BLS 2102 Optimization of DA-Recognition of OHCA Data Table

Communication between Caller and Dispatcher (n=14)

1. Callers emotional state and physical distance from victim (n=4)

Emotionally affected callers had more trouble in recognizing OHCA.[1] A study assessing callers emotional status using Emotional Content and Cooperation Score (ECCS) levels concluded that most callers emotions were manageable with only 8.4% of callers rated as ECCS levels 4-5 (uncooperative, not listening and yelling, uncontrollable and hysterical) resulting in lower DA-CPR rates (36.4%) due to caller being over distraught.[2] Reassuring these callers delayed the time to DA-CPR but once reassured, the callers commenced chest compressions quickly with a shorter median time to OHCA recognition and chest compressions (29 seconds and 122 seconds respectively). Two other studies revealed similar results whereby callers' emotional status delayed the time to recognition of cardiac arrest and hampered clear communication between the telecommunicator and the caller.[3,4]

2. Caller's proximity to OHCA patient (n=2)

Callers being in close proximity to patients, enabled better communication and assessment. Medical dispatchers were able to react fast and initiate EMD algorithms with little or minimal interruptions.[1] Compared to third-party callers (people calling who are not with the patient), accuracy was higher if EMDs were talking with first-party (actual patient)/second party callers (bystander with the patient) or if talking to fourth party (other emergency responder on scene such as police).[5]

3. Effects of telecommunicator behavior and communication with caller on OHCA recognition (n=4)

A study which evaluated telecommunicators' behavior and communication with the caller, concluded that 70% of the dispatchers demonstrated impeccable behavior with short, distinct questions resulting in quick decision making.[6] In 30% of cases, dispatchers demonstrated stressful behavior or omitted to ask important questions. Dispatchers remaining calm and when necessary, interrupting, using short questions and demanding instructions to force the caller to pay more attention was found to be helpful.

A qualitative study exploring how dispatchers perceive their experience concluded that if dispatchers listen by being open-minded that a vast amount of information can be collected.[7] This study further revealed that convincing answers from witnesses prompt a secure feeling and a lack of knowledge in the witness has a negative effect on the efforts made by the dispatcher.

Three studies concluded the reasons for missing a diagnosis of cardiac arrest by the dispatcher. Reasons identified were insufficient questioning such as inquiring about respiration, confusion and inaccurate use of medical language or asking non-essential questions which were misleading the caller and using certain words such as "is the victim conscious?" or "is the victim breathing normally?".[3,4,7]

4. Caller status (healthcare professional vs non-healthcare professional) (n=2)

In a study conducted by Alfsen et al. it was found that when the caller was a healthcare professional (HCP) the dispatcher handed over the responsibility to the caller, whereby the caller took action and the dispatcher played a counseling role.[1] A study conducted in Finland concluded that when the caller was a HCP there was a tendency by the dispatcher not to ask further questions including the ones in the dispatching protocol.[8] In this study t-CPR instructions were given to only 2% of HCP s compared to 27% of laymen (more questions regarding vital signs were asked from laypersons) and 40% of relatives. This was attributed to the fact that dispatchers believed that HCP s could recognize emergencies and evaluate the situation correctly and were able to start CPR without their help.

5. Effects of language barriers (LB) on recognition of OHCA (n=2)

Limited English proficiency was found to be a barrier in early identification and early initiation of CPR, a key aspect in the first link of the chain of survival.[9] A study comparing language barrier (LB) callers versus non-LB callers found that LB callers took longer to recognize OHCA, acquisition of address and initiation of CPR.[10]

6. Linguistic format of qualified breathing questions by the caller (n=1)_

A study analyzing a sample of emergency ambulance calls concluded that the language used by the callers whereby "breathing" is described with additional information such as "yes breathing, but gasping" were not interpreted as OHCA by the call-takers resulting in delayed cardiac arrest response times.[11]

7. Influence of callers "chief complaint" and use of trigger words on recognition of OHCA and initiation of t-CPR (n=3)

Caller's chief complaint type was found to affect the time to recognition of the need for t-CPR. Pursuing the caller's chief complaint, before inquiring about the state of consciousness and breathing of the victim resulted in delaying delivery of t-CPR.[12]

A pilot study looked at the use of trigger words by the caller. The study concluded that no trigger words were associated with confirmed OHCA. However, the most frequently used trigger word was "is wheezing" in the confirmed cardiac arrest stratum.[13]

A study by Riou et al found that declaration of death and OHCA recognition (initial versus delayed) was significantly more frequent in cases where the caller declared the victim to be dead than in cases without a declaration of death.[14] However, they reported whilst declaration of death cases had a higher rate of early recognition of OHCA, the callers were more likely to decline to perform CPR on victims who needed it, when proposed by the telecommunicator, which was potentially detrimental.

