ORIGINAL RESEARCH

Sensitivity and Specificity of the Medical Priority Dispatch System in Detecting Cardiac Arrest Emergency Calls in Melbourne

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Abbreviations:
ALS = advanced cardiac life support
CI = confidence interval
MAS = Metropolitan Ambulance Service
MPDS = Medical Priority Dispatch System

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Abstract

Introduction: In Australia, cardiac arrest kills 142 out of every 100,000 people each year; with only 3–4% of out-of-hospital patients with cardiac arrest in Melbourne surviving to hospital discharge. Prompt initiation of cardiopulmonary resuscitation (CPR), defibrillation, and advanced cardiac care greatly improves the chances of survival from cardiac arrest. A critical step in survival is identifying by the emergency ambulance dispatcher potential of the probability that the person is in cardiac arrest. The Melbourne Metropolitan Ambulance Service (MAS) uses the computerized call-taking system, Medical Priority Dispatch System (MPDS), to triage incoming, emergency, requests for ambulance responses. The MPDS is used in many emergency medical systems around the world, however, there is little published evidence of the system's efficacy.

Objective: This study attempts to undertake a sensitivity/specificity analysis to determine the ability of MPDS to detect cardiac arrest.

Methods: Emergency ambulance dispatch records of all cases identified as suspected cardiac arrest by MPDS were matched with ambulance, patient-care records and records from the Victorian Ambulance Cardiac Arrest Registry to determine the number of correctly identified cardiac arrests. Additionally, cases that had cardiac arrests, but were not identified correctly at the point of call-taking, were examined. All data were collected retrospectively for a three-month period (01 January through 31 March 2003).

Results: The sensitivity of MPDS in detecting cardiac arrest was 76.7% (95% confidence interval (CI): 73.6%–79.8%) and specificity was 99.2% (95% CI: 99.1–99.3%). These results indicate that cardiac arrests are correctly identified in 76.7% of cases.

Conclusion: Although the system correctly identified 76.7% of cardiac arrest cases, the number of false negatives suggests that there is room for improvement in recognition by MPDS to maximize chances for survival in out-of-hospital cardiac arrest. This study provides an objective and comprehensive measurement of the accuracy of MPDS cardiac-arrest detection in Melbourne, as well as providing a baseline for comparison with subsequent changes to the MPDS.

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Introduction

Cardiac arrest is the ultimate medical emergency. Since the early 1980s, the "chain-of-survival" concept has advocated early access to medical services, particularly ambulance services, as an important step in cardiac arrest survival.[1] Timely medical triage of the calls to an emergency ambulance dispatch center is crucial in prioritizing ambulance response to the patient. The Metropolitan Ambulance Service (MAS) in Melbourne, Australia, has adopted the Medical Priority Dispatch System (MPDS), a computerized, protocol-based system used in many ambulance services around the world.

The aim of medical priority dispatch is to differentiate between those cases that are, or are not, time critical. This is important, because inappropri-

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ate, high-priority responses may result in reduced resources for those cases that do warrant rapid response.[2] In addition, high-speed, ambulance responses create significant traffic hazards[3] and may result in a higher death rate of responding paramedics.[4,5]

The city of Melbourne uses the Australian emergency number "000" for ambulance, police, and fire emergency calls. Medical emergency calls are triaged by a dispatcher who is trained in the use of the MPDS, but is not trained medically. The dispatcher reads predetermined scripted questions that are designed to direct the caller to one of 248 response determinants. In conjunction with the use of MPDS, the MAS has specified a desired ambulance resource allocation for each determinant. If, during initial questioning, the caller reports the patient is unconscious and not breathing, MPDS identifies the case as a "suspected cardiac arrest". A suspected cardiac arrest is designated a "Priority Zero", which is allocated a maximal emergency ambulance response, including intensive care ambulances and first responders (fire officers trained in basic life support and equipped with defibrillators) where available. Ten of the 248 MPDS determinants are dispatched as "Priority Zero" and include: (1) breathing problems, when the patient is not alert; (2) suspected cardiac/respiratory arrest; (3) choking when the patient is not alert; (4) convulsions when the patient is confirmed not breathing; (5) near drowning/diving incidents in which the patient is unconscious, in respiratory arrest, or still under water; (6) electrocution when the patient is unconscious or the power still is connected; and (7) psychiatric problems resulting in an attempted hanging or suffocation.

