Spontaneous trigger words associated with confirmed out-of-hospital cardiac arrest: a descriptive pilot study of emergency calls

Joonas Tamminen 1,2*, Erik Lydén 2, Jan Kurki 2, Heini Huhtala 3, Antti Kämäräinen 2 and Sanna Hoppu 2

Abstract

Background: According to the International Liaison Committee on Resuscitation (ILCOR), the trigger words used by callers that are associated with cardiac arrest constitute a scientific knowledge gap. This study was designed to find hypothetical trigger words in emergency calls in order to improve the specificity of out-of-hospital cardiac arrest recognition.

Methods: In this descriptive pilot study conducted in a Finnish hospital district, linguistic contents of 80 emergency calls of dispatcher-suspected or EMS-encountered out-of-hospital cardiac arrests between January 1, 2017 and May 31, 2017 were analysed. Spontaneous trigger words used by callers were transcribed and grouped into 36 categories. The association between the spontaneous trigger words and confirmed true cardiac arrests was tested with logistic regression.

Results: Of the suspected cardiac arrests, 51 (64%) were confirmed as true cardiac arrests when ambulance personnel met the patient. A total of 291 spontaneous trigger words were analysed. ‘Is not breathing’ (n = 9 [18%] in the true cardiac arrest group vs n = 1 [3%] in the non-cardiac arrest group, odds ratio [OR] 6.00, 95% confidence interval [CI] 0.72–50.0), ‘the patient is blue’ (n = 9 [18%] vs n = 1 [3%], OR 6.00, 95% CI 0.72–50.0), ‘collapsed or fallen down’ (n = 12 [24%] vs n = 2 [7%], OR 4.15, 95% CI 0.86–20.1) and ‘is wheezing’ (n = 17 [33%] vs n = 5 [17%], OR 2.40, 95% CI 0.78–7.40) were frequently used to describe true cardiac arrest. ‘Is snoring’ was associated with a false suspicion of cardiac arrest (n = 1 [2%] vs n = 6 [21%], OR 0.08, 95% CI 0.009–0.67).

Conclusions: In our pilot study, no trigger word was associated with confirmed cardiac arrest. ‘Is wheezing’ was a frequently used spontaneous trigger word among later confirmed cardiac arrest victims.

Keywords: Out-of-hospital cardiac arrest, Bystander cardiopulmonary resuscitation, Dispatch, Emergency calls, Trigger words

Background

Survival after out-of-hospital cardiac arrest (OHCA) remains modest despite standardised dispatch protocols in emergency medical services (EMS) systems, increased community training and the introduction of post-resuscitation care [1–3]. Nevertheless, early pre-hospital interventions do have a substantial impact on the survival of OHCA victims. Bystander-initiated cardiopulmonary resuscitation (CPR) increases the chances of 30-day survival twofold and is associated with improved long-term neurological outcome [4, 5].

Early recognition of cardiac arrest is the cornerstone of the chain of survival [6–8]. The well-known clinical signs of cardiac arrest are unresponsiveness and absent or abnormal breathing [6]. However, it is unclear how these signs and symptoms, especially agonal breaths, are interpreted and described by laypeople. Besides cardiac arrest, these clinical signs and symptoms are also related to many other medical conditions, which results in significant amount of false positive suspicions of OHCA. Emergency calls could contain hypothetical trigger words...
that current dispatch protocol may not recognise; the International Liaison Committee on Resuscitation (ILCOR) has announced that trigger words form a scientific knowledge gap [9]. These trigger words could be used to facilitate recognition of OHCA, to reduce time to dispatch EMS and to increase immediate bystander CPR rates. Importantly, they could be used to reduce the number of false positive alarms and thus to improve the specificity of recognition of cardiac arrest.

To test whether hypothetical trigger words exist and to generate more specific hypotheses, our study was designed as a descriptive pilot study. This pilot study aims to examine the association between true OHCA confirmed by ambulance personnel and laypeople’s spontaneous trigger words regarding physiological deterioration of a patient in the context of emergency-dispatcher-suspected or EMS-encountered OHCA.