New technology to improve telecommunicator recognition of OHCA (n= 7)

1. CCTV (n=2)

CCTV in relation to OHCA recognition was reported in 2 studies.[15,16] The first study reported 21 OHCA cases where CCTV recordings and audio files from the emergency dispatch center were collected and in qualitative study, Linderoth et al. assessed how 10 emergency medical dispatchers perceived provision of visual information through CCTV.[16]The authors concluded that providing medical dispatchers with visual information from the location of OHCA might improve their understanding of the OHCA-scenario, which might enhance communication, their ability to guide more bystanders and improve the quality of cardiopulmonary resuscitation. A study on the use of CCTV in relation to OHCA recognition concluded that communications between the caller and the dispatcher were more direct and structured when using this technology. However, the speaker function of the phones placed on the floor was found to be inactivated during CPR, which can be a solution (keep it activated) to communication challenges encountered during OHCA.[15]

2. Machine learning to aid telecommunicators in recognition of OHCA (n=4)

Machine learning algorithm using words

One study from Denmark and one from Sweden have assessed whether a machine learning framework could recognize OHCA from audio files of calls to the EMS.[17,18] The Danish study examined all (n=108,607) emergency calls from Copenhagen EMS during 2014, of which 918 (0.8%) were OHCA calls eligible for analysis.[17] Compared with medical dispatchers, the machine learning framework had a significantly higher sensitivity (72.5% vs. 84.1%, $p < 0.001$) with lower specificity (98.8% vs. 97.3%, $p < 0.001$). The machine learning framework had a lower positive predictive value than dispatchers (20.9% vs. 33.0%, $p < 0.001$). Time-to-recognition was significantly shorter for the machine learning framework compared to the telecommunicators (median 44 seconds vs. 54 s, $p < 0.001$). The Swedish study trained a deep neural network model to detect OHCA through speech recognition. They used 3944 OHCA calls to the EMS in Sweden in 2016 and 39,888 calls without OHCA to train the model.[18] The machine learning model was then tested on validated OHCA calls (n=851) and no OHCA calls (n = 85,205) from 2018. The machine learning model was able to recognize OHCAs <60s in a higher proportion of cases (25% (n = 213) by telecommunicators vs 36% (n = 305) by the model. Median time to recognition was 94 s (IQR, 51–174 s) by telecommunicators versus 72 s (IQR, 40–132 s) for the machine learning model. The OHCA was recognized at any time during the call in 84% (n = 715) by dispatchers and in 86% (n = 729) by the ML (Table 2). The ML could recognize an additional 6% (n = 52) OHCA not recognized by dispatchers, and 4% (n = 38) OHCA were recognized by dispatchers discriminated by the ML. In matched paired observations, where both the telecommunicator and the machine learning model recognized the OHCA (n = 677), the median time to recognition was 93 s (IQR, 52–171 s) by dispatchers versus 71 s (IQR, 39–128 s) for the machine learning model. The mean difference was 28 s (SD, 92 s) ($P < 0.001$).

One randomized study has been conducted to evaluate the effect of implementing a machine learning algorithm (described above) on telecommunicators' recognition of OHCA.[17,19] The study was a double-masked, 2-group, randomized clinical trial which randomized calls to the emergency medical center 1:1 to intervention vs. control. Telecommunicators in the intervention group were alerted when the machine learning model identified OHCA, and those in the control group followed normal protocols without alert.

The primary end point was the rate of telecommunicator recognition of subsequently confirmed OHCA. A total of 169 049 emergency calls were examined, of which the machine learning model identified 5242 as suspected OHCA. Calls were randomized to control (2661 [50.8%]) or intervention (2581 [49.2%]) groups. Of these, 336 (12.6%) and 318 (12.3%), respectively, had confirmed OHCA. Telecommunicators in the intervention group recognized 296 confirmed OHCA cases (93.1%) with machine learning assistance compared with 304 confirmed OHCA cases (90.5%) using standard protocols without machine learning assistance (P = .15). Machine learning alerts alone had a significantly higher sensitivity than telecommunicators without alerts for confirmed OHCA (85.0% vs 77.5%; P < .001) but lower specificity (97.4% vs 99.6%; P < .001) and positive predictive value (17.8% vs 55.8%; P < .001). The authors concluded that the study did not find a significant increase in telecommunicators' ability to recognize OHCA when using the machine learning algorithm.