A Priority Zero event is given a three-tiered response by the MAS consisting of: (1) a general purpose ambulance carrying qualified, advanced life support (ALS), ambulance paramedics; (2) a Mobile Intensive Care Ambulance carrying intensive care paramedics with further qualifications in resuscitation and management of unconscious patients; and (3) the Metropolitan Fire and Emergency Services Board first responders (available in inner-city area only). This first responder program recently has been implemented in Melbourne for Priority Zero cases only, in order to reduce the frequency of long response times (>10 minutes) to out-of-hospital cardiac arrest.[6] Priority Zero cases require all responders to proceed to the scene with urgency.

The occurrence of out-of-hospital cardiac arrest has been reported as 30 per 100,000 persons per year in Melbourne, and the survival rate of out-of-hospital cardiac arrest patients is 3%,[7] not dissimilar to survival in other western countries.[8] The MAS supplies emergency care and patient transports for the 3.4 million people in the city of Melbourne, Australia, covering a service area of approximately 9,000 square kilometers (3,475 square miles). The paramedics of the MAS attend to approximately 700 medical emergencies during an average day, (>255,000 calls each year).[9] Of the 255,000 emergency calls received in Melbourne anually, approximately 4,000 are Priority Zero cases, of which, 72,000 are actual cardiac arrests.

Scant data have been published on the ability of MPDS to correctly allocate a priority level.[10] The use of MPDS to triage emergency ambulance calls, has been investigated and assessed the subsequent resource allocation in several studies. In Delaware, USA, inappropriate ALS responses (patients for whom only basic life support was required) were reduced by 19.9% using MPDS, rather than a chief complaint-based system.[11] In Salt Lake City, Utah USA, the MPDS sensitivity in allocating ALS responses where needed was 100%,[12] and in Cleveland, Ohio USA, the agreement of patient urgency between the receiving hospital staff and ambulance dispatchers is 74% of cases.[13] However, when the level of agreement was tested according to the specific priority level, receiving hospital staff and ambulance dispatch concurred with the dispatcher in just 43% of cases. One study in Atlanta, Georgia USA, found concordance between an automated dispatch system and emergency medical technicians in just 19.2% of cases,[14] and a similar UK-based study reported only 14% agreement on a priority level between automated dispatch system and a panel of experts.[15] The comparison of these studies is limited by the use of varied measurements and methods, but they all indicate high levels of disagreement of medical urgency between ambulance triage systems and health professionals.

The sensitivity of detecting cardiac arrest using MPDS has been evaluated in a few studies, with a sensitivity of 65.9% and positive predictive value of 76.3% in Montreal,[2] a sensitivity of 68.3% and a positive predictive value of 65.0% in Kansas USA,[16] but only 30% sensitivity in Cincinnati, Ohio USA.[17] The London Ambulance Service reports a sensitivity of 50%,[18] which constituted a 200% increase in cardiac arrest detection since the introduction of MPDS.

The aim of this study was to measure the ability of the use of MPDS to recognize cardiac arrest cases. A sensitivity and specificity analysis of cardiac arrest cases determined the proportion of cases that a cardiac arrest was correctly identified. Secondary analysis was conducted on cases that were cardiac arrests but were not identified as such by use of the MPDS.

Methods

A retrospective analysis was conducted using data from the Victorian Ambulance Cardiac Arrest Registry and the MAS dispatch and patient care records. Data for three consecutive months of cases triaged by the use of MPDS were collected from 01 January through 31 March 2003. This time period ensured an adequate study sample to provide confidence intervals (CI) of ±5% or less. During this period, call-taker compliance with the MPDS protocols was 95%.

