OHCAO

WARWICK
CLINICAL TRIALS UNIT

British Heart Foundation

Resuscitation Council (UK)

Out-of-Hospital Cardiac Arrest Outcomes Registry Epidemiology Report, 2017

English Ambulance Services

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FOREWORD

It is our pleasure to write the foreword to this fourth report from the Out-of-Hospital Cardiac Arrest Outcomes collaborative project. The NHS Long Term Plan[1] has highlighted the need for the registry to enable effective mapping of OHCA incidence that will help direct community CPR training initiatives to areas where they are most needed, and to allow the tracking of survival rates and target unwarranted variation.

Over the last 12 months we have seen further improvements to cardiac arrest pathways in England. The "Chain of Survival" drives our approach to out-of-hospital cardiac arrest, and forms the basis of the consensus guidance, 'Resuscitation to Recovery: A National Framework to improve the care of people with Out-of-Hospital Cardiac Arrest in England', which was published in March 2017. [2]

Key aspects of the Chain of Survival, and collaborative work undertaken, include:

1) **Early recognition:** The Ambulance Response Programme has raised the standards and expectations for a timely response for out-of-hospital cardiac arrest. [3]
2) **Early CPR:** Together with the Resuscitation Council (UK), British Heart Foundation and other organisations, NHS Ambulance Services again trained nearly 200,000 people as part of the "Restart a Heart" initiative. Great work has also been undertaken by other organisations to promote immediate and effective CPR.
3) **Early defibrillation:** The British Heart Foundation has joined forces with UK Ambulance Services, the NHS, Microsoft and Microsoft solutions provider to develop the National Defibrillator Network to enable Ambulance Services and bystanders locate the nearest public access defibrillators. [4]
4) **Post resuscitation care:** 'Resuscitation to recovery' called for the development of consistent care pathways to ensure that patients with a return of spontaneous circulation receive the best treatment after arrival in hospital, through the establishment of 'cardiac arrest centres'.

We thank all the many people who contribute to increasing the awareness of cardiac arrest, the importance of CPR and defibrillation, and the care of those who suffer an out-of-hospital cardiac arrest. To monitor progress, and help drive improvement, it is crucial that we have good data, and we therefore commend this report and those who have contributed to it. Working together we can save more lives and reduce the devastation caused by sudden cardiac arrest.

Professor Jonathan Benger
National Clinical Director for Urgent Care, NHS England

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PATIENT TREATMENT IS IN PROGRESS
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MESSAGE FROM THE CHIEF INVESTIGATOR

The Out-of-Hospital Cardiac Arrest Outcomes (OHCAO) registry has now been in existence for five years. In this time we have collected data on nearly 134,000 cases of cardiac arrest where resuscitation was continued or commenced by Ambulance Service personnel. Data has been received from 9 Ambulance Services, borne out of the need to ensure all Ambulance Service Trusts report data to a uniform and consistent standard.

We would like to thank Ambulance Services, their medical directors, clinical audit staff and the ambulance crews for their continued support and providing the data, and the Ambulance Service staff and academics who serve as members of the project team and oversight committee.

The quality, quantity and comparability of information available on OHCAO in England continues to grow. This in itself represents a real achievement, and testifies to the value of cooperation and coordinated actions of the Ambulance Services. Facilitation of the submission of Ambulance Quality Indicators to NHS England and the expansion of the data set to include interventions which are critical to the chain of survival will hopefully lead to further improvements and completeness of data.

We are pleased that the findings from the OHCAO project last year were very useful to the Ambulance Services to highlight their performance in relation to the national picture. We remain committed to continuing to work with NHS England's National Clinical Directors to provide quality data on the epidemiology, process and outcomes from cardiac arrest.

Analysis of data within the registry has been presented at the European Resuscitation Council (ERC) annual congress in Bologna. Further papers have been published in peer-reviewed journals, and research continues to support BHF and RCUK's annual Restart a Heart Day.

A strength of hosting a national registry for cardiac arrest are the opportunities for collaboration with other research groups so that the information you collect is used effectively and widely for the benefit of patients. This has enabled continued UK participation in the European Registry for Cardiac Arrest (EuReCa) project. Members of the project team also attended an international meeting of worldwide cardiac arrest registries to discuss challenges faced in collecting, coding and analysing data, and consider possible opportunities for collaborative research. A summary of on-going collaborative work is included towards the end of this report.

This report is designed to be accessible to the general reader but also strategically focused to serve each participating Ambulance Service. Whatever your perspective, we hope that our collective work will increase your understanding of OHCA and inform future practise to improve patient outcome.

Professor Gavin Perkins
Chief Investigator
Out-of-Hospital Cardiac Arrest Outcomes Project

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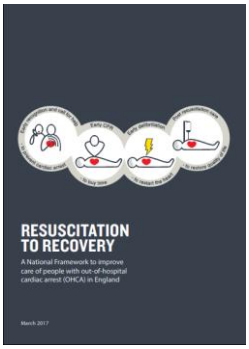
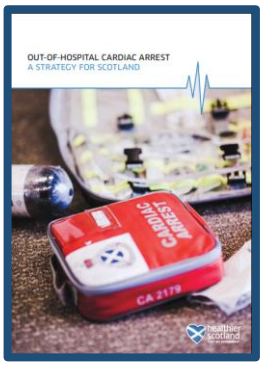
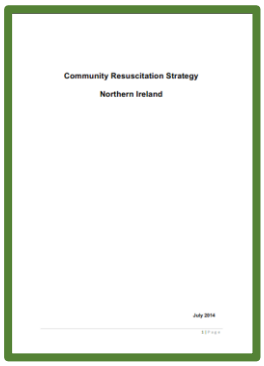
INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) is a significant public health issue in the UK. Every year there are over 40,000 OHCAs where resuscitation is commenced or continued by paramedics. Typically, less than 10% of OHCA patients survive to hospital discharge. However, if cardiopulmonary resuscitation (CPR) and defibrillation are provided quickly, alongside an effective system of care, the chances of an OHCA patient being resuscitated and having good neurological recovery increases significantly.

In order to improve systems of care and patient outcomes, it is essential to monitor performance, identify problems and successes and track progress. This can be achieved through a registry where all patients are enrolled to create a complete patient population. A registry can drive a quality agenda and fosters a culture of excellence in performance. Over the past five years UK Governments have produced OHCA plans that highlighted the need for a UK OHCA registry that gives Ambulance Services the ability to benchmark themselves against the rest of the UK. Currently, the Out-of-Hospital Cardiac Arrest Outcomes (OHCAO) registry receives data on OHCAs that occur in England, and is working towards the inclusion of Wales and Northern Ireland. Scotland is developing an independent registry that will collaborate with OHCAO.







In Seattle, a Resuscitation Academy developed a comprehensive 10 Step Programme to help increase survival that the Global Resuscitation Alliance has adopted. [5] The first step of this programme is to establish an OHCA registry that measures all aspects of resuscitation care and can act as a benchmark for the entire EMS system. “Measure improve, measure, improve…” defines the essence of ongoing quality improvement. If you don’t measure something you can’t improve it. And once you measure it you will reveal things that need improving. And once you improve the system, measure it again to see if it has improved. And so on, and so on. Measurement and improvement can apply to many elements of an EMS system. First and at the most basic level, it refers to measuring OHCA events and outcomes (death, survival, neurological recovery). But it also applies to components of the Emergency Medical Service (EMS) system such as time metrics (time for dispatch, time for response, time for scene arrival, time for patient arrival).

Continuous measurement will determine if implementing changes cause improvements and will identify further steps for improvement.

This is a summary report of the 2017 OHCAO data contributed by 9 Ambulance Service Trusts to the registry. These 9 Trusts serve a population of over 50 million, totalling an area of over 144,000km^2. About 18.0% of the population are aged under 15y, 25.6% are 15-34y, 38.4% are 35-64y, and 18.0% are 65y and over. We present an overview of the results of the epidemiology of cardiac arrest and the data completeness for key variables collected (data quality). The OHCAO registry includes OHCA patients of any age where resuscitation is commenced or continued by the EMS.

Since its conception, we have received details of 133,483 OHCAs from participating Ambulance Services. **Table 1** summarises the total annual number of cases submitted by all Ambulance Services to the registry.

Table 1: Summary of OHCA numbers submitted to the OHCAO registry

	2013*	2014	2015	2016	2017	**Overall**
Total number of cases in OHCAO registry	18,813	28,729	28,914	27,970	29,057	**133,483**

* 2013 data complete from April onwards

In some analyses we excluded data from individual Ambulance Services from the OHCAO Ambulance Service average, because the service does not currently collect that data, or the data is missing for other reasons (e.g. the proportion of missing cases in the data submitted is too large to reliably report the variable).

How Does OHCAO Operate?

The OHCAO registry was established in 2013 to investigate the epidemiology and outcome of OHCA, and explore sources of variation in outcome. The registry is maintained by the Clinical Trials Unit within the Medical School at the University of Warwick. It is overseen by a multidisciplinary Steering Committee, chaired by Dr Jasmeet Soar (Consultant in Intensive Care Medicine and Anaesthetics, North Bristol NHS Trust; Resuscitation Council (UK)). The OHCAO registry incorporates both prehospital clinical and operational data, and survival to hospital discharge. **Table 2** lists all Ambulance Services who submitted data to the registry in 2017.

Table 2: Participating Ambulance Service
East of England Ambulance Service NHS Trust
East Midlands Ambulance Service NHS Trust
London Ambulance Service NHS Trust
North East Ambulance Service NHS Foundation Trust
North West Ambulance Service NHS Trust
South Central Ambulance Service NHS Foundation Trust
South East Coast Ambulance Service NHS Foundation Trust
South Western Ambulance Service NHS Foundation Trust
West Midlands Ambulance Service University NHS Foundation Trust

Eligibility

The OHCAO registry captures data on OHCA patients of all ages attended by the EMS, and where resuscitation was commenced or continued by paramedics.

The OHCAO registry has the following inclusion/exclusion criteria.

Inclusion criteria:

- Patients of all ages who suffer a documented cardiac arrest;
- Resuscitation is continued or commenced by EMS.

Exclusion criteria:

- Patients who suffer a cardiac arrest in a hospital facility where the Ambulance Service may be in attendance;
- Patients who suffer a cardiac arrest whilst being transferred between hospitals;
- Clear evidence of death defined by the Joint Royal College Ambulance Liaison Committee (JRCALC) recognition of life extinct (ROLE) criteria on arrival of EMS[6];
- Bystander suspected a cardiac arrest, where the patient is not in cardiac arrest on arrival of EMS, or no defibrillation prior to arrival, or no other evidence verifying a cardiac arrest state is present;
- Patients that achieve a return of spontaneous circulation (ROSC) prior to the arrival of EMS are not included in the registry unless they subsequently re-arrest in the presence of paramedics.

Ambulance Services in the UK follow the JRCALC guidelines for cardiac arrest resuscitation. Resuscitation is not started if the patient's condition is unequivocally associated with death, the presence of a DNACPR (Do Not Attempt CPR) order or an

Advanced Directive (Living Will) that states the wish of the patient not to undergo attempted resuscitation, patient's death is expected due to terminal illness, or submersion of adults for longer than 1 hour (1½ hours for children).

Cardiac arrest (CA) is usually defined as, "…the cessation of cardiac mechanical activity, confirmed by the absence of a detectable pulse, unresponsiveness and apnoea (or agonal gasping respirations)". An OHCA is described as a sudden CA (SCA), where the CA is unexpected and without obvious warning signs. In cases of SCA, the circulation of blood and oxygen suddenly ceases due to the loss of mechanical heart function. The patient momentarily loses consciousness and inevitably dies if no resuscitation attempts are made.

DATA CAPTURE

The registry is based on the internationally recognised Utstein template and definitions. [7]

Participating EMS routinely collect source data from the 999 call to hospital transportation via Patient Report Forms (PRFs), as well as data related to survival status at hospital discharge. Each Ambulance Service has their own methods for case ascertainment, e.g. screening paper or electronic PRF databases for OHCA case records, dispatch codes, or related clinical or treatment terms. Identified cases are entered into a cardiac arrest database, cleaned and verified by trained members of the EMS clinical audit team. If the patient is conveyed to hospital the EMS collect data on survival at hospital discharge status directly from hospital emergency departments if data sharing protocols are in place. The data are uploaded by each service to the secure OHCAO server, transformed using service-specific rules and securely stored in the OHCAO registry at the University of Warwick.

Data submitted is divided into three type:

- Priority: Occurrence witness; Bystander CPR; Public Access Defibrillator Used; Initial Rhythm; ROSC at any time, ROSC at hospital handover; Survival to hospital discharge
- Core: Patient Details; Date/time of event; Event location; Aetiology; Receiving hospital; Ambulance Stop time
- Supplementary: Other information covering event including interventions, airway management, outcome and process.

Full details of the variables can be found at: https://warwick.ac.uk/fac/sci/med/research/ctu/trials/ohcao/health/data/#Dictionary

DATA QUALITY

The OHCAO registry undergoes data quality control to ensure the accuracy of the data collected. Data quality checks are carried out at various stages within the registry. At the point of data upload the validity of the data are checked against the agreed mapping and transformation criteria to ensure the data supplied fits that stored within the registry. A new process has been put in place to carry out regular audits and quality control checks of the data throughout the year for services that supply data at regular intervals, rather than a whole year's data in September. Any queries with the data are immediately referred back to the relevant service. This process will change once the Ambulance Quality Indicator submission process is running smoothly.

In September every year, when the previous year's data is expected to have been uploaded, our statistician runs a series of logic checks on the data to ensure that it is correct, e.g. using the date of birth to calculate age and comparing it to the stated age.

MISSING DATA

The value of the OHCAO registry relies on the completeness of data capture. Missing data for WMAS remains relatively low for all core and priority variables (**Table 3**). However, there is still room for improvement. Periodic quality control checks and data verification activities ensure the long-term validity of registry data.

