OHCAO

Out of Hospital Cardiac Arrest Outcomes

Epidemiology Report

Report for the period January - December 2016, for the

English Ambulance Services

WARWICK
CLINICAL TRIALS UNIT

Resuscitation Council (UK)

British Heart Foundation

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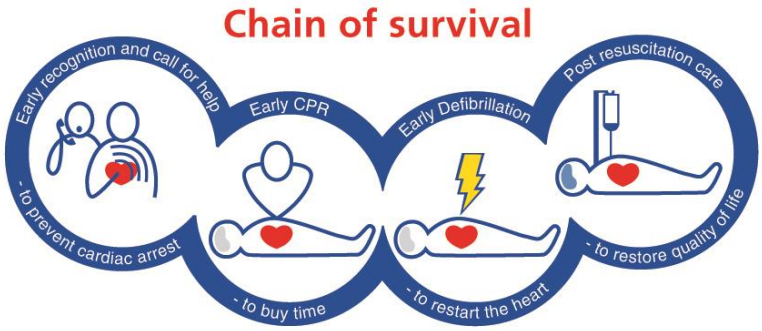
FOREWORD

It is our pleasure to write the foreword to this third report from the Out-of-Hospital Cardiac Arrest Outcomes (OHCAO) collaborative project.

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 (OHCA), 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.



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 OHCA.
2) **Early CPR:** Together with the Resuscitation Council (UK) and British Heart Foundation, NHS Ambulance Services 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 Department of Health provided an additional £1 million pounds for the second year running, to increase the availability of defibrillators in our communities. The British Heart Foundation is funding work to develop a national database of public access defibrillators, so their location is more widely known, particularly to ambulance services.
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 OHCA. 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

Professor Huon Gray, National Clinical Director for Heart Disease, NHS England

MESSAGE FROM THE CHIEF INVESTIGATOR

The Out-of-Hospital Cardiac Arrest Outcomes (OHCAO) registry has now been in existence for four years. In this time we have collected data on nearly 105,000 cases of OHCA where resuscitation was continued or commenced by ambulance service personnel. Data has been received from 10 ambulance services, borne out of the need to ensure all ambulance 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.

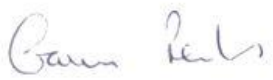
The quality, quantity and comparability of information available on OHCAO in England continues to grow. This in itself represents a real achievement, and testifies to the value of cooperation and coordinated actions of the ambulance services.

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. They were also useful to the Community Resuscitation Group and helped inform the consensus statement "Resuscitation to Recovery"[1]. 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. We welcome the new opportunity to facilitate 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.

Analysis of data within the registry has been presented at the European Resuscitation Council (ERC) annual congress in Freiburg and Resuscitation Council (UK) annual Scientific Symposium. The first papers have been published in peer-reviewed journals, and research has also supported 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. EuReCa Two is collecting data over three months to further our understanding of the epidemiology and outcomes of OHCA. A summary of on-going collaborative work is included in sections 5.2 and 5.3 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

[1] NHS England (2017). Resuscitation to Recovery: A National Framework to improve care of people with out-of-hospital cardiac arrest (OHCA) in England. London: NHS England

ACKNOWLEDGEMENTS

We would like to acknowledge the following individuals in the clinical audit teams for their continued support in uploading data to the OHCAO registry:

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GLOSSARY

Abbreviation	Explanation
AED	Automated External Defibrillator
ALS	Advanced Life Support
BHF	British Heart Foundation
CPR	Cardiopulmonary Resuscitation
CVD	Cardiovascular Disease
EEAS	East of England Ambulance Service
EMAS	East Midlands Ambulance Service
EMS	Emergency Medical Services
EuReCa	European Registry for Cardiac Arrest
LAS	London Ambulance Service
NEAS	North East Ambulance Service
NWAS	North West Ambulance Service
OHCA	Out-of-Hospital Cardiac Arrest
OHCAO	Out-of-Hospital Cardiac Arrest Outcomes
ONS	Office for National Statistics
PAD	Public Access Defibrillator
PEA	Pulseless Electrical Activity
pVT	Pulseless Ventricular Tachycardia
RCUK	Resuscitation Council (UK)
ROSC	Return Of Spontaneous Circulation
SCAS	South Central Ambulance Service
SECAMB	South East Coast Ambulance Service
SWAST	South Western Ambulance Service Trust
VF	Ventricular Fibrillation
WMAS	West Midlands Ambulance Service

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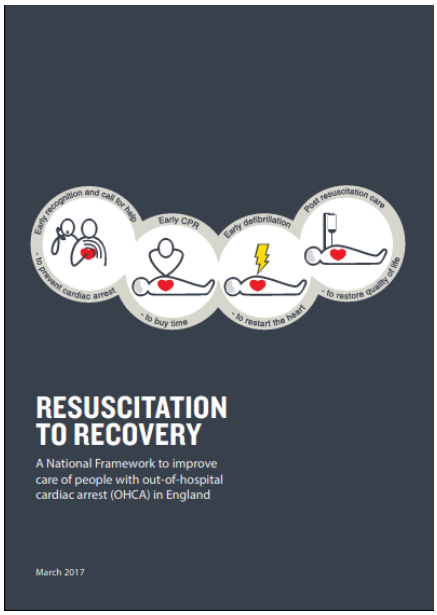
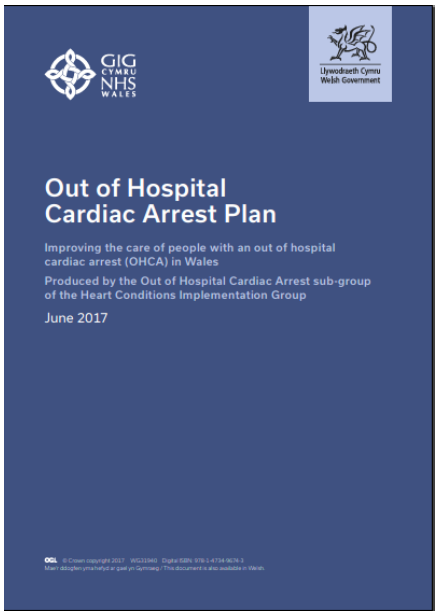
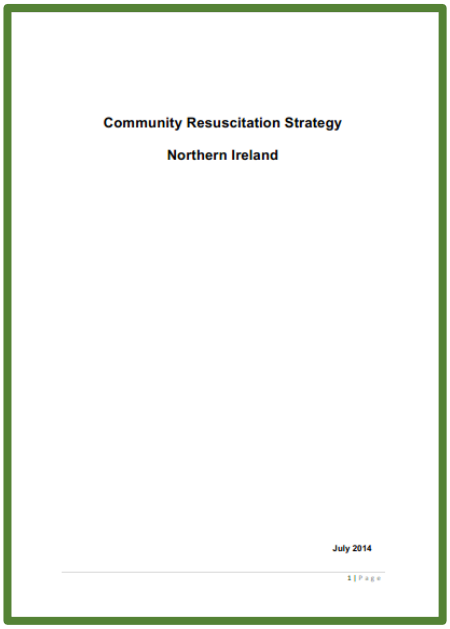
1 INTRODUCTION

Since the Out-of-Hospital Cardiac Arrest Outcomes (OHCAO) registry was set up in 2013 the UK Governments have produced out-of-hospital cardiac arrest (OHCA) plans that highlight the need for a UK OHCA registry that gives ambulance services the ability to benchmark themselves against the rest of the UK. The OHCAO registry is working towards the inclusion of Wales and Northern Ireland. Scotland is developing an independent registry that will collaborate with OHCAO.







The OHCAO registry includes OHCA patients of any age where resuscitation is commenced or continued by the Emergency Medical Services (EMS). This is a summary report of the 2016 OHCA data contributed by the English ambulance services to the registry. Data for two services are not included in the analysis because at the time of producing this report they were not submitting data to the OHCAO registry. We present an overview of the results of the epidemiology of cardiac arrest, comparing data from each of the contributing services and benchmarking against national data where possible, and the data completeness for key variables collected (data quality).

Since its conception, the registry has received details of 104,426 OHCAs, where resuscitation was attempted. A summary of the total number of cases submitted by all Ambulance Services is shown below.

	2013	2014	2015	2016	**Overall**
Total number of cases in OHCAO registry	18,813	28,729	28,914	27,970	**104,426**

NB: 2013 data complete from April onwards; Totals do not include from one service; 2015 data only includes 9 months data from one service; 2016 data does not include one service

In some figures 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).

2 KEY RESULTS FOR OHCAO REGISTRY IN 2016

- During 2016 the ambulance services treated 27,970 OHCA cases, compared to 28,914 in 2015*
- 2.2% of OHCA patients were aged <15-years; 33.3% were aged 15-64-years; 64.5% were aged 65-years and over
- About 64% of the OHCAs treated were male
- The proportion of all cases who received bystander CPR was 55.0% of all cases (range[$]: 28.1% to 65.3%), and 62.3% of non-EMS witnessed cases (range: 28.1% to 70.8%)
- A public access defibrillator was used by a member of the general public in 2.9% of all patients (3.3% of non-EMS witnessed cases)
- EMS arrived within 8-minutes of 999 call for 50.6% of patients (range: 19.7%-68.5%); the median response time was 6.4 minutes (range: 4.6-8.4 mins)
- Ambulance services were successful in restarting 7,366 hearts (ROSC at hospital handover rate of 26.3% of patients treated)
- Ambulance services helped save 2,037 lives from cardiac arrest in 2016 (survival to hospital discharge rate of 7.3%)

* 2015 includes only 9 months data and 2016 has no data from one service
[$] Ranges given are for individuals services

3 AMBULANCE SERVICE DATA 2016

3.1 Incidence and Demographics

The English ambulance service serve a population of over 55 million people (excluding the Isle of Wight which serves around 140,000), with individual ambulance service population ranging from about 2.6 million to nearly 9 million. According to the Office for National Statistics (ONS), 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 from 620 sq. mi. (London) to 20,000 sq. mi. (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 cases, with non-resuscitation decisions being undertaken according to national guidance[2].

Internationally, cardiac arrest survival rates vary widely from 0.6% to 25%[3,4]. In England, survival to discharge rates have been reported at 7.9%[5], and a doubling of this reported rate could save 2,000 lives a year.

In the OHCAO registry for the period 1 January 2016 to 31 December 2016, a total of 27,970 OHCAs were attended and treated by the EMS; this figure is based on data from 9 English Ambulance Services. This is a decrease of about 3.3% on the 2015 figure of 28,914 which was based on data from 10 services.

Data from the Isle of Wight are not included in this report. We are currently working with them to start submitting data in the very near future. Data for one service in 2016 are also not included, but where relevant other year's data are presented.

[2] Joint Royal College Ambulance Liaison Committee Recognition of Life Extinct (ROLE). 2006. https://warwick.ac.uk/fac/med/research/hsri/emergencycare/prehospitalcare/jrcalcstakeholderwebsite/guidelines

[3] Berdowski et al. (2010). Global incidences of out-of-hospital cardiac arrest and survival rates: a systematic review of 67 prospective studies. Resuscitation, 81, 1479-87.

[4] Grasner et al. (2016). EuReCa ONE-27 Nations, ONE, Europe, ONE Registry: a prospective one month analysis of out-of-hospital cardiac arrest outcomes in 27 countries in Europe. Resuscitation, 105, 188-95.

[5] Hawkes et al. (2017). Epidemiology and outcomes from out-of-hospital cardiac arrests in England. Resuscitation, 110, 133-140.

3.1.1 Number of Resuscitations Attempted

In the period January 1 to December 31 2016, the 9 services attempted or continued resuscitation on 27,970 cases, compared to 28,914 (10 services) in 2015. The numbers range from 1,686 in service J and 1,781 in service B, to 3,832 in service F and 4,432 in service A. The OHCAO average was 3,108 (median: 3,420). Figure 1 shows the variation between the services and the change in numbers submitted to the registry 2014-2016.

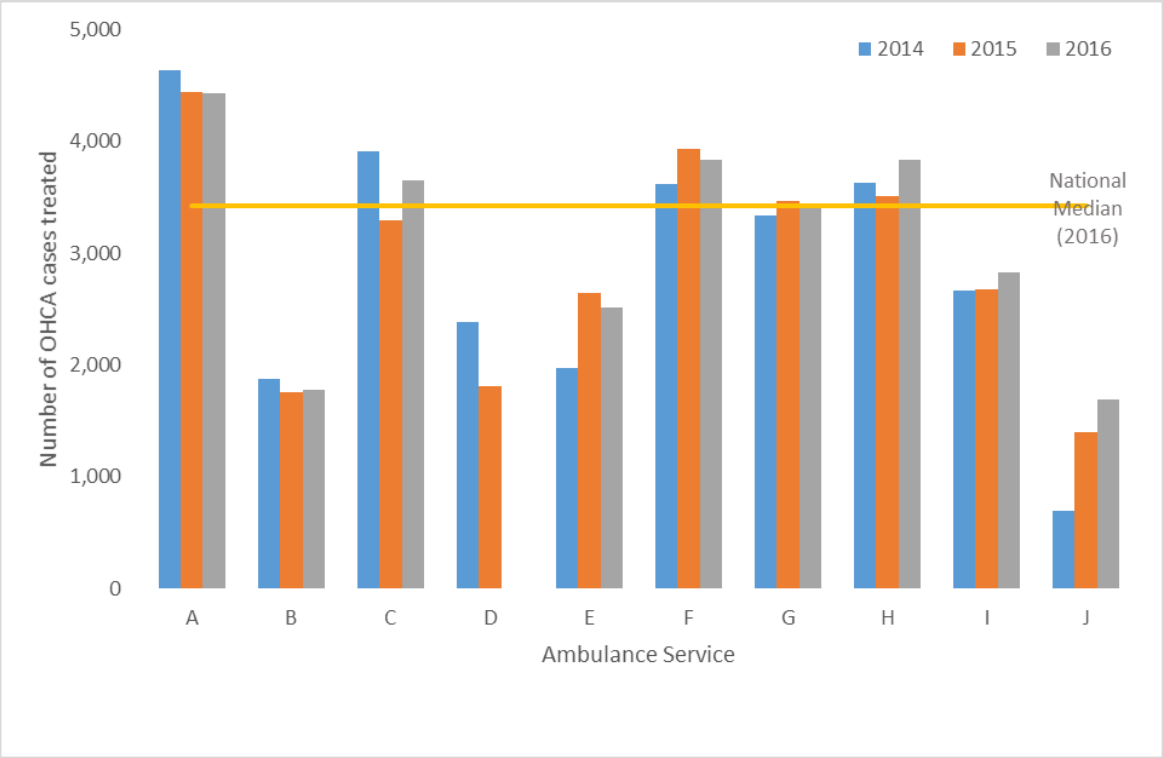


Figure 1: Number of resuscitations attempted cases by each ambulance service between 2014 and 2016

3.1.2 Incidence of Resuscitations Attempted

The variation in incidence of OHCAs, per 100,000 resident population, between the services is shown in Figure 2. The national median is 53.5 which is similar to that in 2015 (53.7). There is a large difference between the services ranging from 28.1 (service J) to 72.0 (service H). Adjusting for the size of the population makes it easier/more accurate to compare incidence across areas serving different size populations.