Patients who were admitted due to doctor requests and inter-hospital transfers were excluded, as these patients bypassed MPDS triage protocols. Cases were included in the study only if the cardiac arrest occurred before paramedic arrival, as those occurring after paramedic arrival were not in cardiac arrest at the time of dispatch.

Whether or not the patient actually had suffered a cardiac arrest (determined via electrocardiogram) was obtained from the Victorian Cardiac Arrest Registry, for all cases dispatched as Priority Zero. The diagnoses of Priority Zero

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		Cardiac Arrest (determined by ECG)	
		Yes	No
Priority Zero (identified by MPDS)	Yes	566 (76.7%)	403
	No	172	21,754 (99.2%)
	Total	**738**	**52,157**

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Table 1—Sensitivity and specificity (ECG = electrocardiogram; MPDS = Medical Priority Dispatch System)

		Cardiac Arrest (determined by ECG)		
		Yes	No	**Total**
Priority Zero (identified by MPDS)	Yes	566 (58.4%)	403	**969**
	No	172	51,754 (99.7%)	**51,926**

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Table 2—Positive and negative predictive values (ECG = electrocardiogram; MPDS = Medical Priority Dispatch System)

cases that were not cardiac arrests were obtained from the patient care records completed by attending paramedics. The dispatch records for all cardiac arrest cases that were not identified as Priority Zero cases were analyzed to determine why cardiac arrest was not identified at the point of call-taking.

The dispatch code and paramedic diagnosis as recorded on the ambulance patient care record was compared between groups used Pearson's Chi Square (χ^2) test and a one-way ANOVA (for continuous variables). A p-value of <0.05 was considered significant statistically.

Results

Over the three months, a total of 52,895 emergency calls were triaged through the MPDS system, of which 969 (1.8%) were triaged as Priority Zero. Of the 969 Priority Zero cases, 566 (58.3%) of these were cardiac arrests, and 403 (41.5%) were not. Further, 172 (30.4%) cardiac arrests were dispatched at lower priorities, leading to a total of 738 cardiac arrests for the study period. Cases that initially were a lower priority and then upgraded to Priority Zero (29.1% of Priority Zero cases) were included as Priority Zero cases.

As shown in Table 1, the sensitivity of the use of the MPDS for detecting cardiac arrest indicated 76.7% of out-of-hospital cardiac arrests were correctly identified as Priority Zero (95% confidence interval (CI): 73.6–79.8%). Similarly, a specificity analysis indicated that 99.2% of non-cardiac arrests were not dispatched as Priority Zero (95% CI: 99.1–99.3%). As shown in Table 2, positive predictive value calculations indicated that 58.4% of the cases for which they were dispatched as Priority Zero were for cardiac arrests (95% CI: 55.2–61.6%). Similarly, negative predictive value calculations indicated that 99.7% of cases not dispatched as Priority Zero were not cardiac arrests (95% CI: 99.6–99.7%).

There are several dispatch determinants that are used to triage a case as a Priority Zero, therefore, each individual Priority Zero event type was analyzed to determine the proportion of cases given that determinant, and which of them were in cardiac arrest. This identified a high number of false positives for some dispatch determinants, as shown in Table 3.

Further analysis was conducted to establish which dispatch determinants were allocated to the 738 actual cases with cardiac arrest. The cardiac arrest cases were assigned to 62 different dispatch determinants. There were seven common dispatch determinants allocated to cardiac arrest cases: (1) suspected cardiac arrest (69.2%); (2) suspected respiratory arrest; (3) carbon monoxide inhalation; (4) severe shortness of breath; (5) unconsciousness; (6) traffic crashes; and (7) hanging or suffocation. In addition to these seven determinants, cardiac arrests were allocated to 52 other determinants, each accounting for <1% of cardiac arrests.

