The Accuracy of Predicting Cardiac Arrest by Emergency Medical Services Dispatchers: The Calling Party Effect

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Abstract

Objectives: To analyze the accuracy of paramedic emergency medical services (EMS) dispatchers in predicting cardiac arrest and to assess the effect of the caller party on dispatcher accuracy in an advanced life support, public utility model EMS system, with greater than 90,000 calls and greater than 60,000 transports per year. Methods: This was a retrospective analysis from January 1, 2000, through June 30, 2000, of 911 calls with dispatcher-assigned presumptive patient condition (PPC) or field diagnosis of cardiac arrest. Sensitivity and positive predictive value (PPV) of the PPC code for cardiac arrest by calling parties were calculated. Homogeneity of sensitivity and PPV of the PPC code for cardiac arrest by calling parties was studied with chi-square analysis. Relevant proportions, relative risk ratios, and associated 95% confidence intervals (95% CIs) were calculated. Student’s t-test was used to compare quality assurance scores between calling parties. Results: There were 506 patients included in the study. Overall sensitivity for dispatcher-assigned PPC of cardiac arrest was 68.3% (95% CI = 63.3% to 73.0%) with a PPV of 65.0% (95% CI = 60.0% to 69.7%). There was a significant difference in the PPV for the EMS dispatcher diagnosis of cardiac arrest depending on the type of caller ($\chi^2 = 17.34$, $p < 0.001$). Conclusions: A higher level of medical training may improve dispatch accuracy for predicting cardiac arrest. The type of calling party influenced the PPV of dispatcher-assigned condition. Key words: emergency medical services (EMS); dispatch; cardiac arrest; prehospital; paramedic. ACADEMIC EMERGENCY MEDICINE 2003; 10:955–960.

Out-of-hospital care providers are faced with economic and manpower limitations that have led emergency medical services (EMS) providers to investigate limiting the use of advanced life support (ALS) care.1–3 The 911 call-taker has become, in effect, the gatekeeper for EMS responses. The accuracy of the EMS dispatcher is paramount if an EMS system is to meet its expressed goals of cost-effectiveness and a low undertriage rate. Research includes reviews of the accuracy of emergency medical dispatch (EMD) for various patient conditions, including stroke and abdominal pain.4,5 The treatment of cardiac arrest (CA) is important because survival is influenced by how rapidly care is delivered, making the accuracy of predicting and dispatching CA an important link in the patient “chain of survival.”6–8 Prearrival instructions given by EMS dispatchers, including the initiation of cardiopulmonary resuscitation (CPR) and the early dispatch of defibrillation-equipped EMS personnel, are therapies proven to increase the survival of CA patients.9 To date, there are few studies describing the accuracy of predicting and dispatching CA calls by EMS dispatchers.

In addition to EMS dispatcher diagnosis accuracy, how the type of caller affects the dispatcher’s ability to correctly identify and dispatch emergency calls is unknown. The type of caller would seem to influence the dispatcher’s ability to accurately predict medical conditions, especially CA, because the patients themselves would not be able to communicate with the EMS dispatcher. Few studies include the caller type as an independent variable when analyzing dispatcher accuracy.10 The purpose of this study was to analyze the accuracy of paramedic EMS dispatchers for predicting CA and to investigate if there were any explicit effect modifications on dispatcher accuracy depending on the type of caller.

METHODS

Study Design. This was a retrospective review of EMS dispatch data, collected over a six-month period,
Study Setting and Population. This study was performed in a Midwest urban EMS system. First responders from the local fire department are trained as EMT-basics and equipped with automatic external defibrillators (AEDs) and basic airway equipment. The fire department responds to all CA calls within the city. The ambulance service is a single-tier, all-ALS, public utility model service, providing exclusive emergency and nonemergency care and transport within the city limits. The system receives approximately 90,000 calls for service and transports more than 60,000 patients a year. The system encounters more than 300 CA patients (from all causes) per year.

In the EMS dispatch center, 911 calls for medical emergencies are triaged and dispatched by system status controllers (SSCs). System status controllers interrogate the caller and assign a presumptive patient condition (PPC) using Advanced Medical Priority Dispatch Systems (Medical Priority Consultants, Salt Lake City, UT) software. System status controllers have a minimum of two years' paramedic field experience, are trained in system status management, and are certified in EMD. System status controllers are licensed by the City's Health Department EMS Section, the State Bureau of EMS, and have National Registry certification.

