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Characteristics of Prehospital Electrocardiogram Use in North Carolina Using a Novel Linkage of Emergency Medical Services and Emergency Department Data

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Abstract

Objective: Prehospital electrocardiography (ECG) is recommended for patients with suspected acute coronary syndrome (ACS), yet only 20–80% of chest pain patients receive a prehospital ECG. Less is known about prehospital ECG use in patients with less common complaints (e.g., fatigue) suspicious for ACS who are transported by emergency medical services (EMS). The aims of this study were to determine: 1) the proportion of patients with chest pain and less typical complaints, and 2) patient characteristics associated with prehospital ECG use in patients transported by EMS to emergency departments across North Carolina.

Methods: A novel linked database was created between prehospital and emergency department (ED) patient care data from the North Carolina Prehospital Medical Information System and the North Carolina Disease Event Tracking and Epidemiologic Collection Tool. Institutional review board approval and a data use agreement were received prior to the start of the study. Patients ≥ 21 transported during 2010–2014 by EMS with select variables were included. We examined patients' complaints (symptoms), characteristics (e.g., race, ethnicity, final hospital diagnosis), and prehospital ECG use (yes/no). Analysis included descriptive statistics and mixed logistic regression.

Results: During 2010–2014, there were 1,967,542 patients with linked EMS-ED data (mean age: 56.9 [SD: 22.2], 43.2% male, 63.7% White). Of these, 643,174 (32.6%) received a prehospital ECG. Patients with prehospital ECG presented with the following complaints: 20% chest pain; 10% shortness of breath; 6% abdominal pain/problems; 6% altered level of consciousness; 5% syncope/dizziness; 4% palpitations; 12% other complaints; and 37% missing. Patients' presenting

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There are no further disclosures to report.

complaints were the strongest predictor of prehospital ECG use, adjusting for age, sex, race, ethnicity, urbanicity, and date and time of EMS dispatch.

Conclusions: Patients with chest pain were significantly more likely to receive a prehospital ECG compared to those with less typical but suspicious complaints for ACS. Patients with less common presentations remain disadvantaged for early triage, risk stratification, and intervention prior to the hospital.

Introduction

Rapid and accurate identification of acute coronary syndrome (ACS) is critical for reducing patient morbidity and mortality and optimizing outcomes.[1] The electrocardiogram (ECG) is the most widely used diagnostic test to determine acute myocardial ischemia and/or infarction and is cheap, non-invasive, and readily available. Mounting evidence suggests that prehospital ECG results are significantly associated with ACS diagnoses, fewer adverse clinical events, less total ischemic burden time, and long-term survival.[2–5] Prehospital ECG findings of myocardial ischemia direct the next steps for emergency medical service (EMS) personnel, such as bypassing the nearest hospital for one farther away offering percutaneous coronary intervention.[6] Prehospital ECG use is associated with decreased time to treatment, increased activation of the cardiac catheterization laboratory, and improved diagnostic accuracy of ACS when used in conjunction with the initial hospital ECG acquired in the emergency department (ED).[4,5] Despite these benefits, prehospital ECG use for chest pain patients varies [20–80%] due to differing levels of prehospital care, lack of standardized protocols, data collection procedures, and differences in EMS personnel training.[7–9]

Prehospital ECG protocols vary by EMS system; thus, there lacks a standardized approach for ECG use in prehospital cardiac care.[6,10] To help standardize care across the state, the North Carolina Office of Emergency Medical Services (NC OEMS) developed a prehospital ECG protocol for patients transported with chest pain and/or anginal equivalents (http://www.ncems.org/nccepstandards/protocols/protocols.pdf (Table 1). Because nearly 20% of ACS patients present with non-chest pain or less typical complaints (e.g., shortness of breath, diaphoresis) that might not be recognized as symptomatic of ACS, comprehensive prehospital ECG protocols are important.[11] Women, the elderly, and diabetics tend to have less typical ACS complaints; consequently, they may experience significant delays in treatment, increased morbidity and mortality, and are disadvantaged in terms of timely diagnoses and life-saving treatment to salvage vulnerable myocardium.[11,12]

The association between prehospital ECG use and less typical ACS complaints by patients transported by EMS is yet unclear. Examining NC data, we aimed to: 1) determine the proportion of patients with chest pain and/or less typical complaints; and 2) describe patient characteristics associated with prehospital ECG use in patients transported by EMS to emergency departments across North Carolina.