One study assessed characteristics of calls where the machine learning algorithm failed to recognize OHCAs.[20] Among OHCAs not recognized by the machine-learning model, in 31% of cases, a different condition was presented by the caller, in 28% of cases the patient was reported breathing normally and language barriers were identified in 23% of cases.

Machine learning algorithm using machine learning algorithm using phonetic characterization of caller's voice

One study reported the development of a machine learning algorithm based on phonetic characterization of caller's voice.[21] The study evaluated 820 calls from Rennes, France. The authors tested 3 different models, a binary logistic regression, random forest and neural network. The best performing model was the random forest model with an AUC of 74.9 (67.4-82.4). The authors concluded that machine learning models can be used to recognize OHCA based on the acoustic characteristics of the caller's voice. Further, they concluded integrating acoustic parameters as identified in the study could increase the performance of decision-making support systems.

Smart Devices to Detect Agonal Breathing (n=1)

One manuscript reported a proof-of-concept study using smartphones to detect agonal breathing.[22] The study introduced a support vector machine using Amazon echo and Apple iPhone. The system was trained using 9-1-1 emergency calls from Public Health-Seattle & King County, Division of Emergency Medical Services. The agonal breathing dataset included 162 calls (19 h) that had clear recordings of agonal breathing (2009-2017). The evaluate how the system performed with real sleep sounds, the system was tested in a sleep lab (n=12) and on real-world sleep data (n=35). In the latter, the system had a sensitivity and specificity of 97.17% (95% CI: 96.79–97.55%) and 99.38% (95% CI: 99.20–99.56%), respectively. The false positive rate was 0.21761%, corresponding to 515 of the 236,666 audio segments (164 h) used as test data. The system has not been tested on real OHCA cases.

Quality Improvement/ Implementation of New Protocols to Improve Telecommunicator Recognition of OHCA (n=26)

Twenty-six studies evaluated the accuracy of OHCA recognition in relation to the use of dispatch protocols and quality improvement.[23–48] Twenty of the twenty-six studies reported only the accuracy of OHCA detection in terms of the proportion of cardiac arrests recognized of those confirmed to be cardiac arrest on-scene by EMS and did not report both sensitivity and specificity. All protocols had two very similar starting questions, firstly assessing consciousness, and then breathing (no/normally).

1. Medical Priority Dispatch System (MPDS)

Eight studies evaluated the Medical Priority Dispatch System (MPDS) or very similar protocols, such as the Ontario Dispatch Priority Card Index (DPCI).[25,29,31,40,41,44,45,47] Of these MPDS protocol studies, two evaluated a bespoke Los Angeles Tiered dispatch protocol compared to MPDS, with the Los Angeles Tiered dispatch protocol having a similar recognition rate to MPDS.[40,41] In particular, the Los Angeles Tiered dispatch protocol evaluated differences in recognition in relation to callers having English as a second language (ESL) and noted no difference in recognition but a higher proportion of T-CPR in callers with ESL using the Los Angeles Tiered dispatch protocol.[41] Two papers evaluated the Ontario DPCI, one comparing different dispatch centers and the second undertaking a sub-analysis for reasons for non-recognition, noting agonal respirations as the primary reason for non-detection of OHCA.[44,45] Three studies evaluated MPDS in relation to ‘no protocol’, NHS pathways for children less than 16yo and Criterion-Based Dispatch (CBD). Compared to no-protocol, MPDS had a higher rate of recognition; and compliance with MPDS was also associated with higher recognition.[31] Poorer recognition using MPDS was associated with symptoms of breathing, fluctuating consciousness and the patient being female.[47] Recognition of OHCA in children under 16 years using NHS Pathways, a United Kingdom dispatch protocol demonstrated a similar sensitivity and specificity to that of MPDS and noted that the most common category for incorrect recognition were those being coded to unconscious breathing difficulties.[25]