Field paramedics assign patient conditions for all calls on the ambulance report form. Paramedics in the system are licensed by the City Health Department EMS Section, the State Bureau of EMS, and have National Registry certification.

Medical oversight of the system is by the City Health Department EMS Section. The Health Department employs a 0.80 full-time equivalent (FTE) medical director, a 0.35 FTE associate medical director, and two full-time paramedic assistants. The EMS Section routinely reviews all runs coded as CA.

Study Protocol. Data from January 1, 2000, through June 30, 2000, were retrospectively reviewed using an ambulance diagnostic code database and the EMS computer-aided dispatch database (Visicad 3.7.3; Tritech Software Systems, San Diego, CA). Calls were included in the study if they received either a field diagnosis code or PPC code for CA. Calls were cross-matched with their respective dispatch PPC or field diagnosis. Calls that were coded by field paramedics as nontraumatic dead on arrival (DOA, no treatment or transport) were included in the study.

To determine the type of calling party, a trained member of the research team (BC) listened to dispatch tapes of all of the calls included in the study. To ensure the validity of calling party assignment, a certified EMD reviewer, blinded to the other researcher's results, categorized calling parties for all calls. A third researcher, blinded to the other results, reviewed calls when there was disagreement and assigned a tie-breaking calling party category.

Measures. Persons talking to the SSCs were divided into four different groups of calling parties. First-party callers were callers who were the actual patient, of whom there were four. Second-party callers were callers with immediate access to the patient, whether or not they were willing to answer the EMS dispatcher's questions. Third-party callers were persons who had either relayed a call from a remote party or persons without access to the patient and unable to provide prearrival care. Fourth-party callers were persons calling from outside dispatch centers, such as the police, sheriff's department, or fire department.

A certified reviewer in EMD listened to and scored a representative sample of the dispatch tapes included in the study using standard industry quality improvement software (AQUA-Pro QA; Medical Priority Consultants, Salt Lake City, UT). This was done to ensure SSC compliance with the EMD protocols.

Data Analysis. Data were entered into a database (Microsoft Access 2000; Microsoft Corp., Redmond, WA) and analyzed using SPSS 10.0 (SPSS Inc., Chicago, IL), and Epi Info (Centers for Disease Control and Prevention, Atlanta, GA).

Descriptive statistics and contingency tables were generated on all reported PPC and field diagnoses. Sensitivity and positive predictive value (PPV) were computed for the PPC code of CA given by SSCs. Homogeneity of sensitivity and PPV of the PPC code for CA by calling parties was determined by chi-square analysis. Relative risk (RR) ratios with 95% confidence intervals (95% CIs) was used to compare the PPV of calling parties. Student's t-test was used to compare quality assurance scores between calling parties. A p-value of $<0.05$ was considered significant.

RESULTS

During the study period, there were 520 calls with a PPC or ICD-9 or both for CA. Fourteen calls could not be reviewed for calling party due to tape failure, leaving 506 (97.3%) calls meeting all of the inclusion criteria.

Of the 506 calls, there were four first-party callers, 304 second-party callers, 99 third-party callers, and 99 fourth-party callers (Table 1). Due to the small number of first-party callers, they were combined with second-party callers for data analysis purposes. Field paramedics gave 136 patients a field diagnosis other than CA to patients given a PPC for CA (group 1). There were 253 calls that had a PPC and field
The sensitivity and PPV for CA, by calling party, are presented in Table 1. Overall, the sensitivity for a PPC code of CA given by a SSC was 68.3% (95% CI = 63.3% to 73.0%) with a PPV of 65.0% (95% CI = 60.0% to 69.7%). Fourth-party callers had the highest sensitivity at 74.29% (95% CI = 62.2% to 83.7%), whereas second-party callers had the highest PPV at 71.67% (95% CI = 65.3% to 77.3%).

Chi-square analysis comparing the sensitivity between the calling parties was not significant ($\chi^2 = 3.728, 2 df, p = 0.17$). Comparing the combined first-party and second-party callers against the stratified groups of third-party and fourth-party callers also produced no significant findings.