Methods

We conducted a large retrospective cohort study of persons activating 9–1-1 with chest pain and/or anginal equivalent complaints in NC between January 1, 2010 and December 31,

2014. We included in the final dataset information from persons ≥ 21 years of age with linked prehospital and ED records. We examined patients' primary complaints reported by EMS providers, and excluded patients with cardiac arrest as the primary complaint or who arrested before or during transport. From population-based registries, we obtained continuously collected data maintained by the NC Department of Public Health, NC Office of EMS, and the Department of Emergency Medicine at University of North Carolina at Chapel Hill (UNC). These registries include patient demographic data, presenting complaints, procedures, and final hospital diagnoses. Approval from the UNC Institutional Review Board was received and a data use agreement completed prior to the start of the study.

Both the NC Prehospital Medical Information System (PreMIS) and the NC Disease Event Tracking and Epidemiological Collection Tool (NC DETECT) track EMS and ED visits across the state (https://www.emspic.org/). PreMIS is a state-mandated internet-based EMS information system that collects data on each EMS patient care report in NC. PreMIS provides standardized diagnostic categories based on the National EMS Information System. EMS providers submit data through a web-based data entry tool or through an XML import process; administrators evaluate data for performance measures. NC DETECT is a statewide syndromic surveillance system created by the Division of Public Health, the Carolina Center for Health Informatics (CCHI), and the UNC Department of Emergency Medicine. NC DETECT addresses the need for early event detection and timely public health surveillance across the state using a variety of secondary data sources, including emergency departments, the Carolinas Poison Center, and PreMIS (https://ncdetect.org/).

Linkage Algorithm.

Using a deterministic match approach, a CCHI data expert in consultation with study investigators linked PreMIS (EMS dataset) and NC DETECT (ED dataset). For an EMS and an ED visit to be linked, the following variables were required: 1) Patient date of birth; 2) patient gender; 3) hospital and ED to which EMS transported the patient; and 4) date and times of EMS arrival and ED registration within an hour of one another, regardless of which came first. The PCR Key (unique key for the PreMIS data), and Visit_ID (unique key for NC DETECT data) linked the datasets.

Proportion of records linked and non-unique matches.

We examined a sample dataset containing over 3 years of EMS call report and ED visit record data to determine the proportion of linked records and estimated accuracy of the linkage. The dataset contained 2,850,642 EMS call reports, of which 1,967,542 (69%) linked to an ED visit record. The data expert (DMF) conducted multiple checks to ensure correct linkage, although this approach did not guarantee a perfect link. We removed all PreMIS and NC DETECT data fields related to patient information, hospital location or name, or any other identifiers from the final dataset.

Statistical Analysis

We computed descriptive statistics (means, standard deviations for continuous variables; frequencies and percentages for categorical variables) for demographic and clinical characteristics by prehospital ECG use. Final diagnoses included ST-elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTEMI), angina pectoris, and/or other acute cardiac disease (e.g., atrial fibrillation, heart failure). The relationship between prehospital ECG use and final hospital diagnosis was assessed using a chi-square test.

