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Challenges in out-of-hospital cardiac arrest – A study combining closed-circuit television (CCTV) and medical emergency calls☆

Gitte Linderoth[a,*], Peter Hallas[c], Freddy K. Lippert[a], Ida Wibrandt[a], Søren Loumann[a,d], Thea Palsgaard Møller[a], Doris Østergaard[b]

[a] Emergency Medical Services Copenhagen, University of Copenhagen, Telegrafvej 5, DK-2750 Ballerup, Denmark
[b] Danish Institute for Medical Simulation, University of Copenhagen, Ringvej 75, DK-2730 Herlev, Denmark
[c] Juliane Marie Centre, Rigshospitalet, University of Copenhagen, Blegdamsvej 9, Copenhagen Ø, Denmark
[d] Department of Anaesthesia, Centre of Head and Orthopaedics, University of Copenhagen, Blegdamsvej 9, Copenhagen Ø, Denmark

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ABSTRACT

The aim of this study was to explore challenges in recognition and initial treatment of out-of-hospital cardiac arrest (OHCA) by using closed-circuit television (CCTV) recordings combined with audio recordings from emergency medical calls.

Method: All OHCA captured by CCTV in the Capital Region of Denmark, 15 June 2013–14 June 2014, were included. Using a qualitative approach based on thematic analysis, we focused on the interval from the victim's collapse to the arrival of the ambulance.

Results: Based on the 21 CCTV recordings collected, the main challenges in OHCA seemed to be situation awareness, communication and attitude/approach. Situation awareness among bystanders and the emergency medical dispatchers (dispatcher) differed. CCTV showed that bystanders other than the caller, were often physically closer to the victim and initiated cardiopulmonary resuscitation (CPR). Hence, information from the dispatcher had to pass through the caller to the other bystanders. Many bystanders passed by or left, leaving the resuscitation to only a few. In addition, we observed that the callers did not delegate tasks that could have been performed more effectively by other bystanders, for example, receiving the ambulance or retrieving an Automated External Defibrillator (AED).

Conclusion: CCTV combined with audio recordings from emergency calls can provide unique insights into the challenges of recognition and initial treatment of OHCA and can improve understanding of the situation. The main barriers to effective intervention were situation awareness, communication and attitude/approach. Potentially, some of these challenges could be minimized if the dispatcher was able to see the victim and the bystanders at the scene.

A team approach, with the dispatcher responsible for the role as team leader of a remote resuscitation team of a caller and bystanders, may potentially improve treatment of OHCA.

1. Introduction

Only 5 to 10 per cent of patients survive out-of-hospital cardiac arrest (OHCA).[1,2] However, survival rates can reach 20 to 40 per cent in witnessed OHCA with ventricular fibrillation in communities where the chain of survival is strong.[3,4] Substantial interventions have been made to increase bystanders' ability to intervene with cardiopulmonary resuscitation (CPR). These efforts have focused on how best to educate laypersons and to use dispatcher-assisted telephone-guided cardiopulmonary resuscitation (T-CPR) to assist them perform CPR during the emergency call.[5–10] Bystanders' interactions with Emergency Medical Dispatchers (dispatcher) during the emergency calls can improve the rate of recognition of cardiac arrest and of bystanders' CPR.[5,11–13] In addition, the dispatcher can refer the caller to the nearest Automated External Defibrillator (AED).[14] However, we have little knowledge of bystander behaviour and challenges at the scene before the arrival of an ambulance.

The aim of this study was to explore challenges of recognition and initial treatment of out-of-hospital cardiac arrest (OHCA) by

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* Corresponding author.
E-mail address: gitte.linderoth@gmail.com (G. Linderoth).

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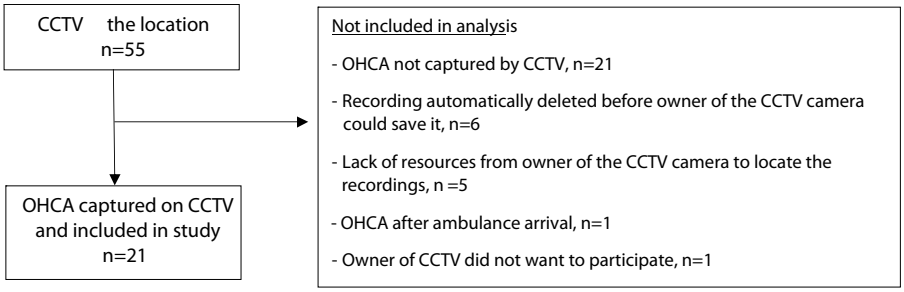

Fig. 1. Flow-diagram: out-of-hospital cardiac arrests (OHCA) captured by closed-circuit television (CCTV) in the Capital Region of Denmark, 15 June 2013–14 June 2014.

using closed-circuit television (CCTV) recordings combined with audio recordings from the emergency medical call.

