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Clinical paper

Bystander availability, CPR uptake, and AED use during out-of-hospital cardiac arrest

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Abstract

Background: Bystander cardiopulmonary resuscitation (CPR) and defibrillation of a shockable rhythm improve survival following out-of-hospital cardiac arrest (OHCA). Little data exists on bystander participation during genuine cardiac arrest calls.

Method: This was a prospective audit of bystander participation during OHCA calls to a single ambulance service in the United Kingdom. A convenience sample of consecutive OHCA calls from March 2022 until April 2023, where an adult cardiac arrest was confirmed and CPR was advised, was audited by a call handler. Cases with a valid do not attempt CPR decision were excluded. Data on key time intervals and bystander participation were extracted and analysed in R (v4.2).

Results: In total, 451 cases were analysed. Median time until cardiac arrest recognition was 42 s (IQR 94.7 s) and until the initiation of CPR was 161 s (IQR 124 s). A lone bystander was present in 162 (35.9%) cases, two bystanders in 149 (33.0%) cases, and three or more bystanders in 140 (31.0%) cases. CPR was attempted by a bystander in 382 (84.7%) cases. Physical inability, refusal, and inability to correctly position patient were common reasons for not performing CPR. A defibrillator was retrieved before the arrival of emergency medical services in 36 (8%) cases and a shock was administered in 9 (2%) cases, while a shock was not advised in 20 (4%) further cases.

Conclusion: Cardiac arrest was identified rapidly but there was a delay to initiation of CPR. A lone bystander was present in over one third of cases, eliminating the possibility of bystander defibrillation in the absence of a lay first responder.

Keywords: Cardiopulmonary resuscitation, Bystander, Audit, Defibrillation, Cardiac arrest, Layperson, Laypeople

Introduction

Following out-of-hospital cardiac arrest (OHCA), the probability of survival and good neurological outcome decreases rapidly without cardiopulmonary resuscitation (CPR) and defibrillation of shockable rhythms.[1,2] Bystander CPR and public access defibrillation (PAD), administered by laypeople, reduces the time to initiation of these life-saving interventions and is consistently associated with improved survival and functional outcomes for patients.[1] The relative benefit is greater with longer Emergency Medical Service (EMS) response times, which is particularly important for rural communities.[3]

Currently, an automated external defibrillator (AED) is applied before the arrival of EMS in just 0.15% to 4.3% of OHCAs, despite often being within 100 m of the patient.[4] Additional mapping work by Deakin et al. found that an AED was close enough to be brought to the scene before the arrival of EMS at 25.6% of OHCA.[5] Therefore, whilst there is clearly room for improvement, low coverage is no longer the primary barrier to more widespread PAD in the UK. Current barriers include difficulty locating or accessing a device (due to poor signposting, locked AED cabinets, or placement within buildings only accessible during the daytime), the need to prioritise cardiopulmonary resuscitation (CPR) if the rescuer is alone, and low public knowledge and confidence in using a device.[6–8]

For OHCA, the chain of survival primarily involves bystanders for the first three of four links, with a disproportionate benefit to survival provided by the early links.[9] Although considerable work has been done to strengthen these early links, such as improving the effectiveness of telephone CPR (T-CPR) scripts, encouraging bystander CPR, and establishing a network of public access defibrillators (which can only realistically be retrieved if a second bystander is present), little is known about the bystander(s) themselves. Information is lacking about bystander demographics, their physical ability to

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deliver CPR, and how often more than one bystander is present to retrieve and use an AED.

We therefore audited EMS 999 calls where a cardiac arrest was identified by the emergency medical despatcher and CPR was advised. We aimed to ascertain the demographics of bystanders, examine how frequently additional bystander(s) are available at OHCA events in our catchment area, and therefore understand the feasibility of current CPR and defibrillation instructions provided to bystanders.

We further aimed to audit how successful bystanders are at retrieving and using public access defibrillators before the arrival of emergency medical services, with a view to improving the current instructions that are provided by emergency medical despatchers. This audit therefore aimed to inform a quality improvement process within local despatch procedures.