We then identified which patient characteristics (e.g., age, gender) were most associated with prehospital ECG use. In preliminary analyses, we fit a logistic model including all characteristics as predictors to assess the association between each characteristic and whether or not patient gets an ECG, controlling for the effects of all other predictors in the model. However, in this model, all predictors were significant due to the large magnitude of the dataset. We, therefore, split the data into approximately 300 randomly selected independent subsets and fit a logistic model with the group lasso penalty.[13] We included the presence/absence of prehospital ECG as a response variable and included all characteristics as predictors. Age was the only continuous variable identified as important in each subset, implying a bias of this penalty towards continuous variables; therefore, we examined variable importance scores obtained from the tree ensemble classification approach of Random Forests. [14] With this approach, a random forest is an ensemble (i.e., group) of classification trees constructed from patient characteristics in a particular dataset to classify whether a patient gets classified into the group that receives an ECG or the group that does not receive an ECG. A patient gets classified into the group with the majority vote across the classification trees in the ensemble. Due to the bias of Random Forests toward continuous variables or variables with many categories, we considered an unbiased approach to Random Forests to remove this bias.[15] Specifically, we applied the unbiased Random Forests approach to each subset and computed the variable importance scores for each characteristic, which was the same random subsampling approach from our preliminary analyses. Across subsets, we computed the median variable importance score for each characteristic and identified those with scores in the top 50th percentile as those most associated with whether or not a patient received a prehospital ECG. We then estimated the magnitude of the impact of these identified characteristics and fit a logistic mixed effects model, including these characteristics as predictors, presence/absence of prehospital ECG as the response variable, and a random effect of year (when EMS unit left the scene) to account for correlation among observations within the same year.

To deal with missingness when identifying which characteristics are most associated with whether or not a patient receives an ECG, the variable importance measures obtained from Random Forests implicitly adjust for missing values.[16] To deal with missingness in estimating the effects of patient characteristics identified as being most associated with whether or not a patient receives an ECG, logistic mixed effects modeling is used, which has been shown to yield unbiased estimates of these effects (i.e., estimates equal to the true values of these effects) when values are missing at random (i.e., when missingness for a particular patient characteristic is not related to the observed values for that characteristic)[17].

To fit the group lasso penalized logistic models in our preliminary analyses, we used the R **grplasso** package v3.4.4.[13] We ran our application of the unbiased Random Forests approach using the R **party** package v3.4.4.[15] Our logistic mixed models were fit using SAS

PROC GLIMMIX (Version 9.4). The Kenward-Roger denominator degrees of freedom method was used to correct for the fact that the estimated variability of the fixed effects parameter estimates tends, on average, to be lower than the actual variability of these estimates.[18] We conducted all statistical tests at the 0.05 significance level and 0.1 marginal significance level, computed 95% confidence intervals (CIs). The Bonferroni correction was used when appropriate for multiple comparisons.

Results

The final linked data set from PreMIS and NC DETECT yielded 1,967,542 patient encounters across NC during 2010–2014, omitting visits with a primary complaint of cardiac arrest or cardiac arrest prior to EMS arrival. Of the total sample, 643,174 (32.7%) received at least one prehospital ECG before hospital arrival. Prehospital ECG use differed significantly by patients' presenting complaints, age, gender, urbanicity, race, and ethnicity.

Patient Characteristics

Patient demographics and characteristics are displayed in Table 2. The sample mean age was 56.9 years (SD: 22.2), 43.2% male, and 63.7% White. The distribution of patients' presenting complaints is displayed in Table 3. Among all patients who received at least one prehospital ECG, the percentage of patients with a known primary complaint was highest for chest pain/discomfort (20.1%). Among our total cohort, 43,535 patients had a confirmed final diagnosis of ACS (Table 6). Patients diagnosed with ACS (STEMI, NSTEMI, or unstable angina) received significantly more prehospital ECGs compared to those with other diagnoses.

We identified and examined the following characteristics from our unbiased Random Forests variable selection approach: age, gender, race, ethnicity, urbanicity, dispatch notified day of week, and dispatch notified time of day. Controlling for all other effects in our logistic mixed model, prehospital ECG use differed significantly by patients' presenting complaints (p=0.01), age (p <0.0001), gender (p <0.0001), urbanicity (p <0.0001), race (p <0.0001), and ethnicity (p =0.01). Dispatch notified time of day approached but did not reach significance (p=0.08). For every yearly increase in age, the odds of getting a prehospital ECG increased by 1.44% (OR = 1.01; 95% CI: 1.01–1.01). Women were 22% less likely to receive a prehospital ECG compared to men (OR = 0.78; 95% CI: 0.78–0.79). Compared to Whites, the odds of receiving a prehospital ECG range from 11% lower for African Americans (OR = 0.89; 95% CI: 0.88–0.90) to 30% higher for Asians (OR = 1.30; 95% CI: 1.24–1.37) (Table 5). Non-Hispanics were 17% more likely to receive a prehospital ECG than Hispanics (OR = 1.17; 95% CI: 1.13–1.19). Patients in rural areas were 24% less likely to receive a prehospital ECG than those in urban areas (OR = 0.76; 95% CI: 0.75–0.76).

