Telephone-CPR and Recognizing Out-of-Hospital Cardiac Arrest: Analyzing Chief Complaints to Identify Delays

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Abstract

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Survival from cardiac arrest remains low.[1] Cardiopulmonary resuscitation (CPR) has been proven to increase a cardiac arrest patient's chance of survival.[2] Telephone-assisted CPR (T-CPR) instructions have been shown to improve the proportion of patients who receive CPR from bystanders in an out-of-hospital setting.[1] Our study sought to identify delays to recognizing out-of-hospital cardiac arrest and initiating telecommunicator-assisted CPR by analyzing the chief complaints of 449 real calls in which cardiac arrest was determined to have occurred. Previously-collected data from the STAT 911 parent study was used in our analysis.[3,4] Chief complaints were categorized into four codes distinguished by the callers' description of the patient's breathing. Survival curves were created and analyzed for statistical significance. Our results showed no statistically significant difference in the time to recognition of the need for CPR or in the time to first compression by the description of patient breathing given in the caller's chief complaint.

Introduction

Problem Description

The United States alone sees more than 350,000 out-of-hospital cardiac arrests (OHCA) each year.[5] Because the percent of cardiac arrest patients surviving remains in the single digits,[1] cardiac arrest remains a public health problem. As Vaillancourt et al have noted, OHCA comprise the majority of cardiac arrest cases. [1]

Importance of CPR

Cardiac arrest patients only have minutes without oxygen before brain injury or death is guaranteed.[6,7] As each minute passes, the likelihood of survival decreases.[2,8–11] Cardiopulmonary resuscitation (CPR) can buy time for patients by manually circulating oxygenated blood before the patient is brought to a hospital where advanced treatment can be provided, increasing their chance of survival.[2] Indeed, patients who received CPR were 45% more likely to survive than patients who did not.[12] Thus, improving CPR delivery could save lives.

Cardiac Chain of Survival

In an ideal situation, a cardiac arrest patient will be assisted by a bystander who first calls for help, then performs high-quality CPR and starts use of an automated external defibrillator (AED) before emergency medical personnel arrive and quickly transport the patient to advanced care. This is known as the "cardiac chain of survival."

Figure 1: Cardiac Chain of Survival[13]

Why T-CPR?

Despite its importance in the chain of survival, more than 50% of cardiac arrest patients do not receive CPR.[14] Because bystanders who call 911 for patient often do not know how to perform CPR,[15] 911 telecommunicators have received training on how to guide bystanders through CPR over the phone. Telephone-assisted CPR (T-CPR) has been demonstrated to increase the proportion of patients receiving

CPR since the early 1990s.[16] T-CPR is feasible,[9] increases the proportion of patients who receive CPR,[1] and effective in improving patient survival.[12,17,18]

Challenges to Recognizing OHCA

However, a telecommunicator cannot help a caller deliver CPR to a patient if no one recognizes the patient is in cardiac arrest. Numbers vary by study, from 59% of OHCA going unrecognized during the call[19] to 30%.[20] Calls in which OHCA was present but went unrecognized by the telecommunicator resulted in delayed telephone-assisted CPR and lower survival for the patient.[21] "Delayed recognition"[22] thus has negative implications for patient survival. Therefore, it is essential that the telecommunicator recognizes OHCA from the caller's verbal description of the patient.

Agonal Breathing

The literature has documented the challenge that agonal breathing poses to correctly identifying OHCA in emergency calls. When present, agonal breathing is part of the process of dying and cannot bring a patient out of cardiac arrest.[23] Patients in cardiac arrest present with agonal breathing in anywhere from 37% of cases[1] to 60%[24] to 64%.[25] Agonal breathing is not normal breathing; whereas normal breathing is effectively silent, agonal breathing is relatively loud.[23] Agonal breathing can confuse callers, who may think that the patient is breathing adequately[26,27] or that the patient is not otherwise in cardiac arrest.[25]

Previous research has found that callers describe agonal breathing in a variety of ways.[1,8,25] The variety and ambiguity of their descriptions is a major obstacle to effective communication and, therefore, recognizing OHCA.[20,24,27,28] T-CPR is thus also delayed. For an incomplete list of examples, see Table 1. Table 1 does not show whether a word or phrase was also found by other researchers.

Table 1: Examples of Descriptions of Agonal Breathing from the Literature[1,20,25,28,29]

Study	Adverbs/Adjectives	Verbs	Phrases
Bang et al 2003	difficulty	gasping	
	poorly		
	occasional	wheezing	
	impaired		
Berdowski et al 2009	barely	sighing	
	hardly		
	heavy		
	labored		
	noisy		
Riou et al 2018			turning blue/purple
			can't breathe at all
			fighting for air
			making funny noises
			[breathing] just a little
Vaillancourt et al 2007		gurgling	
		moaning	
Bohm et al 2009	hard	snoring	
	labored		
	difficult	snuffling	
	bad		
	poor		

The confusion around callers' comprehension of agonal breathing and resulting description of the patient's condition appears to create ambiguity around whether the patient is breathing normally. The ambiguity appears to cause delays in recognizing OHCA and beginning T-CPR. Indeed, literature has found that telecommunicators are faster to initiate T-CPR when callers presented patients as not breathing than as with some breathing.[24] Fukushima found that 84.2% of "not breathing" calls were correctly identified, but less than 27.8% of calls describing abnormal breathing were.[24]

Many protocols instruct telecommunicators to ask two questions following the chief complaint in order to clarify such ambiguity: "is the patient conscious?" and, more importantly for this study, "is the patient breathing?".[3,30,31] Asking these questions can help dispatchers identify up to 90% of OHCAs with very high specificity.[32]