Method

Design

This prospective audit reviewed recorded telephone calls to South Central Ambulance Service from March 2022 until April 2023, where cardiac arrest was identified. In accordance with the Health Research Authority decision tool, this project was classified as an audit and therefore did not require formal ethical approval. The audit was prospectively registered in the South Central Ambulance Service audit registry.

Audit setting

The South Central Ambulance Service NHS Foundation Trust (SCAS) provides emergency services for 7 million people across 9205 km^2 of rural and urban environments in southern England. In 2022, SCAS attended 2666 OHCAs where resuscitation was commenced or continued by ambulance personnel. Of these, 58.3% were witnessed. For the Utstein comparator group (356 cases), 49.4% had ROSC at hospital admission and the 30-day survival was 31.2%. A community first responder scheme operates in the region with volunteer members trained by SCAS. Despatch of both professional and volunteer resources occurs via the emergency operations centre. Therefore, in our system, first responders cannot be considered as laypeople.

Call handlers follow National Health Service (NHS) Pathways Module 0, a clinical decision support algorithm used across NHS emergency services in England.[10] Guidance is tailored according to the response of the caller to each question.

Audit standard

National standards for the recognition of cardiac arrest and delivery of T-CPR and AED advice in the United Kingdom are lacking. The American Heart Association (AHA) published performance standards for T-CPR in 2017, stating that the median time from call transfer to an EMS service to recognition of cardiac arrest should be less than 90 s, and that the median time from call transfer to delivery of the first T-CPR chest compression should be less than 150 s.[11]

Audit participants

All emergency calls to South Central Ambulance Service regarding an adult (>= 18 years), coded as a 'cardiac arrest', following which a bystander was advised to begin CPR, were eligible for inclusion. Exclusion criteria included a valid do not attempt CPR (DNACPR) order, if CPR was not advised by an emergency medical despatcher for another reason (e.g. clear signs of decomposition, or injuries not compatible with survival such as decapitation), or third-party calls where a call was passed to SCAS from another service because reliable timings were not always recoverable.

Data collection

A convenience sample of recorded calls to 999, answered by SCAS within the audit period and meeting the inclusion criteria, was identified by a single senior member of the emergency operations centre. There are two emergency operations centres in the SCAS region; this audit collected data from one of them. Calls were then extracted by SCAS data analysts from the locally hosted case file repository. An auditor, an experienced SCAS paramedic working on a research secondment, accessed call recordings either whilst physically on SCAS premises or via a VPN connection to the SCAS computer system using hardware compliant with SCAS information governance policy. The auditor excluded calls based on the exclusion criteria after review of the call recordings, as it was not always clear from the meta-data in the case database. The auditor extracted the anonymised data into a pre-piloted, password-protected Excel file for analysis. All timings started from when the call was answered.

Variables

Extracted variables regarding the arrest included arrest location (public or private venue), patient gender and patient age category (18 – 65 years, > 65 years, unknown). Variables pertaining to the bystanders included the bystander gender, age group, understanding and performance of CPR, and reasons for not performing CPR for each of the three most prominent bystanders where present. Variables relating to AED utilisation and reasons for non-collection or non-utilisation were also recorded. Finally, a suite of timestamps was recorded by the auditor including the time the call was made, time that the call was answered, time that cardiac arrest was identified, time that CPR was advised, time that CPR was initiated, time that an AED was advised to be collected, time that an AED arrived, time of first shock, and time of EMS arrival. Where CPR was ongoing at the time the call was answered, the time to CPR was documented as zero seconds.

A bystander was defined as any individual present at an OHCA who is not identified as being part of an on-duty EMS team (e.g. not community first responders, police responders, ambulance personnel). Bystanders were categorised in the order that they were identified in the call, for example the call maker was always 'bystander one'.

Audit size

We aimed to achieve a convenience sample of 500 included calls. Calls were selected consecutively from the SCAS database until the sample size was reached.

Analysis and missing data

Data was tidied and a descriptive analysis was performed in R statistical software version 4.3.1 (2023-06-16).[12] No inferential statistical analyses were performed. Due to the controlled data collection strategy, missing data was expected to be minimal and was therefore presented as a separate category. Any outcome with a frequency ≤ 3 was censored to eliminate any residual chance of patient identification.