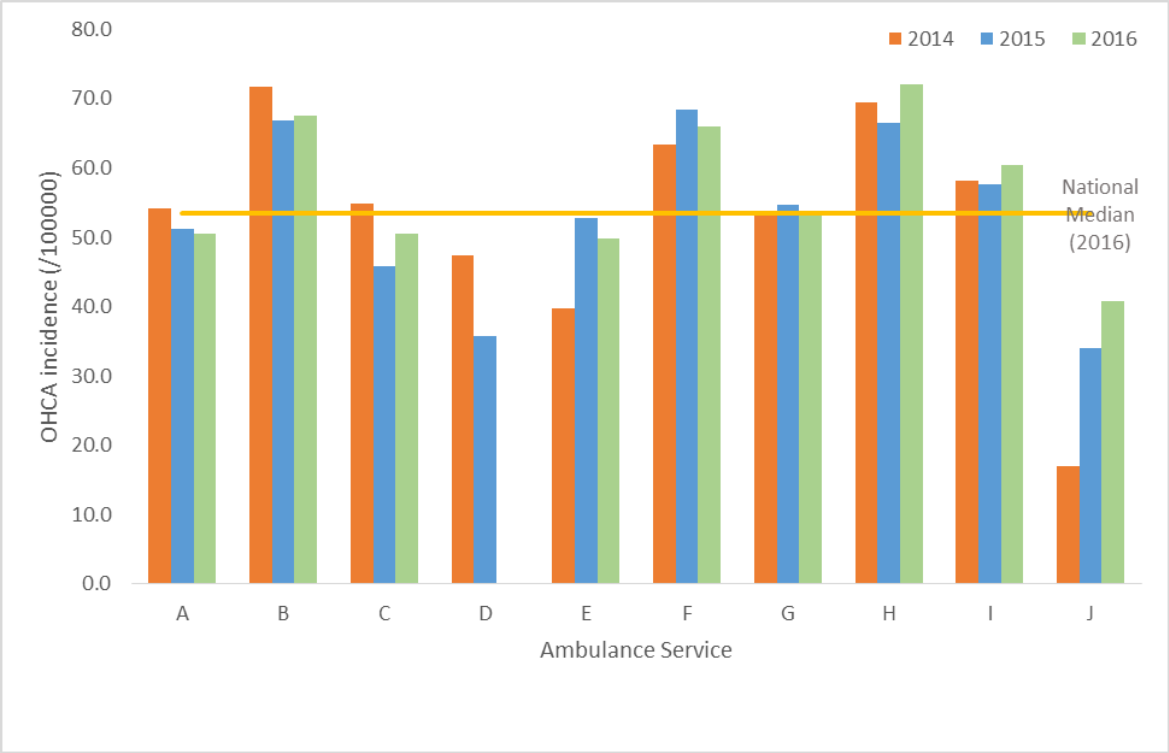


Figure 2: Comparison of Incidence (/100,000) of OHCAs where resuscitation was attempted, 2014-2016

3.1.3 Patient Demographics

Almost twice as many men as women suffer from cardiovascular disease (CVD) and they are also at greater risk of dying from CVD[6]. The risk of dying from CVD also significantly increases with age in both sexes.

The age and sex distribution of OHCAO cases for 2016 is shown in Figure 3. In all age groups more men than women have an OHCA. There were 17,567 male and 9,937 female OHCAs reported to the OHCAO registry in 2016, giving a ratio of 1.77:1. In 2015 the ratio was 1.82:1 (N: males=17,626, females=10,237). The number of cases increased exponentially in both sexes after age 0-4 years.

Figure 3 also shows the incidence of OHCA. The incidence among males was on average twice that of females. Approximately 2.9% of OHCAs were aged under 20 years and 64.5% 65 years and over; the respective incidence rates were 5.4/100,000 and 160.2/100,000.

[6] BHF (2017). CVD Statistics – BHF UK Factsheet. London: British Heart Foundation

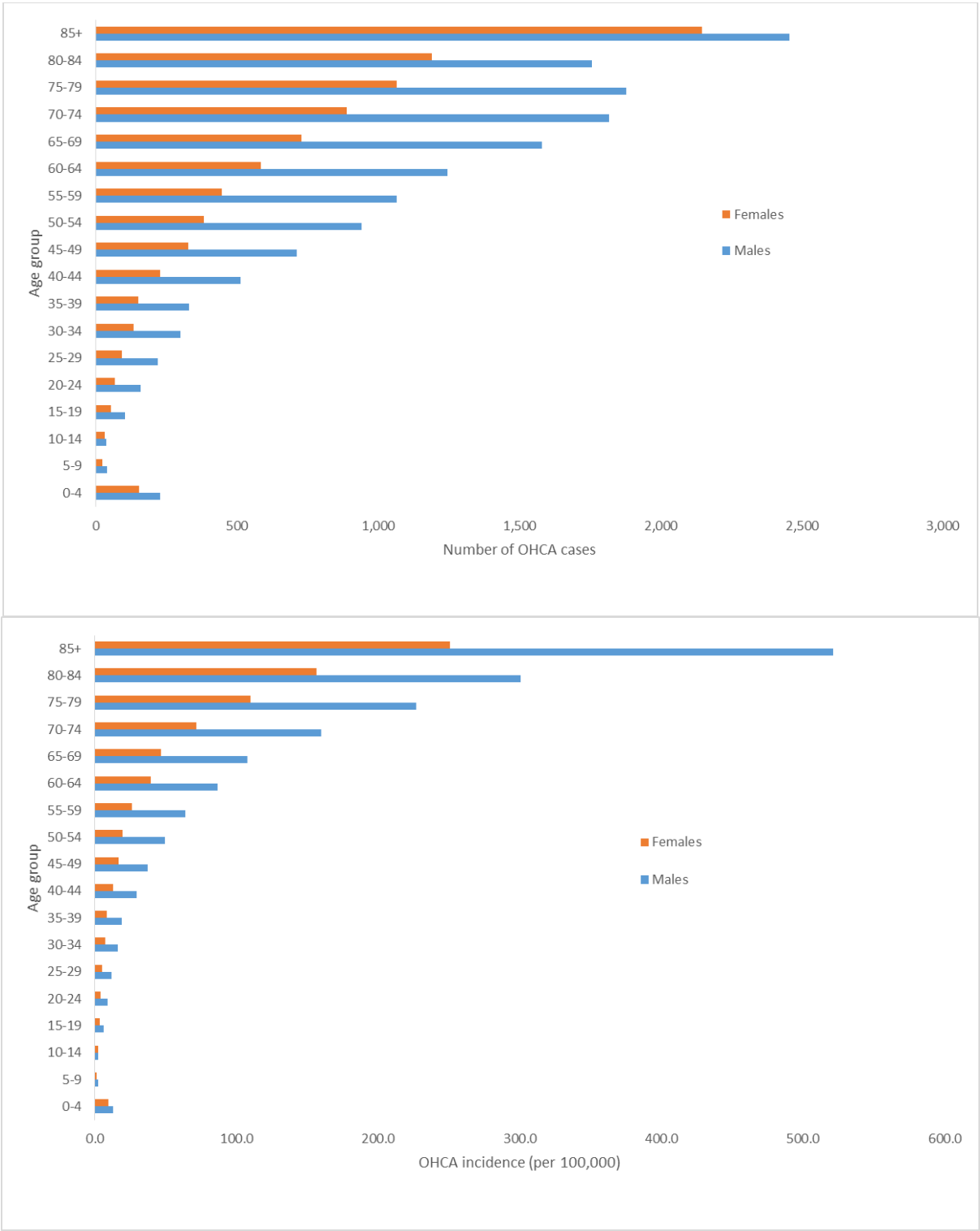


Figure 3: Number (top) and incidence (bottom) of resuscitation attempted cases age group and sex.

Age standardisation allows for direct comparisons of incidences between the different ambulance services when the size and age/sex distributions of the service populations differ. Age standardisation of the incidence, to the European Standard Population[7], for OHCAO data gave an overall figure of 43.7/100,000 for males and 20.2/100,000 for females, a ratio of 2.16:1. Table 1 shows the standardised figures for each ambulance service (2015 figures are presented for services D and G).

The figures indicate that the OHCA incidence in services A, B, F, and H among males is higher than areas covered by other services, whereas incidence in service J is lower. Similarly, for females incidence is also higher in these areas. The ratio of male:female incidence is consistently around 2.0, with the exception of service G.

Table 1: Comparison of crude and age/sex standardised OHCA incidence (/100,000) for all ambulance services

	Crude OHCA incidence			Standardised OHCA incidence		
	Male	Female	Ratio	Male	Female	Ratio
	64.6	36.1	1.79	66.5	30.3	2.19
B	85.5	48.8	1.75	63.4	30.8	2.06
C	63.4	37.8	1.68	48.2	24.9	1.94
D	58.9	34.1	1.73	45.0	22.5	2.00
E	64.4	35.1	1.83	48.1	22.4	2.14
F	85.7	45.6	1.88	65.1	28.5	2.28
G	65.9	44.5	1.48	45.6	31.1	1.47
H	85.7	45.6	1.88	65.1	28.5	2.28
I	69.7	35.9	1.94	49.8	21.7	2.29
J	50.9	30.0	1.70	38.5	18.1	2.12

[7] Pace et al (2013). Revision of the European Standard Population, Report of Eurostat's Task Force. Luxembourg, European Union.

3.1.4 Patient Clinical Characteristics

Figure 4 gives information on the initial aetiology of OHCA cases for each service compared to the OHCAO registry average for 2016. Cases are grouped into cardiac causes, which include cases where the cause is “unknown” or “unobtainable” (according to Utstein criteria), and non-cardiac causes. As expected, the significant majority of cases (75.8%) were of cardiac origin, which was lower than the figure for 2015 (79.2%). The proportion of OHCA cases that were of cardiac origin ranged between the services, from 56% to 98%.

The non-cardiac causes were trauma (2.5%), asphyxia (2.2%), drug overdose (1.5%) and submersion (0.3%).

In children under 20 years 58.9% (47.8% to 98.9%) were of cardiac aetiology, whereas in over 65-year-olds it was 78.2% (57.8% to 98.7%).

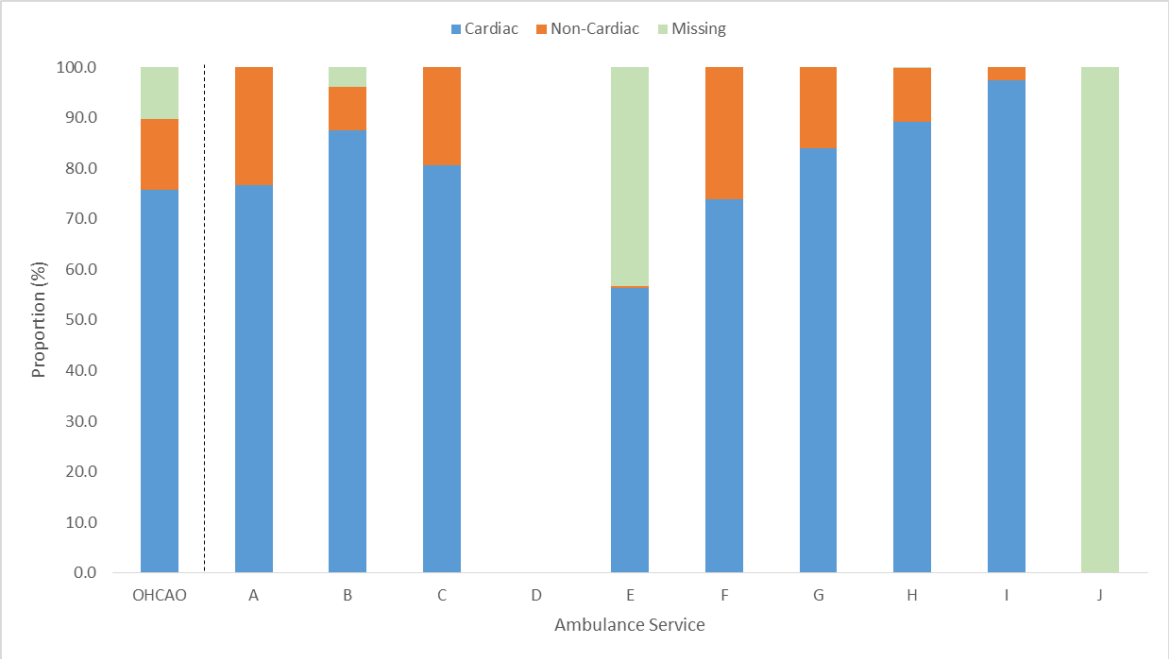


Figure 4: Initial aetiology of resuscitation attempted cardiac arrests for 2014-2016

3.1.5 Initial Rhythm

Research shows a patient who is found by an ambulance service paramedic in a shockable rhythm (ventricular fibrillation or pulseless ventricular tachycardia (VF/pVT)) is more likely to achieve return of spontaneous circulation (ROSC) and to survive to hospital discharge with a favourable neurological outcome[8,9].