2. Criterion Based Dispatch

Criterion-Based Dispatch (CBD) was the other most used protocol. CBD is a two-question protocol asked by trained medical professionals, usually nurses or paramedics: “Is the patient conscious?” and “Is the patient breathing normally?” dispatchers also use the information the caller spontaneously provides. The Hardeland et al study evaluated MPDS versus CBD through analysis of recognition of OHCA in a USA-based dispatch center versus a Norway-based dispatch center, respectively.[29] This study showed both systems were similar in recognition of OHCA, with the most frequent reason for non-recognition being misinterpretation of agonal breathing. Similarly, Sweden and Denmark's National Emergency Dispatch System (EDS) is a protocol beginning with these CBD questions, with the differences in the countries being that in Sweden, 53% of the dispatchers are lay/non-medical, whereas in Denmark they are all medical professionals.[36] When these locations were compared, both had similar recognition rates of OHCA.[36] Four additional studies evaluated CBD with recognition with rates ranging between 70% and 83%.[23,24,30,37,46] One of study evaluated themes around non-recognition when using the CBD protocol and noted 1) The use of protocol and whether dispatchers considered it a good tool for decision support during cardiac arrest varied widely 2) collaboration between caller and dispatcher was considered essential for dispatchers recognition and an important factor in this was the emotional state of the caller 3) dispatchers found it difficult to assess breathing as ‘Normal breathing” was not defined in the protocol, and each dispatcher had their own definition.[30]

3. Breathing

Other protocols utilized similar protocols to CBD but focused on either bypassing the breathing assessment or using differing methods for assessment breathing assessment.[26,27,34,35,38,39,42,43] Bypassing the breathing assessment was evaluated using a review of all unconscious calls to determine the rate of unrecognized cardiac arrest within a cohort of patients coded as unconscious by dispatchers, this was a theoretical study that proposed that utilizing the usual two-question protocol this identified 90% of cardiac arrests, with a one-question protocol this would have identified all cardiac arrests however it would have also tripled the number of unconscious non-arrests coded as arrest by dispatchers.[38] The ALERT protocol from Belgium and the Czech Protocol check for consciousness and then ask the bystander to place the patient on the floor prior to the assessment of breathing; using the ALERT protocol there was a rate of recognition at 75% and with a similar Czech Protocol a rate of > 90% recognition was achieved.[35,39,42] Similarly, studies from France and Singapore used ‘hand on belly’ to assess breathing by asking bystanders to place their hand on the patient's belly or abdomen and feel for breathing with further elaboration by counting between breaths or asking if they can feel breathing.[26,34,43] The hand on belly studies reported a range of recognition rates between 61% and 93%.[26,34,43] A modified protocol using 5 key descriptions: ‘not breathing’, ‘weak breathing’, ‘not sure if the person is breathing’, ‘weak snoring’, and ‘not breathing normally have also been used as additional triggers for determination of cardiac arrest demonstrating a sensitivity of 93% and a specificity of 50%.[27] There was also a combination protocol trialed where breathing was assessed as being abnormal and then the patient was placed on their side with bystanders looking and feeling for breathing with a recognition rate of 72%.[48] This protocol was further improved by changing how the breathing assessment was asked, the addition of counting breaths and trigger words such as gurgling for initiation of the counting protocol with recognition going from 72% to 81%.[48]

4. Other

Two papers describe QI activities and standard protocol implementation. The first used implementation of “no-no-go” similar to the CBD model of: Are they awake? are they breathing normally? If no to both then it is cardiac arrest. Post training in this model with associated QI activities had a sensitivity for identifying OHCA calls at 93% (ref).[28] The other paper also went from descriptive text/no-protocol to using a similar protocol to CBD and included an extensive training and QI program, with QI and protocol implementation this improved recognition from 55% to 69% (ref).[32]

The last paper showed a correlation between increased recognition and the number of cardiac arrest calls taken by a dispatcher with more than 4 showing greater recognition, <4 calls; 59/77 (76.6%); 4-9 calls, 107/131 (81.7%); >9 calls, 130/165 (78.8%) (ref).[33]

Symptoms and Patient Characteristics (n=19)

