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Estimating the Probability of Cardiac Arrest Based on How Callers Describe Breathing during Emergency Dispatches

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Abstract

During emergency calls, people reporting an incident describe a patient's breathing—or the lack of it—in many different ways. Call-takers must interpret these varied descriptions and, for an unresponsive individual, decide whether the situation meets the dispatch criteria for a cardiac arrest. This study set out to organise the types of breathing descriptions offered by callers and to estimate how often those categories corresponded to a true cardiac arrest. We analysed audio recordings of calls and linked ambulance dispatch data from St John Western Australia for events between January and June 2021 in which the case was initially categorised as out-of-hospital cardiac arrest (OHCA). From these calls, we developed a structured classification of breathing-related terms and coded the presence of each descriptor. For every category, we calculated the percentage of cases confirmed by Emergency Medical Services (EMS) on arrival as being in cardiac arrest (true positives). Among 375 incidents dispatched as OHCA, EMS later verified arrest in 85.3% (n = 320). Callers used a broad spectrum of terms—23 categories in total—to describe breathing. Categories most strongly associated with EMS-confirmed cardiac arrest included Dead, NOT breathing, Blue/Purple, and Unsure. Other descriptors, such as Barely, Gasp, and Laboured, were less frequently linked with cardiac arrest but still exceeded a 50% true-positive rate. Individuals flagged as OHCA during emergency call-taking were described with a wide array of breathing-related expressions. Although the predictive accuracy varied among descriptor categories, all demonstrated reasonably high proportions of confirmed arrests. We suggest that call-takers receive training that familiarises them with the full breadth of caller terminology and supports them in addressing callers' interpretations of residual signs of life.

Keywords: Emergency dispatch, Cardiac arrest prediction, Breathing descriptors, Out-of-Hospital Cardiac Arrest (OHCA)

Introduction

When bystanders contact emergency services for someone experiencing an out-of-hospital cardiac arrest (OHCA), rapid recognition of the arrest by the call-taker is essential to ensure prompt dispatch and to deliver immediate instructions for cardiopulmonary resuscitation (CPR) and defibrillation [1- 3]. A persistent obstacle in recognising OHCA is the presence of agonal breathing, a transient and misleading breathing pattern common shortly after arrest [4-6], which callers often interpret as normal or effective breathing [7, 8]. Dispatch protocols therefore incorporate a set of breathing descriptions that should trigger cardiac-arrest handling for an unconscious person [9]. For instance, the Medical Priority Dispatch System (MPDS) indicates that an unresponsive patient should be treated as being in arrest when described as "not breathing," "barely breathing," "can't breathe at all," "fighting for air," "gasping for air," breathing "just a little," "making funny noises," or any comparable descriptions [10].

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Despite expectations that call-takers initiate dispatcher-assisted CPR [11] promptly once arrest is identified, callers may refuse CPR because they believe the patient is still alive [12], often due to abnormal or agonal respirations [13]. To overcome this resistance, call-takers need confidence in treating the patient as being in arrest, even when the caller's description is vague or equivocal.

In this study, we sought to quantify how reliably different caller-provided breathing descriptions correspond to true cardiac arrest once EMS arrives. Our objectives were: (1) to create a categorisation of the breathing-related descriptors used by callers during the initial case-entry phase, and (2) to determine the proportion of these cases that were confirmed as cardiac arrest—i.e., the positive predictive value—for each descriptor category.

Methods

Study design

This investigation utilised a retrospective cohort approach, examining emergency ambulance telephone calls that had been categorised as out-of-hospital cardiac arrest (OHCA) by a single emergency medical service (EMS) between 1 January and 30 June 2021. Researchers reviewed the call recordings and systematically documented the breathing-related terminology spoken by callers during the initial "case entry" portion of the call, using a coding structure developed specifically for this project.