About 19.8% of all OHCA cases were in shockable rhythm (range: 9.0% to 23.6%) (Figure 5), which is no different from that in 2015. It appears that significantly fewer OHCAs cases were in shockable rhythm in service B compared to the other services, who also had significantly more with an unknown rhythm. About 7.2% of OHCAs <20-years had a shockable rhythm, compared to about 18.2% of >65-year-olds.

Approximately half of all OHCA cases were in asystole (52.4%; compared to 48.1% in 2015). The proportion ranged from 46% to 74%. About 20.9% of patients were in pulseless electrical activity and 0.6% in bradycardia. An initial rhythm was not recorded in 6.3% of cases.

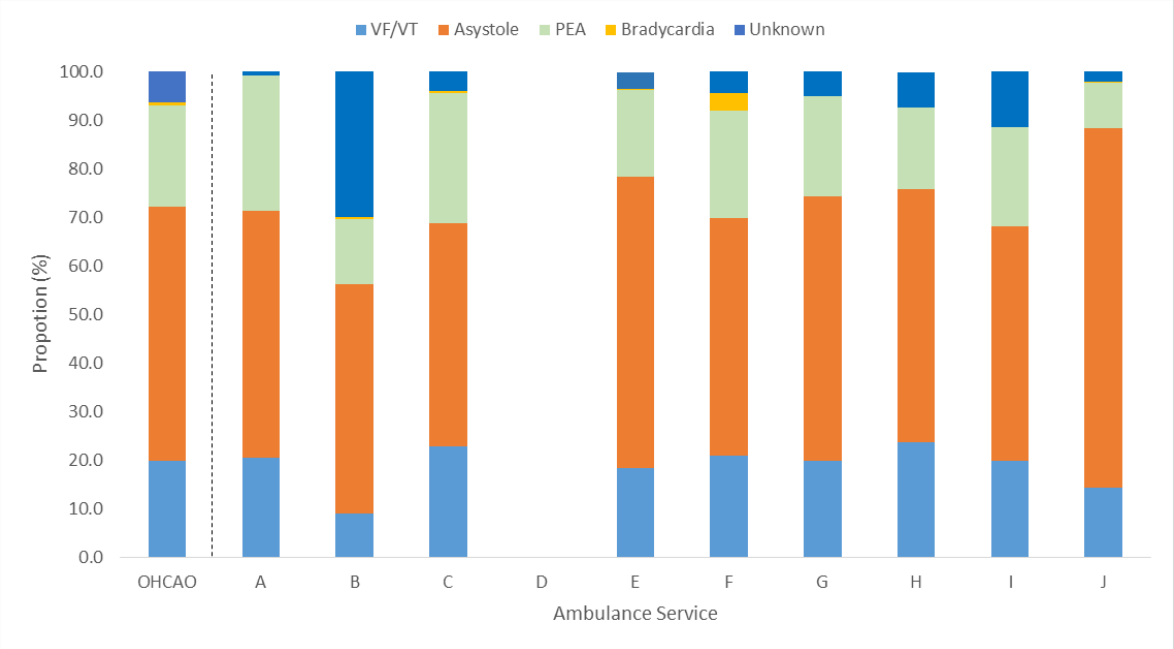


Figure 5: Comparison of initial rhythm in OHCAO cases in 2016

[8] Sasson et al. (2010). Predictors of survival from out-of-hospital cardiac arrest: A systematic review and meta-analysis. Circ Cardiovas Qual Outcomes, 3, 63-81.

[9] Mader et al. (2012). Out-of-hospital cardiac arrest outcomes stratified by rhythm analysis. Resuscitation, 83, 1358-62.

3.1.6 Location of OHCA

OHCA event location plays a critical role in the eventual outcome for the patient. Whether an OHCA happens in the home or elsewhere and the neighbourhood characteristics of where it takes place, such as social deprivation, population density and ethnic make-up, impacts on the patient's chances of survival. Events occurring in public places, such as the workplace, shops, and sporting/recreational facilities have a better outcome than those occurring in a residential setting. This is because in the former, OHCA events are more likely to be witnessed, more likely to have a prompt 999 call, more likely to have bystander CPR, and more likely to have an AED deployed.

Approximately 51% of OHCAs occurred inside the home in 2016 (range: 15.6 to 84.9%), and 8.8% elsewhere (Figure 6). However, we were not able to categorise 40.2% of locations as home or non-home accurately; removing these from the analysis resulted in 85.2% occurring in the home.

The location (home, non-home, unknown) was defined by comparing the postcode of the EMS location of the OHCA and the patient's home postcode. If postcodes were similar, the location was defined as "Home", if not they were defined as "Non-home". If the Utstein location was given, it was used to define location. For patients with incomplete home/event postcode data, the location was defined as "Unknown". Therefore, even though services were able to provide an address for an OHCA event, if a postcode was not present we could not compare it with the provided patient's postcode (if that was also present) to confirm if the event occurred at home or not. Future work, involving geocoding the OHCA location to provide a postcode and using the Ordnance Survey's AddressBase to classify the postcode into a basic land and property unit will enable us to update this analysis. Provision of the Utstein location in addition to a full location address in future by all services will also help us in this analysis in future.

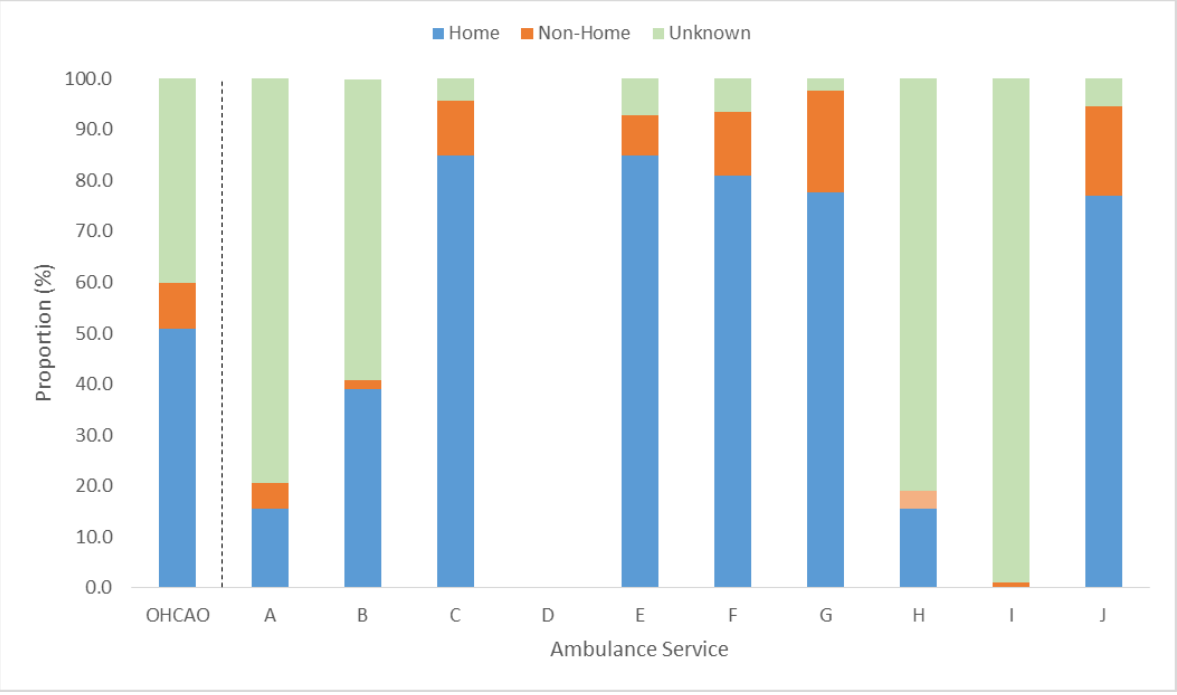


Figure 6: Comparison of location of cardiac arrest in 2016

3.2 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[10]. It describes a sequence of four steps that, when all are in place, optimises the chance of survival (Figure 7).

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 defibrillation is delayed, chances of survival reduces by 10%[11]. Early defibrillation can triple a person's chances of survival;
4. Post-resuscitation care

Figure 7: Chain of survival

[10] Newman (1989). The chain of survival concept takes hold. J Emerg Med Serv, 14, 11-13

[11] Larsen et al (1993). Predicting survival from out-of-hospital cardiac arrest: A graphic model. Ann Emerg Med, 22, 1652-8.

3.2.1 Early Recognition

Early recognition of an OHCA is essential to minimise the time in which the brain is without oxygen. If an OHCA is witnessed by a bystander the likelihood of the patient surviving to hospital handover and to hospital discharge is four times greater than in cases that are not witnessed. If an OHCA is witnessed by EMS personnel, the odds of survival were over seven times greater[12,13].

In 2016 about 43% of OHCA cases were witnessed by a bystander and about a further 13% witnessed by the EMS (Figure 8). However, about 35% of cases were not witnessed at all. Corresponding figures for 2015 were 45%, 13% and 37%, respectively. The proportion that were witnessed by EMS personnel ranged from 4.5% to 19.7%, and by a bystander from 24.2% to 53.5%.

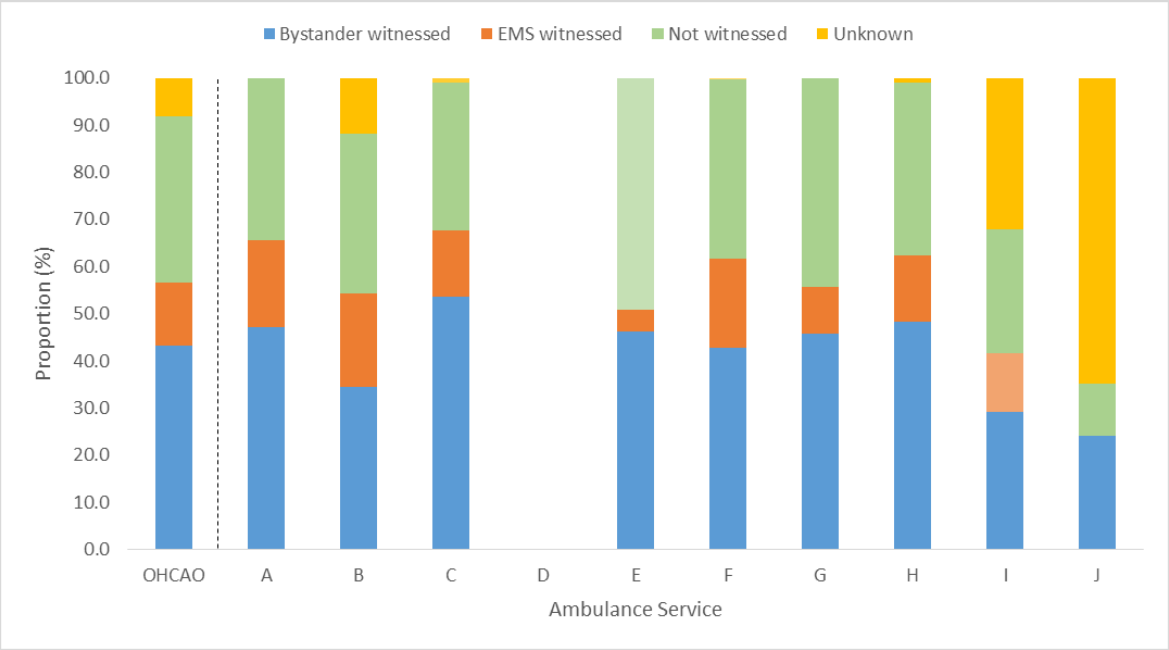


Figure 8: Proportion of OHCAs that were not witnessed, witnessed by Emergency Medical Services (EMS) or by a bystander in 2016

[12] Rea et al. (2010). Predicting survival after out-of-hospital cardiac arrest: Role of the Utstein data elements. Ann Emerg Med, 55, 249-57.

[13] Sasson et al. (2010). Predictors of survival from out-of-hospital cardiac arrest: A systematic review and meta-analysis. Circ Cardiovasc Qual Outcomes, 3, 63-81.

3.2.2 Early CPR

Brain tissue starts to die within 3 to 5 minutes after circulation stops, due to a lack of oxygen. Simply by providing early chest compressions, bystander CPR provides the blood flow needed to buy the time needed for the ambulance to arrive and provide care. Bystanders providing CPR and/or using a publically accessible defibrillator improves survival following OHCA. Early CPR can increase the odds of survival by up to five times[14,15].

About 62.3% (range: 28.1% to 74.6%; median: 61.5%) of OHCAs not witnessed by ambulance clinicians received bystander CPR (Figure 9). In 2015, the corresponding figure was 59.6% (range: 31.7% to 68.2%). Recent analysis of the OHCAO data has also shown that since the registry began, bystander CPR rates have significantly increased, and that there was significant temporal variation[16]. The 2016 figures are higher than those previously observed in different areas of the UK, which ranged from 19.6% to 43.2%[17,18,19,20]. The majority of services have seen a small increase in bystander CPR rates.