1. Agonal breathing

Agonal breathing is a frequent symptom reported in cardiac arrests with a prevalence of 30-60% and is in addition positively associated with survival.[7,11,27,45,49,50] Furthermore, the presence of agonal breathing is the most frequently mentioned barrier of cardiac arrest recognition in multiple studies from 2002 to 2021.[7,27,30,43,47,50] Agonal breathing is described by callers using a wide array of wordings, including gasping, snoring, and weak breathing, among many others.[51,52] Agonal breathing is often misinterpreted as normal breathing by callers and dispatcher.[11,30,53] Lack of or challenging communication regarding the patient's breathing status leads to unrecognized cardiac arrests.[30,43,45,49,54,55]

2. Patient status

One study investigated the callers use of the word 'dead'.[11] Use of the word dead improved dispatch recognition the cardiac arrest. However, the use of the word death was associated with patient characteristics unfavorable to survival. Telecommunicators were less likely to recognize witnessed cardiac arrest than unwitnessed cardiac arrests.[56] When a caller expresses emotions during an EMS call, it is more likely that the patient is in cardiac arrest compared to cases where the caller is calm.[2,58]

3. Seizures

Two studies investigated if the description of seizures was a barrier to dispatch recognition of cardiac arrest. Seizures-like have been reported in 4% of cardiac arrest calls, and 2% of calls regarding seizures are actually cardiac arrests.[23,57] The description of seizures was a barrier for dispatch recognition and positively associated with survival.[57]

4. Patient demographics

Two studies investigated the characteristics of patients and their association with dispatch recognition. One study including pediatric cardiac arrest found younger age of cardiac arrest patients to be negatively associated with cardiac arrest recognition.[59] Another study found low area-level socio-economic status to be negatively associated with dispatch recognition of cardiac arrest.[60]

References

1. Alfsen D, Moller TP, Egerod I, Lippert FK. Barriers to recognition of out-of-hospital cardiac arrest during emergency medical calls: a qualitative inductive thematic analysis. *Scandinavian journal of trauma, resuscitation and emergency medicine*. 2015;23(101477511):70. doi:10.1186/s13049-015-0149-4
2. Chien CY, Chien WC, Tsai LH, et al. Impact of the caller's emotional state and cooperation on out-of-hospital cardiac arrest recognition and dispatcher-assisted cardiopulmonary resuscitation. *Emergency medicine journal : EMJ*. 2019;36(10):595-600. doi:10.1136/emermed-2018-208353
3. Missel AL, Dowker SR, Chiola M, et al. Barriers to the Initiation of Telecommunicator-CPR during 9-1-1 Out-of-Hospital Cardiac Arrest Calls: A Qualitative Study. *Prehospital emergency care*. 2023;(c5i, 9703530):1-8. doi:10.1080/10903127.2023.2183533
4. Richards CT, McCarthy DM, Markul E, et al. A mixed methods analysis of caller-emergency medical dispatcher communication during 9-1-1 calls for out-of-hospital cardiac arrest. *Patient education and counseling*. 2022;105(7):2130-2136. doi:10.1016/j.pec.2022.03.004
5. Garza AG, Gratton MC, Chen JJ, Carlson B. The accuracy of predicting cardiac arrest by emergency medical services dispatchers: the calling party effect. *Academic emergency medicine : official journal of the Society for Academic Emergency Medicine*. 2003;10(9):955-960.

