64 years, and 97 minutes for individuals aged >64 years; multivariate adjusted *P* value <0.01).

### Association of Race/Ethnicity With Time

Table 2 shows the median times by race/ethnicity. After adjusting for covariates, race/ethnicity was not associated with significant differences in median time from symptom onset to 9-1-1 call, on-scene time, and hospital arrival to balloon inflation. Race/ethnicity data were not available for the largest cohort of participants (all participants receiving an out-of-hospital ECG), for whom the analysis of time from EMS arrival to out-of-hospital ECG was conducted.

After adjusting for covariates, the participants without chest pain called 9-1-1 faster than those with chest pain (unadjusted median times 37 versus 54 minutes; multivariate adjusted *P* -value <0.01).

### Association of Chest Pain as the Primary Complaint With Time

Table 3 shows the median times by the presence of chest pain as the primary complaint. After adjusting for covariates, we assessed the participants without chest pain as a primary complaint who called 9-1-1 compared with participants with chest pain (unadjusted median times: 37 versus 54 minutes; multivariate adjusted *P* value <0.01). The primary complaints associated with shorter median times to call were abdominal pain (n=6; median, 17.5 minutes), cardiac arrest (n=1; median, 2 minutes), chest numbness (n=1; median, 41 minutes), diaphoresis (n=2; median, 3 minutes), dizziness (n=4; median 24 minutes), epigastric pain (n=1; 17 minutes), heartburn (n=3; median, 24 minutes), implantable cardiac defibrillator firing (n=1; median, 16 minutes), loss of consciousness (n=9; median, 11 minutes), near syncope (n=1; median, 10 minutes), seizure (n=2; median, 34 minutes), shoulder/arm pain (n=7; median, 45 minutes), sudden collapse (n=1; median, 1 minute), and syncope (n=3; median, 5 minutes). Additionally, some participants with shortness of breath, palpitations, and weakness called the EMS faster than the median time for those with chest pain.

**Table 3. Association of Primary Complaint and Past Medical History With Median Times**

Interval	Median Times, min*								
	Chest Pain Primary Complaint			History of Diabetes Mellitus			History of Cardiovascular Disease		
	Yes	No	<i>P</i> Value†	No	Yes	<i>P</i> Value†	No	Yes	<i>P</i> Value†
Symptom onset to 9-1-1 call (n=677)	54	37	<0.01	50	60	0.02	56	50	0.03
EMS arrival to out-of-hospital ECG (n=49 061)	13.5	17	<0.01	n/a‡	n/a‡		n/a‡	n/a‡	
Scene time (n=859)	19	21	0.89	19	21	0.47	19	20.5	0.35
Hospital arrival to balloon inflation (n=301)	63	53	0.85	61	67	0.41	60	66.5	0.49
Medical contact to balloon inflation (n=298)	94	85.5	0.78	94	97	0.46	92.5	97	0.47
Symptom onset to balloon inflation (n=252)	158	122	0.16	156	159	0.81	159	152	0.07

EMS indicates emergency medical services; and n/a, not available.

\*Median times are unadjusted.

†*P* values are adjusted for age, race/ethnicity, presence of chest pain as the primary complaint, day of week, time of day, and past medical history of cardiovascular disease and diabetes mellitus.

‡Data on race, ethnicity, and past medical history not available for all participants receiving an out-of-hospital ECG.

Participants without a primary complaint of chest pain had longer time from EMS arrival to out-of-hospital ECG after adjusting for covariates (unadjusted median times: 17 versus 13.5 minutes; multivariate adjusted *P* value <0.01). There were no associations of chest pain as the primary complaint with on-scene time, hospital arrival to balloon inflation, medical contact to balloon inflation, or symptom onset to balloon inflation.

#### Association of Past Medical History of CVD and Diabetes Mellitus With Time Intervals

Table 3 shows the median times by medical history of diabetes mellitus and CVD.

#### Symptom Onset to 9-1-1 Call

After adjusting for covariates, participants with a history of diabetes mellitus had longer time from symptom onset to 9-1-1 call (unadjusted median times: 60 versus 50 minutes; multivariate adjusted *P* value=0.02), and those with a history of CVD had shorter time from symptom onset to 9-1-1 call (unadjusted median times: 50 versus 56 minutes; multivariate adjusted *P* value=0.03). There were no associations of history of diabetes mellitus or CVD with on-scene times or hospital arrival to balloon inflation. Data on medical history were not available for the largest cohort of participants, on

whom the analysis of EMS arrival to out-of-hospital ECG was conducted.