2. Methods

We used a triangulated design for this study that combined video and audio recordings from OHCA incidents, focusing on the interval from the victim's collapse to the arrival of the ambulance.

2.1. Setting

The Emergency Medical Dispatch Center (EMDC), Copenhagen, Denmark serves 1.7 million inhabitants. All 1-1-2 emergency calls are initially handled by a call centre. The call centre identifies the location and forwards all medical calls to EMDC. The response in EMDC is two-tiered: an emergency medical dispatcher (dispatcher) answers the call and decides the appropriate response while another EMDC staff member handles the logistics of dispatching ambulances. Dispatchers are specially trained nurses and paramedics whose decision-making is supported by a criteria-based, nationwide emergency medical dispatch system called the Danish Index for Emergency Care.[15] The main priority of the Danish Index for Emergency Care is to discover whether the individual is unconscious and breathing abnormally. If OHCA is suspected, dispatchers guide bystanders to perform CPR. If bystanders have no previous CPR training, dispatchers are instructed to give guidance on administering chest compressions only.

2.2. Data collection

All OHCA captured by CCTV in the Capital Region of Denmark, 15 June 2013–14 June 2014, were included. OHCAs in public places were identified, either by the dispatcher or by the physician at the mobile emergency care unit dispatched to the scene. The study group contacted all owners of CCTV in the surroundings of the OHCA incident to ascertain whether the episode was captured on surveillance cameras. Under Danish law, CCTV recordings must be deleted within 30 days if no specific permission is given. However, some recordings are saved for only 24 h.

The corresponding audio recordings from the emergency calls were obtained from the emergency medical service database.

2.3. Ethical approval

The Danish Data Protection Agency approved this study (PHV-2013-001). We applied for ethical approval from The Danish National Committee on Health Research Ethics (DNVK 1211665), but approval was not necessary for this study. All CCTV recordings were formatted to allow access only to investigators. Faces of individuals on the recordings were blurred to prevent identification. Any identifying data for victims and callers were deleted.

2.4. Data analysis

We applied a qualitative research methodology using thematic analysis with an explorative and inductive approach. The first author followed Braun and Clark's six-step analytical approach[16]: familiarizing with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. A single episode of great importance was sufficient to form a theme. Codes and themes were organized using a programme designed to handle qualitative data such as video- and audio recordings (Nvivo10 software, QSR International Pty Ltd, Australia). The first author did the initial analysis. The last author reviewed all the data, coding and themes. All researchers participated in the final analysis in order to enhance confidence in the ensuing findings. Consensus on themes was required.

3. Results

In the study period, we identified CCTV recordings in 55 cases of OHCA in a public place. In 21 of these cases, the CCTV recording captured the OHCA incident and was available for analysis (Fig. 1). In 3 of the 21 cases, the patient was not visible in the recording and only bystanders could be observed. Table 1 shows the demographic characteristics of OCHA victims and callers. All data were estimated from the CCTV or audio recordings. In all cases in which the dispatcher identified OCHA, CPR was performed before the ambulance arrived ($n = 17$). In 10 cases the bystanders started CPR on their own initiative. The dispatchers tried to guide bystanders in CPR after realizing that they were already performing CPR. In 7 cases CPR was initiated in interactions with the dispatcher. Table 2 lists the observed examples of poor quality CPR and AED usage. Bystanders trained in CPR were present in all cases where an AED was retrieved.

We identified three main themes in our qualitative analysis: (1) situation awareness, (2) communication, and (3) attitude/approach. Situation awareness refers to how the bystanders and dispatchers understand the situation; communication includes the type of information and how it is passed on; attitude/approach includes opinions or feelings that affect behaviour. Each theme contains subthemes highly interrelated between bystander and dispatcher. Table 3 contains a summary of the themes and subthemes and provides examples from audio and CCTV recordings that support the themes related to the bystander and dispatcher.