Prehospital use varied by EMS dispatch time of day. Compared to dispatch being notified between 6:00 pm to 11:59 pm, the odds of receiving a prehospital ECG were 11% lower for EMS dispatch between 12:00 am to 5:59 am (OR = 0.89; 95% CI: 0.88–0.91, p < 0.0001); 1% lower for dispatch being notified between 12:00 pm to 5:59 pm (OR = 0.99; 95% CI: 0.97–1.00, p = 0.087); and 1% higher for EMS dispatch between 6:00 am to 11:59 am (OR

= 1.01; 95% CI: 1.00–1.03, $p = 0.095$). There were no significant differences in prehospital ECG use by day of week.

Presenting Complaints

Prehospital ECG use differed significantly by presenting patient complaints (Table 4). Patients presenting with any complaints other than chest pain were significantly less likely to have prehospital ECG use compared to patients presenting with chest pain. Patients with less typical complaints (e.g., abdominal pain, syncope) were significantly less likely to receive prehospital ECG compared to patients with chest pain (OR = 0.11; 95% CI: 0.11–0.12, $p < 0.0001$) or respiratory distress (OR = 0.60; 95% CI: 0.59–0.61, $p < 0.0001$). Patients presenting with respiratory distress were over five times as likely to receive a prehospital ECG compared to patients with chest pain (OR = 5.32; 95: CI: 5.21–5.43, $p < 0.0001$).

Discussion

Findings from our study indicate patients' presenting complaints, specifically chest pain, drive prehospital ECG use. Even after adjustment, patients with chest pain had significantly higher rates of prehospital ECG use compared to those without. Generally, our findings support current NC state EMS protocols recommending that the following receive prehospital ECG: patients presenting with paleness, shortness of breath, nausea, vomiting, dizziness and chest symptoms (pain, pressure, aching, vice-like tightness) including in the substernal, epigastric, arm, jaw, neck or shoulder areas(http://www.ncems.org/nccepstandards/protocols/protocols.pdf). Because paleness and diaphoresis are not currently included in the EMS-ED registries, we were not able to account for these complaints. This is a limitation and a concern because diaphoresis is an important indicator of ACS.[19,20]

Our findings reflect those of prior studies focusing on emergency care of chest pain patients in the prehospital setting. Using PreMIS, Bush and colleagues showed that 61% of EMS patients with chest pain received a prehospital ECG EMS from 2008–2010.[7] Although they report higher ECG use than we found, those investigators did not account for less typical complaints, an important consideration given that nearly 30% of ACS patients do not experience chest pain.[21] Cannon and team linked 2008–2010 PreMIS data with a STEMI registry and found chest pain was a significant predictor of prehospital ECG use by EMS providers (OR =2.24, 95% CI =1.69)[8] and that STEMI patients with chest pain received significantly more prehospital ECG compared to those with less typical symptoms. This study differs from these prior ones because we included all patients presenting to EMS, not just those with chest pain. Importantly, we included all types of potential ACS patients which is significant because the majority of ACS patients (~70%) are diagnosed with non-ST-elevation ACS (non-ST ACS) and less with STEMI.[22]

Our findings reinforce the ongoing need for a high degree of suspicion and liberal use of prehospital ECG in individuals who present without classic symptoms of chest pain, shortness of breath, cold sweat, nausea and lightheadedness.[1] Patients with ambiguous or less typical cardiac complaints are at risk for missed or delayed diagnosis and treatment, which contributes to higher morbidity and mortality.[23,24] Patients presenting without chest pain complaints (~30%), furthermore, have worse outcomes than those with chest pain even accounting for delay in seeking treatment.[21] Although protocols exist for prehospital ECG use, they may not be adequate for less typical complaints of ACS. Moreover, our findings suggest that patient registries, such as PreMIS, lack data elements for less typical complaints such as diaphoresis. Prehospital use, therefore, may be underestimated in patients with less typical complaints. This reflects an ongoing challenge in prehospital research, where information available to EMS providers is often limited and results, therefore, in a less accurate reflection of patients presenting to EMS.[25]