After adjusting for covariates, participants with a history of CVD had a trend toward faster time from symptom onset to balloon inflation (unadjusted median times: 152 versus 159 minutes; multivariate adjusted *P* value=0.07). There was no difference in medical contact to balloon inflation by past medical history.

#### Association of Weekend and Night Presentations With Time

Table 4 shows the median times by day of week and time of day. There were no associations of night or weekend presentation with time from symptom onset to 9-1-1 call or on-scene time. Participants presenting during daytime had longer time from EMS arrival to out-of-hospital ECG compared with those presenting at night, after adjusting for covariates (unadjusted median times: 14.9 versus 15.4 minutes; multivariate adjusted *P* value=0.03). After adjusting for covariates, participants who presented on weekends had longer time from hospital arrival to balloon inflation compared with those who presented on weekdays (unadjusted median times: 72 versus 58 minutes; multivariate adjusted *P* value <0.01). Participants who presented during the night (7 PM to 7 AM) had a longer time

**Table 4. Association of Day of Week and Time of Day With Median Times**

Interval	Median Times, min*					
	Day of Week			Time of Day		
	Weekday	Weekend	<i>P</i> Value†	7 AM to 7 PM	7 PM to 7 AM	<i>P</i> Value†
Symptom onset to 9-1-1 call (n=677)	55	44	0.51	53	34.5	0.37
EMS arrival to out-of-hospital ECG (n=49 061)	15.3	15.1	0.12	15.4	14.9	0.03
Scene time (n=859)	20	19	0.39	19	20	0.4
Hospital arrival to balloon inflation (n=301)	58	72	<0.01	58	69	<0.01
Medical contact to balloon inflation (n=298)	90	104.5	<0.01	89	98.5	<0.01
Symptom onset to balloon inflation (n=252)	160	147.5	0.6	155.5	156	0.51

EMS indicates emergency medical services.

\*Median times are unadjusted.

†*P* values are adjusted for age, race/ethnicity, presence of chest pain as the primary complaint, day of week, time of day, and past medical history of cardiovascular disease and diabetes mellitus.

from hospital arrival to balloon inflation compared with those who presented during the daytime (7 AM to 7 PM; unadjusted median times: 69 versus 58 minutes; multivariate adjusted  $P$  value  $<0.01$ ). A sensitivity analysis was conducted for hospital arrival to balloon inflation because of the presence of outliers, but removing the 4 points identified as outliers had little impact on model coefficients (change of 5% in  $\beta$ -coefficient for night presentation and 6% in  $\beta$ -coefficient for weekend presentation).

After adjusting for covariates, participants who presented on weekends had longer time from medical contact to balloon inflation compared with those who presented on weekdays (unadjusted median times: 104.5 versus 90 minutes; multivariate adjusted  $P$  value  $<0.01$ ). Participants presenting during night had longer time compared with those presenting during daytime (unadjusted median times: 98.5 versus 89 minutes; multivariate adjusted  $P$  value  $<0.01$ ).

### Additional Analyses

A sensitivity analysis excluding corrected times for the analysis of all participants receiving an out-of-hospital ECG was conducted. This had little impact on the estimates, so the corrected times were included in the final analysis.

A sensitivity analysis was conducted for participants with STEMI using truncated door-to-balloon times because of outliers in the door-to-balloon time. This resulted in little impact in the model estimates, so the raw data were used for the final analysis.

### Discussion

In this study of patients calling 9-1-1 for symptoms suggesting ACS, we found delays in the entire chain of care, from the calling of 9-1-1 to care on-scene, to care at the hospital. Delays were present for women and the elderly patients in most time intervals, culminating in larger magnitude differences in total times. These findings indicate the need for a comprehensive approach to improve early detection of ACS, starting with patients themselves.

For the time from symptom onset to 9-1-1 call, the overall median times were close to an hour. This is substantially better than that reported in previous studies,<sup>21–23</sup> but much longer than the goal time of 5 minutes advised by the American College of Cardiology/American Heart Association (ACC/AHA),<sup>24</sup> which only 10% of participants met. Reducing the delay in this time interval has a great potential to improve the outcomes of patients with ACS, given that many deaths occur early.<sup>2–5</sup> Consistent with previous studies, we found that women,<sup>21,25–29</sup> participants with a history of diabetes mellitus,<sup>21–23,26–29</sup> and those without a history of CVD<sup>21,26</sup> took longer to call for help. It is possible that women consider themselves to be at lower risk for ACS and, therefore, delay calling for help. Patients with diabetes mellitus may delay calling because of less severe symptoms, whereas those with a history of CVD may recognize the symptoms and call sooner than those without a history of CVD. It is not clear why a primary complaint of chest pain was associated with a longer time to call 9-1-1 in participants at high risk of ACS. Perhaps those participants without chest pain as their primary symptom still had symptoms characteristic of ACS. This finding was not present in participants with

STEMI. This association is difficult to interpret because of potential inconsistencies in the descriptions of symptoms, and further study is needed.