3.1. Situation awareness

Identification of OHCA depended on the bystandersí situation awareness, which was influenced by what they could observe. If the bystanders were not present when the victim collapsed or if the victim's need for help was less obvious, they hesitated to intervene (Table 3). In addition, bystanders' reactions were dependent on their prior skills and knowledge of OHCA. In 10 cases OHCA was identified and CPR started by the bystanders themselves. However,

Table 1
Demography of out-of-hospital cardiac arrest from public places where closed-circuit television (CCTV) recordings were available ($n = 21$). All data were estimated from the CCTV or audio recordings.

	CCTV
Location	
Train or train station	8
On the street outside a shop or bank	5
Airport	3
Café/restaurant	2
Bowling centre	1
Convention centre	1
Supermarket	1
Length of videos	
Median (range)	9 min 44 s (4 min 56 s–41 min 40 s)
The cardiac arrest victim	
Sex (Male/Female)	15/6
Age	
40–70 yrs	8
>70 yrs	13
Aetiology of OHCA	
Cardiac	19
Hypoxic	1
Trauma	1
Other	0
Bystander/caller[a]	
Number of bystanders when victim collapsed	
None	2
Few (1–4)	6
Many >4	11
Unknown	2
Caller CPR-trained	
Yes	4
No	8
Unknown	9
Callers relationship with patient	
Family	1
Friend/colleague	1
Other/stranger	19
CPR, emergency call	
Time from collapse[b] and bystander presence to emergency call ($n = 16$) Median(range)	24 s (−17 s–2 h)
Recognition of OHCA before arrival of ambulance	17
CPR performed	17
Time from collapse[b] and bystander presence to CPR ($n = 14$) Median(range)	3 min 27 s (1 min 20 s–2 h)
Ventilation performed	
Yes	12
No	3
Unknown	2
Compressions rate, median ($n = 12$)	96 min^{-1} (70–136)
AED	
AED on site before arrival of ambulance personnel	6
AED used	4

[a] "Caller" was the person who primarily had the conversation with the emergency medical dispatcher.
[b] In two cases the victim collapsed while sitting. In these cases the time is measured from presumed cardiac arrest.

Table 2
Examples of bystanders' poor quality CPR and AED use observed on CCTV.

CPR	Compressions performed by only bending and stretching the arms
	Sternum 'massaged' or rubbed rather than compressed
	No change of persons performing compressions
	CPR paused when agonal breathing is present
	Patient placed in recovery position too early
AED	Bystander locates AED using smartphone app, but CPR is not initiated
	AED use terminated when ambulance sirens are heard
	Plastic is not removed from patches
	No CPR performed while patches are placed
	After defibrillation, CPR is not resumed

in all cases, recognition of OHCA was more difficult when the victim had agonal breathing. CPR was delayed until the victim completely stopped breathing, and CPR was stopped when agonal breathing was observed. In four cases OHCA was not identified. In two of these cases the victim was presumed to be intoxicated, including a case where the individual was obviously inebriated and the aetiology was hypoxia because of obstructed airway. In the remaining two cases the cardiac arrests were misjudged as seizures.

The dispatcher's situation awareness was highly dependent on information given by the bystanders. In most cases, physical distance separated the caller from the cardiac arrest victim, and the caller's assessment of the victim was not optimal. Callers seemed to focus on the emergency call, while other bystanders took care of the victim. Therefore, the situation awareness of the caller, other bystanders and the dispatcher was not always identical. In one example, bystanders started CPR while the caller and dispatcher talked about the case, unaware that the victim had a cardiac arrest. In four cases, CPR was initiated during the call without the dispatcher's guidance.

The dispatcher did not always inquire about bystanders' competencies or ask the caller to call out for any healthcare professionals at the scene (Table 3). When bystanders called out for help on their own initiative ($n = 8$), other people willingly assisted and provided CPR without instructions from the dispatcher.

3.2. Communication

In some cases the caller gave misleading information. For instance in two cases, bystanders told the dispatcher that the victim was sitting; however, it was bystanders who had placed the cardiac arrest victim in a sitting position.

Intervention was delayed when the dispatcher asked only whether the victim was breathing and did not listen carefully or react to answers such as 'he is breathing a little bit'.

Other bystanders were often closer to the victim than was the caller, who had to relay the dispatcher's questions to them (Dispatcher: 'Is he breathing?' Caller to other bystanders: 'Is he breathing?'). Similar communication challenges occurred when the caller was the intermediary for the dispatcher's instructions to the bystanders on how to administer CPR. In only one case did the dispatcher directly instruct the person performing CPR. This case was the only one in which the caller was the sole bystander.