Table 3: Number and proportion of missing data for select registry variables, 2017

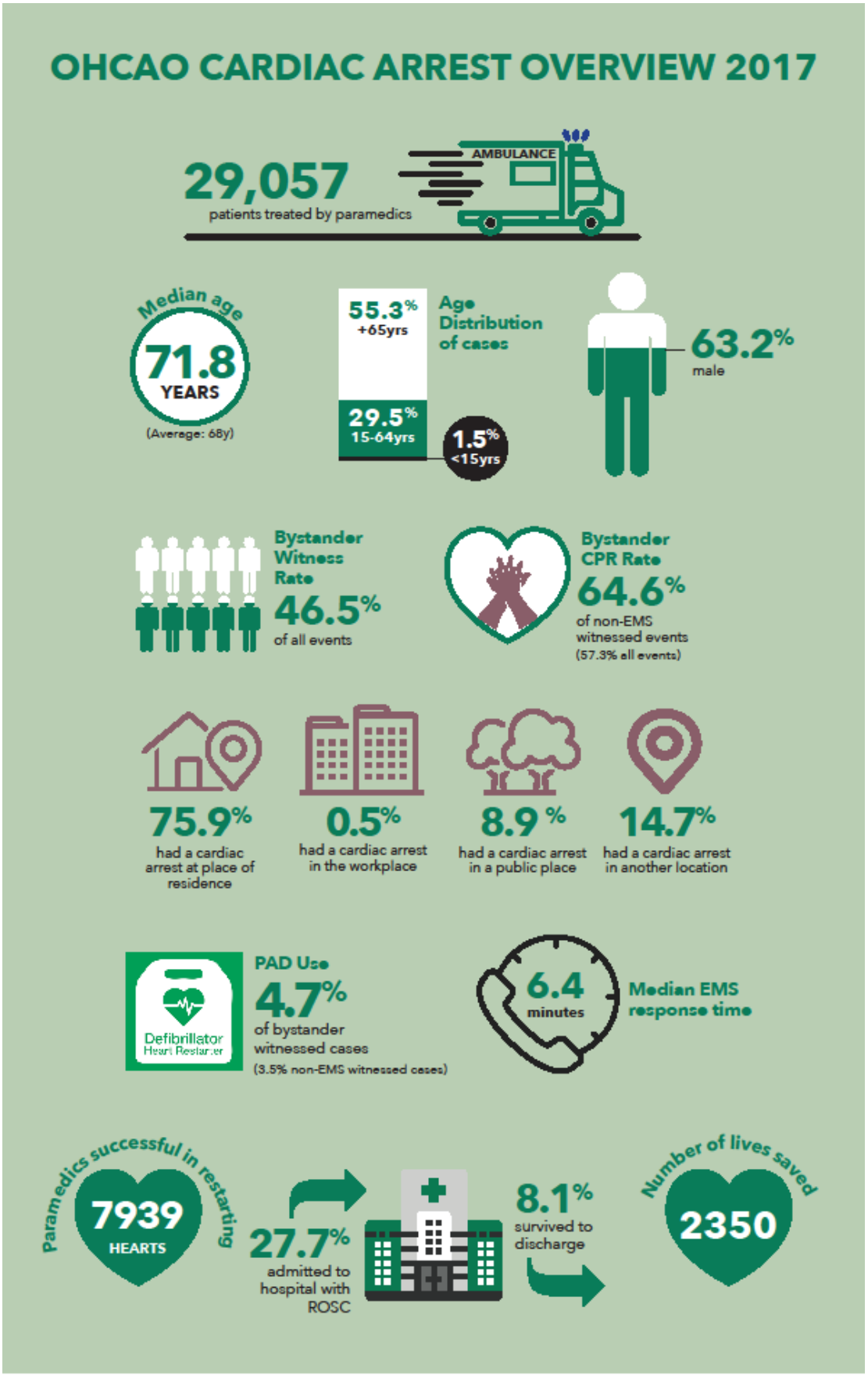
	National (29,057)
Patient age	3,977 (13.7%)
Patient sex	172 (0.6%)
Arrest location	10,072 (34.7%)
Witnessed status	2,278 (7.8%)
Bystander CPR	1,900 (6.5%)
Rhythm on arrival	738 (2.5%)
EMS response time	3,512 (12.1%)
Outcome at scene (ROLE)	5,838 (20.1%)
Event survival	1,814 (6.2%)
Hospital discharge status	1,814 (6.2%)

ETHICAL REVIEW

In accordance with Information Governance the OHCAO registry has approval from the NHS Medical Research and Ethics Committee (MREC) and Confidentiality Advisory Group (CAG) to receive data without consent.

The National Research Ethics Service granted ethics approval, reference number 13/SC/036. The study has also received approval from the CAG Ethics and Confidentiality Committee, reference number ECC8-04(C)/2013, which provides authorisation, on behalf of the Secretary of State, to lawfully hold identifiable data on patients where it is not practical to obtain consent. The study complies with the common law of duty of confidentiality owed by health professionals in regard to information provided by patients in the course of clinical care, and the principles of the General Data Protection Regulation. The project has received approval from the CAG for permission to implement Section 251 of the NHS Act (2006) originally enacted under Section 60 of the Health and Social Care Act 2001), which allows identifiable patient information to be used without consent in very specific circumstances. The CAG approval also provides the Steering Committee with the authority to provide other researchers access to anonymised data in specific circumstances.

AMBULANCE SERVICE DATA 2017


OHCAO CARDIAC ARREST OVERVIEW 2017
29,057
patients treated by paramedics
AMBULANCE
Median age
71.8
YEARS
(Average: 68y)
55.3%
+65yrs
Age Distribution of cases
29.5%
15-64yrs
1.5%
<15yrs
63.2%
male
Bystander Witness Rate
46.5%
of all events
Bystander CPR Rate
64.6%
of non-EMS witnessed events
(57.3% all events)
75.9%
had a cardiac arrest at place of residence
0.5%
had a cardiac arrest in the workplace
8.9%
had a cardiac arrest in a public place
14.7%
had a cardiac arrest in another location
Defibrillator
Heart Restarter
PAD Use
4.7%
of bystander witnessed cases
(3.5% non-EMS witnessed cases)
6.4
minutes
Median EMS response time
Paramedics successful in restarting
7939
HEARTS
27.7%
admitted to hospital with ROSC
8.1%
survived to discharge
Number of lives saved
2350

INCIDENCE AND DEMOGRAPHICS

The English Ambulance Service serves a population of over 55 million people, with individual Ambulance Service populations ranging from about 2.6 million to nearly 9 million. Approximately 18% of the population is under 15 years of age and a similar proportion are aged 65 years or older. The land area covered by each service ranges significantly from 620mi^2 (London) to 20,000mi^2 (South Western).

Every year about 60,000 people sustain an OHCA in England and are attended by the EMS. Resuscitation is attempted in less than half of these, with non-resuscitation decisions being undertaken according to national guidance. [6]

Internationally, cardiac arrest survival rates vary widely from 0.6% to 25%. [8,9] In the UK survival to discharge rates have been reported at 7.9%. [10] Increasing the reported UK survival rates to a level comparable with the best performing systems could save 1,000 lives a year. [11]

For the period 1 January 2017 to 31 December 2017, a total of 29,057 OHCAs were attended by the various EMS; this figure is based on data from 9 English Ambulance Services. This is an increase of about 3.3% on the 2016 figure of 27,970 which was also based on data from 9 services. In the registry an OHCA is defined as one where resuscitation was commenced or continued by the EMS.

During 2017 9 Ambulance Services treated 29,057 OHCA cases, a 3.3% increase on the 2016 figure of 27,970

Incidence of all adult & paediatric events

Approximately 84.7% of OHCA events were defined as adults aged greater than 15 years (55.3% greater than 64 years), and 1.5% less than 15 years. Age could not be calculated for 13.7% of events

The crude incidence of OHCA has increased by about 10 cases per 100,000 over the lifetime of the registry. In 2017, the unadjusted incidence was 65.8 OHCA events per 100,000 population (**Figure 1**). Compared to 2016, the incidence has decreased by about 19% in paediatrics but increased by 4.5% in adults (increased by 3.3% overall).

Over the four years, the incidence of adult events (2017: 68.0 per 100,000) has increased by about 6 cases, but for paediatric events (2017: 5.6 per 100,000) decreased by about 2 cases.

The age-adjusted incidence was 60.7 per 100,000 (based on data from 8 services). Age standardisation is a technique for comparing populations where the age profiles are different. Age-adjusted rates are those rates that would exist if the population in a given year had the same age distribution as the standard population. In this case we have used the 2013 European Standard Population. [12] Age-adjusted incidence rates over the last 4 years have been relatively stable. The age-adjusted OHCA incidence rates for males and females during 2017 was 84 and 41 events per 100,000, respectively.

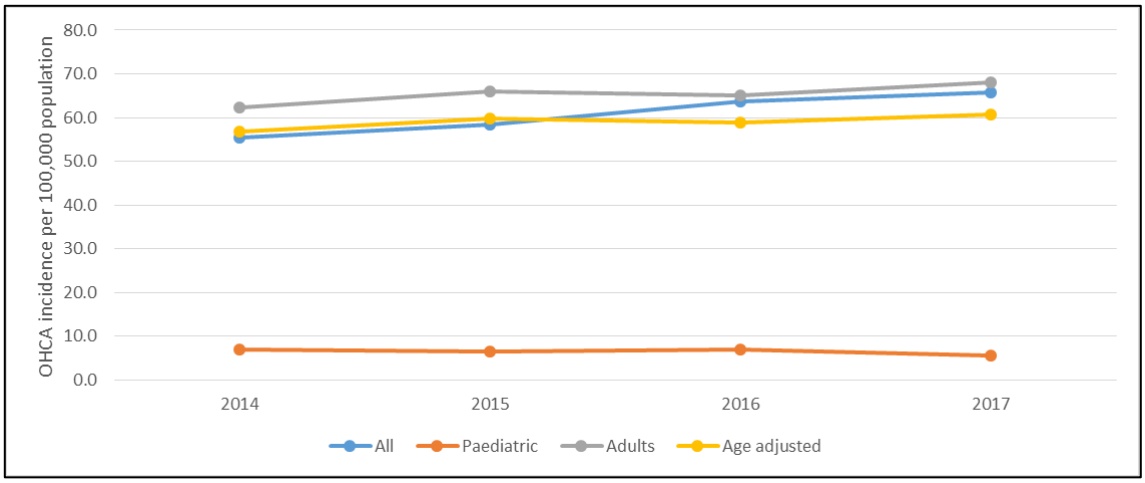


Figure 1: Crude incidence of all ages, adult and paediatric EMS-attended OHCA in England, and age-adjusted incidence rates of EMS-attended events (includes EMS-witnessed events).

Incidence across Ambulance Services

Figure 2 compares the incidence of OHCA events submitted to the OHCAO registry across the Ambulance Services (anonymised) between 2014 and 2017. Figures in 2014 and 2015 for some services are inaccurate because data was only submitted for part of that year. **Figure 2a** shows the crude incidence and **Figure 2b** the age-adjusted incidence. The figures clearly shows a significant variation in incidence between the services, with AS05 having the higher incidence and AS02 the lowest.

Figure 2: Crude (**2a**: top) and age-adjusted (**2b**: bottom) incidence of EMS-attended events across Ambulance Services.

Incidence across England

In 2017, data from 6 services indicated that about 85% of OHCA events across the country occurred in urban areas. The crude incidence in urban areas (62.3 per 100,000) was higher than that in rural areas (60.0 per 100,000) (**Figure 3**).

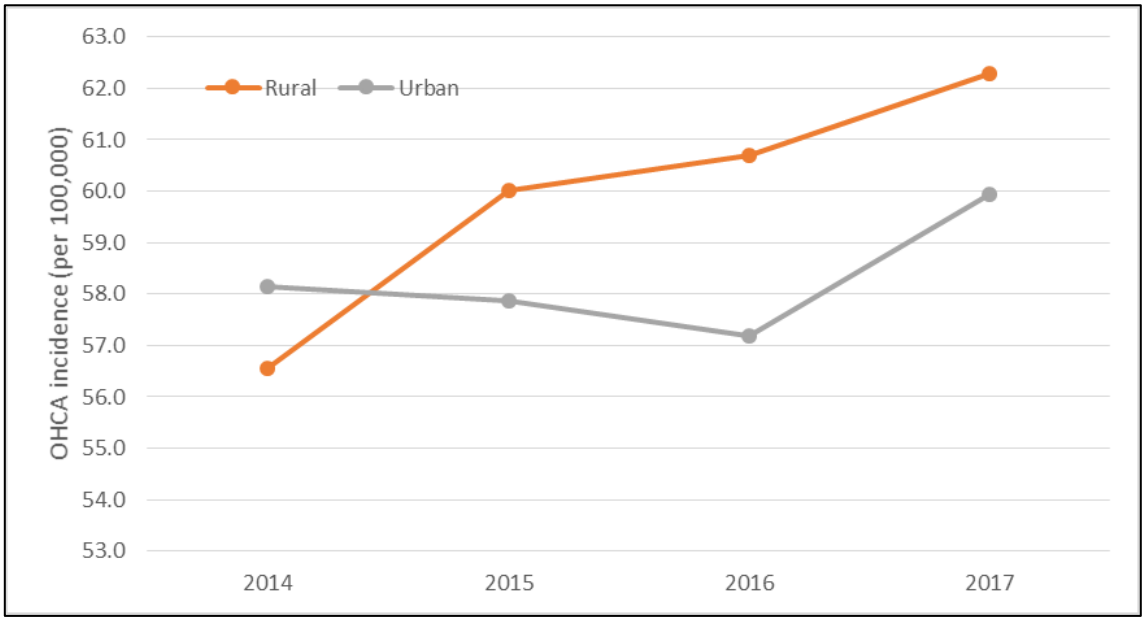


Figure 3: Yearly crude incidence of EMS-attended events across urban and rural regions of England (includes EMS-witnessed events)

Demographics of adults

The demographic profile of adult OHCA events has been consistent over the past four years in England. Attended events were predominantly male (63.3%). The median age of patients was 72.2 years. The age distribution varied significantly across the sexes (**Figure 4**), with females having a higher median age of arrest than males (75.9 vs. 70.2 years). The proportion of cases that were witnessed by a bystander was 46.8%, and the proportion in a public location was about 7% (based on data from 6 services). The proportion of adult patients receiving bystander CPR was 57.2**%** (72.8% of bystander witnessed cases) which compared to 55.0% (62.3%) in 2016. In 2017 20.3**%** of adult OHCAs in WMAS presented in a shockable rhythm (ventricular fibrillation [VF] or ventricular tachycardia [VT]) to either EMS or a bystander who made use of an automated external defibrillator (AED).

1.5% of OHCA patients were aged <15-years;
29.4% were aged 15-64-years;
55.3% were aged 65-years and over;

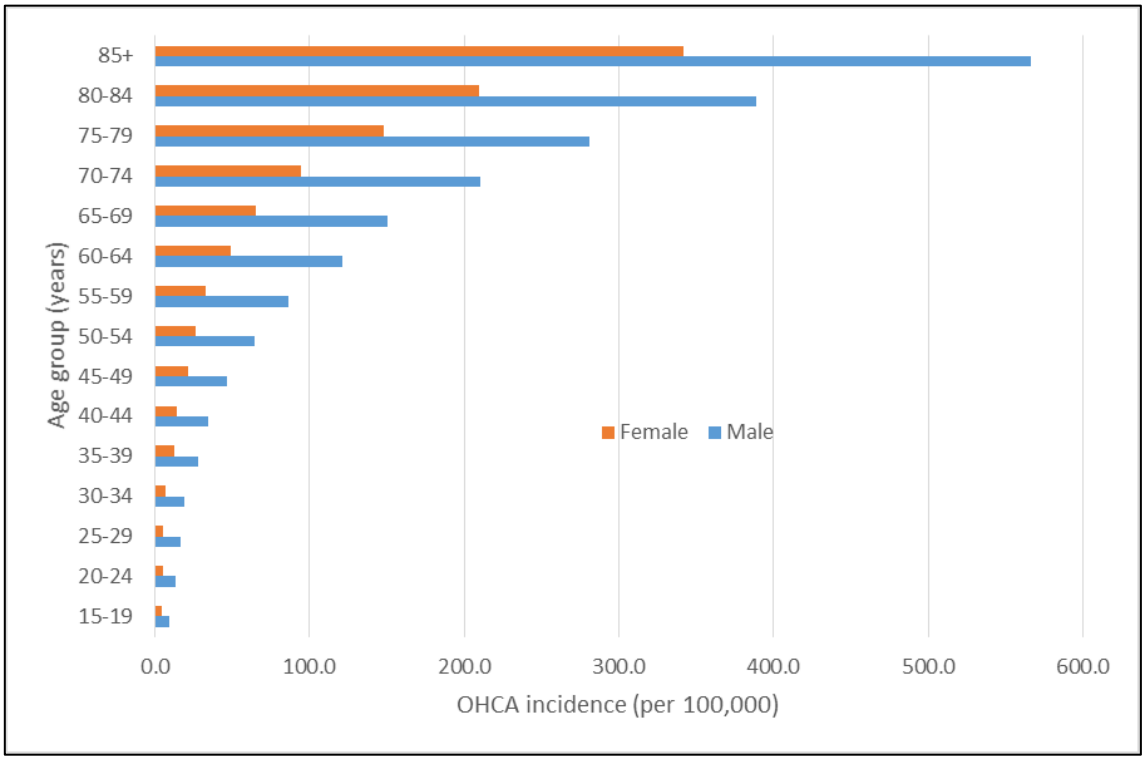


Figure 4: Age distribution of EMS-attended adult OHCA events, 2017

About 63% of the OHCAs treated were male

Demographics of paediatrics

The frequency of EMS attended paediatric events has remained relatively low over the last four years, with about 500 events per year (450 in 2017). The median age of arrest was 7.4 months, which is similar to previous years. During 2017, 63.6**%** of paediatric OHCA events occurred in children aged less than three years.