To ensure a relatively homogeneous sample, only patients whose collapses appeared to stem from an undifferentiated cause—namely, those reported as unconscious and breathing ineffectively or not at all—were eligible. Thus, the dataset was restricted to cases assigned by call-takers to MPDS case-entry codes 09E01 (OHCA, No breathing at all) and 09E02 (OHCA, Uncertain breathing). We intentionally removed cases where arrest was linked to an identifiable mechanism (for example, allergies, chemical or fume exposure, hanging, strangulation, or suffocation). Additional exclusions involved calls in which the caller was not physically present with the patient (i.e., not a second-party caller), and situations where the individual was clearly not in cardiac arrest at case entry—such as when they were said to be conscious, speaking, responsive, or upright. Because the study gathered episodes dispatched as cardiac arrest, the final sample inevitably included both true and false positives, with classification later confirmed upon EMS arrival (see data collection procedures).

Ethical approval for the study was granted by the St John WA Research Governance Committee and the Curtin University Human Research Ethics Committee (HR128/2013).

Context

St John WA (SJ-WA) is the exclusive emergency ambulance provider across Western Australia. All Triple Zero (000) calls requiring ambulance attendance are handled through the SJ-WA State Operations Centre in Perth, where call-takers use the Medical Priority Dispatch System™ (MPDS) version 13.2 [10] to guide call processing. Additional contextual details are summarised in **Table 1**.

Table 1. Characteristics of the St John Western Australia call centre

Characteristic	Detail
Number of call-takers	A workforce of 85 call-takers staffed the centre.
Total calls received (1 Jan–30 Jun 2021)	The centre handled 110,401 incoming emergency calls during the six-month study window.
Call-taker training requirements	Clinical certification is not mandatory. New staff complete a structured training package consisting of: • Senior first aid training and instruction in medical terminology • The Advanced Emergency Medical Dispatcher certification issued by the International Academies of Emergency Dispatch, enabling them to operate the Medical Priority Dispatch System (MPDS) through the ProQA platform
Internal training components	Additional in-house preparation covers: • Techniques for managing and directing callers • Operation of the Computer Aided Dispatch (CAD) platform • Use of mapping tools • Wellbeing and support education • Training focused on diversity and cultural competence • Supervised practice in taking emergency calls

Data collection

The cohort **(Figure 1)** was defined as patients for whom call-takers had dispatched a cardiac arrest by the conclusion of the case entry stage. As illustrated in **Figure 1**, audio call retrieval achieved a 90.3% match, while 9.7% of calls (n = 59) could not be retrieved due to constraints in our extraction method, which relied on identifying a unique match based on call timing.