3.3. Attitude/approach

When OCHA was identified, CPR was delayed if bystanders believed resuscitation was futile or if they could not or would not perform CPR. The emotional stress of the sudden dramatic event may have affected some bystanders. When bystanders were told that the ambulance was on its way, levels of anxiety and stress seemed to be reduced as they exhibited less agitated behaviour. However, in many cases the caller was relatively calm during the entire period and provided good information.

Many bystanders passed by or left the scene after a while, leaving the resuscitation to a few. The caller performed tasks that should have been delegated to these bystanders; for example, in one case the caller walked away from the scene to receive the ambulance, causing the dispatcher to lose contact with those performing CPR. In addition, we found incidents of the dispatcher showing poor leadership and responsibility for the entire resuscitation by ending the conversation before the ambulance arrived, and CCTV showed that no CPR had been performed. Further, some dispatchers failed to ask whether an AED was nearby ($n = 5$). In at least one case, an AED was in the neighbouring building but was not used (Table 3).

Table 3
Themes and data-provided examples of reasons for delay in recognition and initial treatment of out-of-hospital cardiac arrest (OHCA).

Main themes	Sub-themes (codes are listed under the individual subtheme)	Data extract (example)
Bystander		
Situation awareness	**Circumstances**	
	Non-witnessed cardiac arrest	CCTV: The cardiac arrest victim is lying down upon arrival of two bystanders. The bystanders hesitate to help the victim
	Less obvious need for help	CCTV: The victim is sitting in the train and does not collapse to the floor. Nobody helps before the terminal station
	Distance	CCTV: Caller stands in another room and do not have visual contact to the victim
	Short time at scene	CCTV: A person on bike observes the victim's collapse, but continues to ride bike away quickly
	Knowledge of OHCA	
	Agonal breathing	CCTV: The victim is unconscious and has agonal breathing. Bystanders are shaking him; no CPR
	No re-assessment of patient	CCTV: After placing the patient in recovery position, none of the bystanders observes the victim closely
	Wrong diagnosis	Audio: Caller: 'It is epilepsy. . .
Communication	Providing information to dispatcher	
	Misleading information	Audio: Caller: "He is sitting. . ." CCTV: The bystanders are holding the unconscious patient in the sitting position
	Instructions are not passed to the bystanders who perform CPR	Audio: Dispatcher: 'Press 5-6 cm. . .' Caller does not relay the instructions to the persons performing the CPR. CCTV: The other bystanders can't hear the conversation
Attitude/approach	Thoughts about pointless resuscitation	The victim had been sitting in the car for about two hours. Audio: Caller: 'There is nothing to do; he is totally dead'. Long time before CPR starts
	Barriers to perform CPR	Audio: Caller: 'I don't believe there is any life. He is not breathing'. Dispatcher: 'You have to start CPR'. CCTV: Caller is not performing CPR. Audio: Caller to another bystander: 'Ask if the young lady up there can do CPR'. CCTV: The lady comes, but begins looking for an AED with other bystanders; nobody starts CPR until later
	Stress/affect	Audio: In audio recordings bystanders' tone of voice is affected and some speak very fast. CCTV recordings show that some callers move around for no apparent reason. Inability to inform sufficiently could be the result. Audio: Dispatcher: 'Does she have convulsions?' Caller: 'I really do not know what to say'
	Suboptimal priority	Audio: Caller: 'I will go to receive the ambulance'. Dispatcher loses contact with bystanders. OHCA is not identified
	Others are helping	CCTV: Many bystanders pay attention to the victim, but leave after a short time
Dispatcher		
Situation awareness	No use of potential resources	CCTV: Location with many people. Audio: Dispatcher does not ask caller to ask other bystanders to call out for health professionals, retrieve an AED or receive the ambulance
	Instructions given too early	Audio: Dispatcher: 'The rate is one, two, three, four, five. . .'CCTV: The victim is still sitting in a chair
	Inappropriate instructions	Audio: Dispatcher: '. . .Is there a ventilation mask in box? . . . Use that for ventilations. . .' CCTV: An AED is available. Instead of placing patches on the patient, the bystanders first find the mask and start to use it
Communication	**Insufficient adherence to criteria-based protocol**	
	Abnormal breathing	Audio: Only questions about whether or not the patient is breathing. Dispatcher: 'Is he breathing. . .?' Caller: 'Yes.'. Dispatcher does not encourage to CPR CCTV: Agonal breathing
	T-CPR instructions	
	Inadequate instructions	Audio: Dispatcher: 'They can switch when they get a bit tired and so'. . . .'Give it all you got' CCTV: Only one person performs CPR despite many people present
	No confirmation that instructions are followed	Audio: Dispatcher: '. . .The rate of compressions is 100 per minute. . .' CCTV: Compressions are performed at a slower rate
Attitude/approach	Inability to convert to a severe emergency situation	Audio: Caller: 'He is unconscious. . .Not breathing–or maybe he is breathing a little bit'. Dispatcher: 'Unconscious–are you sure? Try to stimulate him with pain'. Caller: 'He is totally gone'. Dispatcher: 'How old is he?' CCTV: The victim doe not react to stimulation. Breathing patterns cannot be observed
	No responsibility for resuscitation and leadership	Audio: Dispatcher: 'I can see you have everything in control, so I will end the conversation'. CCTV: No CPR and nobody retrieves AED