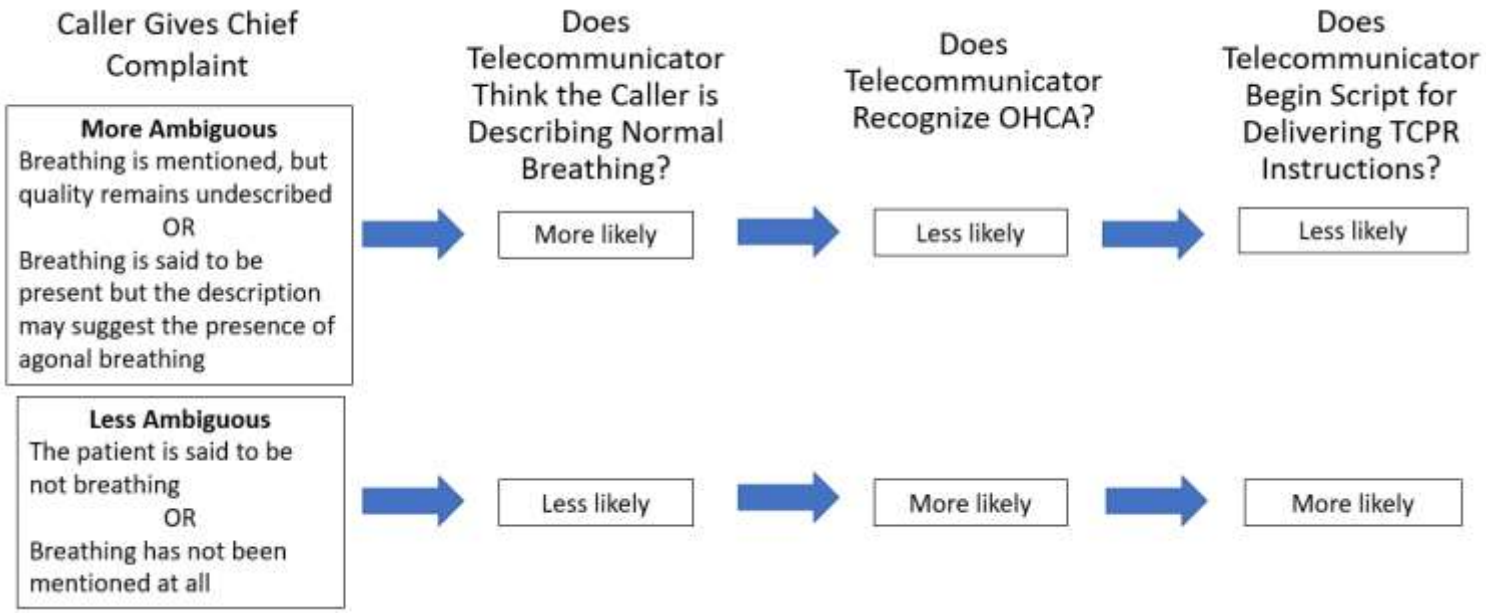
Research Question & Conceptual Model

For their analysis of delays, previous studies have selected the transcripts of entire calls, chief complaints, answers to specific questions such as "Is the patient breathing?", or a combination of those call components.[27–29,33,34] Our study analyzes only the chief complaints that callers give to telecommunicators. A chief complaint is the first description given by the caller to the telecommunicator about why the caller has dialed for emergency services. As the first part of an emergency call, analysis of chief complaints may identify one of the first possible delays in identifying OHCA. Figure 2 describes how the chief complaint might increase delays in recognition of the need for T-CPR.

This study builds on the works by Berdowski et al and Riou et al, who created similar categories, though they use different code definitions and combine telecommunicator follow-up questions with caller description.[25,28] As we look solely at chief complaints, we created the categories on the left side of

the model. Additionally, we added descriptions of agonal breathing from other studies into our codebook.

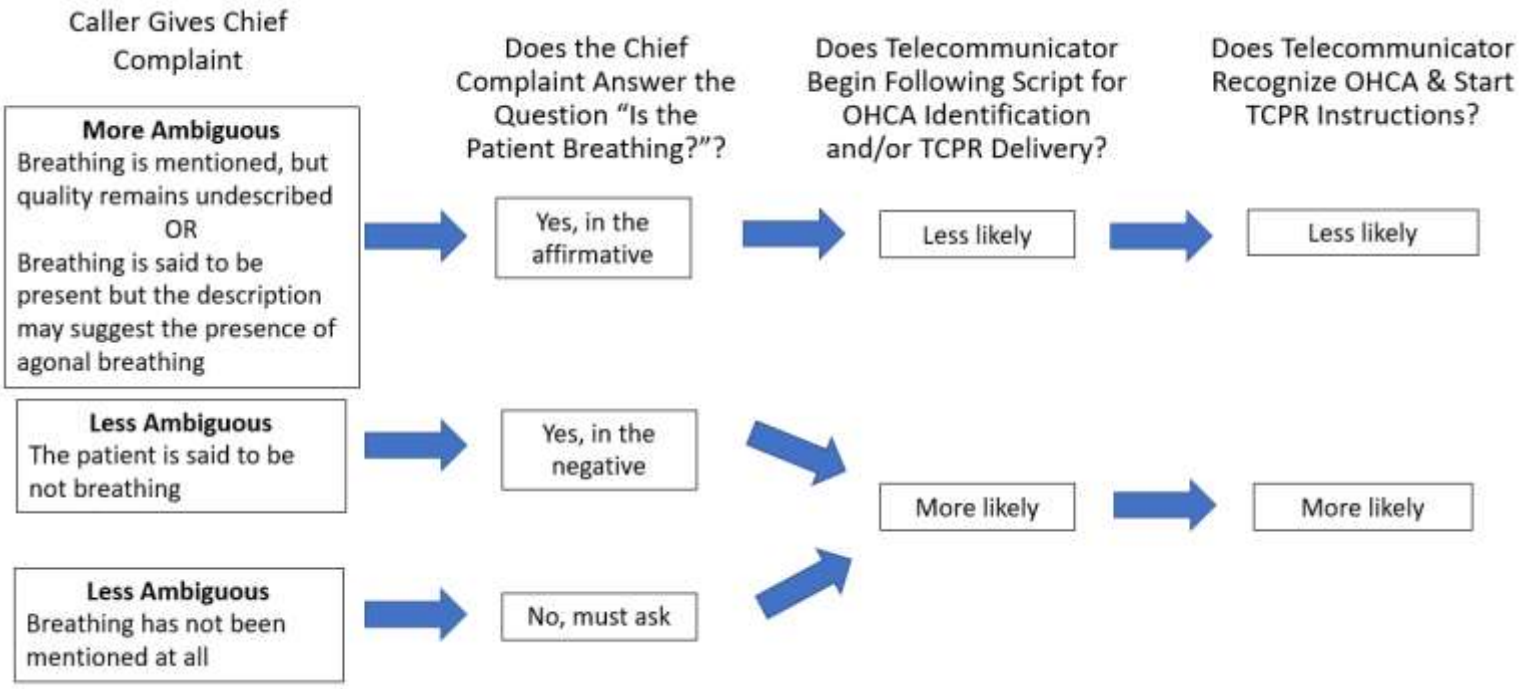
Figure 2: Conceptual Model 1



Based on the literature, we hypothesize that calls in which the chief complaint could be describing agonal breathing are more likely to be misinterpreted as situations in which the patient is breathing normally and/or breathing in a way that would not communicate cardiac arrest. Calls in which the presence of breathing is noted but not otherwise described may also be interpreted as a situation like the above. Based on the literature, both of these categories may likely be interpreted as describing normal breathing. Conversely, when callers describe patients as not breathing, there is less potential ambiguity in which the caller and telecommunicator may misunderstand each other. This is supported by the literature mentioned above.

Below is a conceptual model that describes the same hypothesized outcome for each category but under a different line of reasoning.

Figure 3: Conceptual Model 2



Furthermore, chief complaints that do not mention breathing would necessitate a line of questioning from that telecommunicator that determines the presence or absence of normal breathing. Telecommunicator protocols indicate that the question "Is the patient breathing?" should be asked in all calls, but not all calls are compliant with such protocol.[35] Adherence to protocol is associated with better patient survival in OHCA cases.[20] Therefore, we hypothesize that a chief complaint that does not provide any answer to "Is the patient breathing?" would not encourage skipping this question.

Again, if the caller mentions that breathing is present, the telecommunicator may assume normal breathing and not follow up by asking additional clarifying questions. This could lead to delayed recognition of OHCA and initiation of T-CPR.