6. Bang A, Herlitz J, Holmberg S. Possibilities of implementing dispatcher-assisted cardiopulmonary resuscitation in the community. An evaluation of 99 consecutive out-of-hospital cardiac arrests. *Resuscitation*. 2000;44(1):19-26.
7. Bang A, Ortgren PO, Herlitz J, Wahrborg P. Dispatcher-assisted telephone CPR: a qualitative study exploring how dispatchers perceive their experiences. *Resuscitation*. 2002;53(2):135-151.
8. Castren M, Kuisma M, Serlachius J, Skrifvars M. Do health care professionals report sudden cardiac arrest better than laymen?. *Resuscitation*. 2001;51(3):265-268.
9. Bradley SM, Fahrenbruch CE, Meischke H, Allen J, Bloomingdale M, Rea TD. Bystander CPR in out-of-hospital cardiac arrest: the role of limited English proficiency. *Resuscitation*. 2011;82(6):680-684. doi:10.1016/j.resuscitation.2011.02.006
10. Perera N, Birnie T, Ngo H, et al. “I’m sorry, my English not very good”: Tracking differences between Language-Barrier and Non-Language-Barrier emergency ambulance calls for Out-of-Hospital Cardiac Arrest. *Resuscitation*. 2021;169(r8q, 0332173):105-112. doi:10.1016/j.resuscitation.2021.10.035
11. 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(r8q, 0332173):92-98. doi:10.1016/j.resuscitation.2017.11.058
12. Stangenes SR, Painter IS, Rea TD, Meischke H. Delays in recognition of the need for telephone-assisted CPR due to caller descriptions of chief complaint. *Resuscitation*. 2020;149(r8q, 0332173):82-86. doi:10.1016/j.resuscitation.2020.02.013
13. Tamminen J, Lyden E, Kurki J, Huhtala H, Kamarainen A, Hoppu S. Spontaneous trigger words associated with confirmed out-of-hospital cardiac arrest: a descriptive pilot study of emergency calls. *Scandinavian journal of trauma, resuscitation and emergency medicine*. 2020;28(1):1. doi:10.1186/s13049-019-0696-1
14. Riou M, Ball S, Morgan A, et al. “I think he’s dead”: A cohort study of the impact of caller declarations of death during the emergency call on bystander CPR. *Resuscitation*. 2021;160(r8q, 0332173):1-6. doi:10.1016/j.resuscitation.2021.01.001
15. Linderoth G, Hallas P, Lippert FK, et al. Challenges in out-of-hospital cardiac arrest - A study combining closed-circuit television (CCTV) and medical emergency calls. *Resuscitation*. 2015;96(r8q, 0332173):317-322. doi:10.1016/j.resuscitation.2015.06.003
16. Linderoth G, Moller TP, Folke F, Lippert FK, Ostergaard D. Medical dispatchers’ perception of visual information in real out-of-hospital cardiac arrest: a qualitative interview study. *Scandinavian journal of trauma, resuscitation and emergency medicine*. 2019;27(1):8. doi:10.1186/s13049-018-0584-0
17. Blomberg SN, Folke F, Ersboll AK, et al. Machine learning as a supportive tool to recognize cardiac arrest in emergency calls. *Resuscitation*. 2019;138(r8q, 0332173):322-329. doi:10.1016/j.resuscitation.2019.01.015
18. Byrsell F, Claesson A, Ringh M, et al. Machine learning can support dispatchers to better and faster recognize out-of-hospital cardiac arrest during emergency calls: A retrospective study. *Resuscitation*. 2021;162(r8q, 0332173):218-226. doi:10.1016/j.resuscitation.2021.02.041
19. Blomberg SN, Christensen HC, Lippert F, et al. Effect of Machine Learning on Dispatcher Recognition of Out-of-Hospital Cardiac Arrest During Calls to Emergency Medical Services: A Randomized Clinical Trial. *JAMA netw open*. 2021;4(1):e2032320. doi:10.1001/jamanetworkopen.2020.32320
20. Blomberg SN, Jensen TW, Andersen MP, et al. When the machine is wrong. Characteristics of true and false predictions of Out-of-Hospital Cardiac arrests in emergency calls using a machine-learning model. *Resuscitation*. 2023;183. doi:10.1016/j.resuscitation.2023.109689
21. Rafi S, Gangloff C, Paulhet E, et al. Out-of-Hospital Cardiac Arrest Detection by Machine Learning Based on the Phonetic Characteristics of the Caller’s Voice. *Studies in health technology and informatics*. 2022;294(ck1, 9214582):445-449. doi:10.3233/SHTI220498
22. Chan J, Rea T, Gollakota S, Sunshine JE. Contactless cardiac arrest detection using smart devices. *npj Digit Med*. 2019;2(1):1-8. doi:10.1038/s41746-019-0128-7
23. Dami F, Rossetti AO, Fuchs V, Yersin B, Hugli O. Proportion of out-of-hospital adult non-traumatic cardiac or respiratory arrest among calls for seizure. *Emergency medicine journal : EMJ*. 2012;29(9):758-760. doi:10.1136/emermed-2011-200234
24. Besnier E, Damm C, Jardel B, Veber B, Compere V, Dureuil B. Dispatcher-assisted cardiopulmonary resuscitation protocol improves diagnosis and resuscitation recommendations for out-of-hospital cardiac arrest. *Emergency medicine Australasia : EMA*. 2015;27(6):590-596. doi:10.1111/1742-6723.12493