The demographic profile of paediatric OHCA varies significantly across reporting years because of the small sample size. Attended events were predominantly male (54.2%).

About 85 of events occurred in the home. Significantly more paediatric patients received bystander CPR than adult patients during 2017 (60.7% of all cases, 68.7% of bystander witnessed cases). The majority of paediatric patients presented in asystole (70.2**%**); only 6.0% in shockable rhythm. In 2017, 7 paediatric patients were defibrillated prior to the arrival of EMS with a public AED; 110 (24.4%) patients were admitted to hospital with ROSC and 298 (66.2%) with ongoing resuscitation; 39 (8.7%) survived to hospital discharge.

In 2017, Ambulance Services attended 450 paediatric events
Median age was 7.4 months

Precipitating events for adults

The precipitating causes of OHCA events for adults are defined by paramedics and recorded directly from the patient care records. The aetiology of OHCA is presumed to be of cardiac origin, unless it is clearly described as trauma, drowning, drug overdose/poisoning, asphyxia, exsanguination, electrocution, or other (non-cardiac). [13]

In 2017, 83.4% of adult OHCAs receiving attempted resuscitation by EMS were presumed to be of cardiac cause (**Figure 5**). Other frequent causes were: trauma (2.5%) and asphyxia (2.9%).

The precipitating event for arrests across age groups is given in **Figure 6**. The graph clearly demonstrates the relationship between arrest aetiology and patient age. Presumed cardiac cause was the predominant precipitating event for all age groups; 35-64 years (80.2%), 65-84 years (89.1%), 85+ years (89.8%). However, in the 15-34 years age group, the precipitating events for trauma (16.2%), drug overdose (10.9%) and asphyxia (15.7%) were significantly higher than in the older age groups. In this age group, presumed cardiac cause was still the main precipitating event for 47.0% of OHCA events. There are only a few OHCAs due to drug overdose/poisoning, trauma or hanging in the older age groups.

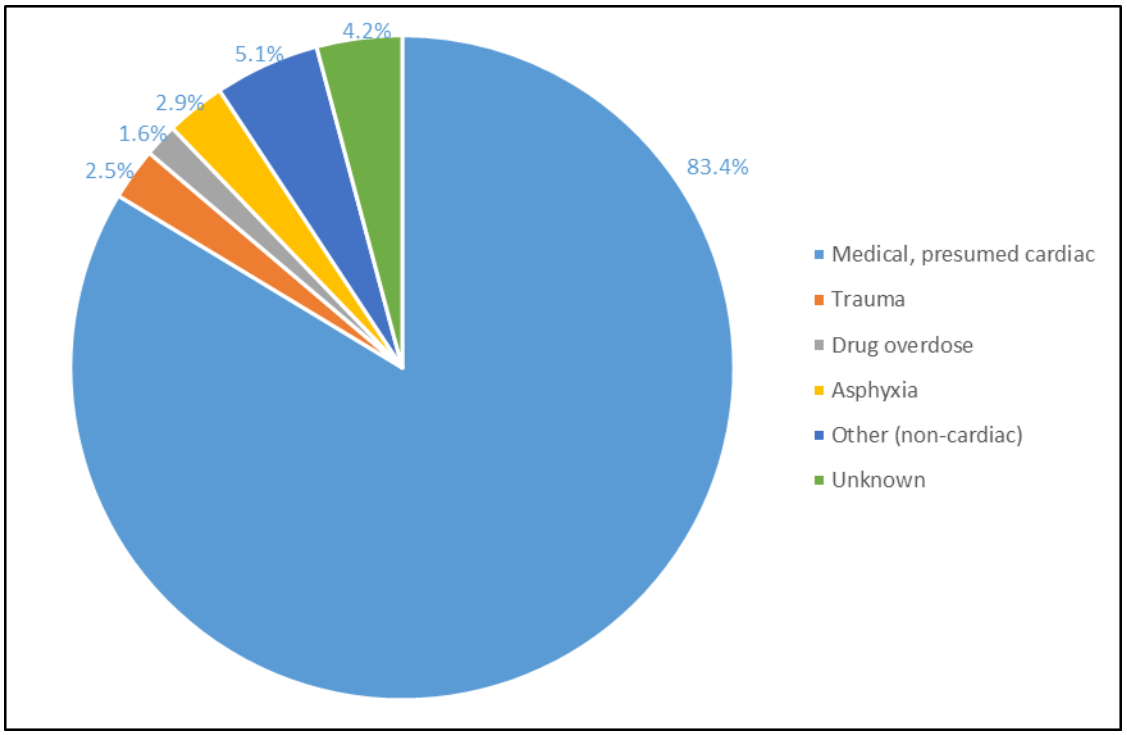


Figure 5: Adult precipitating events for EMS-attended events

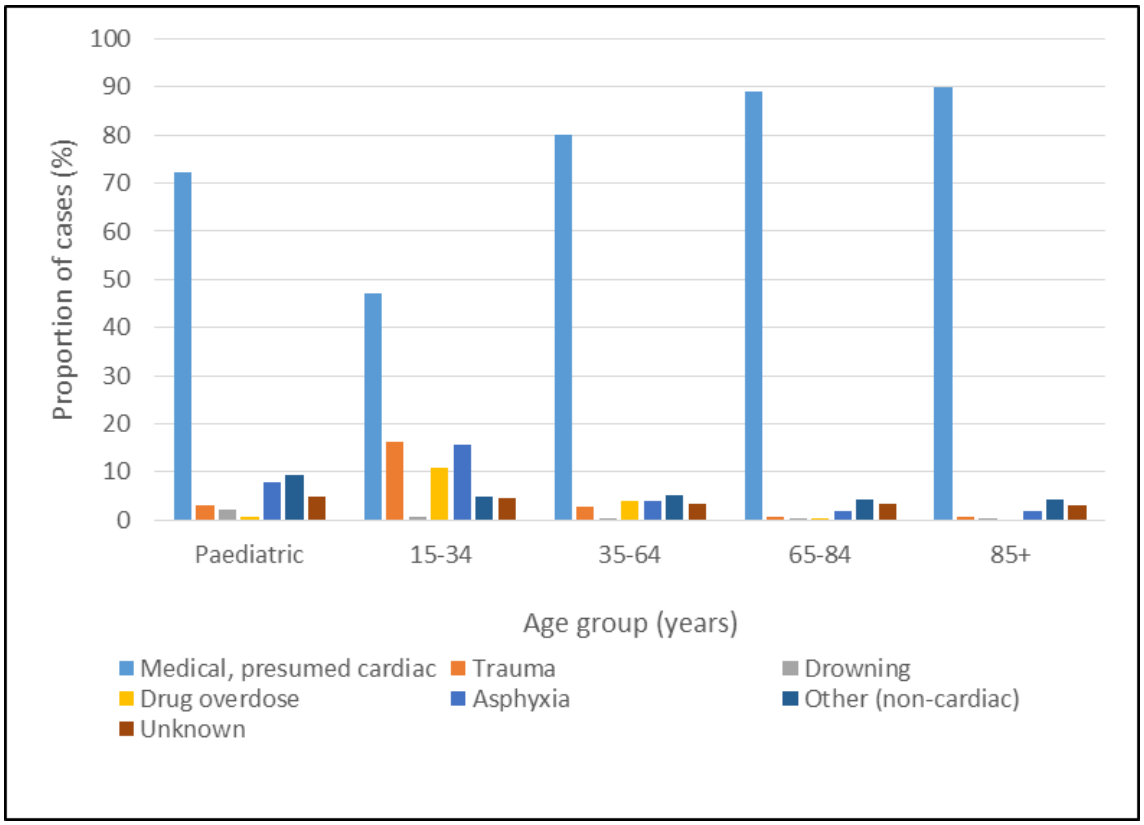


Figure 6: Precipitating events across age groups for EMS-attended events

Precipitating events for paediatrics

The pattern of precipitating events for paediatrics who suffer an OHCA is completely different from that of adults (**Figure 6**). In 2017, 72.2% of EMS-treated paediatric events were due to a presumed cardiac cause. Other precipitating events included: trauma (3.0%), drowning (2.1%), drug overdose (0.7%), asphyxia (7.9%), and other non-cardiac cause (9.3%). The proportion of cases in the latter category is significantly higher than in other age groups.

Other registries have shown that respiratory illness and sudden infant deaths syndrome (SIDS) are a dominant cause of paediatric OHCAs (about 25%). [14] Previous research of traumatic paediatric OHCA events have shown that resuscitation efforts were rarely effective and associated with poor neurological outcomes for the patient. [15,16]

Arrest location for adults and paediatrics

The location of where an OHCA event occurs has an impact on the likelihood an OHCA event is witnessed and whether the patient will receive bystander CPR[17], and has important implications on outcome. The OHCAO registry collects information on the exact location of the OHCA (address) and the Utstein location. [7] Utstein lists 9 potential

OHCA locations. However, the quality of the data provided by each Ambulance Service is variable. **Figure 7** presents the Utstein location for events in OHCAO in 2017, for adults from 6 services. Significantly more paediatric (86.0%) cases were confirmed to have occurred in private residences, compared to adult (75.9%) cases. However, only 4.5% of paediatric cases occurred in a public place compared to 9.6% of adult cases; the latter including places of work, streets or roads, shops, vehicles, sporting/recreational facilities and public buildings.

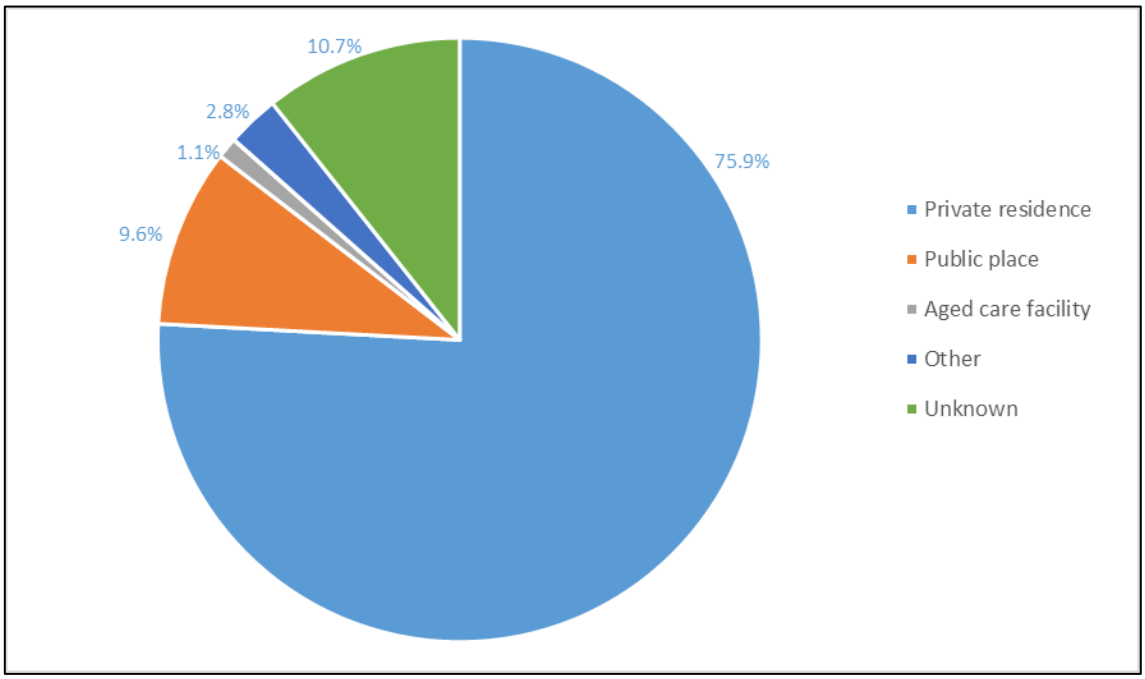


Figure 7: Location of arrest for EMS-attended adult events

Figure 8 shows the proportion of cases that were bystander witnessed, received bystander CPR, achieved ROSC at hospital handover and discharged alive by location. The presence of bystanders, witnessing the arrest and/or providing CPR, in public places has an important role on survival for adult events occurring in these locations. In comparison to arrests in private residences, patients who arrested in public places were significantly more likely to be witnessed by a bystander (64.7% *cf* 48.0%) and receive bystander CPR (75.0% *cf* 58.7%) prior to EMS arrival. Subsequently, they were more likely to be admitted to hospital with ROSC (survived event; 36.8% *cf* 27.7%) and be discharged alive (16.0% *cf* 7.1%). OHCA events in schools (adults and children) were even more likely to be witnessed (80%), and receive bystander CPR (80%) as those that occurred in public places. They were also much more likely to be discharged alive (40%); however, numbers were small.

OHCA events in aged care facilities had a 55% chance of being witnessed but the greatest chance of receiving bystander CPR (82.3%). Nevertheless, although about 25.1% survived the event, they had a poor prognosis, only 4.2% being discharged alive.

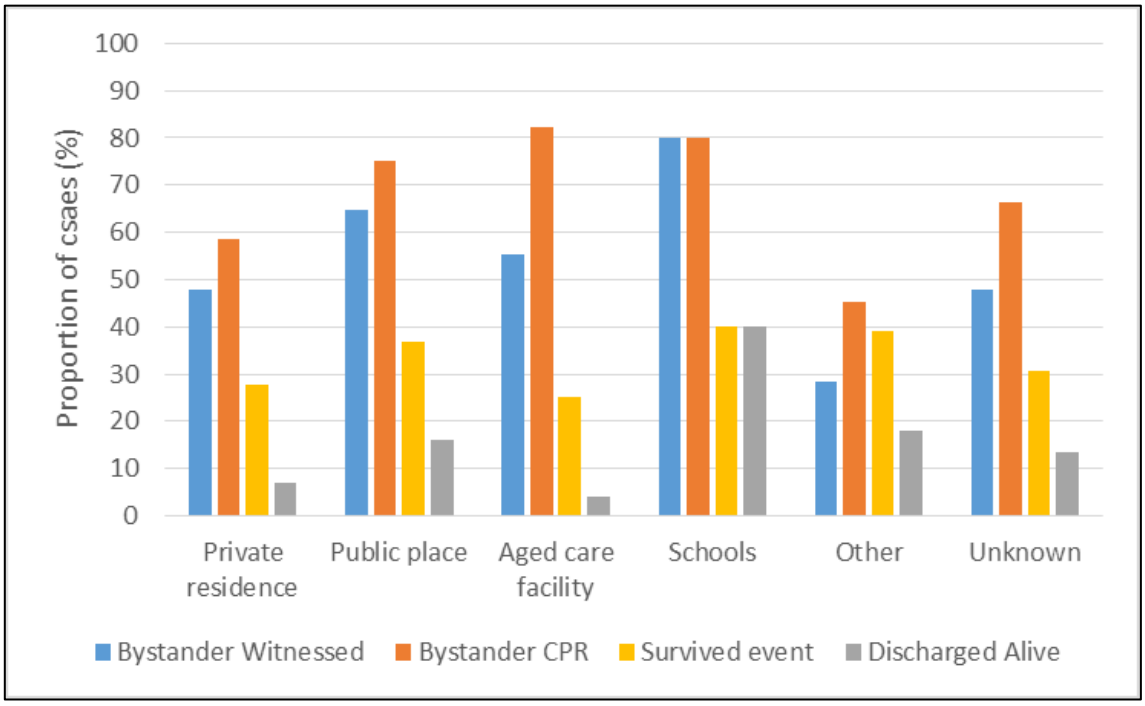


Figure 8: Proportion of EMS-treated adult events that are bystander witnessed, receive bystander CPR and are discharged alive across arrest locations

CHAIN OF SURVIVAL

The next section presents key performance information under the theme of the Chain of Survival. The Chain of Survival was first introduced over 40 years ago. [18] It describes a sequence of four steps that, when all are in place, optimises the chance of survival (**Figure 9**).