Hypothesis

Under this reasoning, we would expect that calls that are more likely to describe agonal breathing would encourage the telecommunicator to follow a set of questions different from the two that assess the patient's consciousness and breathing. We hypothesize that these calls would result in longer times to recognizing OHCA and initiating T-CPR, while the less ambiguous categories of not breathing and breathing not mentioned would have shorter times to each.

Methods

This data was collected as part of the STAT 911 study. STAT 911 was a randomized controlled trial of a training intervention designed for 911 telecommunicators from call centers in the northwest United States. The training targeted the identification of the need for CPR over the phone. Telecommunicators assigned to the intervention group participated in trainings in which they received simulated (mock) 911 calls, some of which included OHCA. Participants took part in four trainings, which were held over several months. Telecommunicators received immediate feedback following the trainings. The primary evaluation was conducted by evaluating communication skills of both

intervention and control participants during simulated calls. Additionally, the simulation training's effectiveness was evaluated by analyzing time intervals and the communication skills exhibited by study participants during 561 real cardiac arrest calls.[3] Participants who received the training performed better than the control group, including identifying OHCA and starting T-CPR more quickly.[4] Information about the chief complaint, time to call pickup, time to transition to CPR script, time to T-CPR initiation, time to first compression, end of call, and telecommunicator demographics was abstracted from the call recordings.[4]

The chief complaint was defined as the first description of the caller's reason for calling 911 either spontaneously or when prompted by the telecommunicator. One individual listened to recordings of each of the calls and noted the chief complaint of each into a spreadsheet. Chief complaints were considered to be the first description the caller gave to the telecommunicator as to why they were calling. The description could be spontaneous or in response to a telecommunicator's prompt.

Data was de-identified prior to our analysis. As no new data was collected, this study was covered under the human subjects approval for the parent study.

Description of Dataset

This paper describes a retrospective study that used data from the STAT 911 parent study. Five hundred real calls were collected from five call centers in Seattle, Washington State, of which 467 met our study criteria. Of those 467, 449 had a recorded chief complaint and were included in the analysis. The case definition was cardiac arrest from a nontraumatic origin, which means that arrests due to physical injury, such as a car crash, were excluded. This is because calls regarding physical trauma are usually categorized using the trauma itself, not any subsequent cardiac arrest.[26,34] Calls in which the patient was unambiguously dead, i.e. decapitation or decomposition, were also excluded. Some studies have excluded pediatric patients because CPR instructions differ slightly due to age;[26,34] however, we did not as we only focused on the identification of OHCA and of the need for CPR.

Coding Process

Each chief complaint was coded into one of four categories based on the caller's description of the patient's breathing, which are described in Table 2. The examples on the rightmost column are taken from our dataset and are thus real chief complaints that we thought typified the code. For the code Quality Unmentioned, the provided examples were the only two of that code in our dataset.

Table 2: Code Descriptions

Code	Description*	Example Chief Complaints
Abnormal or Inadequate	The caller provides a description of the patient's breathing as anything other than normal breathing or completely absent. Includes the presence of a physical sign (temperature, skin color) in the patient that could indicate breathing distress.	"isn't really conscious, breathing really deeply"; "turning blue"; "barely breathing"
Quality Unmentioned	The caller says the patient is breathing without giving any qualifiers. This includes chief complaints in which the patient is said or implied to be breathing normally, or information is given that makes the presence of breathing/airflow obvious – for example, the patient is talking.	"breathing, but not responding"; "eyes rolled back, on floor, slurring, pain"
Not Breathing	The caller says the patient is not breathing.	"unconscious and not breathing"; "choking, not breathing"
Breathing Not Mentioned	The caller does not mention the patient's breathing.	"unresponsive"; "seizure"

*A full description of each code and a decision-making tree are included in Appendix 1.

A codebook was created iteratively. After developing a first draft, twenty chief complaints were randomly chosen using a random number generator.[36] Two individuals coded the twenty chief complaints; disagreements and ambiguous chief complaints were evaluated, agreed upon, and the codebook was subsequently amended. All chief complaints were re-coded according to the final version of the codebook (Appendix 1) by the first coder. This process of evaluation and amendment was completed three times. Across the three sets of twenty double-coded chief complaints, interrater reliability was assessed using Kappa.[37]

Survival Analysis

Descriptive statistics were calculated for the time from the start of call to OHCA recognition and from start of call to T-CPR initiation. As there were calls in which OHCA was not identified and/or T-CPR not begun, these were considered censored observations and were analyzed using Kaplan-Meier survival curves. End of call was treated as a censoring event, while the censoring time was the elapsed time from when the telecommunicator picked up the call to when they ended the call. The effects of code on time to OHCA recognition and time to T-CPR initiation were compared using Cox proportional hazards regression.[38] Statistical analyses were performed in R using the "survival" package.[39,40]

Results

Results of Coding Exercise

Interrater reliability was considered excellent for the 60 double-coded chief complaints. Kappa was 0.90 overall and was 0.928 for the first set of twenty, 0.92 for the second, and 0.856 for the third.

Table 3: Code Distribution

Code	Percent* (n=449)	Hypothesized Impact on OHCA Identification & TCPR Initiation
Abnormal or Inadequate	20 (90)	Delayed
Quality Unmentioned	0* (2)	Delayed
Not Breathing	18 (80)	Expedited
Breathing Not Mentioned	62 (277)	Expedited

*Percentages have been rounded to the nearest whole number.

Table 3 describes the frequency of each code in our dataset and our prediction of each code's impact on the time to OHCA identification and the time to T-CPR initiation. The most common code was Breathing Not Mentioned, which applied to over half of the chief complaints. Not Breathing and Abnormal or Inadequate each applied to about one-fifth of the chief complaints. Chief complaints that fell under the Quality Unmentioned code were very infrequent, so we were unable to do any meaningful analysis of this category on its own.

Of 449 calls, OHCA was identified in 366, or 81.5%. Of the 366 in which OHCA was identified, T-CPR was delivered in 219, or 59.8%, before emergency medical services arrived. T-CPR was not initiated before the arrival of emergency medical services in 147 calls during which the need for T-CPR was recognized, or 40.2%.

Results of Survival Analysis

Tables 4 and 5 show descriptive statistics of the dataset by code and by recognized versus unrecognized. In Table 4, the median times between three chief complaint categories to OHCA recognition show little difference in calls where OHCA was recognized, and the mean times to OHCA recognition actually contradict our hypothesis. When it came to calls in which OHCA went unrecognized, those with "more ambiguous" chief complaints had longer mean and median times to end of call than those with "less ambiguous" chief complaints. However, none of these findings were statistically significant.

Table 4 includes the 438 calls for which full data was available.