Importantly, we found that compared to patients in urban areas, patients in rural NC received significantly fewer prehospital ECGs. This suggests that disparities persist among rural communities, despite efforts to integrate prehospital ECGs across communities. This disparity may be related to EMS levels of care, which vary by community and resources. Emergency medical technicians (EMTs) are trained to several competency levels (first responder; EMT-basic; EMT-intermediate, EMT-paramedic); yet rural areas are often staffed with first responders or EMT-basic level who generally are not trained for prehospital ECGs acquisition. The decision for EMS providers to obtain a prehospital ECG is largely protocol-driven, but EMS protocols vary widely by local agencies and resources.[8] Current NC EMS protocols include both EMT-basic and EMT-intermediate providers for prehospital ECG acquisition (https://www.ncems.org/nccep.html), but our results suggest this may not yet be routine practice in rural communities. In a recent review of the literature, Powell, Halon and Nelson suggested prehospital ECG acquisition and transmission by EMS providers without advanced training is safe and feasible.[26] Prehospital ECG use in rural areas is associated with reduced time from first medical contact to reperfusion and improved 1-year mortality.[26,27] Future research is needed to explore further potential barriers to prehospital ECG use among rural communities.

We had findings that were unexpected related to ACS diagnoses. Among patients with a confirmed ACS diagnosis, those with NSTEMI received more prehospital ECGs compared to STEMI, unstable angina, or other acute/subacute heart disease. These results are unexpected because ECG changes (ST-elevation) are part of the criteria for a STEMI diagnosis.[28] We speculate that patients ultimately diagnosed with STEMI were unstable at EMS arrival; therefore, providers prioritized rapid transport to the hospital over prehospital ECG acquisition.

Limitations

Our study had limitations. First, we were unable to identify patients who presented to EMS more than once in the time period because our dataset was de-identified, and therefore the same patient may have been included more than once. Next, our data were limited by lack of specific EMS unit level information (e.g. individual EMS protocols), which may impact prehospital ECG use, and as such we were unable to adjust for EMS unit level factors. Moreover, we relied on EMS providers' identification and transcription of patients' presenting complaints; due to the time sensitivity in prehospital care, EMS providers may not have always accounted for this appropriately. We found multiple missing data points in both PreMIS and NC-DETECT registries, despite being collected on an ongoing basis as part of quality assurance. This demonstrates ongoing challenges in prehospital research, which requires tracking patients across multiple phases of care.[25] Linked datasets, therefore, are inherently limited but beneficial for descriptive purposes.[29]

Conclusion

Prehospital ECG is a key component in prehospital systems of care because it provides early identification of STEMI patients, allows for direct transfer of patients to the closest hospital with percutaneous coronary intervention capabilities, and initiates early activation of the cardiac catheterization laboratory before patient arrival.[30] In a novel statewide linked dataset between prehospital and hospital data elements, we determined 32% of patients presenting to EMS with symptoms suspicious for ACS received prehospital ECG. Patients with chest pain complaints had significantly greater prehospital ECG use compared to patients with less typical cardiac complaints.

Our study is timely because of new national efforts focused on the prehospital period and EMS to reduce time to treatment for ACS patients.[31] Specifically, the focus is on reducing time between symptom onset and first medical contact to decrease total ischemic burden time.[31] This is in response to overall patient mortality, which has remained unchanged for patients hospitalized with STEMI who require emergent percutaneous coronary intervention, despite successful efforts for decreased door-to-balloon times.[31] Future efforts are needed to promote use of prehospital ECG among patients with less typical cardiac complaints and those patients living in rural areas.

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Table 1.

North Carolina Office of Emergency Medical Services protocol for patient symptoms that trigger acquisition of a prehospital electrocardiogram http://www.ncems.org/nccepstandards/protocols/protocols.pdf

Symptoms
Chest pain (includes pressure, aching, vice-like tightness)
Location (substernal, epigastric, arm, jaw, neck, shoulder)
Radiation of pain
Pale, diaphoresis
Shortness of breath
Nausea, vomiting, dizziness

Table 2.