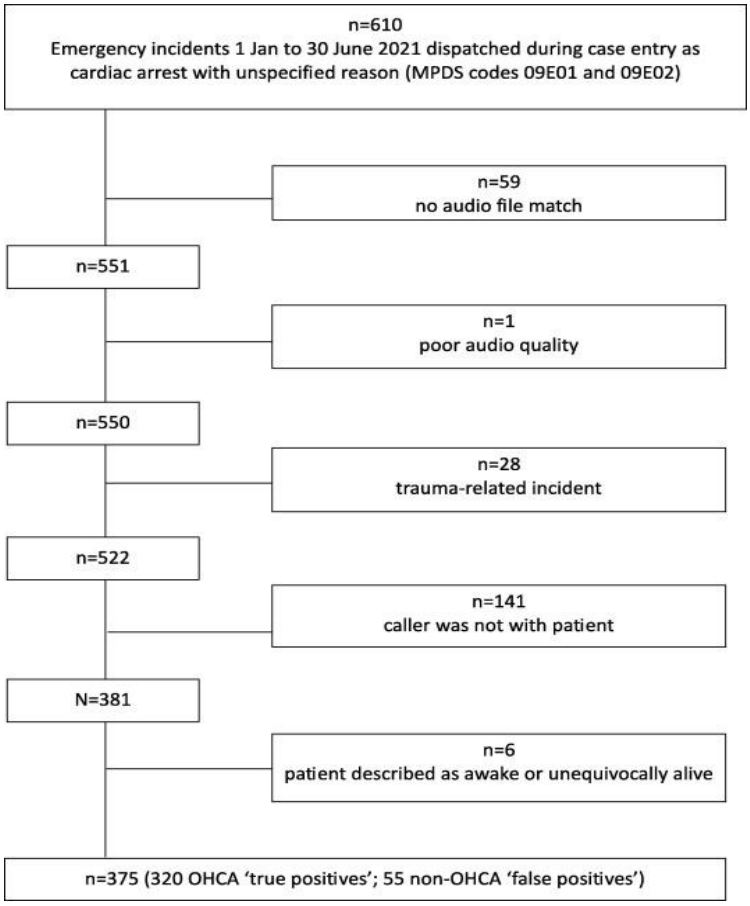

Figure 1. Study flow diagram. 'True positives' were defined as unwitnessed or bystander-witnessed out-of-hospital cardiac arrests (OHCA) confirmed by emergency medical services (EMS), whereas 'false positives' included all remaining cases (i.e., EMS-witnessed cardiac arrests or incidents that were not confirmed as OHCA by EMS)

We obtained ambulance dispatch records from St John Western Australia's (SJ-WA) ProQA system [14] to identify which incidents were initially dispatched as suspected OHCA during the call-taking process. Additional clinical and outcome data were extracted from the SJ-WA OHCA Registry, which prospectively captures all ambulance-attended OHCAs in Western Australia. The true positive subgroup included only patients who suffered an EMS-confirmed OHCA that was either unwitnessed or bystander-witnessed. The false positive (comparator) subgroup consisted of patients who were dispatched as OHCA but either did not arrest at all or arrested only after ambulance arrival (EMS-witnessed OHCA). Audio recordings of all emergency calls were retrieved from the SJ-WA call database.

Development of the coding schema

We began by listening to the first 50 emergency call recordings from the total cohort of 375 calls to identify and catalogue the various descriptors callers used to describe the patient's breathing. A preliminary coding schema was then developed to categorise these descriptors by grouping expressions that conveyed similar meanings, building on the framework previously described by Fukushima *et al.* [15]. An expert multidisciplinary panel—including linguists, prehospital researchers, emergency call centre managers, and clinicians—refined the resulting (non-exhaustive) list of descriptor categories presented in **Table 2**. To ensure appropriate grouping of descriptors, semantic similarity was evaluated using WordNet® [16], a large lexical database of English that organises words into interconnected networks of related concepts.

Table 2. Coding framework for breathing and patient descriptors in EMS calls dispatched as cardiac arrest

Category	Illustrative words/phrases (non-exhaustive)
BREATHING STATUS CONFIRMATION	
Breathing present	yes, they're breathing, I think so, appears to be breathing, seems like they are
Not breathing	no, nope, doesn't seem to be breathing, I don't think so, doesn't appear to be, stopped breathing (possibly)

BREATHING CHARACTERISTICS	
Barely	barely, hardly, not properly, not well, sort of, kind of, weak, insufficient, minimal, not quite
Short of breath	breathless, struggling to breathe, out of breath
Cannot breathe	cannot breathe, unable to breathe
Deep	deep breaths, big breaths
Irregular	erratic, sporadic, intermittent, inconsistent
Laboured	laboured, strained, heavy, difficult, struggling, fighting for air, challenging
Shallow	shallow, tiny breaths, faint, weak, feeble, light, just a little, minimal
Slow	slow breathing
AUDITORY FEATURES	
Gasp	gasping, gulping
Gurgle	gurgling, gargling, sputtering, spluttering
Pant	panting
Raspy	raspy sound
Snore	snoring
Snort	snorting, grunting
Unusual sounds	strange, odd, weird, funny noises
OTHER OBSERVATIONS	
Cyanosis	blue lips, blue face, turning purple
CPR in progress	CPR already started, compressions ongoing
Deceased	dead, gone, passed away, deceased
Uncertain	unsure, not sure, can't tell, uncertain, don't know
Verification strategies	e.g., caller asked call-taker to listen, call-taker notes agonal breathing
Miscellaneous	coughing, hiccupping, chest or stomach movement, heaving, dry retching, general breathing issues