Tables 4: Time to OHCA Recognition

Time to Beginning CPR Script (Recognizing Need for TCPR*) or End of Call, in Seconds				
Code**	Mean time to recognition	Median time to recognition	Fastest Time	Slowest Time
Overall	83.82	64	5	817
Recognized				
Abnormal or Inadequate	69.49	56	11	287
Not Breathing	74.47	47.5	14	487
Breathing Not Mentioned	74.12	59.5	5	817
Quality Unmentioned & Abnormal or Inadequate (More Ambiguous)	69.59	56	11	287
Not Breathing & Breathing Not Mentioned (Less Ambiguous)	74.2	57.5	5	817
Unrecognized	Mean time to end of call	Median time to end of call	Shortest Call	Longest Call
Abnormal or Inadequate	160.5	143	30	420
Not Breathing	130.6	96	46	299
Breathing Not Mentioned	115.9	93	30	346
Quality Unmentioned & Abnormal or Inadequate (More Ambiguous)	160.5	143	30	420
Not Breathing & Breathing Not Mentioned (Less Ambiguous)	118.7	93.5	30	346

*OHCA Recognition. Strictly speaking, telecommunicators must recognize the need for T-CPR since they cannot diagnose cardiac arrest.

**Quality Unmentioned applied to only two calls, so this code was not analyzed on its own.

Table 5 includes only the 377 calls for which full data was available. Unlike Table 4, the mean and median times to T-CPR delivery are similar by code. The longest time to end of call for T-CPR initiation is shorter than the longest time to end of call in Table 4 likely because emergency services arrived more quickly once OHCA was recognized.

Table 5: Time to T-CPR Delivery

Time to First Compression (initiating TCPR) or End of Call, in Seconds				
Code**	Mean time to TCPR	Median time to TCPR	Fastest Time	Slowest Time
Overall	169.3	147	30	594
Initiated				
Abnormal or Inadequate	162.5	130	44	594
Not Breathing	154.6	149	30	286
Breathing Not Mentioned	161.8	144	30	586
Quality Unmentioned & Abnormal or Inadequate (More Ambiguous)	162.5	130.5	44	594
Not Breathing & Breathing Not Mentioned (Less Ambiguous)	160.2	145	30	586
Uninitiated	Mean time to end of call	Median time to end of call	Shortest Call	Longest Call
Abnormal or Inadequate	181.5	169.5	82	335
Not Breathing	159.8	138.5	62	304
Breathing Not Mentioned	216.6	190	32	510
Quality Unmentioned & Abnormal or Inadequate (More Ambiguous)	181.5	169.5	82	335
Not Breathing & Breathing Not Mentioned (Less Ambiguous)	205.1	180	32	510

**Quality Unmentioned applied to only two calls, so this code was not analyzed on its own.

Table 6: Times by Code and Grouped by Hypothesis

Event of Interest		Strata	p-value	z-value	hazard ratio*	coefficient (log hazard ratio)*	se(coef)*
OHCA	n= 438	Abnormal or Inadequate	0.70	-0.39	0.76	-0.28	0.72
	# of events = 353	Not Breathing	0.82	-0.23	0.85	-0.17	0.72
	# missing data = 28	Breathing Not Mentioned	0.71	-0.38	0.77	-0.27	0.71
		QI vs. BN**	**0.84**	**0.21**	**1.03**	**0.03**	**0.13**
TCPR	n = 377	Abnormal or Inadequate	0.40	-0.83	0.43	-0.85	1.16
	# of events = 175	Not Breathing	0.35	-0.93	0.39	-0.95	1.02
	# missing data = 89	Breathing Not Mentioned	0.34	-0.96	0.38	-0.97	1.01
		QI vs. BN	**0.47**	**-0.72**	**0.88**	**-0.13**	**0.19**

*compared to Quality Unmentioned, rounded to 2 decimal points

**QI = "more ambiguous" categories of Quality Unmentioned and Abnormal or Inadequate; BN = "less ambiguous" categories of Breathing Not Mentioned and Not Breathing

Table 6 shows that no statistically significant difference was found between the survival curves between the two groups of codes or between all four codes. In the column labeled “Strata,” “QI” is a group consisting of calls which were labeled “Quality Unmentioned” or “Abnormal or Inadequate.” “BN” is a group consisting of calls which were labeled “Breathing Not Mentioned” or “Not Breathing.”

Figure 4 shows the survival curve for OHCA recognition across all of our data. The overall mean time to OHCA recognition, recorded in Table 4, was 83.82 seconds.

Figure 4: OHCA Recognition Overall

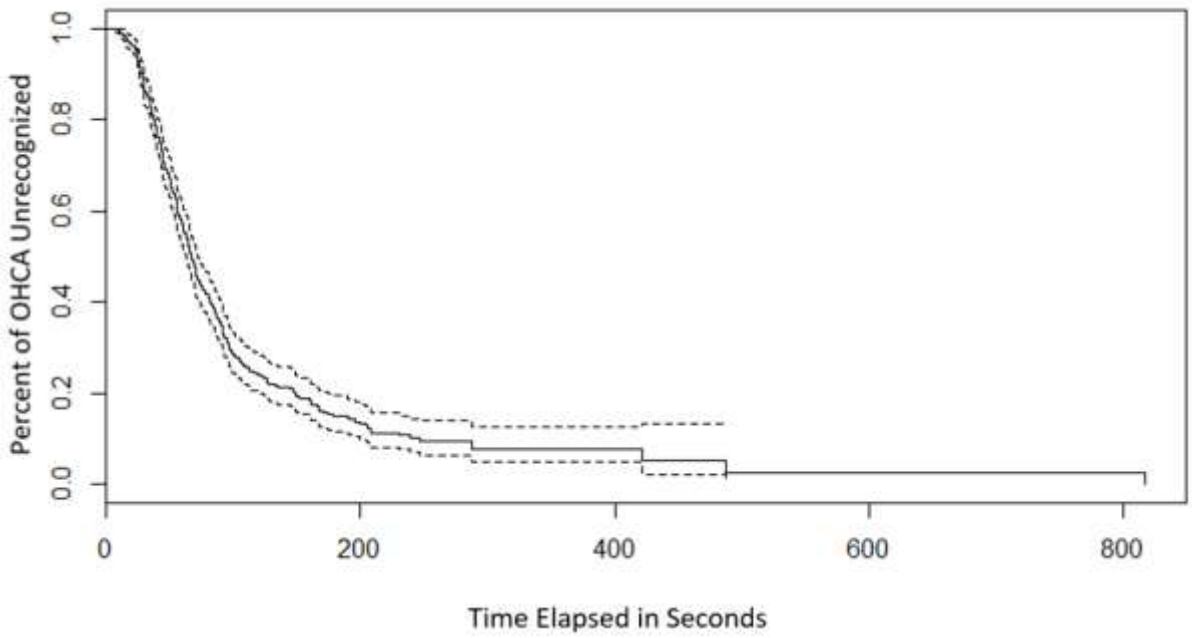


Figure 5 shows OHCA recognition by code. The survival curves look similar and provide visual confirmation to the statistically insignificant results recorded in Table 6.