25. Deakin CD, England S, Diffey D, Maconochie I. Can ambulance telephone triage using NHS Pathways accurately identify paediatric cardiac arrest?. *Resuscitation*. 2017;116(r8q, 0332173):109-112. doi:10.1016/j.resuscitation.2017.03.013
26. Derkenne C, Jost D, Thabouillot O, et al. Improving emergency call detection of Out-of-Hospital Cardiac Arrests in the Greater Paris area: Efficiency of a global system with a new method of detection. *Resuscitation*. 2020;146(r8q, 0332173):34-42. doi:10.1016/j.resuscitation.2019.10.038
27. Fukushima H, Imanishi M, Iwami T, et al. Implementation of a dispatch-instruction protocol for cardiopulmonary resuscitation according to various abnormal breathing patterns: a population-based study. *Scandinavian journal of trauma, resuscitation and emergency medicine*. 2015;23(101477511):64. doi:10.1186/s13049-015-0145-8
28. Gram KH, Praest M, Laulund O, Mikkelsen S. Assessment of a quality improvement programme to improve telephone dispatchers' accuracy in identifying out-of-hospital cardiac arrest. *Resusc Plus*. 2021;6(101774410):100096. doi:10.1016/j.resplu.2021.100096
29. Hardeland C, Olasveengen TM, Lawrence R, et al. Comparison of Medical Priority Dispatch (MPD) and Criteria Based Dispatch (CBD) relating to cardiac arrest calls. *Resuscitation*. 2014;85(5):612-616. doi:10.1016/j.resuscitation.2014.01.029
30. 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(r8q, 0332173):56-63. doi:10.1016/j.resuscitation.2016.09.027
31. Heward A, Damiani M, Hartley-Sharpe C. Does the use of the Advanced Medical Priority Dispatch System affect cardiac arrest detection?. *Emergency medicine journal : EMJ*. 2004;21(1):115-118.
32. Huang CH, Fan HJ, Chien CY, et al. Validation of a Dispatch Protocol with Continuous Quality Control for Cardiac Arrest: A Before-and-After Study at a City Fire Department-Based Dispatch Center. *The Journal of emergency medicine*. 2017;53(5):697-707. doi:10.1016/j.jemermed.2017.06.028
33. Kuisma M, Boyd J, Vayrynen T, Repo J, Nousila-Wiik M, Holmstrom P. Emergency call processing and survival from out-of-hospital ventricular fibrillation. *Resuscitation*. 2005;67(1):89-93.
34. Mao DR, Ee AZQ, Leong PWK, et al. Is your unconscious patient in cardiac arrest? A New protocol for telephonic diagnosis by emergency medical call-takers: A national study. *Resuscitation*. 2020;155(r8q, 0332173):199-206. doi:10.1016/j.resuscitation.2020.08.009
35. Michiels C, Clinckaert C, Wauters L, Dewolf P. Phone CPR and barriers affecting life-saving seconds. *Acta Clin Belg*. 2021;76(6):427-432. doi:10.1080/17843286.2020.1752454
36. Moller TP, Andrell C, Viereck S, Todorova L, Friberg H, Lippert FK. Recognition of out-of-hospital cardiac arrest by medical dispatchers in emergency medical dispatch centres in two countries. *Resuscitation*. 2016;109(r8q, 0332173):1-8. doi:10.1016/j.resuscitation.2016.09.012
37. Nurmi J, Pettila V, Biber B, Kuisma M, Komulainen R, Castren M. Effect of protocol compliance to cardiac arrest identification by emergency medical dispatchers. *Resuscitation*. 2006;70(3):463-469.
38. Orpet R, Riesenberg R, Shin J, Subido C, Markul E, Rea T. Increasing bystander CPR: potential of a one question telecommunicator identification algorithm. *Scandinavian journal of trauma, resuscitation and emergency medicine*. 2015;23(101477511):39. doi:10.1186/s13049-015-0115-1
39. Plodr M, Truhlar A, Krencikova J, et al. Effect of introduction of a standardized protocol in dispatcher-assisted cardiopulmonary resuscitation. *Resuscitation*. 2016;106(r8q, 0332173):18-23. doi:10.1016/j.resuscitation.2016.05.031
40. Sanko S, Kashani S, Lane C, Eckstein M. Implementation of the Los Angeles Tiered Dispatch System is associated with an increase in telecommunicator-assisted CPR. *Resuscitation*. 2020;155(r8q, 0332173):74-81. doi:10.1016/j.resuscitation.2020.06.039
41. Sanko S, Feng S, Lane C, Eckstein M. Comparison of Emergency Medical Dispatch Systems for Performance of Telecommunicator-Assisted Cardiopulmonary Resuscitation Among 9-1-1 Callers With Limited English Proficiency. *JAMA netw open*. 2021;4(6):e216827. doi:10.1001/jamanetworkopen.2021.6827
42. Stipulante S, Tubes R, El Fassi M, et al. Implementation of the ALERT algorithm, a new dispatcher-assisted telephone cardiopulmonary resuscitation protocol, in non-Advanced Medical Priority Dispatch System (AMPDS) Emergency Medical Services centres. *Resuscitation*. 2014;85(2):177-181. doi:10.1016/j.resuscitation.2013.10.005
43. 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