'Audio' and 'CCTV' refer to information from the emergency call and what is observed on CCTV, respectively. Ellipses indicate where words have been left out. Victim = Cardiac arrest victim.

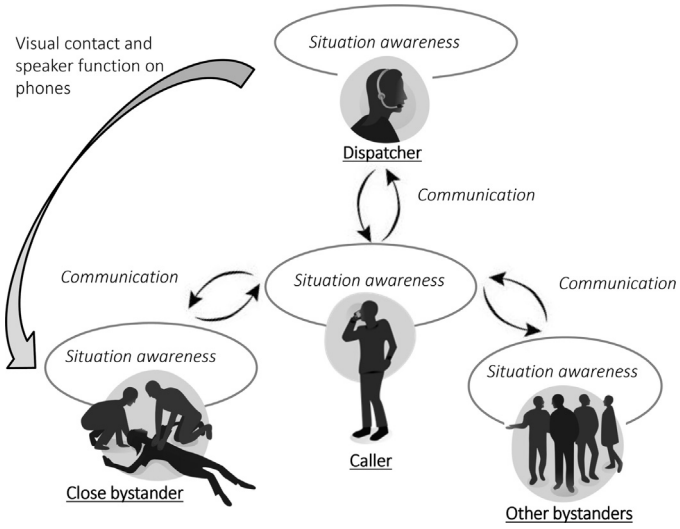

Fig. 2. An illustration of communication pathways to achieve shared situation awareness in out-of-hospital cardiac arrest. Visual contact (CCTV/video call from smartphone) and the speaker function on phones might minimize some of these challenges.

4. Discussion

The combination of CCTV and audio recordings from emergency calls provides the opportunity to gain vital knowledge about how to improve early identification of OHCA and how to provide better guidance on how to perform bystander CPR. The main challenges of effective intervention of OCHA were situation awareness, communication and attitude/approach. Efficient and effective communication is essential to obtain sufficient and identical situation awareness. Understanding these challenges in the recognition and treatment of OHCA is an important step towards improving survival.

Without visual contact, dispatchers' situation awareness relies on the information provided by the caller. This implies that bystander situation awareness is crucial for early identification and treatment of OHCA, which depends on the bystanders' skills and how obvious the victim's need is for help. The information given to the dispatcher is important. For example, when the caller uses the word "sitting", the dispatcher misinterprets this information as if the victim is alive and has enough muscle tonus to sit. With the use of CCTV the dispatcher could have seen that the victim was unconscious and the misunderstanding could have been corrected.

Fig. 2 is an illustration of communicative pathways. The Danish Index for Emergency Care is designed as if the dispatchers are speaking with the person closest to the victim and that person is performing the CPR. Only in one case did the caller perform the CPR. This case was also the only one in which the caller was the sole bystander. Thus, communication was more direct and structured compared with the other cases. However, the phone was placed on the floor without activated speaker function during CPR. Educational programmes for dispatchers should focus on communication challenges in relaying information and instructions through the caller to other bystanders. Communication and identifying breathing patterns were difficult, as described in other studies.[18,19] In several cases in our study, CPR was first started when the patient stopped breathing completely, and CPR was stopped if agonal breathing was present. It is important knowledge that bystanders discontinue CPR when any breathing occurs. It is critical to follow guidelines and perform CPR when abnormal breathing is present, rather than only if the dispatcher is convinced that breathing is agonal. Clegg et al.[20] analyzed recordings from emergency calls and found that identification of breathing patterns was one of the most time consuming tasks during OHCA incidents, which underscores the importance of simplicity in communication.