Figure 5: Kaplan-Meier Survival Curve Depicting Percent of Calls with Unrecognized OHCA, by Code

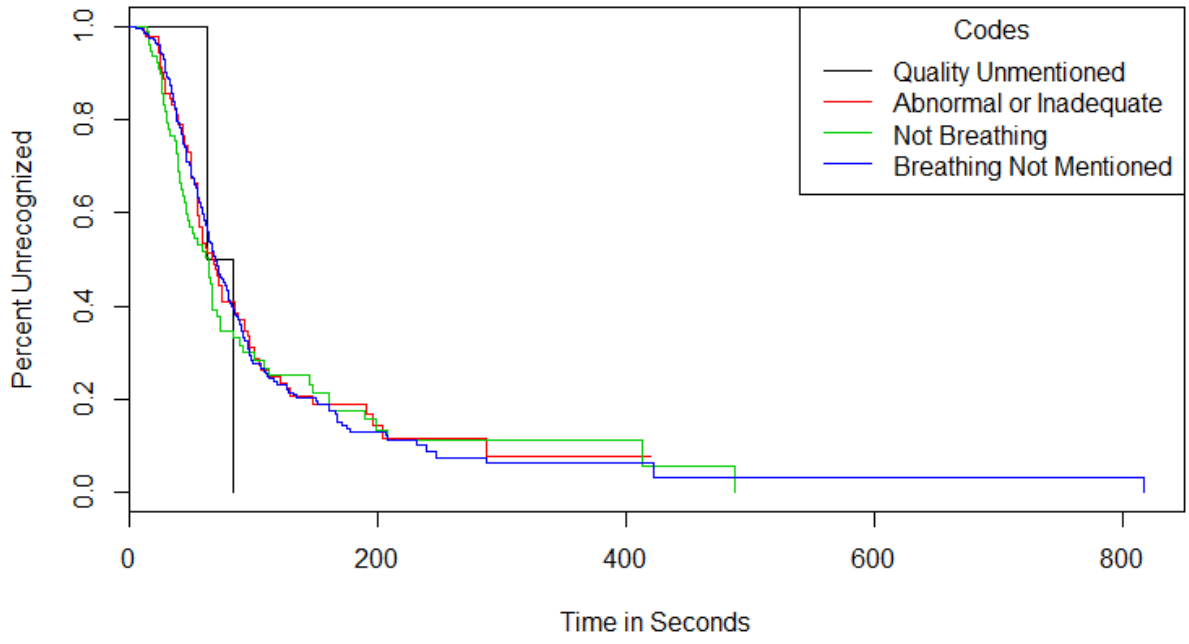


Figure 6 shows the overall survival curve for the time to T-CPR initiation. The mean time to T-CPR overall is 169.3 seconds, recorded in Table 5.

Figure 6: Kaplan-Meier Survival Curve Depicting Time to First Compression, Overall

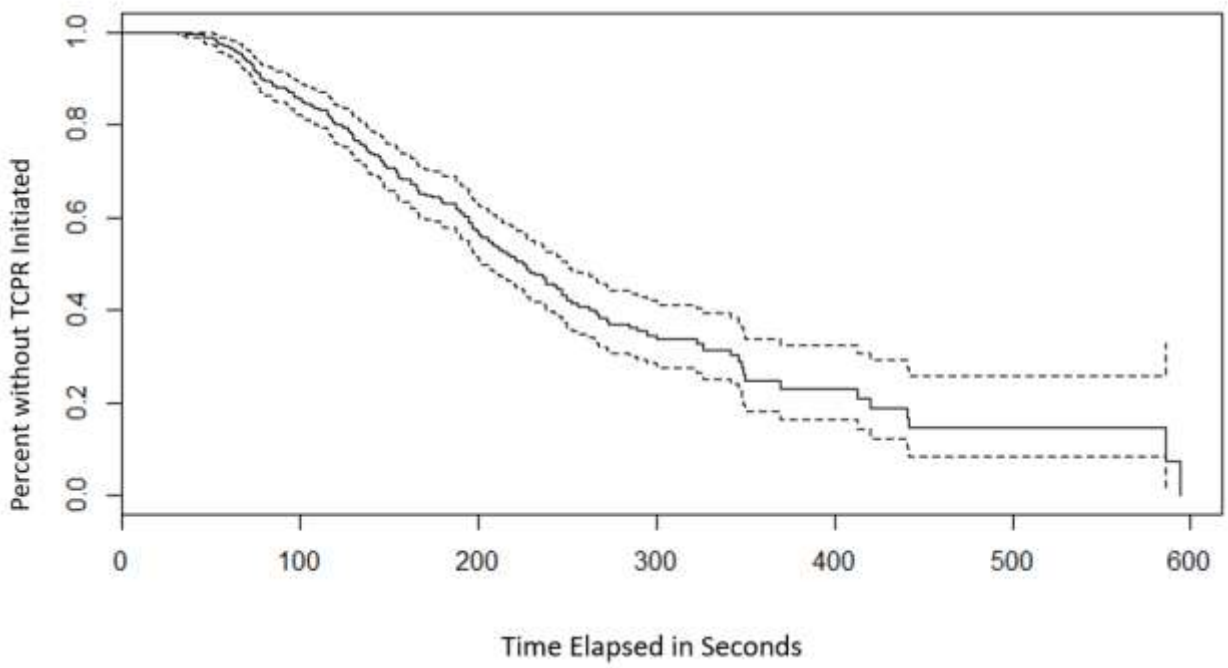
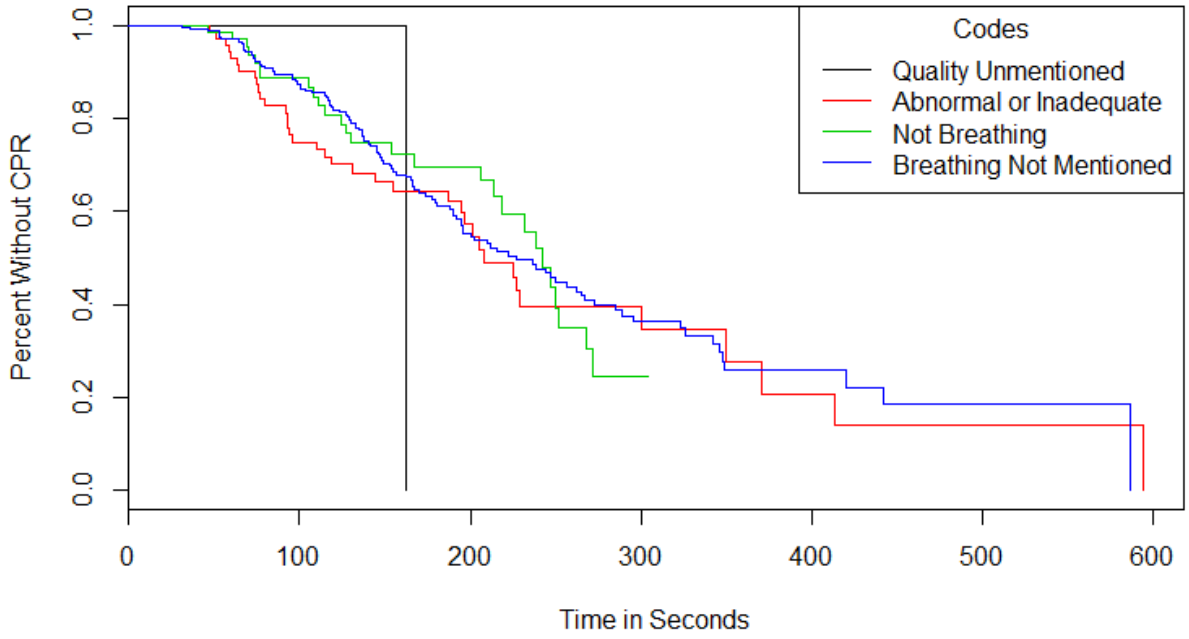


Figure 7 shows T-CPR initiation by code. The survival curves look similar and provide visual confirmation to the statistically insignificant results recorded in Table 6.