Methods
This descriptive pilot study was conducted in the Pirkanmaa Hospital District, Finland, which serves the city of Tampere and a surrounding rural area covering a population of 510,000 [10]. In the study area, emergency calls are processed by trained emergency dispatchers, majority of whom are not medical professionals. The length of the formal dispatcher education is 1.5 years in Finland [11]. The national call processing is protocol-based and computer-aided. Recognition of cardiac arrest is based on three questions: (1) Tell me exactly what happened, (2) Is she/he conscious? and (3) Is she/he breathing normally? [11] During the study period, the emergency dispatcher did not receive any additional feedback that differed from the standard quality control.

Between January 1, 2017 and May 31, 2017, all audio recordings and electronic mission reports of consecutive emergency calls of dispatcher-suspected OHCA or EMS-encountered OHCA that a dispatcher had not suspected in the study area were extracted from the EinsatzLeitSystem (ELS) database maintained by the Emergency Response Centre Agency [12]. As the aim of the study was to address laypeople’s interpretations of physiological deterioration of an OHCA patient, cases with unwitnessed OHCA, traumatic cause for OHCA or an institutional resuscitation attempt were excluded.

As the study was retrospective and based on registry data only, with no interventions or patient contact involved, the need for patient consent was waived. The study protocol was approved by the institutional review board of the Pirkanmaa Health District (R17156, November 7th, 2017).

Spontaneous trigger words
Spontaneous speech, defined as something that the caller said without being prompted or asked by the dispatcher, was transcribed by authors EL and JK who are professional paramedics. Caller’s whole answer to a preceding question was considered as non-spontaneous speech regardless of the duration or the length of the answer. In order to analyse transcribed speech, different words with the same semantic meaning were put in a single category [13, 14]. Authors JT, EL and JK interpreted the semantic meaning of trigger words and categorised them. The basis of our categorisation was a word list introduced by Berdowski et al. [7], which included seven categories: breathing, consciousness, facial colour, death, heart problems, resuscitation, and other. In addition, the ABCDE approach was used to formulate our categorisation [15]. The ABCDE is a mnemonic for a generally accepted treatment protocol for critically ill patients. In our study, the spontaneous trigger words were grouped into seven main categories and thirty-six subcategories, the former of which included altered level of unconsciousness, death, breathing, circulation, disability, history of present illness, and unclassified. Our circulation category included facial colour and heart problems as subcategories. In cases of an ambiguous trigger word, the other two authors verified the suggested trigger word category.

Each emergency call could fulfil the criteria of each subcategory once. Subsequently, two or more trigger words were counted as a duplicate if the caller repeated the same word or if the caller used words that had a different linguistic form but had an identical semantic meaning. Ultimately, the trigger words were translated from Finnish to English (United Kingdom) by two native Finland linguists who have MA degrees in communication sciences.

Confirmation of true cardiac arrest
The trigger words were stratified into true cardiac arrest and non-cardiac arrest groups. The mission reports were used to identify true cardiac arrests, as there was no national cardiac arrest registry in Finland. After each mission, the EMS personnel filled out specific documentation that contained dispatch and transportation codes (e.g. the patient is confirmed dead, or the patient had return of spontaneous circulation, or CPR was being performed during transportation or the patient had had any other medical emergency). The true cardiac arrest events were confirmed by the EMS personnel based on these documentations. A transportation code for a non-OHCA event could be, for example, rhythm disturbance or intoxication.

Statistical methods
SPSS software version 25 (SPSS Inc., Chicago, IL, USA) was used to perform the statistical calculations. Categorical and continuous variables were reported as frequencies and proportions and as medians and interquartile ranges, respectively. The comparison between the groups was performed using a χ² or a two-tailed Fisher’s exact
test for the categorical data and a Mann–Whitney U-test for the continuous, nonparametric data. A univariate logistic regression was used to assess the association between the spontaneous trigger words and confirmed cardiac arrests, and the results were presented as odds ratio (OR) with 95% confidence interval (CI). A two-sided p-value < 0.05 was considered statistically significant.

Results

During the study period, 112 emergency calls met our inclusion criteria. A total of 32 (29%) cases were excluded because they related to an institutional resuscitation, the patient was awake or other reasons (e.g. poor sound quality), and 80 (71%) emergency calls were transcribed as presented in Fig. 1. Of the suspected cardiac arrests, 51 (64%) were confirmed as true cardiac arrests, and 29 (36%) of the suspected cardiac arrests were regarded as non-cardiac arrest events when EMS evaluated the patient.