The 172 false negatives (cardiac arrests that were not allocated a Priority Zero) were designated 58 different non-Priority Zero dispatch codes. It could be argued that the most common of these determinants, "unconscious or fainting: is unconscious" could be reassigned to a Priority Zero allocation. However, a calculation of the extra resources required to upgrade this determinant to a Priority Zero response shows that there were 818 cases given this determinant during the three-month study, and to reassign all of these to Priority Zero potentially would have resulted in an extra 818 fire, first responders being dispatched where they were available. This equates to a potential average of nine extra high-speed emergency responses each day, with only 25 (3%) of these patients actually being in cardiac arrest.

The results of further analysis of these false negative cases are shown in Table 4. The majority of cases were characterized as a "Priority 1", which is the next highest priority after Priority Zero. The resource allocation shows that as a Priority 1, these cases still receive a maximal ambulance response, but without first responders.

Overall, resuscitation was attempted by paramedics in 41.8% of cardiac arrest cases, and there was no significant difference in resuscitation attempts according to case priority. Survival was measured upon arrival to the hospital, rather than at hospital discharge, as this information was available in the available ambulance data sets. There was no significant reduction in survival-to-hospital among those cardiac arrests that were not allocated a Priority Zero response ($\chi^2 = 0.345$, $p = 0.557$).

Discussion

The results of this study indicate that 76.7% of cardiac arrests are dispatched correctly as Priority Zero. This is of clinical importance because it means that just over three quarters of out-of-hospital cardiac arrests are allocated the maximal ambulance response. Of those cases identified by use of the MPDS as potential cardiac arrests, 58.2% were actual cardiac arrests, suggesting that 41.8% of maximal responses are dispatched at this level unnecessarily.

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Event Type	Number of cardiac arrests	Total cases allocated to event type	Percent true positives (%)
Breathing problems: Not alert	3	109	(2.8)
Suspected cardiac arrest	511	744	(68.7)
Suspected respiratory arrest	9	29	(31.0)
Choking: Not alert	3	10	(30.0)
Convulsions: Confirmed not breathing	1	2	(50.0)
Near drowning/Diving: Unconscious	5	7	(71.4)
Drowning: Respiratory arrest or under water	0	1	(0)
Electrocution: Unconscious	0	0	(0)
Electrocution: Power still connected	0	1	(0)
Psychological: Attempted hanging or suffocation	34	66	(51.5)

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Table 3—Cardiac arrest frequency among Priority Zero determinants

Priority	Number of Cardiac Arrests	Percentage of Total Number of Cardiac Arrests (%)
1	144	(83.7)
2	17	(9.9)
3	4	(2.3)
4	7	(4.1)
Total	**172**	**(100.0)**

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Table 4—Priority allocated to cardiac arrests that were not identified as Priority Zero

However, when compared to a system that sends a maximum response to all calls, it is clear that by using a system such as MPDS, resource allocation is improved, particularly by reducing number of high speed responses, which reduces unnecessary risks to paramedics and other road users.

"Suspected Cardiac Arrest" was the most common dispatch determinant. If the "suspected cardiac arrest" determinant was the only determinant sent as a Priority Zero, this would result in a sensitivity of 69.2%, which is similar to the results from Montreal[2] and Atlanta.[14] This would mean that cardiac arrests from other categories would be missed. To further improve sensitivity by upgrading selected determinants to Priority Zero would result in an increased resource burden and increased high-speed traffic on the road, with limited improvement in patient survival from out-of-hospital cardiac arrest.

This study did not review the content of the actual calls received by the ambulance call-taker, which is a limitation to this study, as the MPDS system is dependent on information provided by the caller to the dispatcher, which depends on the caller's ability to identify symptoms and to report accurately these to the dispatcher. Future studies could consider reviewing the accuracy of caller reporting.

Conclusions

The MPDS identifies cardiac arrest well, and in most cases, errs on the side of caution when classifying a case as a "potential cardiac arrest". For those cases that were not identified as cardiac arrests, there was no significant difference in survival rate, as the vast majority received the next highest ambulance resource allocation response. This study identifies the need for further research into the ability of use of the MPDS to classify cases within other priority levels to better allocate ambulance resources; supporting a better health outcome for all patients, and a safer working environment for paramedics.

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