44. Vaillancourt C, Charette M, Kasaboski A, et al. Cardiac arrest diagnostic accuracy of 9-1-1 dispatchers: a prospective multi-center study. *Resuscitation*. 2015;90(r8q, 0332173):116-120. doi:10.1016/j.resuscitation.2015.02.027
45. Vaillancourt C, Verma A, Trickett J, et al. Evaluating the effectiveness of dispatch-assisted cardiopulmonary resuscitation instructions. *Academic emergency medicine : official journal of the Society for Academic Emergency Medicine*. 2007;14(10):877-883.
46. Viereck S, Moller TP, Ersboll AK, et al. Recognising out-of-hospital cardiac arrest during emergency calls increases bystander cardiopulmonary resuscitation and survival. *Resuscitation*. 2017;115(r8q, 0332173):141-147. doi:10.1016/j.resuscitation.2017.04.006
47. Watkins CL, Jones SP, Hurley MA, et al. Predictors of recognition of out of hospital cardiac arrest by emergency medical services call handlers in England: a mixed methods diagnostic accuracy study. *Scand J Trauma Resusc Emerg Med*. 2021;29(1):7. doi:10.1186/s13049-020-00823-9
48. 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
49. 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
50. Bang 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.
51. Fukushima H, Panczyk M, Hu C, et al. Description of Abnormal Breathing Is Associated With Improved Outcomes and Delayed Telephone Cardiopulmonary Resuscitation Instructions. *Journal of the American Heart Association*. 2017;6(9). doi:10.1161/JAHA.116.005058
52. 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. *Emergency medicine journal : EMJ*. 2015;32(4):314-317. doi:10.1136/emermed-2013-203112
53. Bohm K, Rosenqvist M, Hollenberg J, Biber B, Engerstrom L, Svensson L. Dispatcher-assisted telephone-guided cardiopulmonary resuscitation: an underused lifesaving system. *European journal of emergency medicine : official journal of the European Society for Emergency Medicine*. 2007;14(5):256-259.
54. 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(r8q, 0332173):27-33. doi:10.1016/j.resuscitation.2015.09.390
55. Crabb DB, Elmelige YO, Gibson ZC, et al. Unrecognized cardiac arrests: A one-year review of audio from emergency medical dispatch calls. *The American journal of emergency medicine*. 2022;54(aa2, 8309942):127-130. doi:10.1016/j.ajem.2022.01.068
56. 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
57. Schwarzkoph M, Yin L, Hergert L, Drucker C, Counts CR, Eisenberg M. Seizure-like presentation in OHCA creates barriers to dispatch recognition of cardiac arrest. *Resuscitation*. 2020;156(r8q, 0332173):230-236. doi:10.1016/j.resuscitation.2020.06.036
58. Eisenberg MS, Carter W, Hallstrom A, Cummins R, Litwin P, Hearne T. Identification of cardiac arrest by emergency dispatchers. *The American journal of emergency medicine*. 1986;4(4):299-301.
59. Kim TH, Jung JH, Song KJ, Hong KJ, Jeong J, Lee SGW. Association between patient age and pediatric cardiac arrest recognition by emergency medical dispatchers. *The American journal of emergency medicine*. 2022;58(aa2, 8309942):275-280. doi:10.1016/j.ajem.2022.05.038
60. Tzeng CF, Lu CH, Lin CH. Community Socioeconomic Status and Dispatcher-Assisted Cardiopulmonary Resuscitation for Patients with Out-of-Hospital Cardiac Arrest. *International journal of environmental research and public health*. 2021;18(3). doi:10.3390/ijerph18031207