There were significant differences in the PPV between the calling parties ($\chi^2 = 17.34, 2 df, p < 0.0001$). Comparing the PPV of the combined first-party and second-party callers against all others gave a RR of 1.30 (95% CI = 1.10 to 1.53, $\chi^2 = 11.22, 2 df, p < 0.0001$). After stratifying calling parties into third-party and fourth-party callers, a significant difference was found between the combined first-party and second-party and third-party callers (RR = 1.58, 95% CI = 1.22 to 2.05, $\chi^2 = 17.31, 1 df, p < 0.0001$). There was no significant difference between the combined first-party and second-party group and fourth-party callers. There was, however, a significant difference between the fourth-party callers and third-party callers (RR = 1.42, 95% CI = 1.05 to 1.91, $\chi^2 = 5.60, 1 df, p = 0.0183$).

A convenience sample of 154 first-party and second-party callers (50%) and 50 third-party callers (80%) was reviewed to evaluate the SSC’s appropriateness of the final diagnosis and overall dispatch protocol compliance score using EMD-specific quality assurance software. This review was to ensure there were no differences in how the callers were interrogated by the SSCs. Fourth-party calls were removed from this statistical analysis because they originated at other dispatch centers with no caller available for interrogation about a patient’s condition. The appropriateness of final coding was an overall score on the correctness of the SSC’s PPC assignment. Protocol compliance scores included the following items: were the right questions asked, were questions asked in the right order, and were prearrival instructions given. The final coding score is factored into the overall protocol compliance score.

Overall, the appropriateness of the SSC’s final coding was scored at 94.78% (95% CI = 92.63% to 97.79%), meaning the quality improvement reviewer agreed that the correct dispatch code was given approximately 95% of the time. The overall dispatch protocol compliance score was 85.22% (95% CI = 83.33% to 87.10%), meaning the dispatcher followed the protocol according to the EMD standards, about 85% of the time. There was no significant statistical difference in scores between the calling parties for final coding (p = 0.88) or in protocol compliance (p = 0.37) (Table 2).

For patients who were given a PPC code for CA, the most prevalent field diagnoses (other than CA) are listed in Table 3. For patients given a field diagnosis for CA, the most prevalent PPC codes given by SSCs (other than CA) are listed in Table 4.

**DISCUSSION**

The purpose of this study was to analyze the accuracy of paramedic EMS dispatchers in predicting CA and to investigate the effect of the type of caller on the accuracy in making this prediction. We found that the type of caller did not significantly affect the sensitivity of diagnosing CA by paramedic EMS dispatchers. There was, however, some effect modification on the PPV, depending on the type of caller with whom the dispatcher was talking. System status controllers were able to positively predict CA 1.58 times more accurately if they were talking with first-party controllers.

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**TABLE 1. Sensitivity and Positive Predictive Value (PPV) for Cardiac Arrest by Calling Party (95% Confidence Interval)**

<table>
<thead>
<tr>
<th>No. (%)</th>
<th>First and Second Party</th>
<th>Third Party</th>
<th>Fourth Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Patients</td>
<td>506</td>
<td>308 (60.87%)</td>
<td>99 (19.57%)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>68.38% (63.3 to 73.0)</td>
<td>69.01% (62.7 to 74.7)</td>
<td>58.62% (45.0 to 71.1)</td>
</tr>
<tr>
<td>PPV</td>
<td>65.03% (60.0 to 69.7)</td>
<td>71.67% (65.3 to 77.3)</td>
<td>45.33% (33.9 to 57.2)</td>
</tr>
</tbody>
</table>
party and second-party callers compared with talking with third-party callers. System status controllers were able to positively predict CA 1.42 times more accurately if they were talking with fourth-party callers compared with third-party callers.

Accurate prediction and dispatch of CA are essential to the delivery of out-of-hospital care. Because the treatment of CA is time-critical, it is imperative to arrive rapidly at a correct prediction of a patient’s condition to increase the chance of patient survival. Each day in the United States, approximately 1,000 people experience sudden CA.11,12 Of these, nearly 70% experience ventricular fibrillation.11 Survival after ventricular fibrillation depends on the time from CA onset to defibrillation.13,14 The accurate assessment of CA also allows the dispatcher to provide prearrival instructions, such as CPR. Valenzuela et al.9 showed that the time from initial collapse to initiation of CPR and defibrillation are the two most significant predictors of survival. Past studies have shown significant increases in bystander CPR after prearrival CPR instructions were implemented in EMS dispatch centers.15,16 With such importance placed on aggressive treatment, the proper prediction of CA should be used as a possible benchmark for dispatcher accuracy.