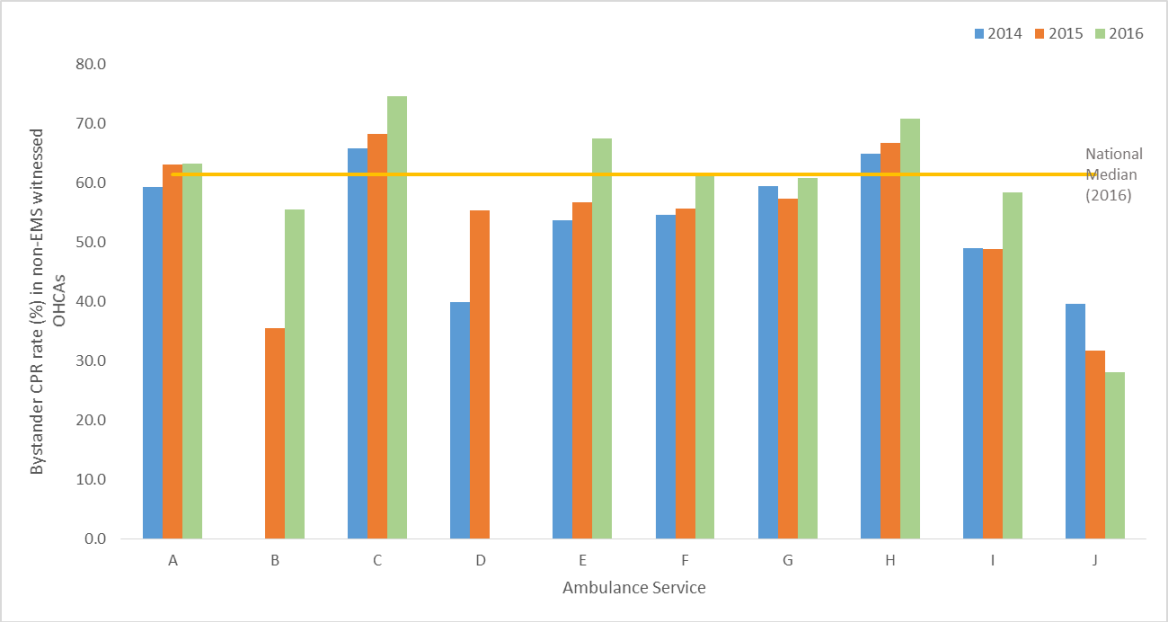


Figure 9: Bystander CPR rate in non-EMS witnessed cardiac arrests

[14] Rea et al. (2010). Predicting survival after out-of-hospital cardiac arrest. Role of the Utstein data elements. Ann Emerg Med, 55, 249-57.
[15] Sasson et al. (2010). Predictors of survival from out-of-hospital cardiac arrest: A systematic review and meta-analysis. Circ Cardiovasc Qual Outcomes, 3, 63-81.
[16] Brown et al. (2017). Temporal changes in bystander cardiopulmonary resuscitation rates in England. Resuscitation, 118(suppl 1), e69.
[17] Soo et al. (2001). Geographical distribution of cardiac arrest in Nottinghamshire. Resuscitation, 48, 137-47.
[18] Ghose et al. (2010). Bystander CPR in south east Scotland increases over 16 years. Resuscitation, 81, 1488-91.
[19] Shah et al. (2010). Out-of-hospital cardiac arrest in South Asian and white populations in London: database evaluation of characteristics and outcome. Heart, 96, 27-29.
[20] Moncur et al. (2016). Does the level of socioeconomic deprivation at the location of cardiac arrest in an English region influence the likelihood of receiving bystander-initiated cardiopulmonary resuscitation? Emerg Med J, 33, 105-08.

3.2.3 Public Access Defibrillator Usage

The earlier a shock is delivered to a victim the better their chances of survival, and use of a public access defibrillator (PAD) can improve survival with good neurological outcome of patients in shockable rhythms. A PAD was indicated as being used by a member of the general public in approximately 4.3% of all OHCA cases that were not witnessed by EMS personnel in the OHCAO registry (Figure 10); this analysis does not include data from four services (services B, D, E, J) who could not confirm whether a PAD was used or not. PADs were used significantly more in non-home locations (4.8%) than among OHCAs that occurred in the home (3.7%), which reflects their availability.

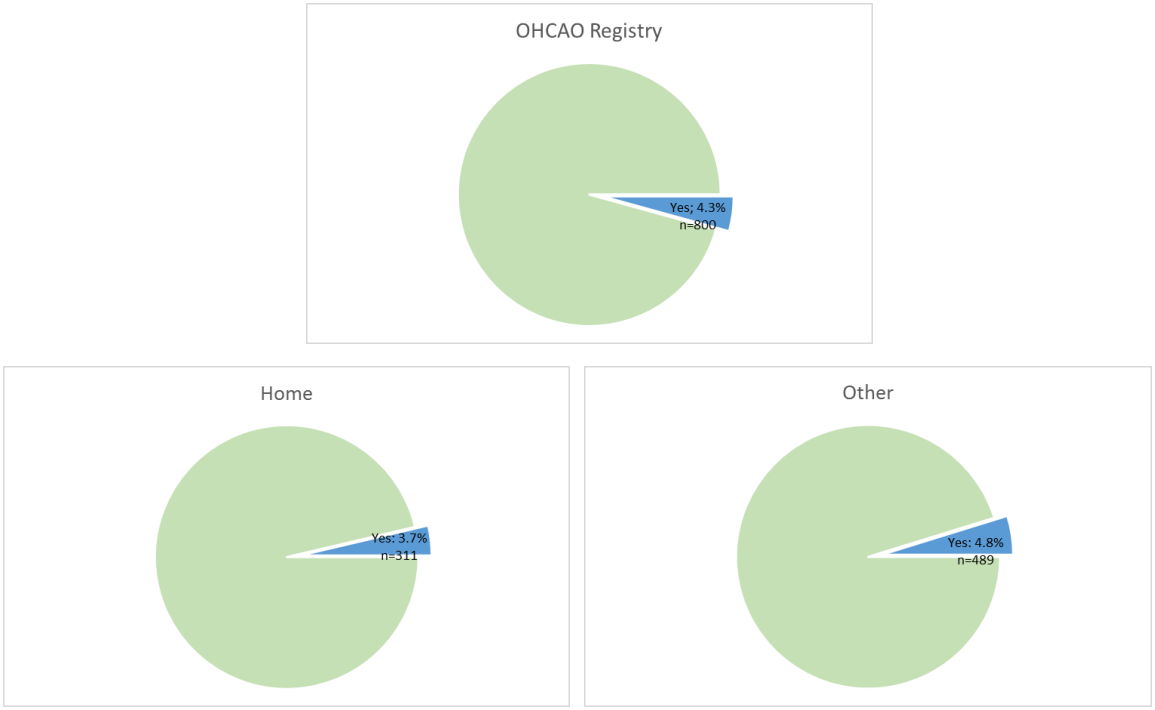


Figure 10: Proportion of public access defibrillation (PAD) usage in OHCAO registry (services B, D, E, J excluded)

3.2.4 EMS Response Time

Studies have shown that the chances of survival decrease significantly the longer it takes the EMS to arrive at the location of the OHCA[21]. Ambulance response times have long been known to be independently associated with defibrillation and survival in OHCAs. The recommended response time is 8-minutes[22].

Figure 12 shows the proportion of cases treated by the response time of the EMS. The EMS response time was calculated from the supplied time of the EMS call and time the EMS vehicle stopped. Both are based on the information provided at the time of the 999 call.

Approximately 46.6% of OHCAO cases were reached within the 8-minute national target, and a further 13.4% of cases were witnessed by ambulance clinicians already at the scene when the patient arrested. Approximately 29.8% of cases were reached between 8 and 19-minutes. Similar patterns were observed for individual service data.

After 8-minutes there was an exponential decline in the proportion of cases, however, approximately 2% of cases were still not reached after 19-minutes. The reason for the latter is unknown. These could include cases where cardiac arrest was not recognised at the time of the emergency call leading to an initial lower response category. It is also possible that it includes patients who sustained a cardiac arrest after the initial 999 call was made. It may also be that the 999 call was made by a third party.

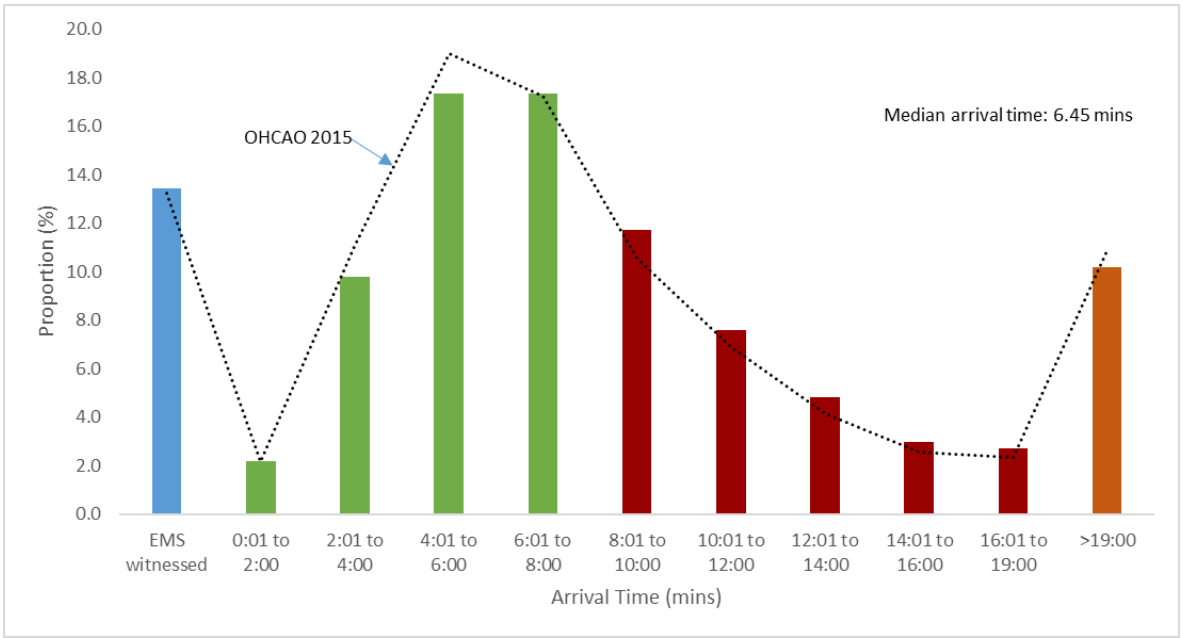


Figure 11: Distribution of arrival time of Emergency Medical Services to OHCA events in 2016

[21] O'Keeffe et al. (2010). Role of ambulance response times in the survival of patients with out-of-hospital cardiac arrest. Emerg Med J, 28(8), 703-06.

[22] Pell et al. (2001). Effect of reducing ambulance response times on deaths from out of hospital cardiac arrest: cohort study. BMJ, 322, 1385-8.

Table 2 compares data for 2016 with 2015. Where resuscitation was commenced or continued by EMS, the median response time was 6.5 minutes, compared to 6.1 minutes in 2015; with variation between the services. We observed a small decrease in the proportion of OHCA cases that were reached in the recommended time, and also witnessed by EMS, with variations between the services.

Table 2: Comparison of EMS response times 2015/2016 between services

	Median		EMS witnessed		Proportion of OHCAs reached within 0:01 to 8:00	
	2016	2015	2016	2015	2016	2015
A	6.80	6.85	18.5	16.8	43.4	46.3
B	4.56	6.27	38.1	13.1	37.2	54.8
C	6.17	6.00	15.7	15.6	60.7	59.4
D		7.27		15.0		35.7
E	8.41	8.92	4.7	0.3	43.1	43.9
F	5.54	4.76	18.9	20.3	54.1	598
G	6.14	5.50	9.9	12.7	55.9	45.5
H	6.66	6.00	14.1	45.5	14.5	34.6
I	6.70	5.77	16.7	11.2	45.1	54.0
J	6.62	6.32	0.0	0.8	63.0	66.1
OHCAO	6.5	6.1	13.4	13.2	46.6	49.4

3.3 OUTCOMES

Neurologically-intact survival from OHCA is regarded as an international benchmark of ambulance service effectiveness. The outcome measures in the OHCAO registry used to monitor the effectiveness are ROSC at hospital handover and survival to hospital discharge. For both ROSC and survival, variation between the services has been previously reported [23].

3.3.1 ROSC at Hospital Handover

In 2015 and 2016 almost 26.3% (median: 26.8%; 24.8% in 2015) of patients, where resuscitation was commenced or continued by ambulance staff, had achieved ROSC at hospital handover. However, one service was unable to provide ROSC information, and therefore, if we take this out of the analysis the figure increases to 27.7% with median of 26.9% (7,292 of 26,284; 2015 figure was 27.9%, median: 26.2%) (Figure 12). Again there was large variation between the services, with a range of 18.6% to 35.1%. The variation could reflect that some services are more selective on whom they attempt resuscitation.