Figure 7: Kaplan-Meier Survival Curve Depicting Percent of Calls Without T-CPR, by Code



Discussion

As noted in the Introduction, quick identification of OHCA and initiation of T-CPR are important parts of the cardiac chain of survival. Research that may help shorten or eliminate delays in the chain of

survival has the potential to save lives. Thus, this study aimed to locate a possible source of delay in recognizing OHCA and initiating T-CPR in the chief complaint by analyzing callers' descriptions of patient breathing. Contrary to our hypothesis, there was no statistically significant difference in time to OHCA recognition or T-CPR initiation between our four chief complaint categories or between the "more ambiguous" and "less ambiguous" groups of breathing descriptions.

While the results did not confirm our hypothesis, there could be factors affecting our study that would differ in another setting. One factor that may have affected our results was the relatively experienced telecommunicators that took part in the STAT 911 study from which we pulled our data. Previous literature has found that telecommunicators with more experience in handling OHCA calls are better at identifying OHCA and are more likely to follow their protocols.[18] In our dataset, the overall time to recognition and time to T-CPR was relatively fast. The mean time to recognizing OHCA was 83.82 seconds, while the mean time to first compression was 169.3 seconds. Previous literature has shown the time from call start to identification of OHCA has been reported to be an average of 158 seconds[1] or a median of 143 seconds.[19] The median delay in initiating T-CPR was 217 seconds.[19] It is possible that the distinction between codes did not result in increased delays because the call centers in this study were particularly skilled.

Alternately, previous studies have created categories that combine chief complaints with the answers to follow-up questions. For example, Riou et al created three categories for caller descriptions.[25] Bohm et al[41] also sorted caller descriptions into three categories, including normal, abnormal, and absent breathing, while Berdowski et al sorted into five categories based on breathing.[28] Berdowski et al combined caller descriptions and callers' answers to follow-up questions from the telecommunicator.[28] This study looks only at chief complaints, the start of communication between telecommunicators and callers. Our results may underscore the importance of asking follow-up questions to the caller's initial description of the patient.

Our results may also give support to another finding in the literature. Patients who were described as "dead" by the caller had particularly expedited delivery of T-CPR compared to other descriptors.[28] Chief complaints that included "dead" in our study were coded as "breathing not mentioned." It is possible that "dead" is such a strong predictor that this study was insufficiently powered to find a relatively weaker potential effect of our hypothesis.

This study was strengthened through the multiple participating call centers from which we gathered our data, thus lessening the chance of bias from any one center.

Limitations

One limitation is that we did not directly analyze the behavior of the telecommunicator. Our reasoning included an assumed step on the part of the telecommunicator that may not be supported by further analysis. Future research could test our conceptual models to confirm whether our chief complaint categories affected the querying behavior of telecommunicators in the way hypothesized in the model.

Appendix 1: Codebook

Note: Some chief complaints will have only one component, i.e. “seizure” or “shortness of breath.” For chief complaints that contain multiple components (ex.: “diabetic, hard time breathing, not responding”), any mention of breathing within one component supersedes other components where breathing is not mentioned. For example, although “diabetic” in “diabetic, hard time breathing, not responding” is a component that does not mention breathing and would be coded as BNM were it a chief complaint by itself, the mention of breathing in the component “hard time breathing” means that, taken as a whole, the entire chief complaint must be categorized as BMd.

See the decision tree (Appendix 2) for more information.

Codes:

Breathing Not Mentioned – BNM

The caller does not mention the patient’s breathing.

BNM - Dead – BNM-D

The caller states that the patient has died. Includes references to suicide – when caller says “suicide” or “suicide by hanging” *without* giving other information about the patient that indicates they survived or were fighting for life.

Breathing Mentioned – BMd

The caller mentions the quality, symptoms, and/or presence of the patient’s breathing.

Quality Unmentioned – QU (or “A” from previous draft) – BMd-QU

The caller says the patient is breathing without giving any qualifiers. This includes chief complaints in which the patient is said or implied to be breathing, or information is given that makes the presence of breathing/airflow obvious – for example, the patient is talking. It also includes chief complaints in which the patient is said to be breathing but no other information is given that would indicate the chief complaint would belong to another of the listed categories.

Not breathing – NB – Bmd-NB

Note: If any component of the chief complaint includes that the patient is not breathing, use this code.

The caller says the patient is not breathing.

Abnormal & Inadequate – BMd-AI

The chief complaint fits into one of the two sub-codes, Abnormal or Inadequate, and does not fit into any of the other codes (Bmd-QU, Bmd-NB, BNM).

Note: If the components of a chief complaint could be coded as either category, the descriptions under “Abnormal” take precedence. Please see the decision tree at the end to clarify.

Abnormal: BMD-AI-A

The chief complaint indicates abnormal breathing. The caller provides a description of the patient’s breathing as anything other than normal breathing or completely absent. The caller could say the patient is breathing abnormally by using verb, adverb, or adjective descriptors that indicate breathing distress. Breathing distress includes noisy breathing, including sounds from the voice box (moaning, groaning) and from the respiratory system (gasping, wheezing – from Bang et al. 2003). Other verbs, adverbs, or adjectives include difficulty, poorly, impaired, and occasional (Bang et al 2003).