The emergency call and mission characteristics are presented in Table 1. Most cardiac arrests were suspected after an ambulance was dispatched, and two confirmed cardiac arrests were not recognised by the dispatcher. The time of OHCA suspicion, the number of trigger words and the duration of speech intervals were similar between the groups. A total of 291 spontaneous trigger words were analysed; 93 (32%) and 41 (14%) of them concerned breathing and altered level of consciousness, respectively. The distribution of spontaneous trigger words in confirmed cardiac arrest and non-cardiac groups is presented in Fig. 2.

The results of the univariate logistic regression are shown in Table 2. The spontaneous trigger words that were more frequently used to describe true cardiac arrest were ‘is not breathing’ (n = 9 [18%] in the true cardiac arrest group vs n = 1 [3%] in the non-cardiac arrest group, odds ratio [OR] 6.00, 95% confidence interval [CI] 0.72–50.0), ‘collapsed or fallen down’ (n = 12 [24%] vs n = 2 [7%], OR 4.15, 95% CI 0.31–20.1) and ‘is wheezing’ (n = 17 [33%] vs n = 5 [17%], OR 2.40, 95% CI 0.78–7.40). ‘Is snoring’ was associated with a false suspicion of cardiac arrest (n = 1 [2%] vs n = 6 [21%], OR 0.08, 95% CI 0.009–0.67).

Discussion

In this descriptive pilot study conducted in a Finnish hospital district, the linguistic contents of 80 emergency calls of suspected, non-traumatic, witnessed OHCA or EMS-encountered, non-traumatic OHCA that a dispatcher had not suspected were evaluated. The focus of the study was on spontaneous speech used by the caller since it was hypothesised to contain trigger words that the current dispatch protocol may have missed. If recognised, these trigger words could make dispatching faster and more specific. Although ILCOR notes that the trigger words associated with OHCA are a scientific knowledge gap, only one Dutch study has explored trigger words and a couple of Australian studies have examined the communication between emergency dispatchers and laypeople [7, 16, 17].

Our emergency dispatchers performed well during the five-month study period; the emergency dispatcher did not recognise two later confirmed cardiac arrests. The sensitivity for OHCA recognition was 96.2% in our material whereas a recently published systematic review concluded that the global sensitivity for OHCA recognition is 73.9% (range 14.1–96.9%) [18]. The review included three studies conducted in Finnish regions which found slightly lower sensitivities as compared with our results: 82.9, 82.3 and 79.4%, respectively [11, 19, 20]. As Viereck et al. argue, the definition of a recognised cardiac arrest is ambiguous and may result in conflicting estimates of the performance of a given EMS system.

According to the European Resuscitation Council (ERC) guidelines, recognition of OHCA is based on the combination of the patient being recognised as unconscious and apnoea or breathing abnormally. One might argue that interpretation of the trigger words in relation to breathing is conditional on what is said about the conscious state and vice versa. However, we postulate that an individual trigger may combine the semantic information regarding both level of consciousness and breathing in the context of a medical emergency.

In our material, there were two important trigger words in the breathing category worth noting: ‘is wheezing’ (Finnish: korisee) and ‘is snoring’ (Finnish: kuorsaa). The former does not mean obstructive wheezing but rather a death rattle or choking sounds, and it seems to be an idiomatic expression in Finnish language. In addition, both trigger words mean that the patient has difficulties maintaining the normal muscle tone of the upper respiratory tract, which, in turn, reflects a markedly altered level
of consciousness. The latter trigger word was associated with a later confirmed non-cardiac arrest event, whereas the former was the most frequently used single trigger word in the confirmed true cardiac arrest stratum.

As discussed above, the emergency dispatcher had missed two cases, in which ambulance personnel encountered cardiac arrest. Interestingly, ‘is wheezing’ was the only spontaneous trigger word in the first missed case. The second case included the following trigger words: ‘shallow breathing’, ‘I’m not sure if the patient is breathing’ and ‘glazed eyes’. These trigger words may reflect agonal breathing, which seems to be a pitfall of recognition of OHCA [21]. Indeed, subtle changes to the current algorithm may result in better sensitivity without a marked decrease in specificity. Riou et al. suggested that the emergency dispatcher should repeat the question regarding breathing pattern if the caller’s initial answer is imprecise or vague [16].