1. Early access and recognition: being able to recognise someone is in cardiac arrest and getting assistance;
2. Early CPR: performing chest compressions can keep their heart going until a defibrillator arrives;
3. Early defibrillation: for every minute the patient doesn't have a defibrillator attached to their chest, their chances of survival reduces by 10%. [19] Early defibrillation can triple a person's chances of survival;
4. Early advanced care: delivered by the paramedics who arrive shortly after arrest. If you start CPR within 2 minutes, place a defibrillator on their chest in four minutes and a paramedic arrives in 8 minutes, they have a 40% chance of survival.

Figure 9: Chain of survival

Bystander call for help

The NHS Ambulance Response Programme (ARP) showed that only 0.6% of 999 calls are for cardiac arrest, highlighting that this is a rare event that can be difficult to detect on the basis of limited information from a telephone call. [3,20] As the likelihood of survival is significantly associated with the ambulance response time[10,21], it is imperative that the dispatcher is able to identify an OHCA as soon as possible and assign an ambulance to respond. Results from the ARP indicated that the majority of OHCA calls (68%) were assigned to the descriptor Red1. However, recently it was shown that systems could not identify an OHCA correctly in 25% of cases, which equated to about 7,500 treatable OHCAs in the UK per year[22], although inaccurate information being passed to the dispatcher by a third party may have been responsible for false negative OHCAs subsequently deteriorating to OHCA after triage. [23] A bystander witnessing an OHCA event and subsequently calling the dispatcher must provide accurate information to help identify the patient is suffering an OHCA and influences the timing of dispatcher-assisted CPR instructions and response of EMS.

Emergency response to the incident

The distribution of response times for OHCAs in 2017 is presented in **Figure 10**. Events that were witnessed by the EMS were assigned to have a response time of 0 minutes. The median response time for EMS-treated events was 6.4 minutes (90th percentile time 14.6 minutes; non-EMS-witnessed events: median=6.4 mins; 90th percentile=15.8 mins).

The overall response time is no different from that in 2016, but that for non-EMS-witnessed cases is faster. (All cases: median time 6.4 mins, 90th percentile 14.2 minutes; non-EMS-witnessed cases: median time 7.0 mins, 90th percentile 15.0 mins). Improvements have been observed in the face of increased demand across all services.

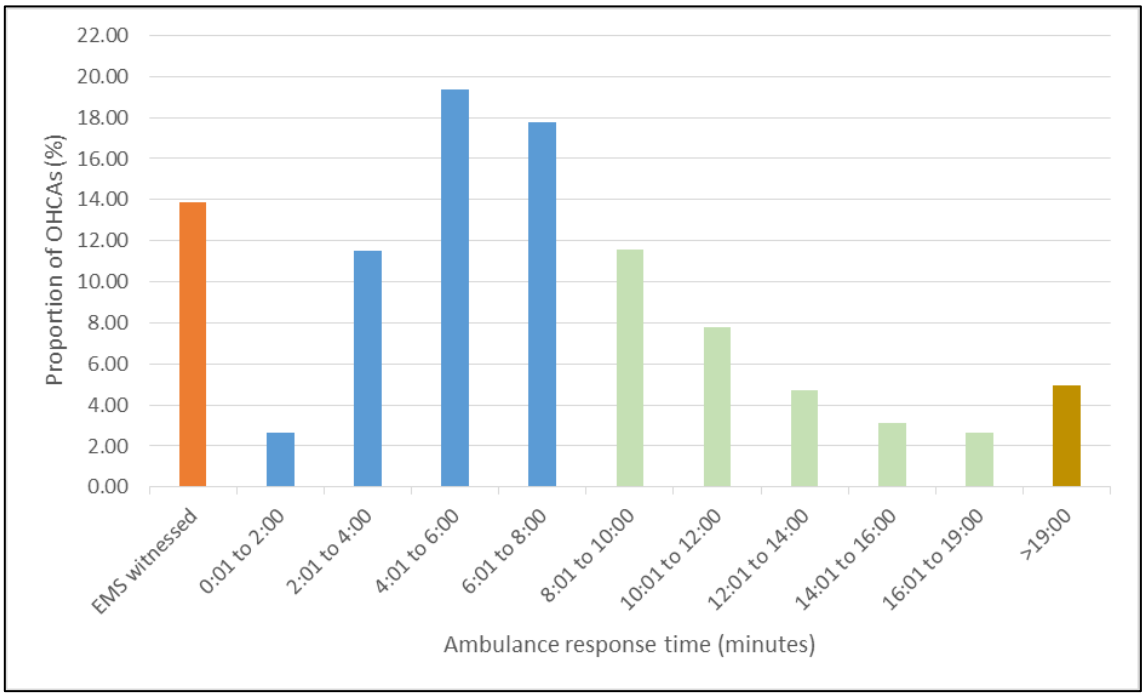


Figure 10: Distribution of time from call to arrival of EMS on scene (ambulance response time in EMS-treated population).

EMS arrived within 8-minutes of 999 call for 65.2% of patients
The median response time was 6.4 minutes

Figure 11 shows the distribution of response times for OHCAs that occurred in urban areas compared to rural areas of England. It clearly shows cases in urban areas are reached sooner than those in rural areas. The respective median response times were 6.2 minutes (90th percentile=13.1 mins) and 9.5 minutes (90th percentile=20.3 mins). Considering only those events that were not witnessed by EMS the respective median response times were 7.0 and 10.7 minutes.

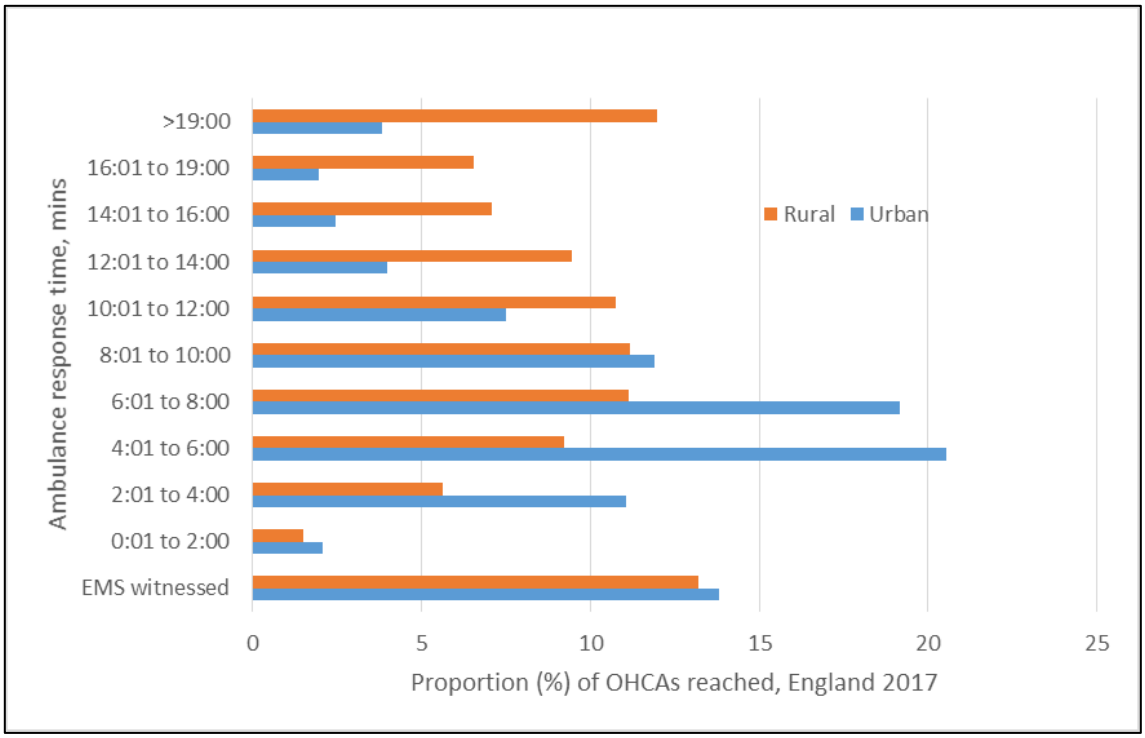


Figure 11: Comparison of ambulance response times between urban and rural OHCAs.

Bystander CPR

Previous research clearly shows that in bystander witnessed events effective bystander CPR increases the likelihood of an initial shockable rhythm and improves the chances of achieving ROSC at hospital handover, and survival to discharge. [24]

Over the lifetime of the OHCAO registry significant increases in bystander CPR rates have been observed in England and shows the impact the various campaigns and initiatives, like Restart a Heart Day, have had. [25,26] Of all the 2017 events in England, 59.8% of patients received CPR performed by bystanders (**Figure 12**). Of those events that were witnessed by a bystander, 72.8% received bystander CPR, compared to 70.0% of patients in 2016 and 63.6% in 2015.

Figure 13 shows unadjusted survival outcomes after bystander CPR in bystander witnessed events. Although the proportion of cases that survived the event (ROSC at hospital handover) was not statistically different between those that had received bystander CPR and those that had not, survival to hospital discharge was significantly higher in those that had received bystander CPR (ROSC at hospital handover 36.0% *cf* 32.8%; Survival to hospital discharge 11.7% *cf* 6.9%).

The proportion of cases who received bystander CPR was 59.8% of all cases, and 68.1% of non-EMS-witnessed cases

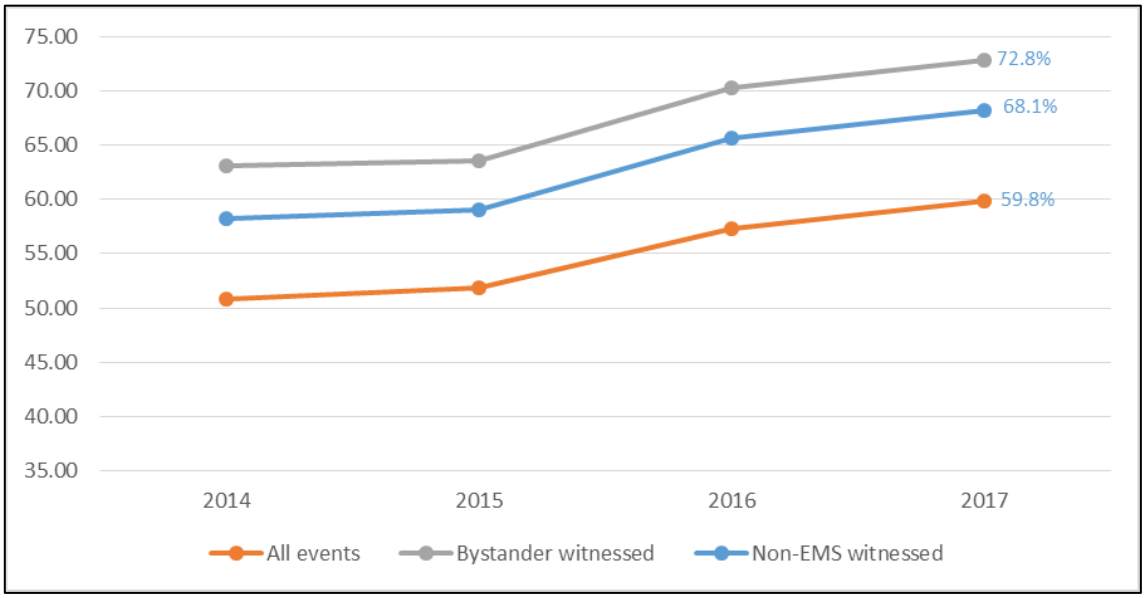


Figure 12: Bystander CPR rates in EMS-treated events

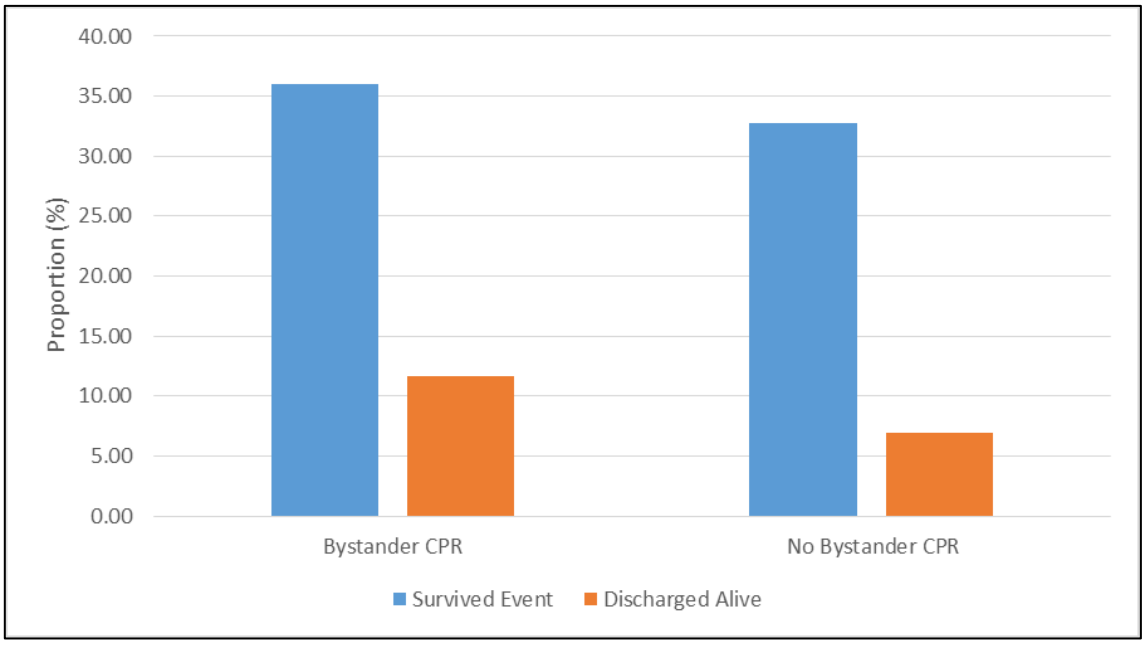


Figure 13: Unadjusted survival outcomes after bystander CPR in the EMS-treated population, 2017.

Impact of bystander on OHCA

Bystanders play an important role in improving OHCA survival. Three of the four steps of the OHCA chain of survival can be carried out by bystanders. Typically, bystanders are the first on the scene and make the emergency call (early access). With the help of the dispatcher, or if skilled through prior CPR training, bystanders can start CPR prior to the arrival of EMS. If an AED is located near the location of the arrest, bystanders have the opportunity to provide vital defibrillation prior to the arrival of EMS. Bystander witnessed OHCA events tend to have more positive survival outcomes.