Results

In total, 939 audio recordings were screened by the auditor, with 439 excluded for the reasons described in Fig. 1. Of the 500 recordings which underwent full audio review, 451 were included in the final data set. A further 8 cases were excluded from the timings analysis as described in Fig. 1.

Details of cardiac arrests

Demographic details of the patients and cardiac arrest location are presented in Table 1. The time to key timepoints in the calls are presented in Fig. 2 and Table 3. The median time from the call being answered to cardiac arrest being recognised was 42 s (IQR 94.7 s), which was better than the minimum standard recommended in the 2017 AHA T-CPR performance standards (90 s). The median time from the call being answered to the initiation of CPR was 161 s (IQR 124 s), which was poorer than the minimum recommended performance standard (150 s).

Details of bystanders

Details of the bystanders are presented in Table 2. A lone bystander was present in 162 (35.9%) cases, two bystanders were present in 149 (33.0%) cases, and three or more bystanders were present in 140 (31.0%) cases. The first bystander frequently (86.3%) knew the patient personally and was often (25.9%) elderly. CPR was attempted by a bystander in 382 of the 451 included cases (84.7%).

CPR not provided

Details of the 69 cases where a bystander was present, but no CPR was provided are presented in Fig. 3. CPR was attempted in 82.1% of cases where a lone bystander was present, 84.6% of cases where two bystanders were present, and 87.9% of cases where 3 or more bystanders were present. Cases where no CPR was provided most frequently involved a lone bystander (45% of cases without CPR) who was physically limited by frailty or disability (27.5% of all cases without CPR). Other common reasons for the lack of CPR were bystander distress, bystander refusal, and difficulties in repositioning patients to perform CPR, for example from the seat of a car onto the ground (Fig. 3). Where multiple bystanders were present and yet no CPR was performed, the additional bystander(s) frequently had arrived shortly before the arrival of EMS or were unable to reposition the patient to perform CPR, often for the same reason as the first bystander. In ≤ 3 case(s), agonal breathing delayed recognition of cardiac arrest until the arrival of EMS and in ≤ 3 case(s) the patient was inaccessible due to entrapment, hanging, or being inside of a locked property or car.

Use of AEDs

The call handler advised the collection of an AED in 62 (14%) cases ($n = 451$), and a bystander attempted to locate an AED in 55 (12%) cases. An AED was retrieved successfully before the arrival of EMS in 36 (8%) cases. Of the cases where an AED was retrieved ($n = 36$), a shock was administered successfully in 9 (25%) cases. In 20 (74%) cases, the AED was connected to the patient, however no shock was advised, in 4 (15%) cases the AED was retrieved, however EMS arrived before the device could be used, and the outcome was unclear in ≤ 3 cases from the audio recording.

Discussion

This audit shines a unique light on the difficulties faced by call handlers in our service and bystanders when confronted with a cardiac arrest. Recognition of cardiac arrest in our system was quicker than the minimum recommended performance standard, while time to initiation of CPR was slower. Nevertheless, bystander CPR was ultimately performed in a high (>80%) proportion of all cases. A lone bystander was present in more than a third (35.9%) of cases, eliminating the possibility of AED retrieval by the bystander present at the scene.

The primary reason for lack of CPR was due to physical frailty of bystanders which precluded CPR or the repositioning of patients to