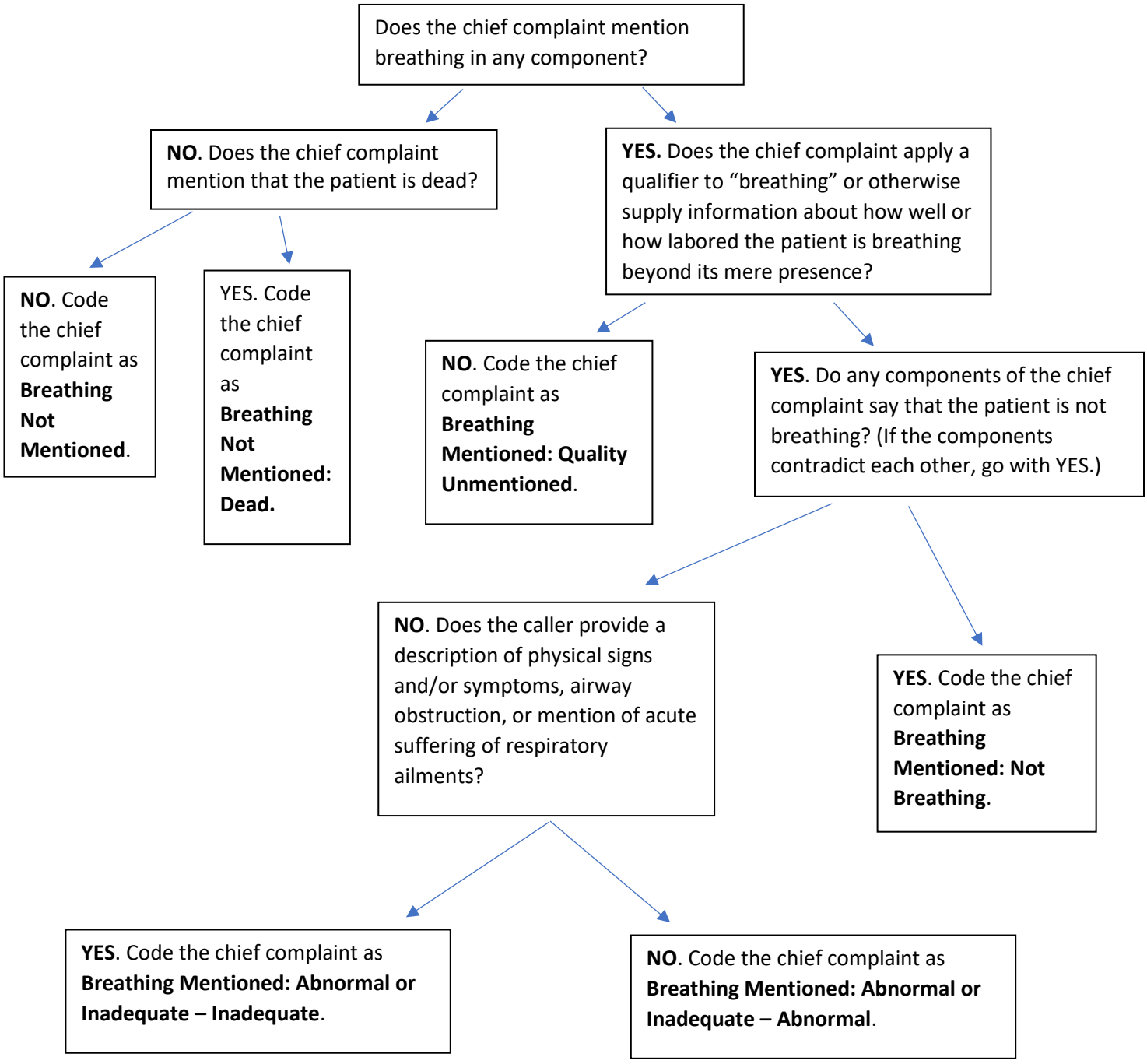
Inadequate: BMD-AI-I

The caller states the presence of a physical sign (temperature, skin color) in the patient or labels the patient’s chief complaint as a respiratory disease/ailment that could indicate the patient’s breathing is not sufficiently oxygenating their body. Also includes abnormalities in the mechanical function of the mouth and/or airway (i.e. choking, swollen tongue or other obstruction of the airway, difficulty speaking, bruises on neck/throat).

Descriptions that include evidence that the patient’s body is cold, blue, or mentions a face color that could indicate breathing distress. Includes “pale” face color.

Includes chief complaints where caller mentions a respiratory disease/ailment: “asthma.”

Appendix 2: Decision Tree



References

1. Vaillancourt C, Verma A, Trickett J, et al. Evaluating the Effectiveness of Dispatch-assisted Cardiopulmonary Resuscitation Instructions. *Acad Emerg Med*. 2007;14(10):877-883. doi:10.1197/j.aem.2007.06.021

2. Viereck S, Mï¿½ller TP, Rothman JP, Folke F, Lippert FK. Recognition of out-of-hospital cardiac arrest during emergency calls - a systematic review of observational studies. *Scand J Trauma Resusc Emerg Med*. 2017;25(1):1-12. doi:10.1186/s13049-017-0350-8

3. Meischke H, Painter I, Turner AM, et al. Protocol: Simulation training to improve 9-1-1 dispatcher identification of cardiac arrest. *BMC Emerg Med*. 2016;16(1):1-8. doi:10.1186/s12873-016-0073-6

4. Meischke H, Painter IS, Stangenes SR, et al. Simulation training to improve 9-1-1 dispatcher identification of cardiac arrest: A randomized controlled trial. *Resuscitation*. 2017;119(2017):21-26. doi:10.1016/j.resuscitation.2017.07.025

5. Pollack RA, Brown SP, Rea T, et al. Impact of Bystander Automated External Defibrillator Use on Survival and Functional Outcomes in Shockable Observed Public Cardiac Arrests. *Circulation*. 2018:CIRCULATIONAHA.117.030700. doi:10.1161/CIRCULATIONAHA.117.030700

6. Iwami T, Nichol G, Hiraide A. Continuous improvements in “chain of survival” increased survival after out-of-hospital cardiac arrests: a large-scale population-based study. *Circulation*. 2009;119:728-734.

7. Holmberg M, Holmberg S, Herlitz J, Gårdelöv B. Survival after cardiac arrest outside hospital in Sweden. Swedish Cardiac Arrest Registry. *Resuscitation*. 1998;36(1):29-36. doi:10.1016/S0300-9572(97)00089-0

8. Breckwoldt J, Schloesser S, Arntz HR. Perceptions of collapse and assessment of cardiac arrest by bystanders of out-of-hospital cardiac arrest (OOHCA). *Resuscitation*. 2009;80(10):1108-1113. doi:10.1016/j.resuscitation.2009.06.028

9. Lewis M, Stubbs BA, Eisenberg MS. Dispatcher-assisted cardiopulmonary resuscitation: Time to identify cardiac arrest and deliver chest compression instructions. *Circulation*. 2013;128(14):1522-1530. doi:10.1161/CIRCULATIONAHA.113.002627

10. Mozaffarian D, Benjamin EJ, Go AS, et al. *Heart Disease and Stroke Statistics-2015 Update : A Report from the American Heart Association*. Vol 131.; 2015. doi:10.1161/CIR.0000000000000152

11. Larsen MP, Eisenberg MS, Cummins RO, Hallstrom AP. Predicting survival from out-of-hospital cardiac arrest: A graphic model. *Ann Emerg Med*. 1993;22(11):1652-1658. doi:10.1016/S0196-0644(05)81302-2

12. Rea TD, Eisenberg MS, Culley LL, Becker L. Dispatcher-Assisted Cardiopulmonary Resuscitation and Survival in Cardiac Arrest. *Circulation*. 2001;104(21):2513-2516. doi:10.1161/hc4601.099468

13. Laerdal Medical. The Chain of Survival: Increasing survival from cardiac arrest. https://www.laerdal.com/us/learn/the-chain-of-survival/.%5C. Accessed May 31, 2018.