An overview of the impact of bystanders is given in **Table 4**. Bystander CPR rates were higher among patients whose arrest was witnessed by a bystander, compared to all OHCA patients (72.1% vs 57.3%, respectively), and also higher than in those cases that were not witnessed at all (56.2%). Bystander witnessed cases were also significantly more likely to present in a shockable rhythm, over 2.6 times than not witnessed cases. Patients presenting in a shockable rhythm were also more likely to have been witnessed by a bystander (65.1%).

When an arrest was witnessed by a bystander, the proportion of patients who were transported to hospital with ROSC (survived event; 34.3%) was higher than for all OHCAs combined (27.3) and those that were not witnessed (15.7). Similarly, the proportion of patients who survived to discharge alive was higher (10.1% *cf* 8.1% and 2.9%).

Table 4: Number and proportion of patients receiving bystander CPR or defibrillation and unadjusted survival, for all and bystander witnessed events.

	OHCAO registry		
	All events	Bystander witnessed	Not witnessed*
Total events	**29,057**	**13,506**	**12,075**
Bystander CPR	16,657 (57.3%)	9,735 (72.1%)	6,789 (56.2%)
Bystander AED use	907 (3.1%)	635 (4.7%)	261 (2.2%)
Shockable rhythm	5,835 (20.1%)	3,714 (27.5%)	1,259 (10.4%)
Survived event[$]	7,939 (27.3%)	4,628 (34.3%)	1,892 (15.7%)
Discharged alive[ɣ]	2,350 (8.1%)	1,369 (10.1%)	354 (2.9%)

* includes not witnessed, unobtainable, unknown and missing

[$] 1 service did not provide complete data, the respective proportions for remaining 8 services were: 29.1%, 35.2%, 17.6%

[ɣ] 1 service did not provide complete data, the respective proportions for remaining 8 services were: 8.7%, 10.4%, 3.4%

NB Only 5 services provided complete data for AED use, the respective proportions for these are 4.6%, 6.5% and 3.6%

Public access defibrillation was indicated to have been used in 3.1% of all patients,
(3.5% of non-EMS-witnessed cases)

Transport to PCI-capable hospital

Approximately 46.5% (n=13,499) of OHCAO cases were transported to hospital, of which 58.8% had already achieved ROSC, and 41.2% with ongoing CPR.

Previous research has shown that transport of OHCA patients to a percutaneous coronary intervention (PCI)-capable hospital is associated with improved survival to hospital discharge. [27,28] There are a number of hospitals within each service that, according to the British Cardiovascular Intervention

Society Adult Interventional Procedures Audit Report, offer PCI. [29]

Across the country in 2017, 47.6% of all EMS-treated cases transported to hospital were conveyed to a PCI-capable hospital. Slightly more of cases due to a presumed cardiac cause were transported (48.4%). Slightly more cases in rural areas were transported to PCI-hospital than in urban areas (48.8% *cf* 44.6%). Over the past five years there has been about an 8% increase in the numbers.

On average, PCI-transported cases are about 1.6-times more likely to survive to hospital discharge (22.5% compared to 13.8%) (**Figure 14**). However, it is possible that other hospital-based factors contribute to the variation in outcomes observed across hospitals, including optimal post-arrest treatment regimes.

Survival of cases transported to non-PCI-capable hospitals has remained static, whereas an increased has been observed in cases transported to PCI-capable hospitals.

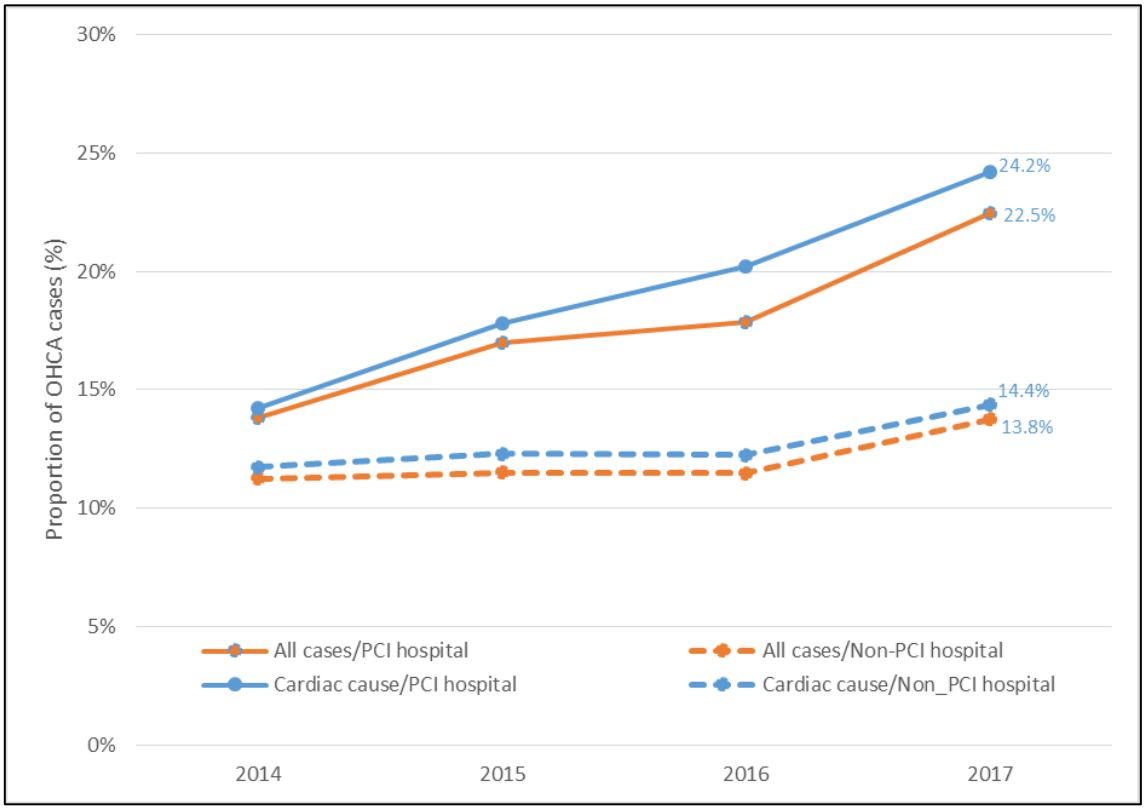


Figure 14: Unadjusted survival to hospital discharge for adult presumed cardiac EMS-treated events according to transport to a PCI-capable hospital.

SURVIVAL OUTCOMES

Scene outcomes in adults

Successful attempts at resuscitation following OHCA have been evaluated by the attainment of ROSC in the field and subsequent transport to hospital.

During 2017 the achievement of ROSC was highest amongst patients who arrested in the presence of EMS (40.9%). Bystander-witnessed OHCAs attained higher rates of ROSC than unwitnessed events (35.1% vs 17.4%). The proportion of cases transported to hospital with ongoing CPR also varied, 28.5% among EMS-witnessed events, 20.1% among bystander-witnessed, and 15.1% among unwitnessed cases.

Across the whole of the country, ROSC was achieved in 29.1% of all cases, 29.2 of adults and 25.2 of paediatrics. ROSC was achieved in 30.5% of events in urban areas (30.7% adults; 22.7% paediatrics) compared to 32.1% in the previous year (32.4% adults, 17.5% paediatrics). In rural areas 23.2% achieved ROSC (23.2% adults; 25.7% paediatrics) compared to 22.2% the previous year (22.3% adults, 18.3% paediatrics). There was a significant difference in ROSC outcomes observed in the urban areas compared to the rural areas, for all and adult cases, but because of small numbers not for paediatrics.

Over time the proportion of cases where resuscitation efforts were ceased at scene has remained relatively constant, whereas the proportion transported to hospital with ongoing resuscitation has shown a decreasing trend of about 2.5% per year (**Figure 15**). The proportion of cases that were transported from the scene with ROSC was 29.6%, which is an increase on the previous year (28.0%); a four-year trend increasing about 1.7% per year.

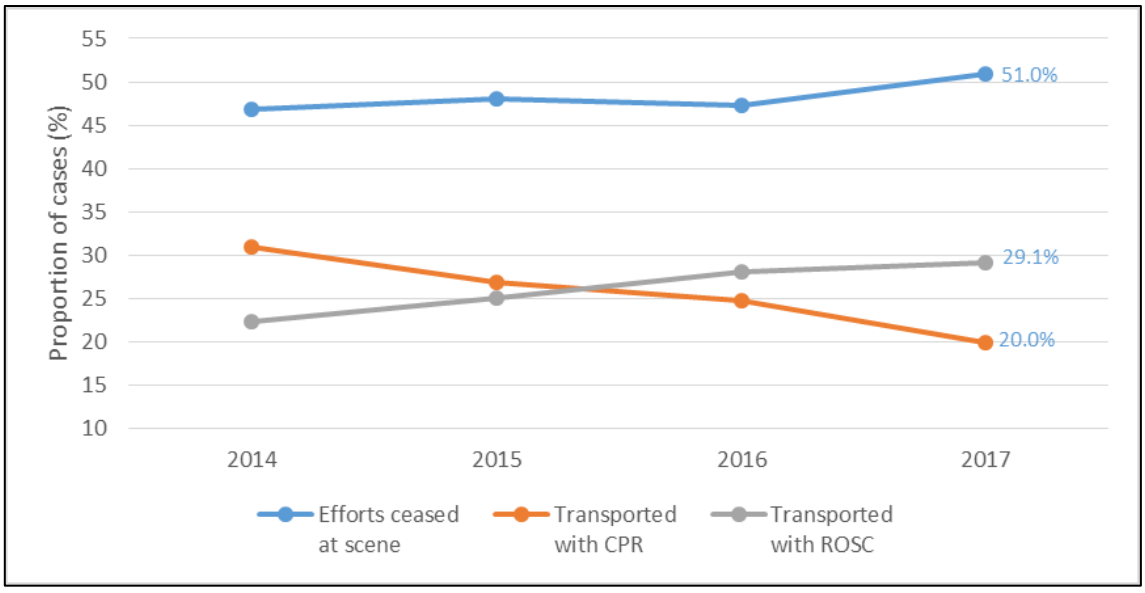


Figure 15: Scene outcomes for adult EMS-treated events

Ambulance Services were successful in restarting 7,939 hearts (ROSC at hospital handover rate of 27.3% of patients treated)

Adult survival from all-cause cardiac arrest

Unadjusted adult survival from all-cause OHCA has increased by about 5% over the past 4 years. In 2017, the rate of event survival for adult EMS-treated events was 29.1% (ROSC at hospital handover) and discharged alive rate was 8.7% (**Figure 16**).

In urban areas during 2017, event survival was 30.7% and discharged alive rate was 9.3%. In rural areas the respective figures were 23.2% and 7.2%.

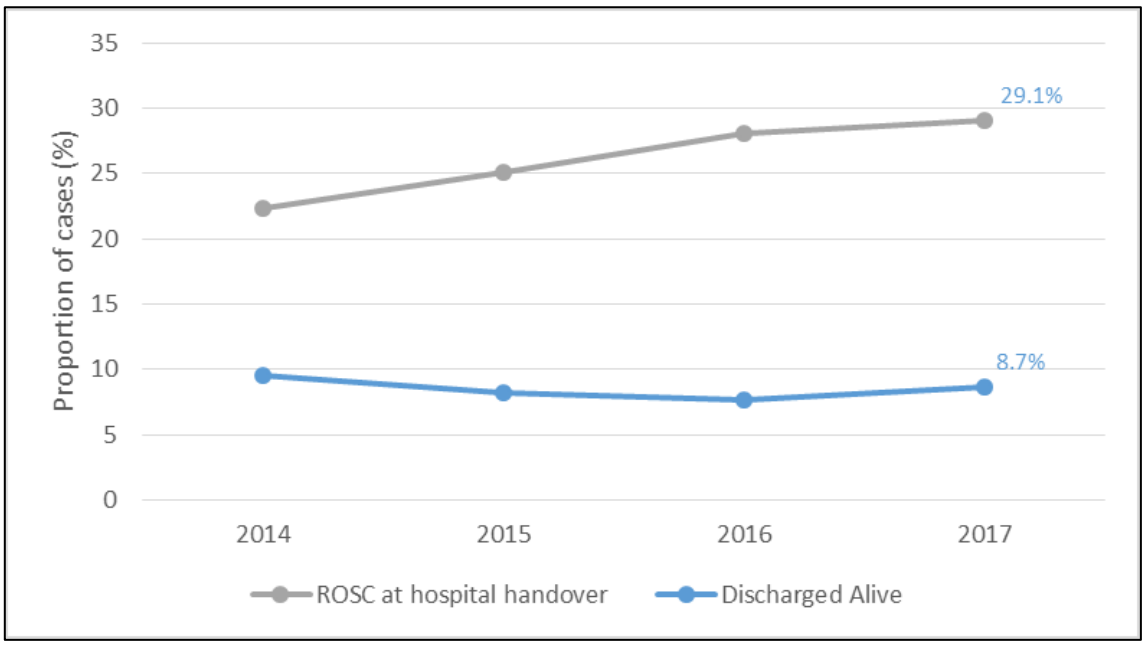


Figure 16: Unadjusted survival outcomes for all-cause adult EMS-treated events

In 2017, 20.1% of the overall adult EMS-treated patient population presented to EMS or bystanders in a shockable rhythm. The proportion of adults presenting in a shockable rhythm has fluctuated around 21% over the last 4 years (**Figure 17**). Outcomes for patients with shockable rhythms have improved over time (**Figure 18**). In 2017, adult event survival for patients presenting in a shockable rhythm was 51.6%. The rate of adult survival to hospital discharge was 27.8%. This is the highest survival in shockable patients achieved in England since OHCAO commenced monitoring OHCA patients.

For paediatrics, only 6.0% presented in a shockable rhythm, 64% of which achieved ROSC at hospital handover and 40% survived to discharge.