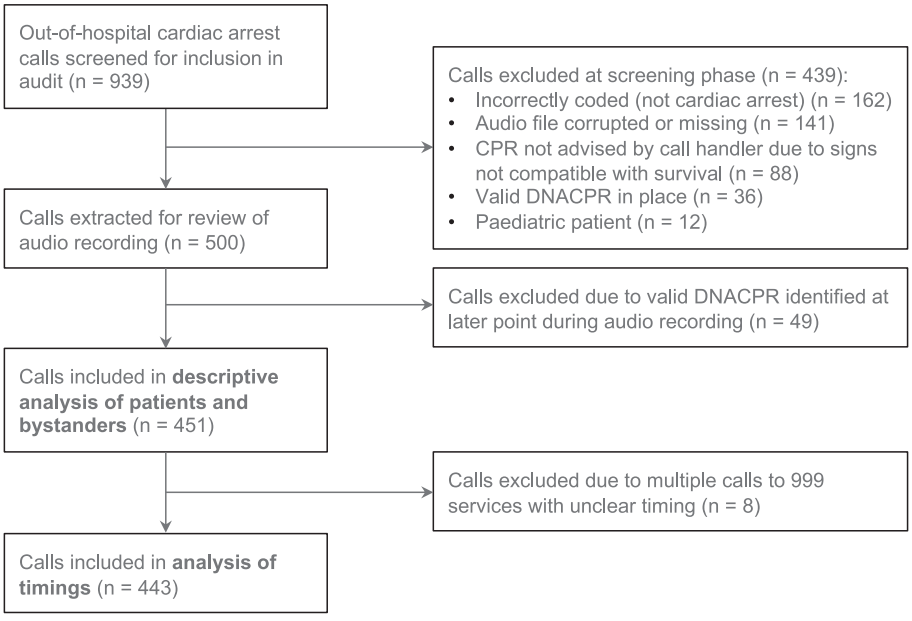

Fig. 1 – Diagram of cases included/excluded from audit. Do Not Attempt CPR decision = DNACPR.

perform CPR, in concordance with previously published findings from the USA.[13] A solution to this barrier is difficult to see beyond improvement of EMS response times. As found in data from Ireland, bystander distress and subsequent refusal or inability to perform CPR were common.[14] However, the overall high uptake of T-CPR but suboptimal time to initiation of chest compressions suggests a general willingness to perform CPR but poor knowledge, which could be improved through expanded CPR training.

In this audit, AED collection was recommended by the call handler in 62 cases, which represents 22% of cases where more than 1 bystander was present. In a 2017 survey of UK adults, 42% said that they would fetch an AED if they witnessed a cardiac arrest, and 35% said they would use one (when prompted by investigators).[15] In comparison, this audit found high AED acceptability in the SCAS region, with 88% of bystanders attempting to retrieve an AED when prompted, the AED being connected to the patient in 81% of cases where it was retrieved, and no cases of bystander refusal to provide a shock. This demonstrates that, in this region, concerns about AED acceptability being affected by factors such as fear of doing harm or legal liability were not supported.[16] On the other hand, generally low referral rates of layperson rescuers to AEDs by EMS despatchers were found, although it was not possible to elucidate the reasons for this. While outside the scope of this audit, activation of ad hoc lay responders may have a role to play in increasing defibrillation rates, particularly when a lone bystander is present.[17]

A key issue encountered in this audit was a lack of up-to-date nationally or internationally agreed standards for the performance

Table 1 – Characteristics of included cases.

	N = 451[1]
Patient gender	
Female	162 (36%)
Male	289 (64%)
Patient age	
Adult	175 (39%)
Elderly	273 (61%)
Unclear	3 (0.7%)
Location	
Healthcare setting	5 (1.1%)
Home	363 (80%)
Other	11 (2.4%)
Public place	70 (16%)
Workplace	2 (0.4%)

[1] n (%).