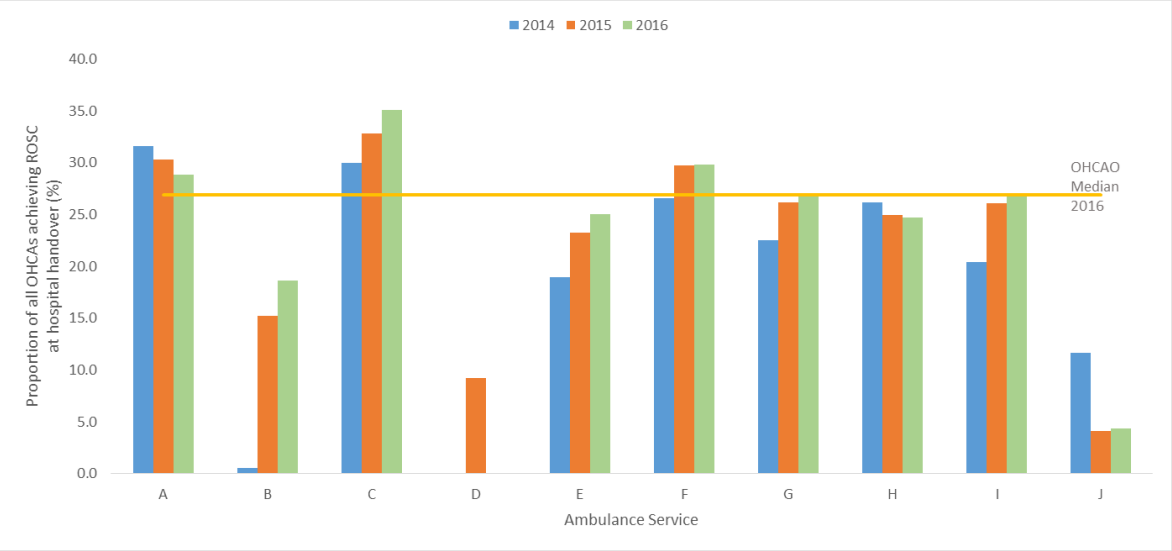


Figure 12: Rate of ROSC at hospital handover, 2014-2016

[23] Perkins & Cooke (2012). Variability in cardiac arrest survival: the NHS Ambulance Service Quality Indicators. Emerg Med J, 29(1), 3-5.
https://www.england.nhs.uk/statistics/statistical-work-areas/ambulance-quality-indicators/

3.3.2 Survival to Hospital Discharge

In 2016, 2,037 of 26,284 (7.7%) OHCA patients survived to hospital discharge, similar to 7.8% in 2015 (Figure 13). As for ROSC, a significant proportion of survival data from two services was 'missing' or 'unknown', and these are not included in the national figure. There is some variation in survival rates between the services, the range being 5.6% to 9.2%.

Figure 14 shows the cumulative number of lives saved (survival to hospital discharge) between 2014 and 2016; a total of 6,150 lives have been saved.

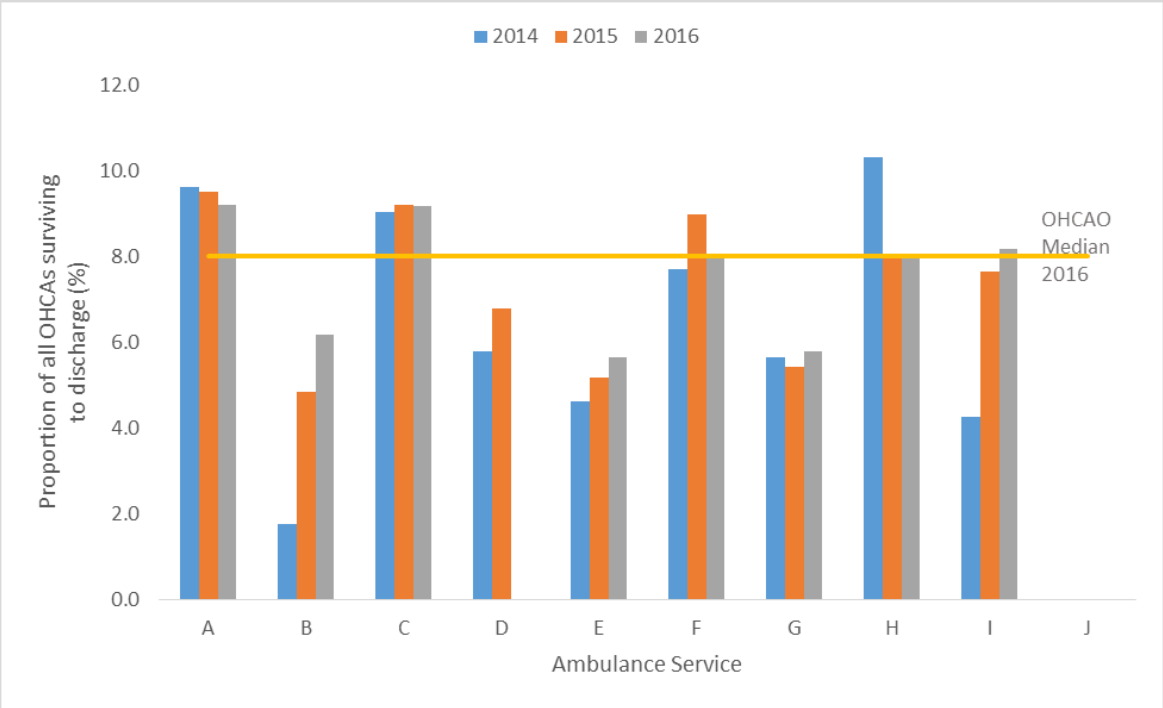


Figure 13: Survival to hospital discharge rate in all EMS-treated cases, 2014-2016

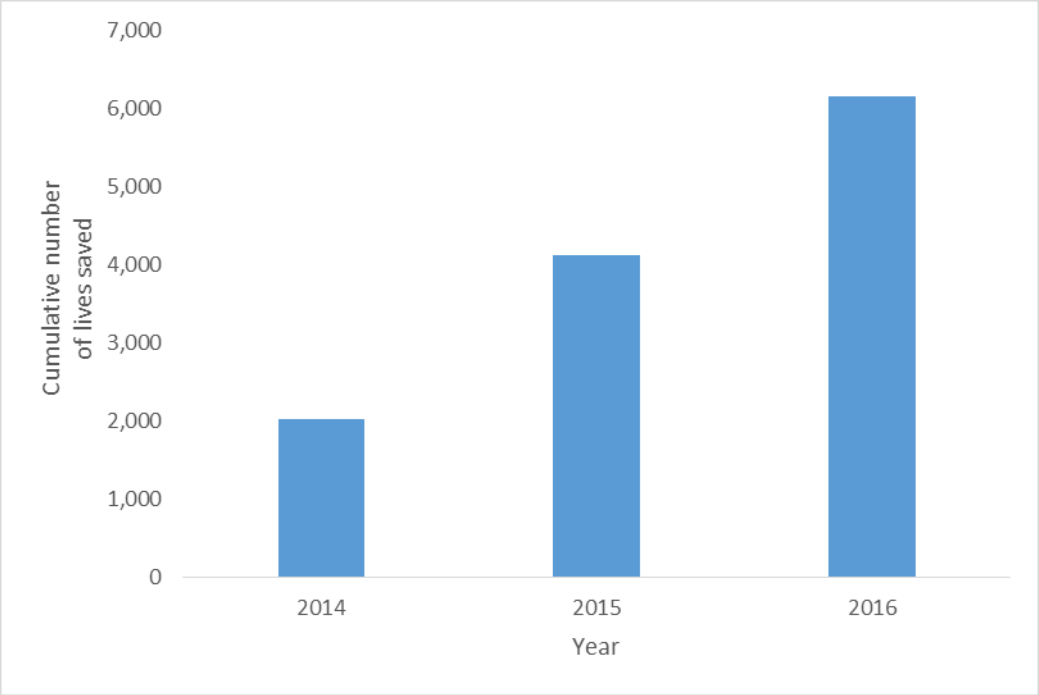


Figure 14: Cumulative number of lives saved 2014 to 2016

In 2016, following all those patients that achieved ROSC at hospital handover (n=7,292), 1,881 cases or 25.8% survived to hospital discharge (Figure 15). This compares to the figure for 2015 of 26.1% (1,816 of 6,959 cases). The range between services was 18.1% to 30.6%.

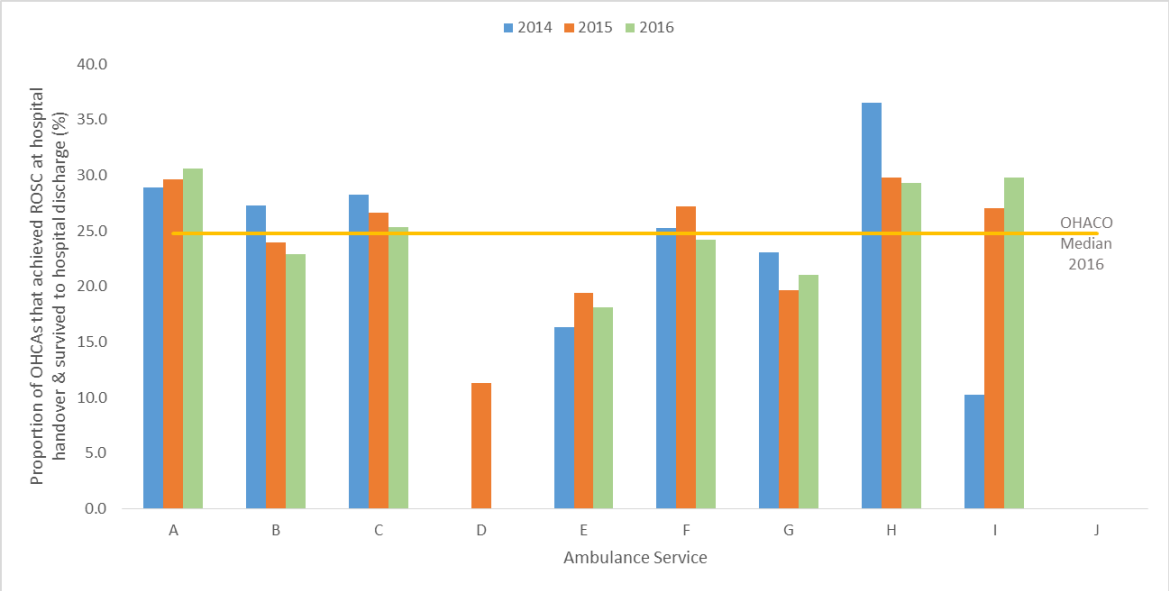


Figure 15: Survival to hospital discharge rate in cases that achieved ROSC at hospital handover, 2014-2016

Previous studies have shown that survival rates are higher the earlier defibrillation is delivered, and the critical role bystanders and first responders play in delivering early defibrillation[24]. Figure 16 shows that if EMS arrive within the first two minutes, survival to discharge is the same irrespective of whether the patient receives any pre-EMS intervention or not. However, after two minutes the chances of survival begin to decrease, the decline is slower the more pre-EMS interventions occur, such that if a patient's OHCA is witnessed by a bystander, they receive bystander CPR, are defibrillated by a bystander and the EMS arrival time is up to 16-minutes, then the odds of survival are three-times those of patients who receive no pre-EMS intervention.

The national picture is presented because of the incompleteness of PAD usage data across the ambulance services.

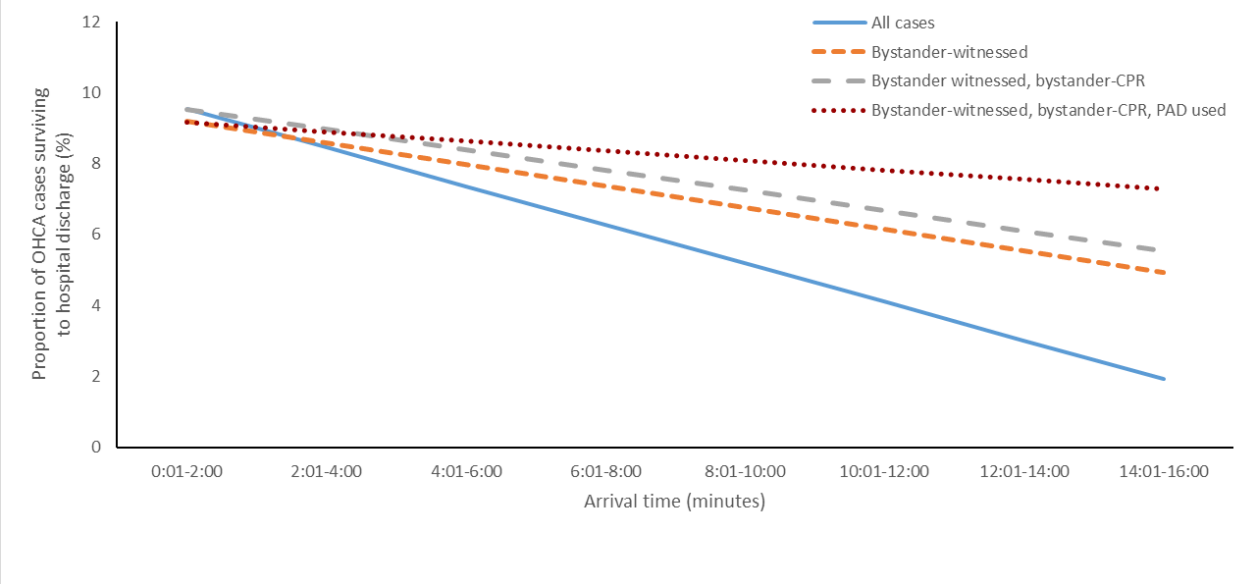


Figure 16: Trend of survival to hospital discharge in all non-EMS witnessed cases and Utstein groups with arrival time of EMS personnel in OHCAO registry in 2016

[24] Hansen et al. (2015). The role of bystanders, first responders, and emergency medical service providers in timely defibrillation and related outcomes after out-of-hospital cardiac arrest: Results from a statewide registry. Resuscitation, 96, 303-9.