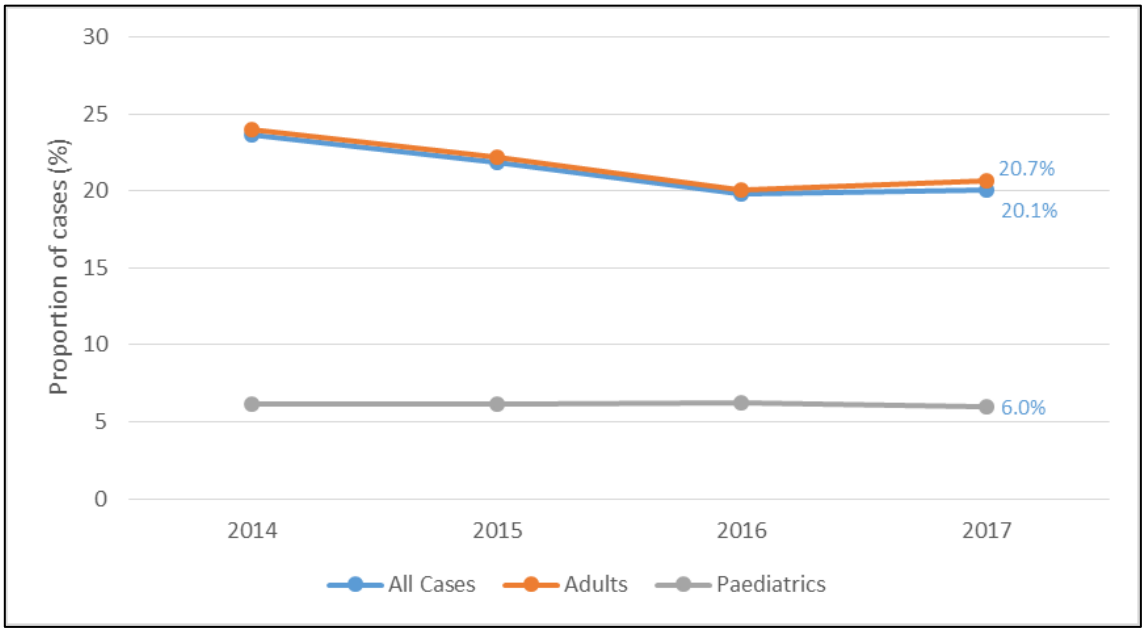


Figure 17: Proportion of adult EMS-treated events presenting in a shockable rhythm

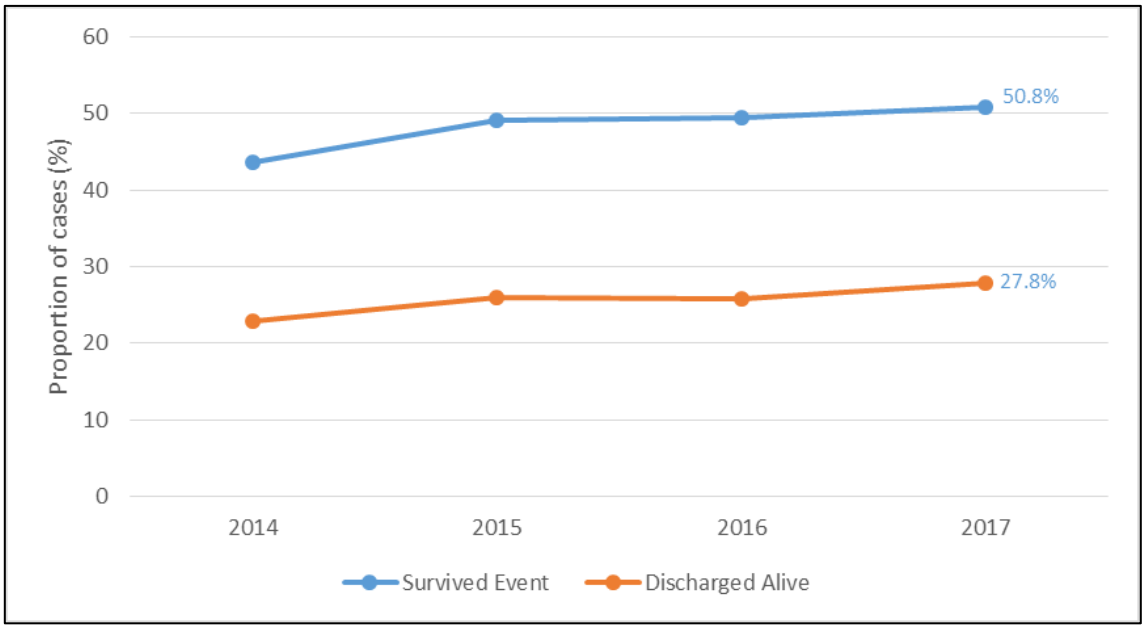


Figure 18: Outcomes of adult OHCAs presenting in a shockable rhythm.

Adult and all-ages survival from shockable rhythms

Survival outcomes for patients presenting to EMS or bystanders in a shockable rhythm are consistently better than patients presenting in pulseless electrical activity (PEA) or asystole. A shockable rhythm is a strong predictor of OHCA survival. [24] Of adult EMS-treated patients, 27.0% of events presenting in a shockable rhythm during 2017 were discharged alive (Figure 19; 2016: 25.9%). In contrast, 4.5% of adult patients who presented in PEA were discharged alive (2016: 4.0%), while few adults presenting in asystole (1.4%) were discharged alive (2016: 1.4%).

For patients of all ages found in shockable rhythm during 2017, the rate of event survival was 51.7% (2016: 49.6%) and discharged alive rate was 28.2% (2016: 25.9%).

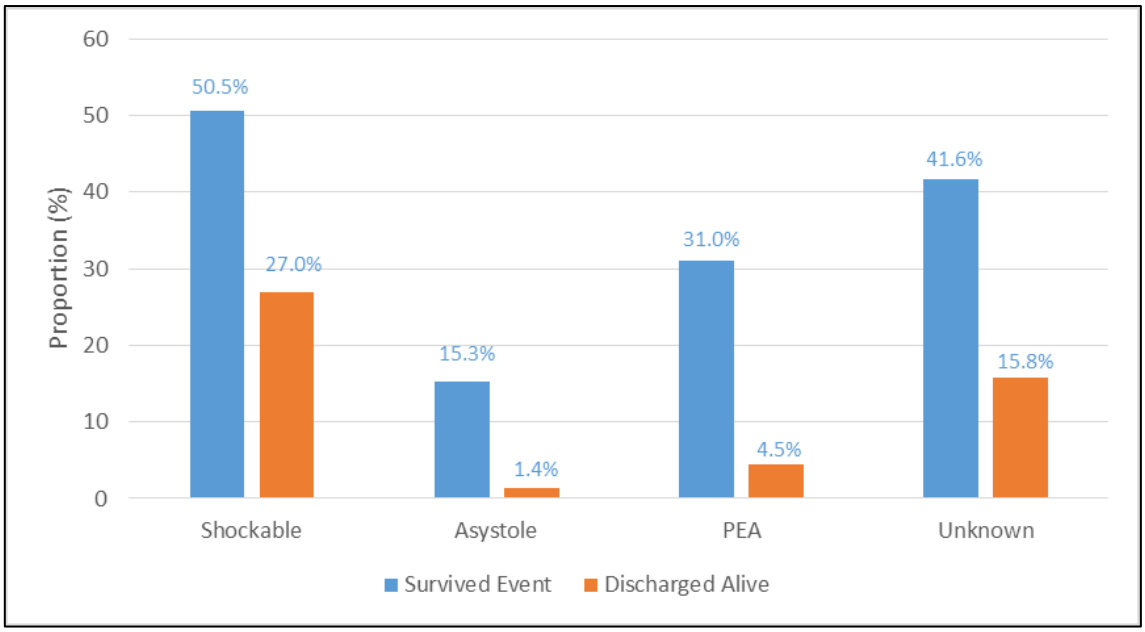


Figure 19: Unadjusted survival outcomes for adult EMS-treated events according to presenting rhythm on arrival

Adult survival from EMS-witnessed arrests

In 2017, for adult EMS-treated and witnessed events, the rate of event survival was 40.9% and the rate of survival to hospital discharge was 18.1%. When considering events that presented in a shockable rhythm the event survival was 70.4% (31.0% in non-shockable rhythm) and the discharged alive rate was 52.9% (6.5% in non-shockable rhythm) (**Figure 21**).

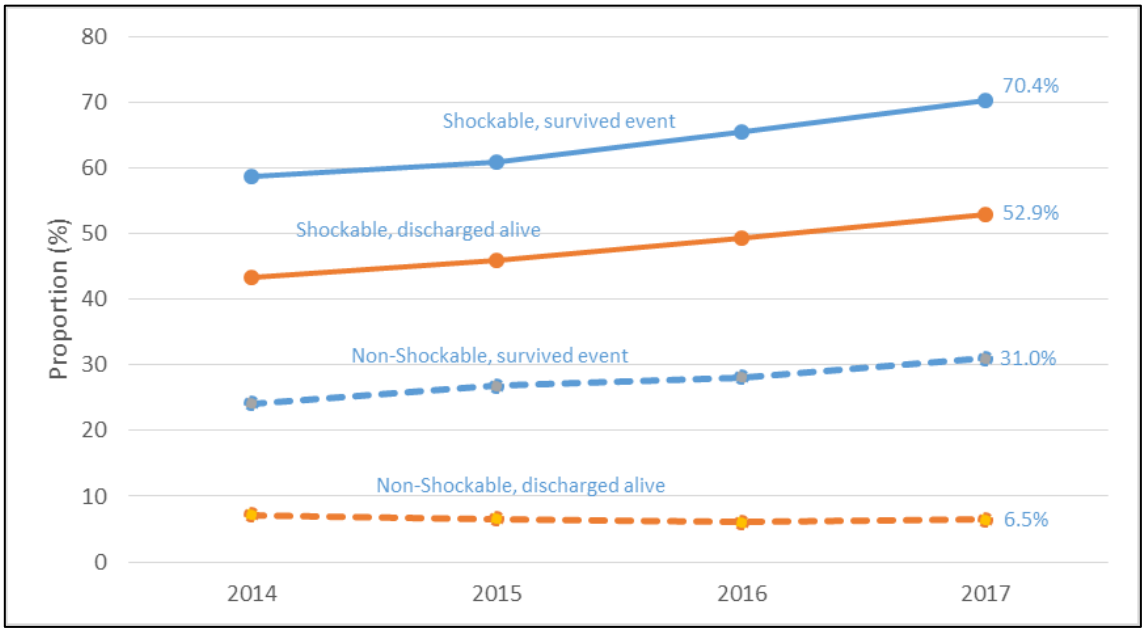


Figure 20: Unadjusted survival outcomes for adult EMS-witnessed, EMS-treated events with a shockable/non-shockable arrest rhythm

Paediatric survival from all-cause cardiac arrest

Annual incidence of paediatric OHCA is low, with survival factors and outcomes differing from adults. Notably paediatric cases rarely present in a shockable rhythm; in 2017 this proportion was 6.0%. Asystole was the most common presenting rhythm (70.2%).

In 2017, 24.4% of paediatric EMS-treated patients survived the event (17.8**%** in 2016).

In 2017 there were 39 paediatric patients (8.7%) who were discharged alive (7.7% in 2016).

There were 35 EMS-witnessed paediatric events in 2017, 13 (37.1%) survived the event but only 5 were discharged alive.

Utstein patient sub-group survival

The Utstein template is part of a set of guidelines which was developed to promote uniform presentation of OHCA survival data across different regions of the world [7]. These guidelines define key data fields to ensure consistency in terminology and make recommendations for core and supplementary data to be recorded for each OHCA event.

OHCA patients who are EMS-witnessed and present in a shockable rhythm are the most likely subgroup to survive an arrest. Data presented using the Utstein template focuses on survival within the following patient subgroup: (i) OHCA events of presumed cardiac origin; (ii) where EMS attempted resuscitation; (iii) where the arrest was witnessed by a bystander; and (iv) the presenting cardiac rhythm was shockable (VF or VT).

Figure 21 shows the total number of OHCA events in 2017 and progressively the breakdown of events according to EMS-attempted resuscitation, precipitating event, witnessed status and presenting rhythm. In 2017, the rate of survival to hospital discharge

for the Utstein patient sub-group was 26.6%. In the previous year the figure was 24.0**%**.

Within urban and rural areas, the rates of being discharged within the Utstein patient sub-group was 28.3% and 16.9%, respectively (ROSC at hospital handover: urban – 53.4%; rural – 40.8%).

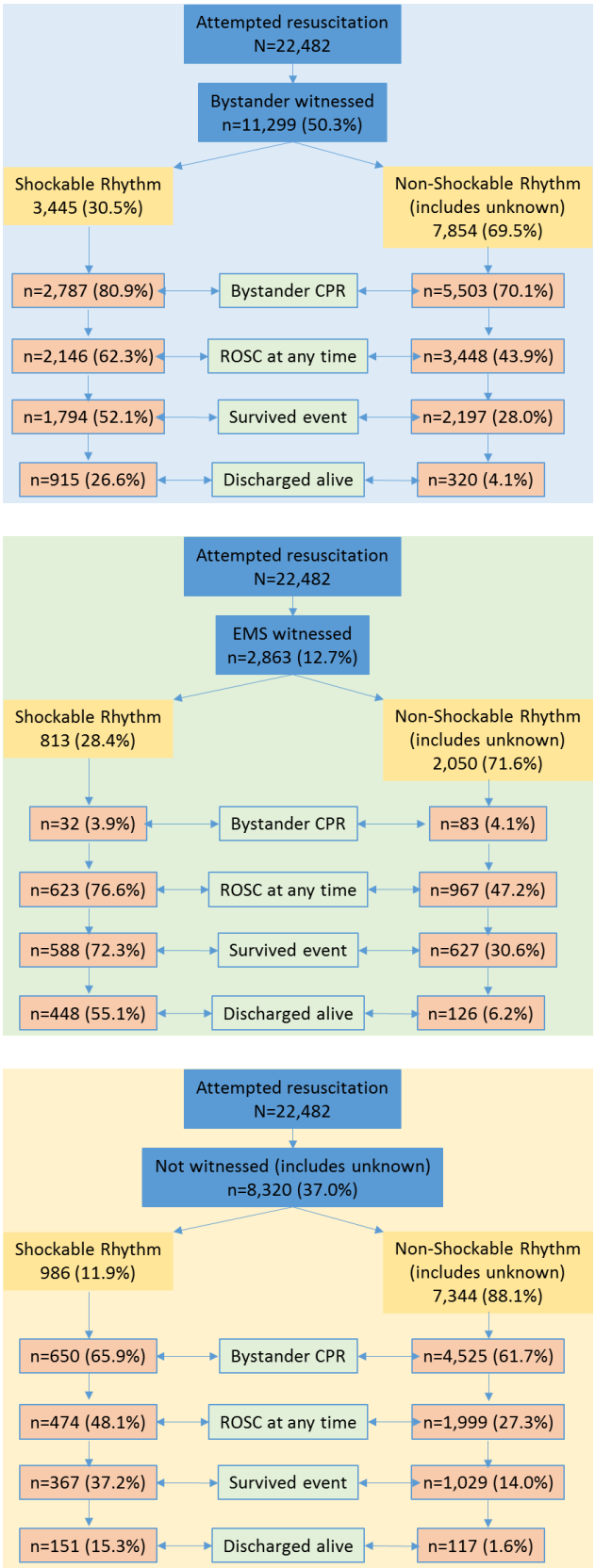


Figure 21: Survival outcomes for the Utstein patient sub-group (data from 1 service is not included because of missing outcome information)

Utstein patient sub-group survival compared to international data

Table 5 compares survival to hospital discharge for the Utstein patient sub-group in WMAS and the OHCAO registry as a whole to other international data for this patient subgroup, a useful benchmarking patient group. Direct comparisons of survival rates are difficult because there are discrepancies in the definition of the Utstein patient sub-group by different international Ambulance Services. Also, different Ambulance Services follow different guidelines for when to start and/or stop resuscitation, which further complicates comparison of resuscitation outcomes data. It is also not possible to accurately know the extent to which some international organisations omit cases from their analyses of patient outcome data (e.g. omitting cases with short, yet futile resuscitation attempts), as suggested by anecdotal evidence.

The OHCAO Utstein patient sub-group includes arrests with a presumed cardiac aetiology due to any cause. Some groups, as indicated in **Table 5**, also focus on the presumed cardiac patient subgroup, whereas others include arrests due to any cause. OHCA patients experience a discharged alive rate for the Utstein patient sub-group (26.6%) which is comparable to that for PAROS, New Zealand, and a previous study in London. It is also similar to the average observed across Europe. However, it is below that observed in Australia and North America, and significantly below that seen in Seattle.