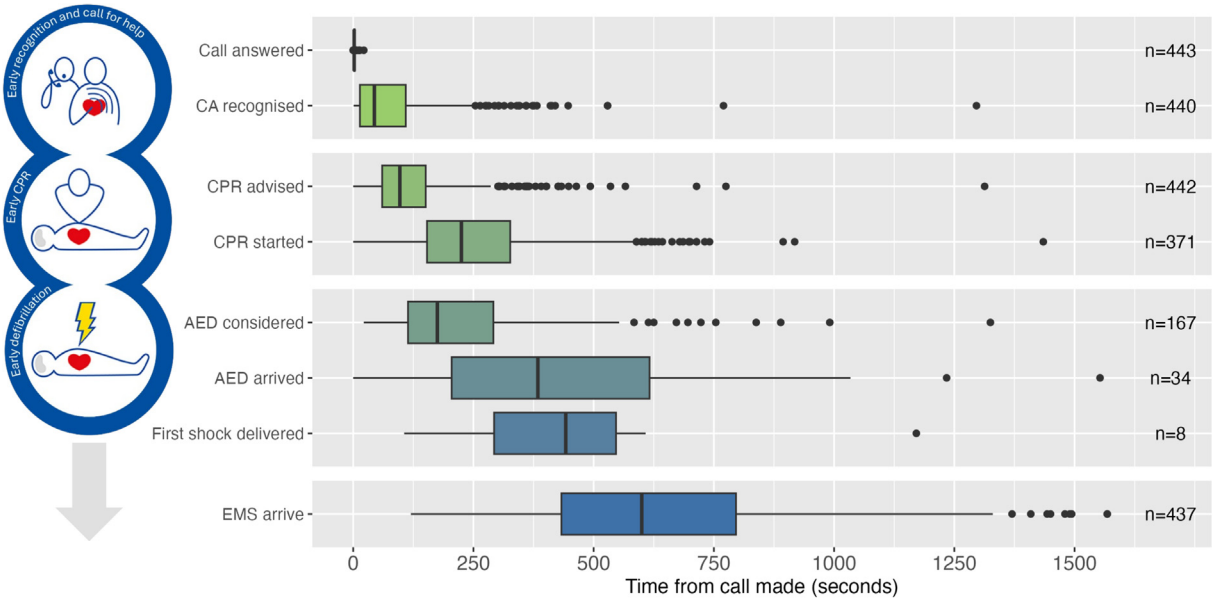

Fig. 2 – Distribution of elapsed time, stratified by link in the chain of survival.

Table 2 – Characteristic of each identified bystander present at included cardiac arrests. Bystanders were numbered in the order in which they were first audible in the recording. For example, the number of calls involving a lone bystander can be confirmed by subtracting the number of instances where a second (Bystander 2) bystander was present from the number of instances where bystander 1 was present.

Bystander	N (total)	Male (%)	Elderly (%)	Bystander knows patient (%)	Bystander knows CPR (%)	Bystander attempts CPR (%)
Bystander 1	451	186 (41.2)	117 (25.9)	389 (86.3)	67 (14.9)	270 (59.9)
Bystander 2	289	138 (47.8)	45 (15.6)	230 (79.6)	62 (21.5)	144 (49.8)
Bystander 3	140	59 (42.1)	8 (5.7)	83 (59.3)	46 (32.6)	74 (52.9)

Table 3 – Time intervals.

Durations	N	Median duration (lower quartile, upper quartile), seconds
Duration from call made to call answered	443	2.0 (2.0, 3.0)
Duration from call answered to CA recognised	440	42.0 (11.8, 106.5)
Duration from CA recognised to CPR advised	399	32.0 (10.0, 61.0)
Duration from CPR advised to CPR started	331	122.0 (81.5, 187.5)
Duration from CA recognised to CPR started	329	161.0 (114.0, 238.0)
Duration from CA recognised to AED considered	166	109.5 (56.0, 197.5)
Duration from AED advised to AED retrieved	35	195.0 (0, 276.0)
Duration from CA recognised to EMS arrival	440	518.0 (358.5, 725.0)