Some of our sub-themes also agree with other studies. In an analysis of emergency calls, Lewis et al. found the factors that delayed dispatcher recognition of cardiac arrest were dispatcher-related (asking unnecessary or inappropriate questions), caller-related (emotional state, vague or misleading answers), and call-related (language barriers, time spent moving the patient).[23] Some factors were easier than others to overcome. For example, the dispatcher's failure to follow guidelines or asking unnecessary or inappropriate questions could be further addressed in their education.

CCTV showed examples of low treatment quality such as low compression frequency, insufficient performance, no changing of person, interruption in CPR and insufficient use of AED. The treatment quality might improve with use of CCTV. Ensuring the quality of the resuscitation is central. In a study by Takei et al., ambulance personnel who evaluated bystander CPR when they arrived at the scene found that the quality was poor in about 20 per cent of cases.[17]

Many bystanders walked away from the victim leaving the resuscitation to only a few people. The message for laypersons should be: you can always help, even if you have not been trained in CPR; you could be the person running for an AED or guiding the ambulance to the victim.

Dispatchers possess knowledge on treatment of cardiac arrest but are not physically present at the scene of the incident. The question is what training is needed for the dispatcher to best guide bystanders? Retrospective CCTV could provide a teaching opportunity for dispatchers, including lessons found in this study. The cases presented here may only be the tip of the iceberg regarding confusing situations. Furthermore, dispatchers and bystanders are not considered or trained as a team. A team approach, with the dispatcher as the team leader and the caller and other bystanders as team members, could be useful in future training programmes for dispatchers. Leadership is important for task management, including delegating various roles during resuscitation. Without leadership, these roles may not be optimally distributed and intervention might not be prioritized or coordinated. Dispatchers who take the responsibility and role of a team leader can guide callers to delegate various functions to other bystanders during the resuscitation. If competent bystanders are present, the dispatchersí role could be more supportive. In-hospital studies show that non-technical skills, such as situation awareness, decision-making, leadership, communication and teamwork, enhance performance.[21,22]

Basic life-support courses could focus on gathering a team and the various tasks for bystanders: resuscitation, communication with dispatcher, quality CPR, receiving the ambulance, retrieving an AED and calling out for help from any healthcare professionals among the bystanders. We should think of the dispatcher and the bystanders as "the first resuscitation team" at the scene, the ambulance personnel are the second team and the receiving team at the hospital as the third—essentially a chain of resuscitation teams performing many of the same tasks.

If dispatchers have visual contact with the victim, their situation awareness might be improved, but the use of live video recordings for emergency medical intervention is still to be investigated. With the right set-up, live streaming could be transmitted to the Emergency Medical Dispatch Center; however, the number of surveillance cameras is limited. As technology improves and smartphones become more widespread, video calls could be a mean of providing better situation awareness and higher-quality T-CPR. In simulation studies, video recordings improved the dispatcher's insight and CPR intervention.[24,25] However, additional education for dispatchers is necessary, and ethical aspects must be addressed.

The speaker function on phones could be a solution to this communication challenge with information passing through the caller to bystanders closer to the victim,[9] although people who lack the technical skills may find this solution difficult.[26] Some of these technical difficulties may be of less concern in the future. How speakerphones would work in real-life and high-stress situations needs further investigation.

Our findings elucidate the challenges of bystander CPR in incidents of OHCA in public places with CCTV cameras but cannot be generalized to every OHCA case, such as those in private homes or remote settings. In private homes, fewer bystanders are available and they are often relatives, whose emotional involvement may present other challenges. The demographic characteristics of our sample correspond to the findings in the Danish Cardiac arrest registry, 64% males and median age of 71 years. In recent publications from Denmark the rate of witnessed arrest was 51% and bystander CPR was performed in 64% of the cases.[4,27] A public location of the collapse increases the probability of witnessed arrest and increases the number of bystanders and access to public AEDs. There are thus better opportunities for quality CPR.

As with all qualitative research, the researchers have an effect on the results. We tried to minimize this effect through investigator triangulation. Our study's strength is that the data were based on real events, and we had no influence on the bystanders' behaviour.

In conclusion, CCTV combined with audio recordings from emergency calls provided unique insights into the challenges of initiating treatment of OHCA and can improve our understanding of these situations. The main challenges of effective and timely intervention were situation awareness, communication and attitude/approach. Potentially, some of these barriers might be minimized if the dispatcher were able to see the victim and bystanders at the scene. A team approach, with the dispatcher responsible for the role of team leader of a remote resuscitation team of a caller and bystanders, may potentially improve treatment of OHCA.

Conflict of interest statement

No conflicts of interest to declare.

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