Demographics of patients overall and by ECG versus no ECG in those transported by North Carolina EMS (2010–2014) (N=1,967,542)

Variable	Category	Total N=1967542 n (%)[a]	ECG N=643174 n (%)[a]	No ECG N=1324368 n (%)[a]
Age (years)		56.88 (22.20)[b]	61.72 (18.98)[b]	54.49 (23.25)[b]
Gender	Female	1,117,139 (56.8)	344,434 (53.6)	772,705 (58.4)
	Male	850,384 (43.2)	298,723 (46.5)	551,661 (41.7)
	Unknown	19 (0)	17 (0)	2 (0)
Urbanicity	Other	250,126 (12.7)	8,4622 (13.2)	165,504 (12.5)
	Rural	620,811 (31.6)	177,447 (27.6)	443,364 (33.5)
	Urban	1,096,605 (55.7)	381,105 (59.3)	715,500 (54.0)
Insurance Coverage	Insurance	32,6249 (16.6)	105,240 (16.4)	221,009 (16.7)
	Medicare/Medicaid	1,149,933 (58.5)	396,616 (61.7)	753,317 (56.9)
	Other	190,126 (9.7)	59,984 (9.3)	130,142 (9.8)
	Other government payments	29,511 (1.5)	9,527 (1.5)	19,984 (1.5)
	Self-pay	260,008 (13.2)	69,975 (10.9)	190,033 (14.4)
	Workers’ compensation	11,715 (0.6)	1,832 (0.3)	9,883 (0.8)
Ethnicity	Not Hispanic or Latino	1,734,862 (88.2)	589,052 (91.6)	1,145,810 (86.5)
	Hispanic or Latino	50,123 (2.6)	12,612 (2.0)	37,511 (2.8)
	Unknown	182,557 (9.3)	41,510 (6.5)	141,047 (10.7)
Race	White	1,252,329 (9.3)	432,531 (67.3)	819,798 (61.9)
	Black or African American	565,479 (28.7)	168,917 (26.3)	396,562 (30.0)
	American Indian or Alaska Native	28,207 (1.4)	8,875 (1.4)	19,332 (1.5)
	Asian	15,562 (0.8)	5,831 (0.9)	9,731 (0.7)
	Native Hawaiian or Other Pacific	1,516 (0.1)	464 (0.1)	1,052 (0.1)
	Other Race	34,275 (1.7)	9,226 (1.4)	25,049 (2.0)
	Unknown/Not available	63,752 (3.2)	17,330 (3.0)	52,844 (4.0)

[a]n = number of patients in the specified variable category and population (Total, ECG, No ECG), % = percentage of patients in the specified population (Total, ECG, No ECG) that are in the specified variable category

[b]Mean (SD) for age in years

Table 3:

Primary complaint stratified by prehospital ECG use in patients with EMS-ED linked data (2010–2014).

Primary Complaint	Total N=1967542 n (%)[a]	ECG N=643174 n (%)[a]	No ECG N=1324368 n (%)[a]
Abdominal pain/problems	176,073 (9)	38,877 (6)	137,196 (10.4)
Altered level of consciousness	68,490 (3.5)	35,163 (5.5)	33,327 (2.5)
Atypical	402,474 (20.5)	78,731 (12.2)	323,743 (24.5)
Cardiac rhythm disturbance	46,196 (2.4)	26,674 (4.2)	19,522 (1.5)
Chest pain/discomfort	189,407 (9.6)	129,315 (20.1)	60,092 (4.5)
Respiratory arrest	6,396 (0.3)	2,161 (0.3)	4,235 (0.3)
Respiratory distress	196,028 (10)	60,517 (9.4)	135,511 (10.2)
Syncope/fainting	68,215 (3.5)	30,404 (4.7)	37,811 (2.9)
Unknown	814,263 (41.4)	241,332 (37.5)	572,931 (43.3)

[a]n = number of patients with the specified primary complaint in the specified population (Total, ECG, No ECG); % = percentage of patients in the specified population with the specified primary complaint

Table 4.