In the future, trigger word combinations could be identified in real time by automatic speech recognition, and machine-learning models could calculate a probability of cardiac arrest. Corti AI, used by emergency dispatchers in Denmark, is an example of an automatic speech recognition program [22]. A recently published study evaluated this machine-learning algorithm to emergency dispatchers and showed that Corti AI seems to outperform emergency dispatchers for recognising OHCA [23].

**Strengths and limitations**

To the best of our knowledge, no previous study focusing on recognition of OHCA has explored spontaneous speech in emergency calls. Besides novelty, the strength of the study is the contribution of two native Finnish linguists, which increases the potential generalisability of the results beyond Finland.

This descriptive pilot study has several important limitations to consider. First, the study failed to detect any association between confirmed cardiac arrests and trigger words, and the confidence intervals for odds ratios were wide in the logistic regression model. However, this study was designed as a pilot study. A further study with a greater sample size is currently being conducted. Second, the study was underpowered to find trigger words associated with false negative cases (i.e. the dispatcher may have not suspected OHCA, even though a true

| Trigger words | True cardiac arrest | Non-cardiac arrest | p-value |
|---------------|---------------------|-------------------|---------|
| Total, n (%)  | 194 (67)            | 97 (33)           |         |
| Median (IQR)  | 3 (2–5)             | 3 (2–5)           | 0.369   |

**Table 1** Emergency call and mission characteristics

| Time of OHCA suspicion, n (%) | True cardiac arrest | Non-cardiac arrest | p-value |
|-------------------------------|---------------------|-------------------|---------|
| Initial reason for dispatch   | 15 (29)             | 6 (21)            | 0.440   |
| EMS en route                  | 34 (67)             | 23 (79)           | 0.307   |
| OHCA not suspected            | 2 (4)               | 0 (0)             | 0.532   |
| Initial dispatch code non-specific | 23 (45)           | 12 (41)           | 0.817   |

**Duration, median (IQR); min:sec**

| Emergency call | 6:47 (5:12–8:35) | 5:31 (3:41–8:49) | 0.423   |
| Total spontaneous speech | 5:12 (3:31–6:44) | 3:55 (3:05–7:08) | 0.506   |
| Initial description of situation | 0:05 (0:04–0:10) | 0:05 (0:04–0:09) | 0.590   |