There have been few publications on the diagnostic accuracy of EMS dispatchers for CA. In one abstract, Fitzgerald et al.17 found an accuracy of 30% among non–medically trained EMS dispatchers. Clark et al.18 described the incidence of CPR instructions being offered to CA calls in King County, Washington. Although the focus of the article was not to assess the accuracy of an EMS dispatch diagnosis of CA, from their data a PPV of 51.6% could be calculated. There was no mention of the EMS dispatcher level of medical training in King County, Washington. We found our PPV to be substantially higher, at 69%.

Studies have shown that there are significant differences of opinion between EMS dispatchers, paramedics, and physicians about the need for ALS versus basic life support transport.4,10,19,20 It is possible that dispatchers with more medical training are better at acquiring key information or processing verbal cues from the caller than non–medically trained dispatchers relying solely on a scripted dispatch format.

The relatively moderate accuracy of EMS dispatchers in assigning the correct diagnostic code for CA is not unexpected and may be the upper limit of their abilities. There are multiple other factors, some of which are out of the SSC’s control, that affect their ability to triage CA calls accurately. It is likely that a percentage of patients have a change in condition between calling 911 and the arrival of EMS. The SSC could be completely accurate assigning a code for “shortness of air,” with the patient deteriorating into CA before EMS arrival. Conversely, patients initially “short of air” on EMS arrival could deteriorate into CA enroute to the hospital and have been coded only as a CA by the paramedic even though their initial medical presentation to the field paramedic was “shortness of air.”

Another possible reason for inaccuracy when EMS dispatchers assign a diagnostic code is the caller’s ability to assess accurately and relay the patient’s condition to EMS dispatchers. There were numerous calls where the caller initially stated that the patient was not breathing and had no pulse, only later to state that he or she thought the patient was breathing. The dispatcher in this scenario most likely would leave the PPC as a CA, feeling they could not trust the caller’s

### TABLE 2. Final Coding and Dispatch Protocol Compliance by Calling Party

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>Second Party</th>
<th>Third Party</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final coding (%)</td>
<td>94.78%</td>
<td>94.91%</td>
<td>94.75%</td>
<td>p = 0.88</td>
</tr>
<tr>
<td>(92.63% to 97.79%)</td>
<td>(92.00% to 97.81%)</td>
<td>(90.02% to 98.98%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protocol compliance (%)</td>
<td>85.22%</td>
<td>85.83%</td>
<td>83.89%</td>
<td>p = 0.37</td>
</tr>
<tr>
<td>(83.33% to 87.10%)</td>
<td>(83.61% to 88.04%)</td>
<td>(80.27% to 87.52%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CI = confidence interval.

### TABLE 3. Field Diagnosis for Calls Dispatched as Cardiac Arrest

<table>
<thead>
<tr>
<th>Field Diagnosis</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac arrest or DOA</td>
<td>63.4</td>
</tr>
<tr>
<td>No patient</td>
<td>6.1</td>
</tr>
<tr>
<td>Syncope</td>
<td>5.6</td>
</tr>
<tr>
<td>Seizure</td>
<td>4.8</td>
</tr>
<tr>
<td>Overdose/alcohol</td>
<td>4.6</td>
</tr>
<tr>
<td>Other</td>
<td>15.5</td>
</tr>
</tbody>
</table>

DOA = dead on arrival.

### TABLE 4. Dispatch Code of Patients Given Field Diagnosis for Cardiac Arrest

<table>
<thead>
<tr>
<th>Dispatch Code</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac arrest or DOA</td>
<td>48.3</td>
</tr>
<tr>
<td>Unconscious</td>
<td>15.9</td>
</tr>
<tr>
<td>Respiratory distress</td>
<td>11.6</td>
</tr>
<tr>
<td>Stab/gunshot wound</td>
<td>5.2</td>
</tr>
<tr>
<td>Seizure</td>
<td>4.7</td>
</tr>
<tr>
<td>Other</td>
<td>14.2</td>
</tr>
</tbody>
</table>

DOA = dead on arrival.
ability to assess the patient’s condition or that it was probably safer and easier to leave the PPC as CA.