Primary complaint comparisons by chest pain and respiratory distress reference groups (n=1,948,787[a])

Comparison[b]	OR[c]	P-value	95% LCL[c]	95% UCL[c]
Abdominal pain vs. Chest pain	0.1298	<0.0001	0.1269	0.1327
Abdominal pain vs. Respiratory Distress	0.6904	<0.0001	0.6752	0.7060
Altered level vs. Chest pain	0.4318	<0.0001	0.4203	0.4436
Altered level vs. Respiratory Distress	2.2977	<0.0001	2.2367	2.3605
Atypical vs. Chest pain	0.1128	<0.0001	0.1107	0.1150
Atypical vs. Respiratory Distress	0.6004	<0.0001	0.5893	0.6118
Cardiac rhythm disturbance vs. Chest pain	0.5539	<0.0001	0.5367	0.5717
Cardiac rhythm disturbance vs. Respiratory Distress	2.9476	<0.0001	2.8562	3.0418
Respiratory arrest vs. Chest pain	0.2077	<0.0001	0.1919	0.2249
Respiratory arrest vs. Respiratory Distress	1.1055	0.0003	1.0210	1.1969
Respiratory distress vs. Chest pain	5.3213	<0.0001	5.2124	5.4324
Syncope/fainting vs. Chest pain	0.3489	<0.0001	0.3395	0.3585
Syncope/fainting vs. Respiratory Distress	1.8565	<0.0001	1.8068	1.9075

[a]Number of observations included in logistic mixed models; 18,755 out of 1,967,542 observations not used due to missing values

[b]Estimates based on logistic mixed model results, controlling for all other model effects. P-value for primary complaint was 0.01, indicating a significant relationship between primary complaint and prehospital ECG use, controlling for all other model effects.

[c]OR-odds ratio; 95% LCL-95% lower confidence limit; 95% UCL-95% upper confidence limit P<0.0001

Table 5.

Primary Comparisons by Race (n=1,948,787[a])

Comparison[b]	**OR**[c]	**P-value**	**95% LCL**[c]	**95% UCL**[c]
American Indian vs. White	0.9856	0.6053	0.9507	1.0219
Asian vs. White	1.3039	<0.0001	1.2444	1.3663
African American vs. White	0.8865	<0.0001	0.8778	0.8952
Hawaiian/Pacific vs. White	0.9870	0.8294	0.8441	1.1541
Other Race vs. White	1.1092	<0.0001	1.0662	1.1539

[a]Number of observations included in logistic mixed models; 18,755 out of 1,967,542 observations not used due to missing values

[b]Estimates based on logistic mixed model results, controlling for all other model effects

[c]OR-odds ratio; 95% LCL-95% lower confidence limit; 95% UCL-95% upper confidence limit

Table 6:

Final hospital diagnoses (includes STEMI/NSTEMI/angina pectoris/acute or subacute forms of ischemic heart disease).

Final Diagnosis	Dx In Any Position?	Total N=1967542 n (%)[a]	ECG N=643174 n (%)[a]	No ECG N=1324368 n (%)[a]
STEMI	Yes	12,770 (0.65)	8,199 (1.3)	4,571 (0.4)
	No	1,954,772 (99.0)	634,975 (99.0)	1,319,797 (99.7)
NSTEMI	Yes	23,729 (1.2)	13,165 (2.1)	10,564 (0.8)
	No	1,943,813 (99.0)	630,009 (98.0)	1,313,804 (99.2)
Angina pectoris	Yes	7,036 (0.36)	4,446 (0.7)	2,590 (0.2)
	No	1,960,506 (99.0)	638,728 (99.3)	1,321,778 (99.8)
Acute/subacute ischemic forms of heart disease	Yes	13,513 (0.7)	8,767 (1.4)	4,746 (0.4)
	No	1,954,029 (99.0)	634,407 (99.0)	1,319,622 (99.6)

[a] n = number of patients with/without the specified final diagnosis in any position in the specified population (Total, ECG, No ECG); % = percentage of patients in the specified population with/without the specified final diagnosis in any position

P<0.0001 for each chi-square test assessing the significance of a relationship between whether the specified final diagnosis is in any position and prehospital ECG use.