Table 5: Published OHCAO and international OHCA survival to hospital discharge data for the Utstein patient sub-group

Organisation	Time period	% survival
OHCAO	**2017**	**26.6**
Pan Asian Resuscitation Outcomes Study (PAROS)[30] $	2009-2012	28
London Ambulance Service[31] $	2016-2017	30
St John New Zealand[32] $$$	2016-2017	30
EuReCa ONE (27 European country OHCA registries)[9]	2014	30
Cardiac Arrest Registry to Enhance Survival (CARES)[33] $$	2013	33
St John Western Australia[34]	2016	35
Ambulance Victoria	2016-2017	37
– Greater Melbourne		38
Seattle/King County EMS[35] $	2016	56

$ Only includes patients arresting due to a presumed cardiac cause
$$ Excludes patients arresting due to a traumatic cause
$$$ Survival to 30 days

Ambulance Services helped save 2,350 lives from cardiac arrest in 2017 (survival to hospital discharge rate of 8.1%)

CURRENT RESEARCH, COLLABORATIONS AND DATA SHARING

Apart from providing the contributing Ambulance Services with annual epidemiological reports the OHCAO project team conducts and collaborates in research projects with colleagues from Ambulance Services, the funders - the British Heart Foundation (BHF) and the Resuscitation Council (UK) – and external clinicians and researchers. We also share anonymised data with other researchers conducting their own high quality emergency care research, according to strict guidelines. Summaries of projects that have been progressing or set-up in 2016 are given below.

OHCAO TEAM RESEARCH PROJECTS

What Happened on Restart a Heart Day 2017

This analysis reported details of OHCAs that occurred on Restart a Heart Day in five Ambulance Services in 2017, and estimated how many OHCAs occurred in UK as a whole and potential number of lives that were lost. It highlighted the role of the OHCAO registry to continually monitor the impact of RHD on outcomes in the UK (**see Appendix 3**). The OHCAO team collaborated with the BHF, RC(UK), EEAST, LAS, NWAS, SWAST, and WMAS on this project.

Bystander Cardiopulmonary Resuscitation: Impact of Training Initiatives

This project analysed bystander CPR rates, using segmented regression analysis, to determine the impact of the various UK CPR training initiatives and publicity campaigns. Although we could not observe a direct link between the initiatives/campaigns and bystander CPR rates using this type of analysis, a significant increase in bystander CPR rates was observed over the lifetime of the registry. The OHCAO team collaborated with the BHF, RC(UK), LAS, SCAS, SWAST, WMAS, and YAS on this project.

Who Receives Bystander CPR in Witnessed OHCAs

This analysis looked at the patient and event characteristics of OHCA events that influenced the likelihood an OHCA patient received bystander CPR. It observed that the likelihood depends on whether the event was in a public place. Younger patients are also more likely to receive bystander CPR, as are those who arrest during daytime. The OHCAO team collaborated with RC(UK), LAS, SCAS, SWAST, WMAS and YAS on this project.

Neighbourhood Characteristics of High Risk Areas for OHCA

The aim of this study was to identify high risk communities in England with a high OHCA incidence and low bystander CPR rate. The results provided key insights into the variation in OHCA incidence and bystander CPR rates across England. The study showed that the most deprived areas of England are at highest risk and could be targeted for programmes of training in CPR and AED use. The OHCAO team collaborated with RC(UK), EMAS, LAS, SCAS, SWAST, WMAS, YAS, and Public Health England (PHE) on this project.

Attitudes to CPR and Defibrillator Use Survey

An online survey was undertaken in 2017 to determine the proportion of UK adults who have been trained in CPR and/or PAD use. This survey was repeated in 2018 on a larger sample, with some additional questions. Preliminary analysis indicated that about 60%

of the sample said they had trained in CPR, the same as in 2017. The OHCAO team collaborated with the BHF, EMAS, LAS, SECAmb and Welsh Ambulance Service (WAST) on this project.

Risk Prediction (Case-Mix) Models for OHCA

An aim of the OHCAO project is to explore the sources of variation in survival after OHCA. In this study we are revising our risk prediction models for (ROSC) at hospital handover and survival to hospital discharge that only included pre-EMS intervention characteristics of OHCA. This time we are including additional variables into the models including the neighbourhood characteristics of where the OHCA occurred. The OHCAO team collaborated with EMAS, LAS, SWAST and PHE on this project.

OHCA in Schools

The aim of this study is to investigate the incidence and location of OHCAs in relation to schools in the West Midlands. The study highlighted OHCAs in schools are a rare phenomenon and more likely to occur in adults. It also showed a significant number of school-based AEDs are not registered with the Ambulance Service and accessibility is often limited. This OHCAO study is being led by Dr Madeleine Benson, and collaboration with WMAS.

Pre-Hospital Adrenaline Administration for OHCA

The aim of this analysis is to use data from the OHCAO registry and a secondary analysis of data from the PARAMEDIC randomised controlled trial to describe the epidemiology and outcomes for pre-hospital administration of adrenaline for OHCA patients in England and Wales between 2010 and 2015. It highlighted a high proportion of OHCA patients received pre-hospital adrenaline, with significant variability in administration between EMS regions. The OHCAO team is collaborating with RC(UK), EMAS, LAS, and WMAS.

Sex Inequality in OHCA Resuscitation Attempts

This continuing analysis is exploring the difference in the number of resuscitation attempts observed between men and women suffering from OHCA, and whether they can be explained by differences in age/sex or disease distribution or establish that other factors may be involved. This analysis is being led by Dr James Mapstone from PHE.

RESEARCH COLLABORATIONS

EuReCa Two

This project is a collaboration with other European OHCA registries. It collected OHCA epidemiology, treatment and outcome data over 3 months (October to December 2017), with special focus on bystander CPR. Data from LAS, SWAST and WMAS was submitted for the UK. In total, 319 regions across 28 countries participated, with details of over 38,000 cases submitted. The data is currently being analysed and a publication is scheduled for early 2019.

DATA SHARING

Prehospital Critical Care for OHCA

Dr Johannes von Vopelius-Feldt from the University Hospitals Bristol NHS Foundation Trust, together with the Critical Care Teams in NEAS, SECAmb, SWAST and WMAS, used data from the OHCAO database to understand the effect of Critical Care Teams compared to advanced life support (ALS) on survival from OHCA. He has submitted his PhD thesis.

Incidence, Outcomes and Predictors of OHCA at International Airports

The primary aim of this study was to determine the incidence and outcome from OHCA that occurred at international airports where resuscitation was attempted between 2013 and 2015 worldwide[36]. The chief investigator was Siobhan Masterson (NUI Galway). The results of this study were published in *Resuscitation* in 2018.

Improving the Use of Public Access Defibrillation in Volunteer Response to OHCA

This continuing project is being carried out by Dr Chris Smith (University of Warwick), an NIHR Research Fellow undertaking a PhD. The three research questions he wishes to answer are:

- What is the effect of the GoodSAM volunteer first responder system on survival from OHCA in London?
- What is the potential for AED use in London for OHCA victims?
- What epidemiological factors predict AED use by GoodSAM responders?

Preliminary analysis indicates that 8.6% of OHCAs occur within 100m and 60.8% within 500m.

Pre-Hospital Factors Affecting OHCA Post-Care in Kids (PRE-PACK)

This project is led by Dr Barney Scholefield (University of Birmingham/Birmingham Children's Hospital). The aim of the study is to describe the epidemiology of children experiencing OHCA in England and Wales and to understand the factors affecting survival and outcome.

RECOMMENDATIONS

We continue to endorse the key recommendations from the 'Resuscitation to Recovery' national framework for OHCA in England. [2]

- The internationally accepted 'Chain of Survival' should be more widely embedded in public consciousness and into clinical pathways and protocols;
- Greater awareness amongst the general public including young people of school age, on how to recognise and manage arrest through the use of CPR and PADs;
- Significant improvement of the systems and process used by Ambulance Services to identify and map the location of defibrillators in public and commercial locations;
- Emergency responders – ambulance and fire services, police and community first responders – should collaborate to ensure that someone trained in resuscitation and equipped with a defibrillator can be at the scene of a cardiac arrest in the shortest possible time;
- Clinical networks should work with the emergency services and voluntary sector to promote awareness of, and training in, CPR and the use of PADs;
- The current Resuscitation Council (UK) guidelines should be followed;
- Each Urgent and Emergency Care Network in England should establish an effective and consistent pathway of care for those with OHCA, from the point of initial resuscitation to management within designated OHCA treatment centres (Cardiac Arrest Centres);
- Data should be submitted to the national Out-of-Hospital Cardiac Outcomes (OHCAO) Registry so that performance and progress towards improved survival rates can be monitored and unwarranted variation can be addressed; appropriate local resources must be allocated for these audit purposes;
- The management and outcomes of patients treated in hospital (from acute care through to secondary prevention and rehabilitation) should be captured through the relevant national registries; and
- Research to improve understanding of resuscitation is a national priority and should be funded and promoted; ambulance and hospital services should work closely together on collaborative projects.

Further we endorse the recommendations of the NHS Long Term Plan[1] that data should enable the effective mapping of OHCA incidence that will help direct community CPR training initiatives to areas where they are most needed.

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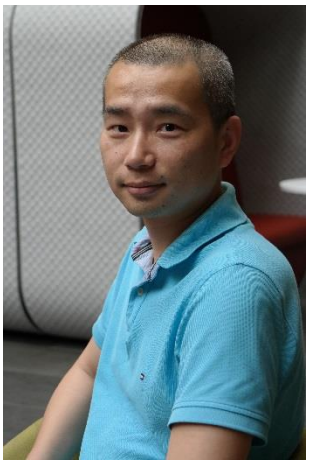

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Adrian Willis, Chief Programmer

Henry Adjei, Programmer

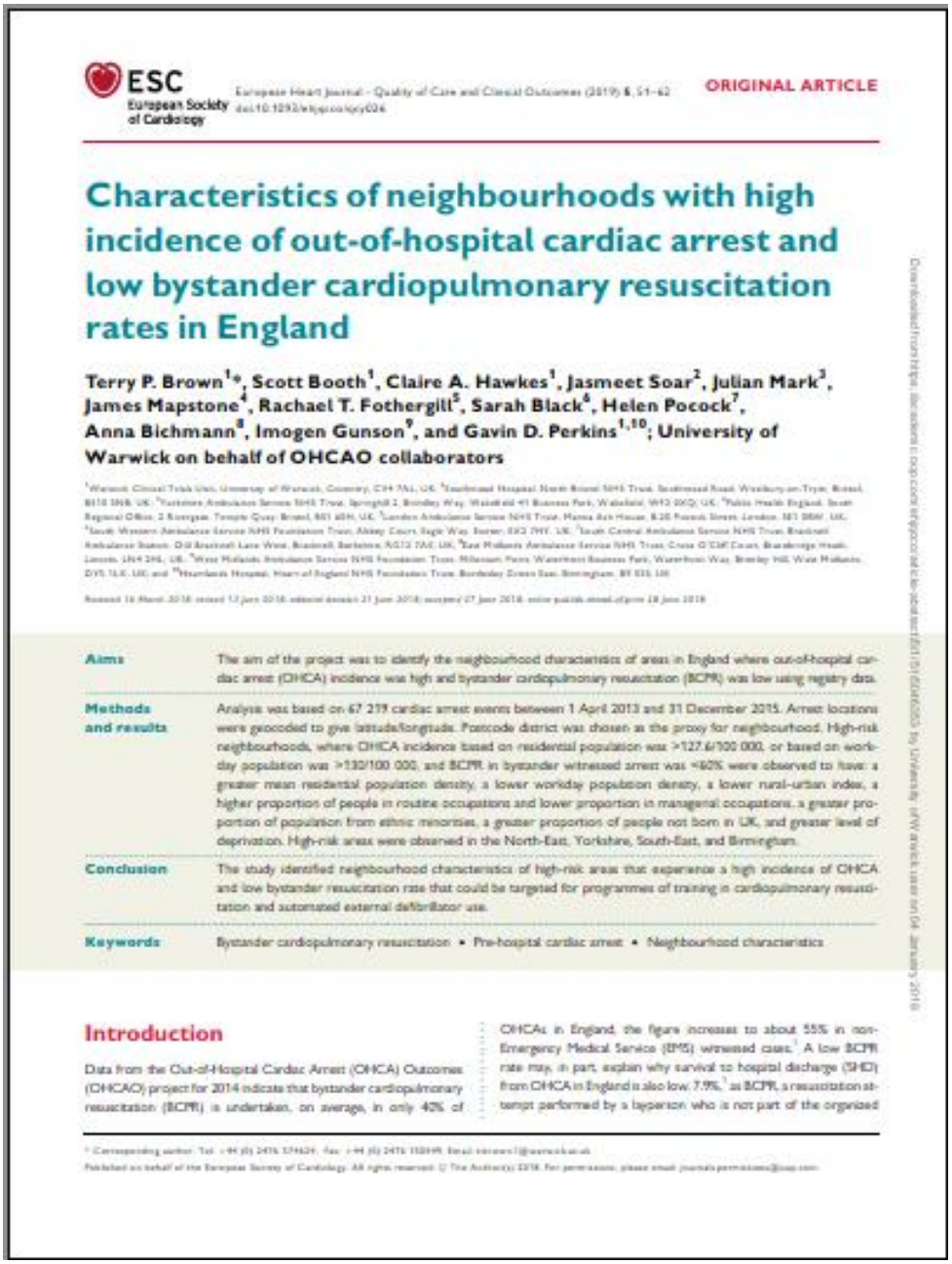
DEFINITIONS

Adults	Patients aged 16 years or older, or where the age is missing/unknown
Asystole	Absence of any cardiac activity
Defibrillation	Providing an electrical shock to a patient in a shockable rhythm
Emergency medical services (EMS)	Denotes Ambulance Service paramedics
EMS response time (EMSRT)	The time from emergency call to arrival of EMS crew on scene
Paediatrics	Patients aged less than 16 years
PCI-capable hospital	Denotes a hospital with access to Percutaneous Coronary Intervention (PCI) facilities
Presumed cardiac aetiology	Cases where the cause of arrest is not due to a known precipitator (e.g. trauma, overdose poisoning, etc.), as reported on PRF
Return of Spontaneous Circulation (ROSC)	Cases in which the resuscitation attempt results in a return of spontaneous circulation (i.e. detectable pulse) at any time
Survival to hospital discharge (or discharged alive)	Patients who are discharged alive from the hospital's acute care unit
Shockable Rhythm	Rhythms which are appropriate to receive defibrillation, including ventricular fibrillation and pulseless ventricular tachycardia, by EMS or a bystander with a public automate external defibrillator
Utstein patient sub-group	Patients whose arrest is medical, presumed cardiac, witnessed by a bystander, presents in a shockable rhythm and an attempt at resuscitation was made by EMS

ABBREVIATIONS

Abbreviation	Explanation
AACE	Association of Ambulance Chief Executives
AED	Automated External Defibrillator
ALS	Advanced Life Support
ARP	Ambulance Response Programme
BHF	British Heart Foundation
BLS	Basic Life Support
CA	Cardiac Arrest
CAG	Confidentiality Advisory Group
CARES	Cardiac Arrest Registry to Enhance Survival
CFR	Community First Responder
CPR	Cardiopulmonary Resuscitation
CVD	Cardiovascular Disease
DNACPR	Do Not Attempt CPR
EEAST	East of England Ambulance Service NHS Trust
EMAS	East Midlands Ambulance Service
EMS	Emergency Medical Services
ERC	European Resuscitation Council
EuReCa	European Registry for Cardiac Arrest
JRCALC	Joint Royal College Ambulance Liaison Committee
LAS	London Ambulance Service NHS Trust
MREC	Medical Research and Ethics Committee
NASMeD	National Ambulance Service Medical Directors
NEAS	North East Ambulance Service NHS Foundation Trust
NWAS	North West Ambulance Service NHS Trust
OHCA	Out-of-Hospital Cardiac Arrest
OHCAO	Out-of-Hospital Cardiac Arrest Outcomes
ONS	Office for National Statistics
PAD	Public Access Defibrillator
PAROS	Pan Asian Resuscitation Outcomes Study
PCI	Percutaneous Coronary Intervention
PEA	Pulseless Electrical Activity
PHE	Public Health England
PRF	Patient Report Form
RCUK	Resuscitation Council (UK)
ROLE	Recognition Of Life Extinct
ROSC	Return Of Spontaneous Circulation
SCA	Sudden Cardiac Arrest
SCAS	South Central Ambulance Service NHS Foundation Trust
SECAmb	South East Coast Ambulance Service NHS Foundation Trust
SIDS	Sudden Infant Deaths Syndrome
SWAST	South Western Ambulance Service Trust NHS Foundation Trust
VF	Ventricular Fibrillation
VT	Ventricular Tachycardia
WAST	Welsh Ambulance Service NHS Trust
WMAS	West Midlands Ambulance Service University NHS Foundation Trust
YAS	Yorkshire Ambulance Service NHS Trust

APPENDIX 1: NEIGHBOURHOOD CHARACTERISTICS & BYSTANDER CPR PAPER



ESC European Society of Cardiology

European Heart Journal - Quality of Care and Clinical Outcomes (2019) 5, 51–62 doi:10.1093/ehjqcco/qcy026

ORIGINAL ARTICLE

Characteristics of neighbourhoods with high incidence of out-of-hospital cardiac arrest and low bystander cardiopulmonary resuscitation rates in England

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Aims The aim of the project was to identify the neighbourhood characteristics of areas in England where out-of-hospital cardiac arrest (OHCA) incidence was high and bystander cardiopulmonary resuscitation (BCPR) was low using registry data.