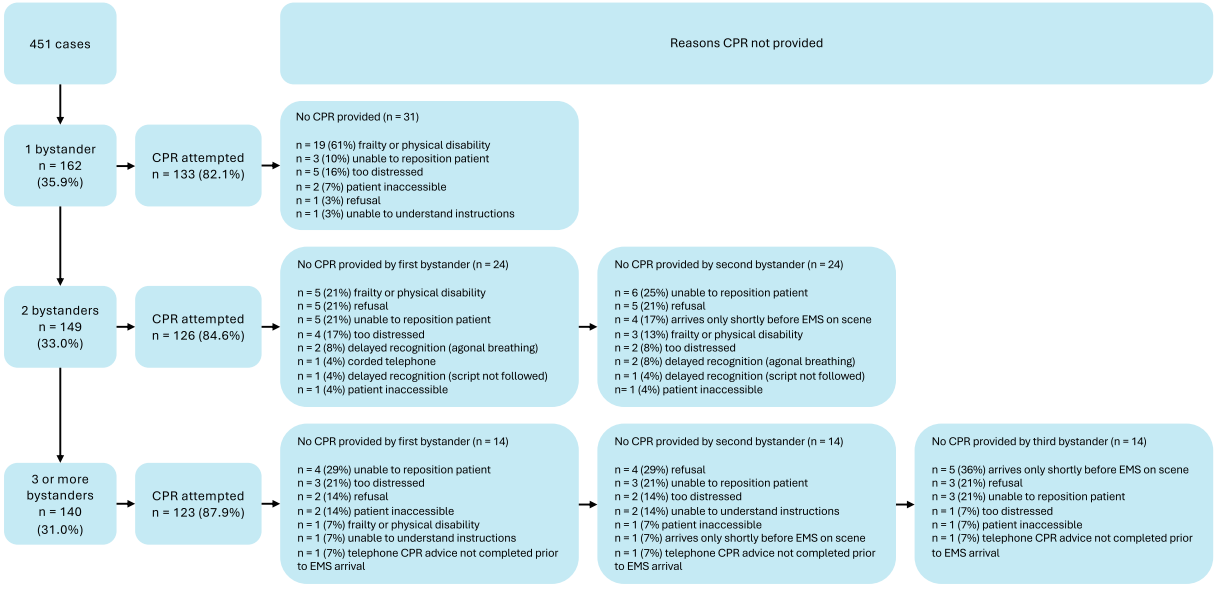

Fig. 3 – Number of bystanders present and reasons for CPR not being provided.

of T-CPR and for telephone advice regarding the use of AEDs. In 2017, the Global Resuscitation Alliance recommended the creation and utilisation of agreed standards to improve these links in the chain of survival and allow comparison between systems, however these have not materialised.[18] Median time to recognition of cardiac arrest appears faster in this audit compared to previously published data collected in the USA between 2011 and 2014 (42 s compared to 69 and 76 s), while median time to initiation of chest compressions was similar (161 s compared to 175 and 176 s.[13,19,20] Although the time to initiation of chest compressions was poorer than the recommended AHA 2017 minimum standard of 150 s, it compared favourably to contemporaneous data published by other UK ambulance services.[11,21] Previous studies in other healthcare systems have found that the factors resulting in a delay to bystander CPR are similar to the barriers that prevent CPR from being performed at all, including physical limitations of the bystander, caller distress, and communication barriers related to technology or language.[22,23]

Limitations

This audit is subject to several limitations, principally that timings were recorded by the auditor to the best of their ability in the context of often chaotic and challenging call recordings. Where endpoints were not verbalised, the auditor was permitted to use other audible signals, for example audible CPR, counting, defibrillator sounds etc as timestamps. This was however unlikely to bias the recorded timestamps in a systemic manner. Paediatric cases were excluded, which are likely to be associated with even greater bystander distress. The audit had hoped to analyse decision-making related to AED advice, however this was often not verbalised. Where a call handler searched the AED register, it was not possible to ascertain the reasons for recommending or not recommending retrieval of a device. The limitations encountered in this study could be addressed by prospective qualitative work involving call handlers.

Conclusion

This audit observed a number of positive findings in the South Central Ambulance Service region including a high level of bystander CPR, rapid identification of cardiac arrest by call handlers, and a high level of willingness of bystanders to retrieve and use AEDs when prompted. However, time to initiation of T-CPR remains suboptimal. Furthermore, this audit found that AED retrieval was not feasible in over a third of cases due to a lone bystander. AED utilisation was low in the remaining cases even where multiple bystanders were present. Future research and quality improvement work is required to

understand the reasons for continued infrequent prompting of bystanders to collect and use AEDs and to further optimise both T-CPR and AED advice.

CRediT authorship contribution statement

David B. Sidebottom: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation. **Robyn Painting:** Writing – review & editing, Resources, Project administration, Investigation. **Charles D. Deakin:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: The authors are employees of or have honorary contracts with South Central Ambulance Service.

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