4 DATA COMPLETENESS OF OHCAO PRIORITY VARIABLES

Concentrating on the key variables that follow the chain of survival we can see where variation in data quality presents, allowing the OHCAO team to develop individual improvement plans with each site. During the data import process, the key variables are assessed as 'valid', 'out-of-range' or 'missing'. A value is 'missing' if nothing has been entered into a field. A 'valid' and 'out-of-range' value is variable specific and depends on the type of variable, all possible entries being agreed on a service-by-service basis.

The OHCAO registry have identified seven key priority variable that each service is requested to provide high quality data for. These are:

- Who witnessed the OHCA occurrence
- Whether a bystander commenced CPR before the arrival of EMS
- Whether a PAD was used by a member of public before the arrival of EMS
- Whether a ROSC was achieved at any time during resuscitation
- Whether there was a ROSC at hospital handover
- Whether the patient survived to hospital discharge

Figure 17 summarises the proportion of each of these key core variables that contains a 'valid' entry, i.e. no missing or out-of-range data. The figure shows that for 2016 the data quality for some services was very good, above the national average for all the key variables. However, there is still room for improvement in other services.

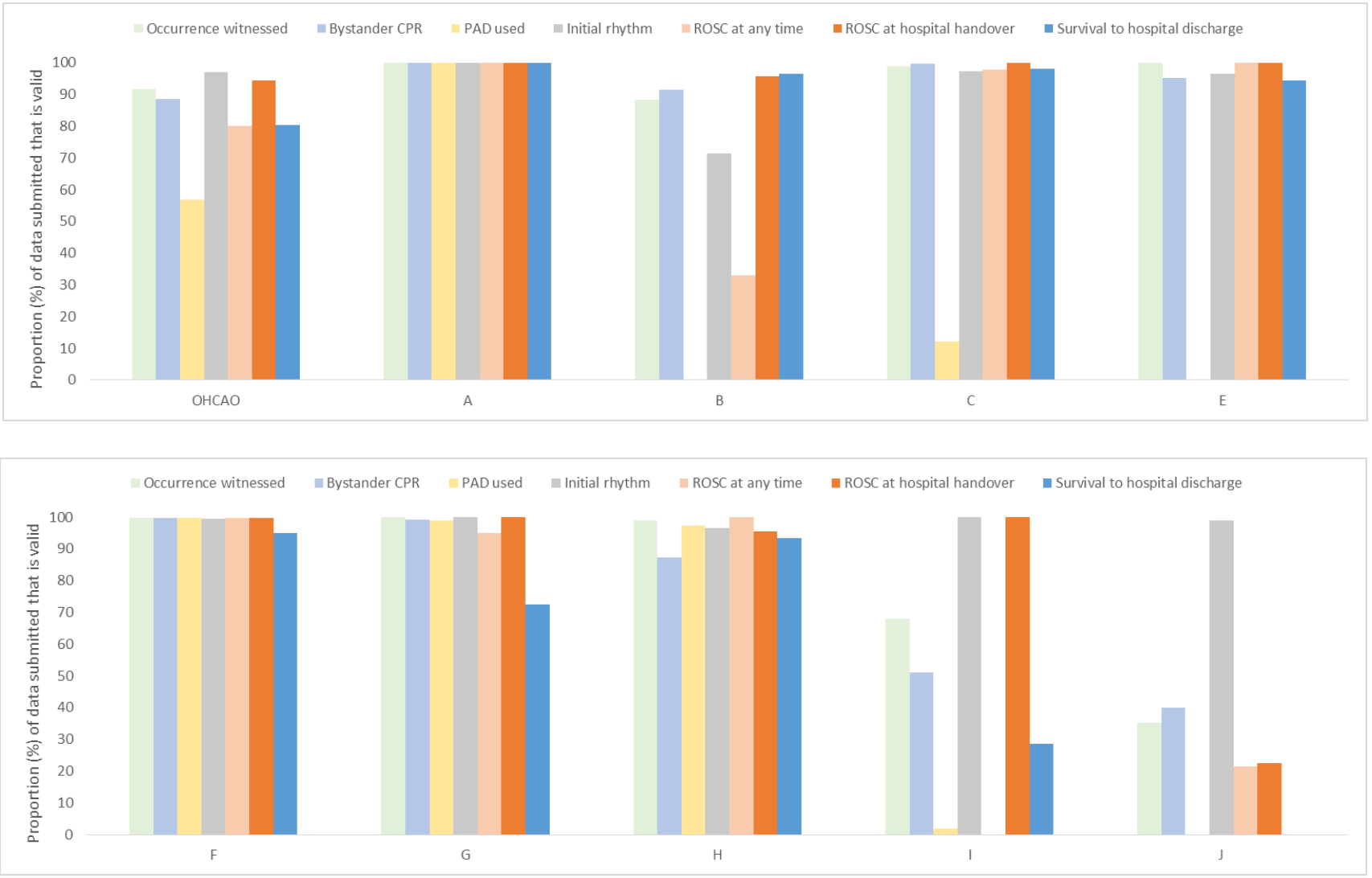


Figure 17: Data completeness of key cardiac arrest variables

5 CURRENT RESEARCH, COLLABORATIONS AND DATA SHARING

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

5.1 OHCAO TEAM RESEARCH PROJECTS

5.1.1 Temporal Trends in Bystander CPR Rates

This project investigates the trends in bystander CPR rates in England[25]. The analysis shows significant temporal variability in OHCA incidence and bystander CPR rate by hour of the day, day of the week, and season. There is an increasing trend between 2013 and 2015 in the number of cardiac arrest cases receiving bystander CPR, which is encouraging and could be associated with national and local training initiatives. The OHCAO team collaborated with EMAS, SECAMB, SWAST and LAS on this project.

5.1.2 Neighbourhood Characteristics of High Risk Areas for OHCA

The aim of this research was to identify high risk communities in England with a high OHCA incidence and low bystander CPR rate. The results could inform the development of targeted training strategies[26]. The study showed that the most deprived areas of England are at highest risk. The OHCAO team collaborated with EMAS, SECAS, SWAS and LAS on this project.

5.1.3 Attitudes to CPR and Defibrillator use Survey

An online survey was undertaken to determine the proportion of UK adults who were trained in CPR and/or PAD use[27]. About 60% said they had trained in CPR. People who had received training said they were more willing to act in the event of a cardiac arrest, both in performing CPR and also getting and using a PAD. The OHCAO team collaborated with BHF, RCUK, EMAS, SECAS and WMAS on this project.

5.1.4 Data Linkage with ONS

The aim of the project was to establish the feasibility of linking OHCAO data to the National Health Service (NHS) patient demographic data and Office for National Statistics (ONS) mortality data held on the NHS Personal Demographic Service (PDS) database[28]. The project demonstrated linkage was

[25] Brown et al. (2017). Temporal changes in bystander cardiopulmonary resuscitation rates in England. Resuscitation, 118(suppl 1), e69.
[26] Brown et al. (2017). Identification of characteristics of neighbourhoods with high incidence of out-of-hospital cardiac arrest and low bystander cardiopulmonary resuscitation rates. Resuscitation, 118(suppl1), e67-e68.
[27] Hawkes et al. (2017). Attitudes to cardiopulmonary resuscitation and defibrillator use: a survey of UK adults in 2017. Submitted for publication.
[28] Rajagopal et al. (2017). Data quality and 30-day survival for out-of-hospital cardiac arrest in the UK out-of-hospital cardiac arrest registry: a data linkage study. BMJ Open, 7:e017784.

feasible, improving demographic and mortality data quality and allowing analysis of 30-day survival status. The OHCAO team worked with collaborators from EMAS, SWAS and WMAS on this project.

5.1.5 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 developed and validated risk prediction models for Return of Spontaneous Circulation (ROSC) at hospital handover and survival to hospital discharge using pre-EMS (Emergency Medical Services) intervention characteristics of OHCA[29]. The developed models showed moderate performance and we will further improve them using new data and EMS intervention related variables. The OHCAO team collaborated with EMAS, SWAS and LAS on this project.

5.1.6 OHCA in Schools

The aim of this work is to investigate the incidence and location of OHCAs in relation to schools in the West Midlands. This project is being conducted by Dr Madeleine Benson with the assistance of the OHCAO team.

5.1.7 Pre-Hospital Adrenaline Administration for OHCA

The aim of this study is to use data from the OHCAO registry and a secondary analysis of data from the PARAMEDIC RCT to describe the epidemiology and outcomes for pre-hospital administration of adrenaline for OHCA patients in England and Wales between 2010 and 2015.

5.1.8 Sex Inequality in OHCA Resuscitation Attempts

This project aims to explore 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 conducted by Dr James Mapstone from Public Health England (PHE).

5.2 Research collaborations

5.2.1 EuReCa Two

This project is a collaboration with other European OHCA registries. It is collecting OHCA epidemiology, treatment and outcome data over 3 months (October to December 2017).

5.3 Data Sharing

5.3.1 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 SWAS, NEAS, WMAS and SECAS, is using data from the OHCAO database to understand the effect of Critical Care Teams compared to advanced life support (ALS) on survival from OHCA.

[29] Ji et al. (2017). Risk prediction models for out-of-hospital cardiac arrest outcomes in England. Resuscitation Council (UK) Scientific Symposium, National Motorcycle Museum, Birmingham, 17 November.

5.3.2 Incidence, Outcomes and Predictors of OHCA at International Airports

The primary aim of this study is to determine the incidence and outcome from OHCA that occurred at international airports where resuscitation was attempted between 2013 and 2015 worldwide. The chief investigator is Siobhan Masterson (NUI Galway). A paper reporting the results of this study has been recently accepted for publication in Resuscitation (https://doi.org/10.1016/j.resuscitation.2018.03.024).

5.3.3 Paramedic 2 – The Adrenaline Trial

Data has been requested by the PARAMEDIC 2 team to supplement descriptive data on the trial's population. The collaboration between OHCAO and Paramedic 2 will ensure efficiency in trial data collection as research paramedics will only collect data for cases not yet available in the OHCAO registry.

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

This 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?

5.3.5 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.

6 RECOMMENDATIONS

We endorse the key recommendations from the Resuscitation to Recovery national framework for OHCA in England [30].

• 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 cardiac 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
• 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

[30] NHS England (2017). Resuscitation to Recovery: A National Framework to improve care of people with out-of-hospital cardiac arrest (OHCA) in England. London: NHS England

APPENDIX 1: DATA LINKAGE PAPER

Open Access Research

BMJ Open

Data quality and 30-day survival for out-of-hospital cardiac arrest in the UK out-of-hospital cardiac arrest registry: a data linkage study

Sangeerthana Rajagopal,[1,2] Scott J Booth,[1] Terry P Brown,[1] Chen Ji,[1] Claire Hawkes,[1] A Niroshan Siriwardena,[3] Kim Kirby,[4] Sarah Black,[4] Robert Spaight,[5] Imogen Gunson,[6] Samantha J Brace-McDonnell,[1,2] Gavin D Perkins,[1,2] on behalf of OHCAO collaborators

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ABSTRACT

Objectives The Out-of-Hospital Cardiac Arrest Outcomes (OHCAO) project aims to understand the epidemiology and outcomes of out-of-hospital cardiac arrest (OHCA) across the UK. This data linkage study is a subproject of OHCAO. The aim was to establish the feasibility of linking OHCAO data to National Health Service (NHS) patient demographic data and Office for National Statistics (ONS) date of death data held on the NHS Personal Demographics Service (PDS) database to improve OHCAO demographic data quality and enable analysis of 30-day survival from OHCA.

Design and setting Data were collected from 1 January 2014 to 31 December 2014 as part of a prospective, observational study of OHCA attended by 10 English NHS Ambulance Services. 28 729 OHCA cases had resuscitation attempted by Emergency Medical Services and were included in the study. Data linkage was carried out using a data linkage service provided by NHS Digital, a national provider of health-related data. To assess data linkage feasibility a random sample of 3120 cases was selected. The sample was securely transferred to NHS Digital to be matched using OHCAO patient demographic data to return previously missing demographic data and provide ONS date of death data.

Results A total of 2513 (80.5%) OHCAO cases were matched to patients in the NHS PDS database. Using the linkage process, missing demographic data were retrieved for 1636 (72.7%) out of 2249 OHCAO cases that had previously incomplete demographic data. Returned ONS date of death data allowed analysis of 30-day survival status. The results showed a 30-day survival rate of 9.3%, reducing unknown survival status from 46.1% to 8.5%.

Conclusions In this sample, data linkage between the OHCAO registry and NHS PDS database was shown to be feasible, improving demographic data quality and allowing analysis of 30-day survival status.

Strengths and limitations of this study

- Data points collected as part of the Out-of-Hospital Cardiac Arrest Outcomes (OHCAO) project were based on established Utstein guidelines.
- The quality of demographic data collected by the OHCAO project was first improved through a list cleaning and patient status service provided by NHS Digital.
- Following list cleaning, exact data matches with Office for National Statistics date of death data allowed calculation of 30-day survival status.
- Provision of National Health Service numbers from OHCAO and NHS Digital provides potential for following long-term survival outcomes in OHCA patients through data linkage.
- Improved data linkage is reliant on improved data capture of patient demographic data by ambulance services.