IQR interquartile range; OHCA out-of-hospital cardiac arrest; EMS emergency medical services
| Trigger words                  | True cardiac arrest | Non-cardiac arrest | OR (95% CI)       |
|-------------------------------|---------------------|--------------------|-------------------|
| Dead or is dying              | 16                  | 10                 | 1.61 (0.39–6.63)  |
| Altered level of consciousness|                     |                    |                   |
| Unconscious                   | 20                  | 31                 | 0.54 (0.19–1.55)  |
| Unable to wake                | 8                   | 7                  | 1.15 (0.20–6.69)  |
| Nonresponsive                 | 12                  | 3                  | 3.73 (0.43–32.7)  |
| Impaired                      | 4                   | 0                  | NA                |
| Unable to speak               | 2                   | 7                  | 0.27 (0.02–3.12)  |
| Unclassified consciousness    | 4                   | 7                  | 0.55 (0.07–4.14)  |
| Breathing                     |                     |                    |                   |
| Is breathing                  | 12                  | 17                 | 0.42 (0.12–1.51)  |
| Not breathing                 | 18                  | 3                  | 6.00 (0.72–50.0)  |
| Laboured                      | 12                  | 3                  | 3.73 (0.43–32.7)  |
| Heavily                       | 0                   | 3                  | NA                |
| Irregularly                   | 6                   | 10                 | 0.54 (0.10–2.88)  |
| Is gasping for breath         | 12                  | 7                  | 1.80 (0.34–9.56)  |
| A deep breath                 | 2                   | 3                  | 0.56 (0.03–9.30)  |
| Is snoring                    | 2                   | 21                 | 0.08 (0.009–0.67) |
| Is wheezing                   | 33                  | 17                 | 2.40 (0.78–7.40)  |
| Unclassified breathing        | 29                  | 14                 | 2.60 (0.77–8.78)  |
| Circulation                   |                     |                    |                   |
| No pulse                      | 4                   | 3                  | 1.14 (0.10–13.2)  |
| Pale                          | 14                  | 3                  | 4.46 (0.52–38.2)  |
| Red                           | 0                   | 1                  | NA                |
| Blue                          | 18                  | 3                  | 6.00 (0.72–50.0)  |
| Cold                          | 10                  | 7                  | 1.47 (0.27–8.09)  |
| Clammy                        | 8                   | 10                 | 0.74 (0.15–3.55)  |
| Is bleeding or there is blood | 4                   | 7                  | 0.55 (0.07–4.14)  |
| Heart pain                    | 6                   | 0                  | NA                |
| Disability                    |                     |                    |                   |
| Is convulsing                 | 4                   | 14                 | 0.26 (0.04–1.49)  |
| Limp                          | 12                  | 10                 | 1.16 (0.27–5.01)  |
| Incontinent                   | 10                  | 3                  | 3.04 (0.34–27.4)  |
| Eyes or gaze                  | 20                  | 14                 | 1.52 (0.43–5.38)  |
| Mouth open                    | 12                  | 3                  | 3.73 (0.43–32.7)  |
| Something from mouth          | 6                   | 14                 | 0.39 (0.08–1.88)  |
| Is moving                     | 8                   | 0                  | NA                |
| History of present illness    |                     |                    |                   |
| Collapsed or fallen down      | 24                  | 7                  | 4.15 (0.86–20.1)  |
| Seizure                       | 27                  | 31                 | 0.84 (0.31–2.28)  |
| Taken something               | 4                   | 10                 | 0.35 (0.06–2.25)  |
| Unclassified                  | 2                   | 24                 | 0.06 (0.007–0.54) |

OR: odds ratio; CI: confidence interval; NA: not applicable.
cardiac arrest had occurred). This was a rare event in our material, as the dispatcher had missed only two later confirmed OHCA. Third, the authors were not blinded to the outcome when transcribing the emergency calls or categorising the trigger words. Fourth, the exact time of trigger words and the time of OHCA suspicion in an emergency call were not considered in our analysis. However, this study was not designed to address trigger words associated with prompt or late recognition of OHCA. Finally, transportation codes were used to confirm cardiac arrest. Nevertheless, it is extremely rare that EMS personnel would have used the transportation codes of OHCA for non-cardiac arrest missions and vice versa.

Conclusions
In conclusion, this pilot study introduces a novel method to categorise laypeople’s spontaneous trigger words in emergency calls in the context of dispatcher-suspected cardiac arrest. No trigger word was associated with confirmed cardiac arrests, but ‘is wheezing’ was the most frequent trigger word in the confirmed cardiac arrest stratum.

Abbreviations
CI: Confidence interval; CPR: Cardiopulmonary resuscitation; ELS: EinsatzLeitSystem; EMS: Emergency medical services; ERC: European Resuscitation Council; ILCOR: International Liaison Committee on Resuscitation; OHCA: Out-of-hospital cardiac arrest; OR: Odds ratio

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Endnotes
Not applicable.

Authors’ contributions
Authors EL and JK transcribed the audio recordings. JT, EL and JK interpreted the semantic meaning of trigger words and categorised them. All authors contributed substantially to the interpretation of the findings and approved the final version of this manuscript.

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Availability of data and materials
The data that support the findings of this study (including the complete list of Finnish trigger words with their English translations) are available from the corresponding author upon request.

Ethics approval and consent to participate
The study protocol was approved by the institutional review board of the Pirkanmaa Health District (R17156, November 7th, 2017). The study was retrospective and based on registry data only, with no interventions or patient contact involved. Thus, the need for patient consent was waived.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Author details
1Faculty of Medicine and Health Technology, Tampere University, PO Box 2000, FI-33520 Tampere, Finland. 2Emergency Medical Services, Tampere University Hospital, PO Box 2000, FI-33521 Tampere, Finland. 3Biostatistics, Faculty of Social Sciences, Tampere University, FI-33014 Tampere, Finland.

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