Data analysis

We reviewed the call recordings and, using the predefined coding framework, documented the breathing-related descriptors provided by callers during the initial portion of the call, referred to as "case entry." This is the preliminary assessment stage of the MPDS protocol, during which information such as the address, phone number, and responses to questions about the patient's consciousness and breathing are collected **(Figure 2)**. Throughout this stage, we captured any comments from callers regarding breathing, whether in response to scripted prompts shown in **Figure 2**, follow-up clarifications by the call-taker (e.g., "So you're saying they are breathing?"), or spontaneously without prompting. The conclusion of case entry was marked by the call-taker posing a question or making a statement that fell outside the scope of the MPDS case entry protocol.

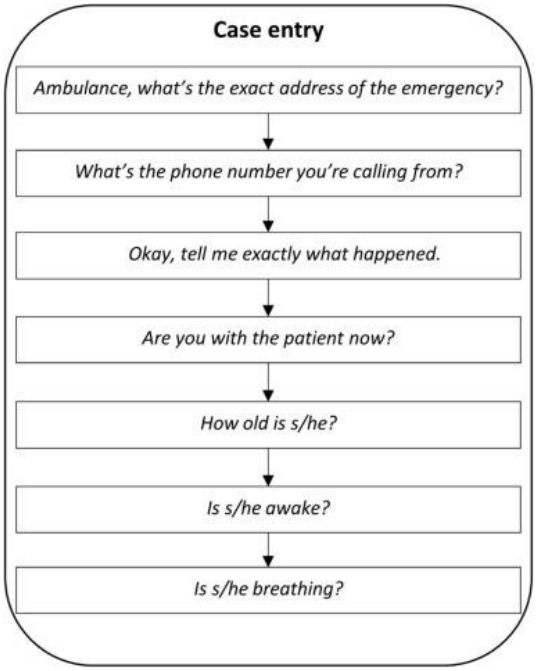

Figure 2. Medical Priority Dispatch System™ case-entry protocol [10]

To mirror actual call-taker conditions, researchers remained unaware of whether each case was a true or false OHCA, and the sequence of calls was randomised.

The first 100 recordings were independently analysed by two authors (TB, MR). Differences were settled through discussion, or by involving a third author when needed, and the coding framework was adjusted accordingly. The rest of the calls were coded independently by two authors (TB, NP), using the same process for resolving discrepancies. Whenever new, repeatedly occurring descriptions appeared, the coding scheme was updated and earlier cases were re-examined and recoded as necessary.

Although the main focus was on how breathing was described, other caller statements (e.g., the patient being blue/purple or "dead") were also captured because they frequently influenced the recognition of cardiac arrest. It became apparent during development that many of these extra descriptions were given directly in answer to the standard question "Is s/he breathing?".

After all calls were coded, the dataset was unblinded and the positive predictive value was calculated for each descriptor category (the proportion of calls dispatched as OHCA during case entry that were later confirmed by ambulance crews as genuine out-of-hospital cardiac arrest, including both unwitnessed and bystander-witnessed events).

Results

The study included 375 emergency calls that received an OHCA dispatch decision during the initial case-entry phase: 320 were confirmed as true OHCAs by responding crews and 55 were unconscious non-cardiac-arrest cases (false positives) **(Figure 1)**.

The final coding framework contained 23 distinct categories:

- 2 confirming breathing status (NOT breathing; YES breathing)
- 8 breathing qualifiers
- 7 descriptions of breathing sounds
- 6 additional patient descriptors **(Table 2)**.

Table 3 presents the frequency of specific breathing descriptors used in emergency calls and their association with true positive cases of OHCA.