INTRODUCTION

Every year in the UK there are around 60 000 out-of-hospital cardiac arrests (OHCAs) attended by Emergency Medical Services (EMS) of which approximately 28 000 have resuscitation attempted.[1 2] This group suffers significant mortality and morbidity,[3 4] and improving outcomes from OHCA remains a worldwide research priority.[5]

Collecting high-quality data is essential as this forms the basis of decisions that ultimately impact on changes in care and healthcare resource allocation. Since 2011, survival to hospital discharge rates for OHCA has been reported as part of the National Health Service (NHS) England Ambulance Quality Indicators (AQIs), with significant variation reported ranging from 2.2% to 12.0%.[6] Regional variation in survival rates has also been observed worldwide.[7–9] Lilford *et al* highlighted that an important source of variation in reporting outcomes can be traced to the quality of data that results are based on.[10] Collecting survival to discharge data in England is a challenging process for

APPENDIX 2: CPR SURVEY PAPER

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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Terry Brown, University of Warwick, UK
Scott Booth, University of Warwick, UK
Rachael T. Fothergill, London Ambulance Service
A. Niroshan Siriwardena, University of Lincoln
Sana Zakaria, British Heart Foundation
Sara Askew, British Heart Foundation
Julia Williams, South East Coast Ambulance Service NHS Foundation Trust
Nigel Rees, Welsh Ambulance Service NHS Trust
Chen Ji, University of Warwick

APPENDIX 3: BYSTANDER CPR PAPER

European Heart Journal - Quality of Care and Clinical Outcomes

Characteristics of Neighbourhoods with High Incidence of Out-of-Hospital Cardiac Arrest and Low Bystander Cardiopulmonary Resuscitation Rates in England

--Manuscript Draft--

Manuscript Number:	EHJ-QCCO-D-18-00030
Full Title:	Characteristics of Neighbourhoods with High Incidence of Out-of-Hospital Cardiac Arrest and Low Bystander Cardiopulmonary Resuscitation Rates in England
Short Title:	Identification of High-Risk Areas for Cardiac Arrest
Article Type:	Original Article
Keywords:	Bystander cardiopulmonary resuscitation; Pre-hospital cardiac arrest; Neighbourhood characteristics
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APPENDIX 4: ERC CONFERENCE ABSTRACTS

AS090

Improving data quality in a UK out-of-hospital cardiac arrest registry through data linkage between the Out-of-Hospital Cardiac Arrest Outcomes (OHCAO) project and NHS Digital

Sangeerthana Rajagopal[1,2], Scott Booth[1,2,*], Terry Brown[1,2], Chen Ji[1,2], Claire Hawkes[1,2], A. Niroshan Siriwardena[3,2], Kim Kirby[4,2], Sarah Black[4,2], Robert Spaight[5,2], Imogen Gunson[6,2], Samantha Brace-McDonnell[1,2], Gavin Perkins[1,2]

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Purpose: The Out-of-Hospital Cardiac Arrest Outcomes (OHCAO) project is a national research database, which aims to understand the epidemiology and outcomes of out-of-hospital cardiac arrests (OHCA) across the UK. This study is a sub-project of OHCAO and aimed to establish the feasibility of linking OHCAO data to National Health Service (NHS) patient demographic data and Office for National Statistics (ONS) mortality data held on the NHS Personal Demographics Service (PDS) database, through the NHS Digital list cleaning service, to improve data quality and establish accurate 30-day survival from OHCA.

Materials and methods: Data from 1st January 2014 to 31st December 2014 were collected as part of a prospective, observational study of OHCAs attended by ten English NHS Ambulance Services. 28,729 OHCA cases had resuscitation attempted by Emergency Medical Services and a randomly selected sample of 3120 cases were securely transferred to the NHS Digital list cleaning service to be matched using OHCAO patient demographic data to return previously missing data and provide ONS date of death data.

Results: A total of 80.5% of OHCAO cases were matched to the NHS PDS database, with the patient's NHS number being the best data point for a successful match. Using the linkage process, missing demographic data was retrieved for 72.7% of cases with incomplete data. Confirmation of 30-day survival improved by 37.6% with a reduction in unknown 30-day survival status from 46.1% to 8.5%.

Conclusions: This study shows the feasibility of linking data from the UK OHCAO project to NHS patient demographic and ONS date of death data, through the NHS Digital list cleaning service. Data linkage was shown to successfully improve the quality of OHCA demographic data and establish 30-day survival status, demonstrating the potential to utilise data linkage methods to follow OHCA patients longitudinally.

http://dx.doi.org/10.1016/j.resuscitation.2017.08.096

AS091

The futility of cardiopulmonary resuscitation attempts in nursing homes and primary care wards

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Purpose of the study: Dispatching emergency medicine service (EMS) to treat nursing home residents or deteriorating patients in local hospitals is a growing phenomenon in Finland. We studied the epidemiology and the outcome after cardiac arrest (CA) in these situations [1,2].

Materials and methods: We conducted an Utstein-style observational study between 1 June 2013 and 31 May 2014 in the county of Pirkanmaa, Finland. We included CA patients in nursing homes and local hospitals if EMS participated in the treatment. Primary outcome was survival to university hospital admission. Secondary outcomes were survival to hospital discharge and 90-day survival.

Results: A total of 355 consecutive CA-patients were attended during the study period and 65 (18%) met the inclusion criteria. An EMS physician was present in 12 (18%) of cases. The most common primary rhythm was asystole ($n = 26$, 40%). Eight (12%) patients survived to university hospital admission and half of them (6%) survived to hospital discharge. Three of them had a neurologically favourable outcome. Only two (3%) patients were alive 90 days after the event–both were less than 70 years old and presented with ventricular fibrillation as the initial rhythm. Survival to hospital was more likely if an EMS physician attended the case (42% vs. 6%; $p = 0.004$).

Conclusions: Resuscitation in nursing homes was found futile, as survival was low. Yet, some patients in local hospitals had a favourable outcome, and the EMS system seems to be able to recognize them and focus resources to provide the best possible treatment for these few patients.

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AS094

Outcomes comparison between a community-wide bystander defibrillation program and dispatcher-assisted CPR in out-of-hospital cardiac arrest at public locations

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Purpose: We compared the outcomes between a community-wide bystander defibrillation program and a dispatcher-assisted cardiopulmonary resuscitation (DA-CPR) program in patients after out-of-hospital cardiac arrest at public sites.

Materials and methods: A prospective 2-year community-wide observational database collected from an OHCA e-Registry in a metropolitan was studied, after a citywide bystander defibrillation rescue program had been launched that strategically providing public accessed AEDs (automated external defibrillators) in designated locations that were also e-registered; and a DA-CPR program had been run. The survival outcomes of OHCA at pubic locations between the two program interventions were compared. Outcomes included 2-h sustained ROSC (return of spontaneous circulation) at hospital, survival to hospital discharge, and good CPC (Cerebral Performance Category Scale 1 or 2). All patient pre-hospital characteristics and outcome relations were evaluated and adjusted by regression analysis.

Results: The density of public AEDs distribution increased from 3.96 to 6.24 per square kilometers in the studied 2 years. Among a total of 6,356 OHCA, 627 patients occurred at public locations, including 28 patients (male for 82%, witnessed arrest for 79%) received bystander aid by public AEDs plus CPR rescue and 243 patients (male for 64%, witnessed arrest for 61%) received dispatcher-assisted CPR. For these 28 patients, 53.6% (15/28) achieved pre-hospital ROSC at scene or during transport, 71.4% (20/28) achieved sustained ROSC after resuscitation at hospital, 57.1% (16/28) achieved survival-to-discharge and noticeably all those 16 (100%, 16/16) survival-to-discharge patients achieved excellent neurological outcome of CPC 1 (CPC Scale 1). Their outcomes were significantly better (71.4 vs 43.6%, OR: 3.2 [95%CI: 1.4–7.6] for sustained ROSC; 57.1 vs 25.9%, OR: 3.8 [95%CI: 1.7–8.5] for survival of discharge; 57.1 vs 16.9%, OR: 6.6 [95%CI: 2.9–14.9] for good CPC; and 100 vs 65.1% for good CPC among survival-to-discharge) compared with those 243 patients by dispatcher-assisted CPR rescue. In 28 patients by bystander defibrillation rescue only one man without pre-hospital ROSC still achieved survival-to-discharge and good CPC.

Conclusions: For OHCA patients at public locations, we found that a community-wide bystander defibrillation program were associated with excellent neurological outcome of CPC 1 and survival to hospital discharge that were significantly higher than those associated with dispatcher-assisted CPR program.

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AS095

Attitudes to CPR and public access defibrillation: A survey of the UK public

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Purpose of the study: To determine the proportion of UK adults who have witnessed an out-of-hospital-cardiac-arrest (OHCA), been trained in cardiopulmonary resuscitation (CPR), compression only CPR (COCPR) or Public Access Defibrillator (PAD) use.

To investigate the influence of training and demographic characteristics on likelihood of acting in the event of witnessing an OHCA.

Materials and methods: Literature and collaborators' expertise informed question development for an online omnibus survey, run by a market research and data company (YouGov). In April 2017, a representative sample of 2084 UK adults responded to the survey.

Results: 19% reported witnessing one or more OHCAs; 58% reported having ever received CPR training and 22% defibrillator training, reducing to 37% and 15% respectively within the last 5 years. Of those ever trained, 53% reported receiving training at work and 15% whilst a pupil at school.

If witnessing an OHCA, most people (93%) were likely to phone Emergency Medical Services (EMS); 58% to perform CPR, 56% to perform COCPR, 42% to retrieve a PAD and 35% to use a PAD. 43% knew where to find the nearest PAD to their home.

If trained in PAD use, 74% said they would retrieve one compared to 33% of those untrained and 74% of those trained compared to 24% not trained would likely use one. For those trained in CPR, 76% were likely to perform CPR compared to 28% who were untrained.

Conclusions: In England in 2014, PAD use in public places for non-EMS witnessed OHCAs was only 4.1% [1]. With only 42% of the UK population likely to retrieve a defibrillator, 15% trained in defibrillator use and 37% in CPR within the last 5 years, the potential to increase survival rates through continuing attempts to improve public awareness and resuscitation skills remains high, especially as almost 1 in 5 people have witnessed an OHCA.

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http://dx.doi.org/10.1016/j.resuscitation.2017.08.101

are known to be associated with survival. Preexisting disorders that were not included in the analyses of this study may be involved in seasonal variations in survival of male OHCAs.

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AP071

Improving the results of resuscitation through structural alterations

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Purpose of the study: Intensive efforts have been made in the last few years to improve the results of resuscitation in the district of East Tyrol/Austria. The changes will be highlighted by a comparison of two six-year periods (2004–2009 versus 2010–2015).

Materials and methods: Resuscitation projects were intensified and new ones created from 2009 onward. Yearly resuscitation exercises were introduced for students in their 7th year of school and became obligatory for all schools in East Tyrol. The emergency medical service was expanded from 3 to 4 teams, which now cover the entire district. The introduction of a QM system in accordance with ISO 2001 and district-wide simulator training for emergency doctors were also introduced in the last few years. From 2011 onward, all patients who have undergone successful initial resuscitation are cooled to 33 degrees for 24 h. Thirty-five public semi-automatic defibrillators are available in the district, and 25 so-called first responders with defibrillators at home can be deployed immediately.

Results: Results are summarized in Table 1. The number of survivors increased from 7.4% to 12.2%. The number of patients who survived without relevant neurological damage could be increased markedly from 4.4% to 9.7%. The mean age of those who died in the hospital as well as those who survived without damage decreased from one time period to the next (74 versus 68 years, and 74 versus 66 years, respectively). The three oldest persons who survived without damage were 88, 89 and 91 years old.

Table 1

	2004–2009	2010–2015
Resuscitated persons	135	196
Successful initial resuscitations	43 (32%)	68 (35%)
Died in the hospital	30	37
Total survivors	10 (7.4%)	24 (12.2%)
Survived without damage[a]	6 (4.4%)	19 (9.7%)
Service time (minutes)	5.8	5.8

[a] Glasgow outcome score 5.6.

Conclusion: The results are indicative of more efficient resuscitation and better post-emergency care after successful initial resuscitation.

The possible causes of these phenomena may be:

- Comprehensive training at compulsory schools, intensified training for teachers, and smooth cooperation between the Red Cross, the Red Cross Youth, and schools.
- Increased numbers of layperson resuscitations, first responders, and public semi-automatic defibrillators.
- Intensified training for emergency physicians and better structuring of the resuscitation teams.
- Consistent cooling of those who had undergone successful initial resuscitation

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AP072

Temporal changes in bystander cardiopulmonary resuscitation rates in England

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Purpose of the study: Bystander CPR (BCPR) more than doubles the chances of survival from out-of-hospital cardiac arrest (OHCA). In UK BCPR rates are variable and lower than those of other countries. This study investigates the trends in BCPR rates in England.

Materials and methods: The OHCAO registry collected details of 76,456 OHCAs from English ambulance services between 2013 and 2015, where resuscitation was commenced or continued by EMS personal; in accordance with Utstein guidelines. We assessed temporal variation and time trends in incidence for OHCA and BCPR.

Results: The odds of having an OHCA varied significantly by time of day and day of week, and there were monthly and seasonal variations.

BCPR rate in bystander-witnessed events increased during the morning to about lunchtime, plateaued until about 19:00 h then declined. The odds of receiving BCPR was significantly higher during the day compared to the night (OR = 1.12; 95%CI = 1.08–1.15). BCPR rates were greater at the weekend than mid-week (OR = 1.04; 95%CI = 1.00–1.07), and during the autumn/winter compared to spring/summer (OR = 1.04; 95%CI = 1.00–1.07).

BCPR rates have increased significantly from 51% in April 2013 to 66% in December 2015 ($p < 0.05$); the increase being observed for both men and women, and most age groups. Regression analysis showed there was significant variation during this time; an increase in February 2014, dips in May 2014 and March 2015, and an increase around June 2015.