To our knowledge, this is the first description of time from EMS arrival to out-of-hospital ECG, a critical time interval in the diagnosis and management of ACS. In our study, time from EMS arrival to out-of-hospital ECG was 15 minutes in all participants. This interval could likely be reduced, leading to earlier detection of ACS. Women, older individuals, members of minorities, and those with a primary complaint other than chest pain had longer median times from EMS arrival to out-of-hospital ECG. Reasons for these differences are unclear. Perhaps, women are perceived as lower risk and the EMS provider takes longer to decide whether to obtain an ECG. It may take longer to obtain an ECG in older individuals because of the difficulty in performing other prehospital tasks such as obtaining intravenous access and placing the patient on a stretcher. It likely takes longer for EMS to obtain a history concerning possible ACS in patients without a primary complaint of chest pain and, thus, to obtain an ECG in those patients.

The overall median on-scene time was 20 minutes for participants with ACS and 16 minutes for those with STEMI, which is closer to the goal recommended by the ACC/AHA.<sup>24</sup> However, women and older individuals had longer times in this interval compared with their counterparts, and targeted improvements are needed.

Women and older individuals had longer times compared with their counterparts after arrival at the hospital, with the magnitude of difference much higher than in the EMS setting. Reasons for these delays are unclear, but our findings are consistent with previous studies<sup>9,10,30</sup> and indicate the need for continued efforts to reduce delays in the hospital setting. Day of week and time of day were only associated with longer times in the hospital setting. Presumably, the absence of this effect in the EMS setting is because of its 24-hour, 7-day function. The implementation of a similar work structure in hospitals may result in improved times on weekends and nights.

This study has several strengths. It addresses the gaps in the knowledge of treatment of patients with suspected ACS and is, to the best of our knowledge, the first study to assess differences in EMS time intervals for all people evaluated by EMS for a possible cardiac complaint. These time intervals are crucial in the diagnosis and treatment of ACS. The data were prospectively collected in a large clinical effectiveness trial that had a very high rate of inclusion of patients calling 9-1-1 for potential cardiac symptoms as well as those from a wide variety of communities and ethnic groups. There were 32 EMS systems in this geographically diverse sample. This increased the study's generalizability as well as the likelihood that our findings are relevant to patients being transported by other EMS systems. There are, however, several limitations to this study that must be kept in mind when interpreting the results. This was intended to be primarily a descriptive study. However, we conducted the analyses to assess differences in times by patient characteristics and did not adjust  $P$  values to account for multiple testing. All of the effects were based on separate hypotheses for which literature and clinical practice provided support, and the analyses were decided a priori.

Second, our largest data set, for which we analyzed time from EMS arrival to out-of-hospital ECG, had more missing data compared with the smaller datasets. Third, information on distance was not collected, and therefore we could not control for possible confounding of effect by distance from hospital. Fourth, the number of participants with STEMI and without chest pain was small. Fifth, the EMS providers received training specific to the study. This may have affected their clinical performance in terms of identifying STEMI and rapidly transporting those patients to the hospital, potentially restricting this study's generalizability to other EMS systems. However, this additional ECG-based training in recognizing ACS and STEMI would likely bias our study against finding delays. Thus, it could be that delays may have been longer than what we found in this study. Sixth, our comprehensive time intervals are for participants with STEMI, thereby limiting our ability to generalize these findings to the general ACS population. Because the time differences for ACS participants were in the same direction as participants with STEMI, it is likely that there was a cumulative effect of time differences for people with ACS as well as those with STEMI, but we are unable to answer this question definitively with our data. Finally, we did not have the data on race and past medical history for all participants receiving an out-of-hospital ECG.

In summary, we found delays along the entire spectrum of care for patients with possible ACS, beginning with the patient's 9-1-1 call. These delays were additive, resulting in longer time differences for women and older individuals in the comprehensive intervals. Although the reduction of delays in all these time intervals is important, we think that reducing time from symptom onset to 9-1-1 call and time from EMS arrival to out-of-hospital ECG are most likely to improve early detection of ACS and thereby impact patient outcomes.

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### Disclosures

None.

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