Table 3. Comparison between breathing descriptors uttered in case entry, in terms of positive predictive value – i.e. percentage of EMS-confirmed cardiac arrests

Category	Positive predictive value (% true positive OHCA) with 95% conf. interval		Breathing descriptors	True positive OHCA cases	Total cases dispatched as OHCA
Confirmation	68.8	(50.0–83.9)	YES breathing	22	32
	86.8	(82.1–90.6)	NOT breathing	230	265
Describing breathing	63.6	(30.8–89.1)	Barely	7	11
	100.0	(2.5–100.0)	Breathless	1	1
	75.0	(34.9–96.8)	Can't breathe	6	8
	100.0	(39.8–100.0)	Deep	4	4
	100.0	(39.8–100.0)	Erratic	4	4
	55.6	(21.2–86.3)	Laboured	5	9
	71.4	(41.9–91.6)	Shallow	10	14
	100.0	(15.8–100.0)	Slow	2	2
Describing sound	63.6	(30.8–89.1)	Gasp	7	11
	100.0	(47.8–100.0)	Gurgle	5	5
	100.0	(2.5–100.0)	Pant	1	1
	100.0	(2.5–100.0)	Raspy	1	1
	83.3	(35.9–99.6)	Snore	5	6
	100.0	(15.8–100.0)	Snort	2	2
	77.8	(40.0–97.2)	Strange noises	7	9
Other	82.6	(61.2–95.0)	Blue/Purple	19	23
	100.0	(76.8–100.0)	CPR already in progress	14	14
	97.8	(92.4–99.7)	Dead	90	92
	76.8	(63.6–87.0)	Unsure	43	56
	0.0	(0.0–84.2)	Verification strategy (Caller tells call-taker to listen to patient)	0	2
	85.3	(81.3–88.8)	TOTAL	320	375

In the study cohort of both true and false positive OHCAs, the breathing descriptors most frequently reported by callers were NOT breathing (70.7 percent), Dead (24.5 percent), Unsure (14.9 percent), YES breathing (8.5

percent), and Blue/Purple (6.1 percent). Among the 32 cases where YES breathing was reported, 15 (46.9%) also included NOT breathing at some point during the call, and 11 (34.4%) paired YES breathing with another descriptor. Overall, 85.3 percent of dispatched cases (320/375) were confirmed as EMS-verified OHCA, corresponding to a positive predictive value of 0.85. The descriptors most strongly predictive of confirmed OHCA were Dead (97.8% true positives), NOT breathing (86.8 percent), Blue/Purple (82.6 percent), and Unsure (76.8 percent). Less frequently reported descriptors (<15 cases, <4%) also showed high association with OHCA, including Breathless (n = 1, 100 percent), CPR already in progress (n = 14, 100 percent), Deep (n = 4, 100 percent), Erratic (n = 4, 100 percent), Gurgle (n = 5, 100 percent), Pant (n = 1, 100 percent), Raspy (n = 1, 100 percent), Slow (n = 2, 100 percent), Snort (n = 2, 100 percent), Snore (n = 6, 83.3 percent), Strange noises (n = 9, 77.8 percent), Can't breathe (n = 8, 75.0 percent), and Shallow (n = 14, 71.4 percent). Descriptors with a weaker link to OHCA included YES breathing (68.8% true positives), Barely (63.6 percent), Gasp (63.6%), and Laboured (55.6 percent).

These findings reveal the broad range of expressions callers use to describe patient breathing in cases dispatched as OHCA and the corresponding likelihood of EMS-confirmed cardiac arrest for each category. While descriptors such as NOT breathing, Dead, Unsure, and Blue/Purple were common, callers also employed a more diverse set of terms across eight breathing type and seven breathing sound categories. Each category represents a cluster of semantically related expressions; for example, Laboured might encompass terms such as "strained," "heavy," "struggling," "challenging," "trouble," "trying hard," "difficulty," or "fighting for air." This emphasizes that call-takers must interpret the underlying meaning rather than focusing solely on specific words, and the schema in **Table 2** can be expanded or adapted to different languages and operational contexts.