Conclusions: We have shown for the first time in England significant temporal variability in OHCA and BCPR incidence. The trend of increasing BCPR is encouraging and likely to be associated with national and local initiatives to improve BCPR rates. However, there is still room for improvement in specific areas of the country, and a need for continued awareness programmes.

https://doi.org/10.1016/j.resuscitation.2017.08.169

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AP066

School teachers profit by observing school children's basic life support training

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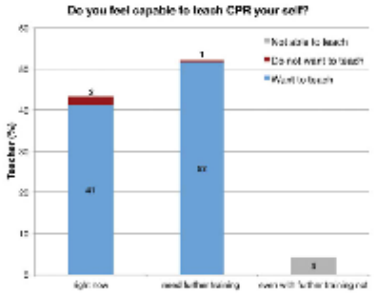
As part of a project, 3rd grade primary school children were trained in CPR and using an AED. We investigated the effect CPR trainings of school classes had on the teacher, who was observing the training. The aim was to evaluate previous knowledge and its improvement. Additionally changes in self-confidence of teachers to provide bystander CPR after observing the training were evaluated.

Methods: During the CPR training for pupils their teachers were present. We asked primary school teachers to participate in a written survey regarding to the training of the pupils. The participants had to complete two surveys, one before, another after the training. In total 197 participated in our survey.

Results: 94% of 182 teachers felt confident to be able to teach CPR skills to children after they had observed the CPR training for kids: 53% felt fit to train CPR to children without any further actions, 41% with additional training. Furthermore there was a significant increase of confidence providing bystander CPR after attending the training as an observer ($p < 0.001$). 53% completed their last first aid training more than 5 years ago. There were partly significant improvements of knowledge in comparison with previous knowledge in CPR skills. 99% out of 191 teachers said, that CPR training for children does make sense.

Conclusions: As a result of watching pupils get taught in CPR, there was a significant improvement of teachers' knowledge about CPR. Furthermore there was an increase of confidence performing bystander CPR if necessary. After observing the training 99% classified CPR training for pupils as meaningful, 94% of the teachers were willing to train children in CPR.



https://doi.org/10.1016/j.resuscitation.2017.08.164

AP068

Identification of characteristics of neighbourhoods with high incidence of out-of-hospital cardiac arrest and low bystander cardiopulmonary resuscitation rates

Terry Brown[1,*], Claire Hawkes[1], Scott Booth[1], Rachael Fothergill[2], Sara Black[3], Anna Bichmann[4], Helen Pocock[5], Jasmeet Soar[6], Julian Mark[7], Jonathan Benger[8], Gavin Perkins[1]

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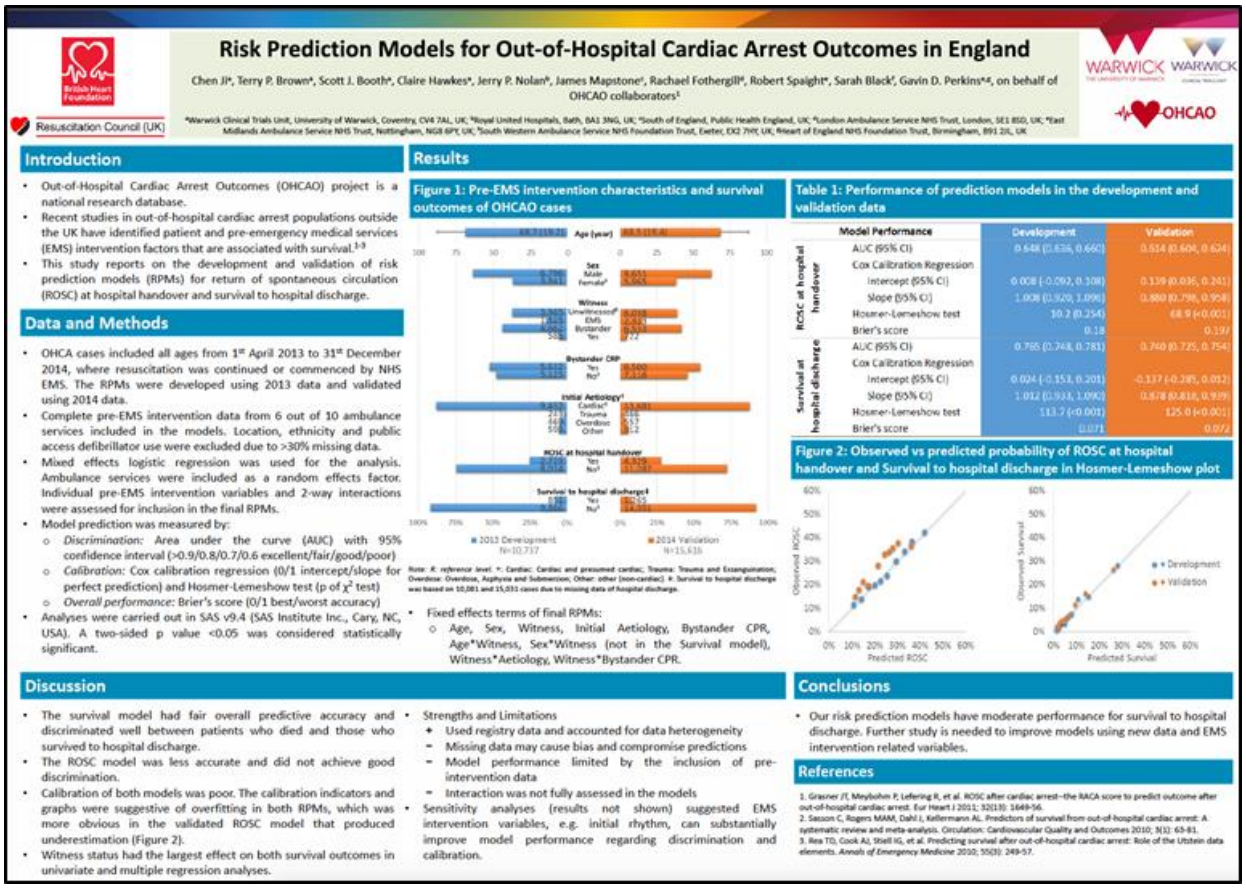
Purpose of the study: The community in which a person sustains an out-of-hospital cardiac arrest (OHCA) influences the likelihood that they will receive bystander CPR (BCPR) and ultimately survive. The aim of this research was to identify high risk communities in England with a high OHCA/low BCPR incidence to enable targeted strategies to be designed and implemented.

Materials and methods: Analysis was based on OHCA events that occurred between 2013 and 2015 in England, where resuscitation was commenced or continued by EMS personnel. OHCA location was geocoded where possible; postcode district (POD) was used as proxy for neighbourhood. Neighbourhood-level variables were linked to each geocoded address with the use of 2011 Census data. The associations between individual-level and neighbourhood-level characteristics and BCPR was assessed by hierarchical regression analysis.

Results: A total of 67,219 cases were included in this analysis. OHCA incidence showed a Poisson distribution in relation to population density (POPD). On average the ethnic composition of the OHCA location was 84.3% white. Incidence increased significantly with deprivation from 7.0% in least deprived areas to 12.3% in most deprived areas. BCPR rate of bystander-witnessed events decreased significantly with POPD from 75.5% (<100/hectare) to 60.9% (>10,000/hectare; $p < 0.05$). There was a significant difference between areas with highest and lowest deprivation (63.0% vs. 67.9%; $p < 0.05$). The OR for receiving BCPR for every 1% increase in

APPENDIX 4: RESUSCITATION COUNCIL (UK) SYMPOSIUM POSTER



Risk Prediction Models for Out-of-Hospital Cardiac Arrest Outcomes in England

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Introduction

- Out-of-Hospital Cardiac Arrest Outcomes (OHCAO) project is a national research database.
- Recent studies in out-of-hospital cardiac arrest populations outside the UK have identified patient and pre-emergency medical services (EMS) intervention factors that are associated with survival.[1-3]
- This study reports on the development and validation of risk prediction models (RPMs) for return of spontaneous circulation (ROSC) at hospital handover and survival to hospital discharge.

Data and Methods

- OHCA cases included all ages from 1st April 2013 to 31st December 2014, where resuscitation was continued or commenced by NHS EMS. The RPMs were developed using 2013 data and validated using 2014 data.
- Complete pre-EMS intervention data from 6 out of 10 ambulance services included in the models. Location, ethnicity and public access defibrillator use were excluded due to >30% missing data.
- Mixed effects logistic regression was used for the analysis. Ambulance services were included as a random effects factor. Individual pre-EMS intervention variables and 2-way interactions were assessed for inclusion in the final RPMs.
- Model prediction was measured by:
  - *Discrimination:* Area under the curve (AUC) with 95% confidence interval (>0.9/0.8/0.7/0.6 excellent/fair/good/poor)
  - *Calibration:* Cox calibration regression (0/1 intercept/slope for perfect prediction) and Hosmer-Lemeshow test (p of χ^2 test)
  - *Overall performance:* Brier's score (0/1 best/worst accuracy)
- Analyses were carried out in SAS v9.4 (SAS Institute Inc., Cary, NC, USA). A two-sided p value <0.05 was considered statistically significant.

Results

Figure 1: Pre-EMS intervention characteristics and survival outcomes of OHCAO cases

Note: *: reference level. *: Cardiac: Cardiac and presumed cardiac; Trauma: Trauma and Exsanguination; Overdose: Overdose, Asphyxia and Submersion; Other: other (non-cardiac). †: Survival to hospital discharge was based on 10,081 and 15,031 cases due to missing data of hospital discharge.

- Fixed effects terms of final RPMs:
  - Age, Sex, Witness, Initial Aetiology, Bystander CPR, Age*Witness, Sex*Witness (not in the Survival model), Witness*Aetiology, Witness*Bystander CPR.

Table 1: Performance of prediction models in the development and validation data

	Model Performance	Development	Validation
ROSC at hospital handover	AUC (95% CI)	0.648 (0.636, 0.660)	0.614 (0.604, 0.624)
	Cox Calibration Regression		
	Intercept (95% CI)	0.008 (-0.092, 0.108)	0.139 (0.036, 0.241)
	Slope (95% CI)	1.008 (0.920, 1.096)	0.880 (0.798, 0.958)
	Hosmer-Lemeshow test	10.2 (0.254)	68.9 (<0.001)
	Brier's score	0.18	0.197
Survival at hospital discharge	AUC (95% CI)	0.795 (0.748, 0.781)	0.760 (0.725, 0.754)
	Cox Calibration Regression		
	Intercept (95% CI)	0.024 (-0.153, 0.201)	-0.117 (-0.285, 0.012)
	Slope (95% CI)	1.012 (0.918, 1.096)	0.878 (0.818, 0.939)
	Hosmer-Lemeshow test	113.7 (<0.001)	125.0 (<0.001)
	Brier's score	0.071	0.072

Figure 2: Observed vs predicted probability of ROSC at hospital handover and Survival to hospital discharge in Hosmer-Lemeshow plot

Discussion

- The survival model had fair overall predictive accuracy and discriminated well between patients who died and those who survived to hospital discharge.
- The ROSC model was less accurate and did not achieve good discrimination.
- Calibration of both models was poor. The calibration indicators and graphs were suggestive of overfitting in both RPMs, which was more obvious in the validated ROSC model that produced underestimation (Figure 2).
- Witness status had the largest effect on both survival outcomes in univariate and multiple regression analyses.
- Strengths and Limitations
  - \+ Used registry data and accounted for data heterogeneity
  - − Missing data may cause bias and compromise predictions
  - − Model performance limited by the inclusion of pre-intervention data
  - − Interaction was not fully assessed in the models
- Sensitivity analyses (results not shown) suggested EMS intervention variables, e.g. initial rhythm, can substantially improve model performance regarding discrimination and calibration.

Conclusions

- Our risk prediction models have moderate performance for survival to hospital discharge. Further study is needed to improve models using new data and EMS intervention related variables.

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APPENDIX 5: EPIDEMIOLOGY 2014 PAPER

Resuscitation 110 (2017) 133–140

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

Epidemiology and outcomes from out-of-hospital cardiac arrests in England☆

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ABSTRACT

Introduction: This study reports the epidemiology and outcomes from out-of-hospital cardiac arrest (OHCA) in England during 2014.

Methods: Prospective observational study from the national OHCA registry. The incidence, demographic and outcomes of patients who were treated for an OHCA between 1st January 2014 and 31st December 2014 in 10 English ambulance service (EMS) regions, serving a population of almost 54 million, are reported in accordance with Utstein recommendations.

Results: 28,729 OHCA cases of EMS treated cardiac arrests were reported (53 per 100,000 of resident population). The mean age was 68.6 (SD= 19.6) years and 41.3% were female. Most (83%) occurred in a place of residence, 52.7% were witnessed by either the EMS or a bystander. In non-EMS witnessed cases, 55.2% received bystander CPR whilst public access defibrillation was used rarely (2.3%). Cardiac aetiology was the leading cause of cardiac arrest (60.9%). The initial rhythm was asystole in 42.4% of all cases and was shockable (VF or pVT) in 20.6%. Return of spontaneous circulation at hospital transfer was evident in 25.8% (n= 6302) and survival to hospital discharge was 7.9%.

Conclusion: Cardiac arrest is an important cause of death in England. With less than one in ten patients surviving, there is scope to improve outcomes. Survival rates were highest amongst those who received bystander CPR and public access defibrillation.

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2016.10.030.

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APPENDIX 6: EURECA ONE PAPER

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Clinical paper

EuReCa ONE—27 Nations, ONE Europe, ONE Registry
A prospective one month analysis of out-of-hospital cardiac arrest outcomes in 27 countries in Europe☆

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