How helpful a caller is with the triage of medical emergencies also may be hampered by the emotional, educational, and cultural differences that exist in different segments of the population. The continuous quality improvement team routinely reviews the emotional component of CA calls, yet variables such as language barriers, slang, and cultural differences cannot be as easily accounted for when assessing dispatcher accuracy. This is, however, the environment in which EMS and all of emergency medicine operates, and dealing with these barriers is a reality that is difficult, if not impossible, to incorporate into a dispatch algorithm.

In a previous study, Neely et al.10 used the type of caller in a logistic regression model when he reviewed the strength of specific EMS dispatcher questions for identifying patients with important clinical field findings. He found no significant effect of the calling party for identifying important field findings; however, the caller was a dichotomous variable of caller or not caller; no attempt was made to identify the caller further as described here.

As was shown in our study, the type of caller has a significant impact on the ability of the dispatcher to dispatch CA accurately. The ability of the dispatcher to acquire information from a source that is with the patient seems an important factor in arriving at a correct dispatch diagnosis. Paramedics were much less likely to have a patient in CA if the SSCs were interrogating callers relaying information from a remote location or passing information from another party (other than fourth-party callers). System status controllers were able to achieve a PPV of around 50% for CA only when talking with third-party callers. This means that when EMS was dispatched for a CA based on information from third-party callers, the chances of having a patient in CA were equivalent to flipping a coin. Fourth-party callers achieved the highest sensitivity and PPV for dispatching CA calls. This is likely due to a law enforcement officer or firefighter, with some degree of medical training, on the scene assessing the patient and giving information to a dispatcher, who subsequently relays this to the EMS dispatcher.

What may be more important, in at least the dispatch of EMS personnel, is not the ability to accurately diagnose CA or any other condition, but rather to recognize a serious medical event that requires a rapid response. In the system presented here, 911 calls that are received in the EMS dispatch center are prioritized as either a code 1 or a code 2 call. Code 1 calls are considered “life-threatening,” have the highest priority in the system, and activate a fire department first response. Code 2 calls are considered “emergency, non–life-threatening,” have a lower priority, and do not always include a fire department first response. Forty-two (8.3%) calls with a field diagnosis of CA were given a lower priority (code 2) by the dispatch center. In this system, there is a dispatch protocol for a code 2 response for CA if the dispatcher has enough information to believe that the patient has been deceased for a long time and likely would be DOA. There were 19 such calls during the study period, none of which resulted in treatment or transport. Most calls other than CA that were given code 2 status were traumatic injuries, including 11 gunshot/stab wounds, three falls, and one motor vehicle collision. In this system, traumatic injuries have a fire department first response. Ignoring the actual dispatch PPC code and reviewing only whether the call was given a code 1 or code 2 status with a fire department first response yields a sensitivity of 97.9%. In the code 1 cases, the same resources would be activated, and the same response times would be achieved regardless of whether the patient had CA or not. In the code 2 with fire department first response cases, there would have been no delay in rapid response of emergency personnel and defibrillation equipment. The true value of arriving at a correct PPC for CA may be to deliver prearrival instructions to the caller. The various other patient conditions that were coded as CA by SSCs were similar to the findings of Hallstrom et al.21 in Seattle in their study of CPR instructions for CA.

LIMITATIONS

By using the field diagnosis codes on the ambulance run form, we were limited to only the diagnosis that the paramedic thought was appropriate. This limitation made it impossible to ensure that CA was the initial presenting patient condition and possibly negatively skew the sensitivity and PPV of the dispatcher. This was a retrospective study. However, not all of the flaws inherent to retrospective studies were applicable, because data were collected in real time.

CONCLUSIONS

The sensitivity of paramedic EMS dispatchers to accurately predict out-of-hospital CA was 68.3% with a PPV of 65.0%. This was significantly better than a previously reported accuracy of 30% by nonmedically trained dispatch personnel. The type of calling party influenced the PPV of the dispatcher-assigned condition. Future research into dispatcher accuracy must include the level of training of the dispatcher and the type of caller before trying to draw conclusions either within or between EMS systems.

References