Analysis of positive predictive values indicates that, across nearly all breathing descriptors, patients were more likely than not to be in cardiac arrest (i.e., >50% true positives), with the exception of a rare category comprising only two cases (verification strategy). Although confidence intervals for some descriptors were wide, limiting their strength as predictors, these findings reinforce the EMS approach of treating abnormal breathing in unconscious patients as presumed cardiac arrest until evidence shows otherwise (e.g., patient responds to CPR) [11,17,18]. Such evidence can help strengthen call-taker confidence in OHCA recognition and guide their actions, particularly when callers hesitate to perform CPR because the patient appears to have signs of life, given the low risk of harm from CPR relative to its life-saving potential [11,17,18].

Our findings show that, although the MPDS question "Is s/he breathing?" is a simple yes/no query, callers often respond in ways that are ambiguous or qualified. These varied responses offer an important opportunity to identify OHCA, but they also create a challenging situation for call-takers, who must interpret combinations of unconsciousness and abnormal breathing as potential cardiac arrest [19]. Looking specifically at EMS-confirmed OHCAs (true positives), the variety of breathing descriptors in our cohort was much broader than the examples in the MPDS for ineffective or agonal breathing [10], suggesting that training call-takers with a wider range of descriptors could be beneficial. At the same time, because cardiac arrest calls represent only a small proportion of emergency ambulance calls [20], call-takers may not always be prepared to treat every descriptor or combination of descriptors as indicative of OHCA.

One of the original aims of this study was to identify descriptors with low positive predictive value for EMS-confirmed cardiac arrest. Unexpectedly, no descriptors met this criterion. Even calls in which YES breathing was reported had a relatively high positive predictive value of 69%, highlighting the uncertainty in this category. In several cases, YES breathing occurred alongside descriptors such as Barely or Laboured (results not shown), confirming previous findings that for unconscious patients, a "yes" response to the breathing question does not necessarily indicate effective breathing [21].

The Unsure descriptor also stands out. It appeared in 15% of calls, making it the third most common category after Not Breathing and Dead, and had a high positive predictive value of 77%. Although "Unsure" might suggest a lack of information, call-takers frequently interpreted such cases as cardiac arrest, consistent with MPDS guidance that uncertain breathing in an unconscious patient should prompt OHCA recognition [10]. The frequency and predictive value of Unsure breathing suggest it may be particularly useful to emphasise in call-taker training.

Limitations

To compare the positive predictive value of different descriptors, we restricted our analysis to cases classified as cardiac arrest during call entry. Future research could also examine false negative cases—patients not initially dispatched as OHCA but later confirmed by EMS—to better understand the absolute likelihood of specific descriptors indicating cardiac arrest.

Although the coding schema was developed systematically with co-author consensus, some categorisation decisions are debatable, and overlaps between categories may exist. We also analysed descriptors in isolation, without accounting for co-occurrence with other breathing or patient descriptors, which could influence call-taker recognition. The fact that YES breathing had a positive predictive value of 69% illustrates the complexity of OHCA recognition, suggesting call-takers respond to additional cues beyond a simple affirmation of breathing.

Future studies should explore the interaction of multiple descriptors in OHCA calls, with linguistic methods likely the most appropriate approach to capture the nuances of caller–call-taker exchanges.

Conclusions

This study demonstrated that callers employed a wide range of breathing descriptors—23 categories in total—when reporting the status of patients later dispatched as OHCA by call-takers. When examined individually, each descriptor had a positive predictive value exceeding 50% for EMS-confirmed OHCA. These findings emphasize the importance of exposing call-takers to the full spectrum of descriptors used by callers during training. Greater confidence in the predictive value of these descriptors could better equip call-takers to manage situations where callers express concern that patients appear to show signs of life.

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Conflict of interest: The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: AW is employed by St John Western Australia (SJ-WA); JF and SB hold adjunct appointments with SJ-WA and JF receives research project funding from SJ-WA. JF is on the Editorial board of Resuscitation.

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