Methods and results Analysis was based on 67 219 cardiac arrest events between 1 April 2013 and 31 December 2015. Arrest locations were geocoded to give latitude/longitude. Postcode district was chosen as the proxy for neighbourhood. High-risk neighbourhoods, where OHCA incidence based on residential population was >127.6/100 000, or based on workday population was >130/100 000, and BCPR in bystander witnessed arrest was <60% were observed to have: a greater mean residential population density, a lower workday population density, a lower rural-urban index, a higher proportion of people in routine occupations and lower proportion in managerial occupations, a greater proportion of population from ethnic minorities, a greater proportion of people not born in UK, and greater level of deprivation. High-risk areas were observed in the North-East, Yorkshire, South-East, and Birmingham.

Conclusion The study identified neighbourhood characteristics of high-risk areas that experience a high incidence of OHCA and low bystander resuscitation rate that could be targeted for programmes of training in cardiopulmonary resuscitation and automated external defibrillator use.

Keywords Bystander cardiopulmonary resuscitation • Pre-hospital cardiac arrest • Neighbourhood characteristics

Introduction

Data from the Out-of-Hospital Cardiac Arrest (OHCA) Outcomes (OHCAO) project for 2014 indicate that bystander cardiopulmonary resuscitation (BCPR) is undertaken, on average, in only 40% of OHCAs in England, the figure increases to about 55% in non-Emergency Medical Service (EMS) witnessed cases.[1] A low BCPR rate may, in part, explain why survival to hospital discharge (SHD) from OHCA in England is also low: 7.9%,[1] as BCPR, a resuscitation attempt performed by a layperson who is not part of the organised

Downloaded from https://academic.oup.com/ehjqcco/article-abstract/5/1/51/5043855 by University of Warwick user on 04 January 2019

Brown TP, Booth S, Hawkes CA, Soar J, Mark J, Mapstone, J, Fothergill RT, Black S, Pocock H, Bichmann A, Gunson I, Perkins GD (2019). Characteristics of neighbourhoods with high incidence of out-of-hospital cardiac arrest and low bystander cardiopulmonary resuscitation rates in England. European Heart Journal – Quality of Care and Clinical Outcomes, 5, 51-62.

APPENDIX 2: CPR SURVEY PAPER

Disclaimer: The manuscript and its contents are confidential, intended for journal review purposes only, and not to be further disclosed.

URL: http://jaha-submit.aha-journals.org

Title: Attitudes to cardiopulmonary resuscitation and defibrillator use: a survey of UK adults in 2017

Manuscript number: JAHA/2017/008267

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Hawkes CA, Brown TP, Booth S, Fothergill RT, Siriwardena AN, Zakaria S, Askew S, Williams J, Rees N, Ji C, Perkins GD (2019). Attitudes to cardiopulmonary resuscitation and defibrillator use: a survey of UK adults in 2017. Journal of the American Heart Association, accepted for publication.

APPENDIX 3: EUROPEAN RESUSCITATION COUNCIL (ERC) 2018 CONGRESS ABSTRACTS, BOLOGNA, 19-21 SEPT.

AS030

Locations of out-of-hospital cardiac arrests and public-access defibrillators in relation to schools in an English Ambulance Service region

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Purpose: Out-of-hospital cardiac arrest (OHCA) occurring in schools is a rare event more likely to occur in adults than in children. The Department for Education in England has advised schools purchase a defibrillator. Guidance suggests defibrillation is performed within 5 minutes of an arrest, allowing a 300 m one-way retrieval journey. Even when registered with the emergency medical services (EMS) there are times when defibrillators are inaccessible. The study aimed to establish the number of OHCAs occurring within 300 m of schools and the number of schools with defibrillators present.

Materials and methods: This observational study used data on OHCAs occurring from January 2014 to December 2016 in the West Midlands Ambulance Service NHS Trust (WMAS) region, from the OHCA Outcomes Registry held at the University of Warwick. An email survey of schools was conducted about defibrillator presence and registration status with WMAS. ArcGIS mapping software was utilised to identify OHCAs occurring within 300 m of a school. Descriptive statistics (Chi-squared test) were used for the incidence and demographics of cardiac arrests and survey responses. A *p*-value of < 0.05 was considered significant.

Results: 39 OHCAs occurred in schools during the study period, representing 0.34% of all OHCAs. 8 occurred in those < 18 years and 21 within school hours. 34.8% of school-based defibrillators were registered with WMAS. 14.87% of all OHCAs in the region occurred within 300 m of a school. Of 323 school survey responses, 184 (57%) had a defibrillator present, of which, 7% were available 24 h/day. The mean length of availability of defibrillators was 9.9 hours.

Conclusions: OHCA occurring in schools is rare and more likely to occur in adults than in children. A significant number of school-based defibrillators are not registered with the EMS and accessibility is often limited. However, if made available they could potentially treat a significant number of OHCAs.

https://doi.org/10.1016/j.resuscitation.2018.07.343

AP169

Prehospital adrenaline administration for out-of-hospital cardiac arrest: The picture in England and Wales

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Purpose: International resuscitation guidelines recommend prehospital adrenaline for out-of-hospital cardiac arrest (OHCA), but evidence for a beneficial effect on survival remains equivocal. Studies also show significant variability in adrenaline administration between and within Emergency Medical Services (EMS) systems worldwide, but there is a paucity of published UK data. This study therefore describes the epidemiology and outcomes for OHCA patients receiving prehospital adrenaline by EMS in the UK.

Materials and methods: Retrospective observational study. Data on adult OHCA patients receiving adrenaline from eight English and the Welsh Ambulance Service regions analysed from two sources: secondary analysis of 2010–2013 data from the PARAMEDIC mechanical chest compression device RCT, and 2013–2015 data from the OHCA Outcomes (OHCAO) project, a UK registry. Chi-square tests were used to test differences in proportions of adrenaline administration between EMS regions. Descriptive statistics were used to report patient demographic and clinical characteristics, bystander response, EMS response time and outcomes.

Results: EMS-treated 47,737 OHCA patients with 36,998 (77.5%) administered adrenaline. Administration varied between EMS regions ranging from 62.2–86.3% (overall difference $p < 0.001$) for all patients, 59.9–85.3% (overall difference $p < 0.001$) for shockable and 66.0–91.0% (overall difference $p < 0.001$) for non-shockable rhythm patients. Mean age of patients administered adrenaline was 71.0 (SD = 16.4) years and 63.0% were male. The bystander CPR rate (non-EMS-witnessed cases) was 54.2%. Cardiac was the main cause of OHCA (88.6%), whilst the initial rhythm was non-shockable in 78.1% of patients. Mean EMS response time was 7.8 (SD = 7.1) minutes. The ROSC at hospital transfer rate was 22.8% and survival to discharge was 2.9% for patients administered adrenaline.

Conclusions: A high proportion of OHCA patients received pre-hospital adrenaline from EMS between 2010–2015 in England and Wales, with significant variability in administration found between EMS regions. Patients administered adrenaline had an overall low survival to discharge rate.

https://doi.org/10.1016/j.resuscitation.2018.07.211

AP161

What happened on Restart a Heart Day 2017 in England?

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Purpose of the study: Restart a Heart (RSaHD) is an annual European day of action that aims to teach life-saving CPR skills to as many people as possible. In 2017, UK stakeholders collaborated to train over 195,000 young people in CPR. The event was organised by a partnership between the Resuscitation Council (UK), British Heart Foundation, British Red Cross, St John Ambulance and all UK Ambulance Services. In 2018 RSaHD is going global under the oversight of ILCOR (http://www.ilcor.org/wrah/). The aim of this study is to report details of the out-of-hospital cardiac arrests (OHCAs) that occurred on RSaHD 2017 in English NHS Ambulance Service Trusts.

Materials and methods: Details of OHCAs that occurred on 16th October 2017 were obtained from the OHCA Outcomes (OHCAO) registry at University of Warwick.

Results: There were 48 OHCAs (68.8% male) attended by EMS from 5 Ambulance Services (Age: mean = 65.4 y; median = 71 y; crude incidence: 0.14/100,000). About 69% occurred in the home. 41.7% cases were bystander witnessed and 52.1% not witnessed. In witnessed OHCAs, 55.0% received bystander CPR (BCPR); only 1 case had a PAD applied and shock delivered. In not witnessed cases, 64% received BCPR (PAD used in 1 case). In both groups 5 cases achieved ROSC at hospital handover, only 2 and 3 cases had received BCPR, respectively. 1 case in each group survived to hospital discharge, both received BCPR.

We estimate that on RSaHD, there were about 79 cases in England (UK = 94), of which about 16 (UK = 19) cases achieved ROSC at hospital handover and 3 (UK = 4) survived to discharge.

Conclusions: This crude analysis estimated that on Restart a Heart Day in 2016 about 76 lives were lost to cardiac arrest in England (90 in UK). The OHCAO will enable us to monitor the impact of RSaHD on outcomes after OHCA in the UK.

https://doi.org/10.1016/j.resuscitation.2018.07.203

AP162

Who receives bystander CPR in a witnessed out-of-hospital cardiac arrest in England

Terry Brown [1], Scott Booth [1], Claire Hawkes [1], Rachel Fothergill [2], Sarah Black [3], Helen Pocock [4], Imogen Gunson [5], Jasmeet Soar [6], Julian Mark [7], Gavin Perkins [1]

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Purpose of study: Bystander CPR (BCPR) in out-of-hospital cardiac arrest (OCHA) significantly improves the likelihood an individual survives. Various neighbourhood characteristics where an OHCA occurs influences whether the patient receives BCPR or not [1]. We also need to know how the patient and event characteristics of an OHCA influence the behavioural responses of bystander witnesses to initiate BCPR to help understand differences in survival between Ambulance Service providers.

Materials and methods: Data for April 2014 to December 2015 was obtained from the OHCA Outcomes registry held at the University of Warwick. Using BCPR as the dependent variable, multivariate logistic regression was undertaken to examine the factors collected by Ambulance Services. A probability of $p > 0.05$ was set for removal from the model. For cases that were missing data for at least one variable, hotdeck imputation was used to substitute for these data points.

Results: A number of variables, and interactions, were significantly associated with the likelihood an individual received BCPR or not. The importance of the variables was in the following order: witnessed by a bystander > location of the OHCA > gender of the OHCA patient > age of the patient. The final regression model included location out of home (OR_{adj} 1.54), age under 65 y (OR_{adj} 1.19), OHCA occurring between 10 am and 10 pm (OR_{adj} 1.25), and ambulance response time (OR_{adj} 1.04).

Conclusions: The likelihood an OHCA patient in England will receive BCPR depends on a number of patient/event-specific factors. The most important are whether the event was witnessed by a bystander or not and whether the event was in a public place. Young patients are also more likely to receive BCPR, as are patient who arrest during daytime.

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[1] Brown TP, et al. Identification of characteristics of neighbourhoods with high incidence of out-of-hospital cardiac arrest and low bystander cardiopulmonary resuscitation rates. Resuscitation 2017; 118S: e43–4.

https://doi.org/10.1016/j.resuscitation.2018.07.204

AP160

Bystander cardiopulmonary resuscitation: Impact of training initiatives

Terry Brown [1], Scott Booth [1], Andrew Lockey [2], Sara Askew [3], Claire Hawkes [1], Rachel Fothergill [4], Sarah Black [5], Helen Pocock [6], Imogen Gunson [7], Jasmeet Soar [8], Julian Mark [9], Gavin Perkins [1]

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Purpose of the study: Bystander CPR (BCPR) improves survival from out-of-hospital cardiac arrest (OCHA). This analysis aims to determine whether the various UK training initiatives and publicity campaigns for BCPR have influenced English BCPR rates.

Materials and methods: Data for the period 04/2013 to 12/2016 was supplied by the OHCA Outcome Registry for the three Ambulance Services for which there was complete data. Monthly rates for BCPR in bystander witnessed OHCAs were calculated as the three-month-moving average. Segmented regression analysis (SRA) of interrupted time series data was used to analyse the data to assess the impact of Restart a Heart Day (RSaHD; October 2013, 2014, 2015) on BCPR rates.

Results: Restart a Heart Day has seen increasing numbers of people receive CPR training, national figures for 2016 and 2017 were over 150,000 and 195,000, respectively. Over the analysis time period there was a significant increase in BCPR rate (58.9% to 72.3%). Segmented regression analysis noted temporal changes in the rate of bystander CPR associated with RSAHD. The time following RSaHD 2015 saw the greatest increase in the rate of bystander CPR.

Conclusions: Whilst a direct link with events and the RSaHD campaigns cannot be established by this type of analysis, we observed that over the analysis time period, there has also been a significant increase in BCPR; about 23% over 45 months. The observed initial rising trend has been maintained by ongoing campaigns and initiatives. Repeated campaigns to provide participation in CPR training over time are required to continually reinforce the benefits of BCPR training.

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AP031

The potential for bystander automated external defibrillator deployment in London, UK

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Purpose: Bystander Automated External Defibrillator (AED) use is associated with increased survival from out-of-hospital cardiac arrest (OHCA) [1]. However, it is only used in a minority of cases, limiting its effectiveness at population level [2]. The effective coverage area of an AED is a subject for debate, but a range of 100 m to 500 m is often quoted in the literature [2]. The aim of this study was to determine the proximity of OHCA to AEDs in London, to assess the current potential for bystander AED use.

Materials and methods: We obtained the locations of OHCA in the area served by London Ambulance Service between 1st April 2016 and 31st March 2017 from the national OHCA Outcomes Registry, and the locations of AEDs known to London Ambulance Service. We have mapped these locations using ArcGIS (Geographical Information Systems) software. Subsequently, we will calculate the proportion of OHCA occurring within 100 m, 200 m, 300 m, 400 m and 500 m of the nearest AED.

Results: There were 4448 OHCA and 2948 AEDs registered with London Ambulance Service in this time period. Results available by July 2018 will report upon the number of OHCA occurring within the specified distances of the nearest AED, as measured by both a simple radius and by using actual walking distance (using paths, roads etc.)

Conclusions: These results will give an indication of the potential for bystander AED in London. Comparing this to the actual rate of bystander AED use will indicate the additional potential for bystander AED.

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