14. Nichol G, Huszti E, Birnbaum A, et al. Cost-Effectiveness of Lay Responder Defibrillation for Out-of-Hospital Cardiac Arrest. *Ann Emerg Med*. 2009;54(2):226-235.e2. doi:10.1016/j.annemergmed.2009.01.021

15. Case AR, Cartledge S, Siedenburg J, et al. Identifying barriers to the provision of bystander cardiopulmonary resuscitation (CPR) in high-risk regions: a qualitative review of emergency calls. *Resuscitation*. 2018;129(March):43-47. doi:10.1016/j.resuscitation.2018.06.001

16. Culley LL, Clark JJ, Eisenberg MS, Larsen MP. Dispatcher-assisted telephone CPR: Common delays and time standards for delivery. *Ann Emerg Med*. 1991;20(4):362-366. doi:10.1016/S0196-0644(05)81655-5

17. Viereck S, Møller TP, Ersbøll AK, et al. Recognising out-of-hospital cardiac arrest during emergency calls increases bystander cardiopulmonary resuscitation and survival. *Resuscitation*. 2017;115(2017):141-147. doi:10.1016/j.resuscitation.2017.04.006

18. Kuisma M, Boyd J, Väyrynen T, Repo J, Nousila-Wiik M, Holmström P. Emergency call processing and survival from out-of-hospital ventricular fibrillation. *Resuscitation*. 2005;67(1):89-93. doi:10.1016/j.resuscitation.2005.04.008

19. Travers S, Jost D, Gillard Y, et al. Out-of-hospital cardiac arrest phone detection: Those who most need chest compressions are the most difficult to recognize. *Resuscitation*. 2014;85(12):1720-1725. doi:10.1016/j.resuscitation.2014.09.020

20. Bång A, Herlitz J, Martinell S. Interaction between emergency medical dispatcher and caller in suspected out-of-hospital cardiac arrest calls with focus on agonal breathing. A review of 100 tape recordings of true cardiac arrest cases. *Resuscitation*. 2003;56(1):25-34. doi:10.1016/S0300-9572(02)00278-2

21. Axelsson C, Borgström J, Karlsson T, Axelsson ÅB, Herlitz J. Dispatch codes of out-of-hospital cardiac arrest should be diagnosis related rather than symptom related. *Eur J Emerg Med*. 2010;17(5):265-269. doi:10.1097/MEJ.0b013e328332b912

22. Hardeland C, Sunde K, Ramsdal H, et al. Factors impacting upon timely and adequate allocation of prehospital medical assistance and resources to cardiac arrest patients. *Resuscitation*. 2016;109:56-63. doi:10.1016/j.resuscitation.2016.09.027

23. Zhao L, Li C, Liu B, Wang M, Shao R, Fang Y. The association of gasping and outcome, in out of hospital cardiac arrest: A systematic review and meta-analysis. *Resuscitation*. 2015;97:7-12. doi:10.1016/j.resuscitation.2015.09.377

24. Fukushima H, Imanishi M, Iwami T, et al. Abnormal breathing of sudden cardiac arrest victims described by laypersons and its association with emergency medical service dispatcher-assisted cardiopulmonary resuscitation instruction. *Emerg Med J*. 2015;32(4):314-317. doi:10.1136/emermed-2013-203112

25. Riou M, Ball S, Williams TA, et al. 'She's sort of breathing': What linguistic factors determine call-taker recognition of agonal breathing in emergency calls for cardiac arrest? *Resuscitation*. 2018;122:92-98. doi:10.1016/j.resuscitation.2017.11.058

26. Roppolo LP, Westfall A, Pepe PE, et al. Dispatcher assessments for agonal breathing improve detection of cardiac arrest. *Resuscitation*. 2009;80(7):769-772. doi:10.1016/j.resuscitation.2009.04.013

27. Alfsen D, Møller TP, Egerod I, Lippert FK. Barriers to recognition of out-of-hospital cardiac arrest during emergency medical calls: A qualitative inductive thematic analysis. *Scand J Trauma Resusc Emerg Med*. 2015;23(1):1-8. doi:10.1186/s13049-015-0149-4

28. Berdowski J, Beekhuis F, Zwinderman AH, Tijssen JGP, Koster RW. Importance of the first link: Description and recognition of an out-of-hospital cardiac arrest in an emergency call. *Circulation*. 2009;119(15):2096-2102. doi:10.1161/CIRCULATIONAHA.108.768325

29. Bohm K, Stålhandske B, Rosenqvist M, Ulfvarson J, Hollenberg J, Svensson L. Tuition of emergency medical dispatchers in the recognition of agonal respiration increases the use of telephone assisted CPR. *Resuscitation*. 2009;80(9):1025-1028. doi:10.1016/j.resuscitation.2009.06.004

30. Dami F, Heymann E, Pasquier M, Fuchs V, Carron PN, Hugli O. Time to identify cardiac arrest and provide dispatch-assisted cardio-pulmonary resuscitation in a criteria-based dispatch system. *Resuscitation*. 2015;97:27-33. doi:10.1016/j.resuscitation.2015.09.390

31. Deakin CD, England S, DIffey D. Ambulance telephone triage using “NHS Pathways” to identify adult cardiac arrest. *Heart*. 2017;103(10):761-765. doi:10.1136/heartjnl-2016-310651

32. Vaillancourt C, Charette ML, Bohm K, Dunford J, Castrén M. In out-of-hospital cardiac arrest patients, does the description of any specific symptoms to the emergency medical dispatcher improve the accuracy of the diagnosis of cardiac arrest: A systematic review of the literature. *Resuscitation*. 2011;82(12):1483-1489. doi:10.1016/j.resuscitation.2011.05.020

33. Penn C, Koole T, Nattrass R. When seconds count: A study of communication variables in the opening segment of emergency calls. *J Health Psychol*. 2017;22(10):1256-1264. doi:10.1177/1359105315625357

34. Riou M, Ball S, Williams TA, et al. The linguistic and interactional factors impacting recognition and dispatch in emergency calls for out-of-hospital cardiac arrest: A mixed-method linguistic analysis study protocol. *BMJ Open*. 2017;7(7). doi:10.1136/bmjopen-2017-016510

35. Nurmi J, Pettilä V, Biber B, Kuisma M, Komulainen R, Castrén M. Effect of protocol compliance to cardiac arrest identification by emergency medical dispatchers. *Resuscitation*. 2006;70(3):463-469. doi:10.1016/j.resuscitation.2006.01.016

36. Haahr M, Haahr S. RANDOM.ORG. Randomness and Integrity Services Ltd. https://www.random.org/. Accessed August 20, 2006.

37. Cohen J. A coefficient of agreement for nominal scales. *Educ Psychol Meas*. 1960;20(1):37-46. doi:10.1177/001316446002000104

38. Cox DR. Regression Models and Life-Tables Authors (s): D . R . Cox Source : Journal of the Royal Statistical Society . Series B (Methodological), Vol . 34 , No . 2 Published by : Wiley for the Royal Statistical Society Stable URL : http://www.jstor.org/stable. *J R Stat Soc Ser B*. 1972;34(2):187-220. doi:10.2307/2985181

39. Therneau T. A Package for Survival Analysis in S. 2015. http://cran.r-project.org/package=survival%3E.

40. Therneau TM, Grambsch PM. *Modeling Survival Data: Extending the Cox Model*. New York: Springer; 2000.

41. Bohm K, Rosenqvist M, Hollenberg J, Biber B, Engerström L, Svensson L. Dispatcher-assisted telephone-guided cardiopulmonary resuscitation: An underused lifesaving system. *Eur J Emerg Med*. 2007;14(5):256-259. doi:10.1097/MEJ.0b013e32823a3cd1