REPORT

# National database of Automated External Defibrillator (AED) use

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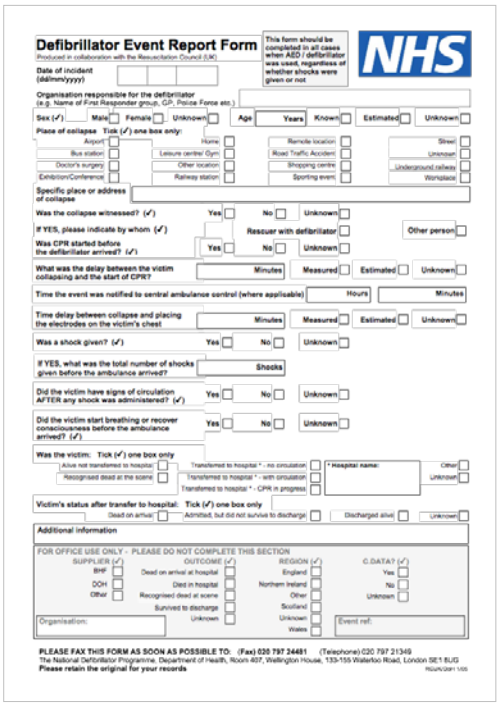
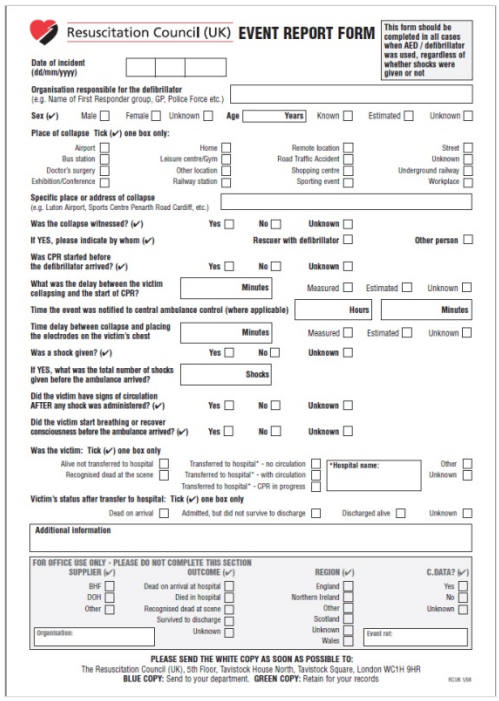
## Introduction

Since 1999 the Resuscitation Council (UK) has conducted a survey of the use of AEDs deployed in the community for use by lay persons in a public access defibrillation (PAD) role. The major organisations that promote first responder defibrillation, including the Department of Health (DH), British Heart Foundation (BHF) and the Voluntary Aid Societies, have all reported resuscitation attempts where their AEDs have been used. Many smaller organisations have also contributed. Data for each resuscitation attempt has been collected on the standard report forms reproduced here:




In many cases the AED was located at a fixed location in a busy public place (like a railway station or airport) and used by people working nearby. These sites were initially identified from ambulance data about the location of cardiac arrests in the area they served. We have also collected information from first responders who are mobile lay volunteers appointed by ambulance services who are dispatched in response to 999 calls where a person may have suffered a cardiac arrest, and the responder can reach the person more quickly than a conventional ambulance. Several ambulance services have contributed some hundreds of reports. Police forces and fire services who also act as first responders have also participated.

Initial results from the survey, based on 1530 events reported between March 1999 and December 2005 in England and Wales have been published in the journal "Resuscitation" Volume 78 No.3 September 2008, pages 275-280. This paper is titled "A national scheme for public access defibrillation in England and Wales: Early results".

An analysis of almost 3,500 report forms has recently been completed and here we describe the results and share some of these with all those who have contributed. **At the same time we would like to announce that the survey in this format is now complete and that we will not be collecting any further forms.** We would also like to take this opportunity to thank everyone who has contributed over the years - the lessons learnt from the survey have been crucial in guiding current practice and planning the future of public access defibrillation.

The survey will be continued later this year using a new database managed by the University of Warwick who already run the national out-of-hospital cardiac arrest audit. Data would not be collected directly by the RC (UK) and it is anticipated that online data entry will be a feature. An announcement about this will be made in the near future.

## Methods – the report form

At the outset, the survey was designed to be completed by those who had actually participated in the resuscitation attempt; in almost all cases these were lay persons without specialised medical or first aid knowledge. Straightforward questions were answered on a form that was compatible with the Utstein system for recording prehospital resuscitation attempts. The form occupied one side of A4 paper and many questions required only a Yes/No response; a ‘don’t know’ option was also standard. The intention was that the form was completed immediately after the incident when events are most likely to be recalled.

The endpoint was the presence of a circulation (i.e. the return of spontaneous circulation or ROSC) when the patient was transferred to hospital. There was no requirement to find out whether the patient survived because this information would be considered confidential and not released by the hospital authorities. Fifteen years later, the same endpoint was chosen by the Department of Health for ambulance services to report all resuscitation attempts in which ambulance personnel participated. Despite the simple design of the survey, much important data was captured about the circumstances of the arrests, whether shocks were given and the time intervals known to influence the outcome of resuscitation attempts. By collecting ROSC some insight can be gained into possible survivors.

## Methods – data analysis

The data from all the forms was entered onto a Microsoft Access database. Only two people entered the data (the author and Jane Turner at the Prehospital Emergency Research Unit at Cardiff University). Standard reporting templates were used to enable quick searches of data and produce standard reports.

This report includes data from 3,485 resuscitation attempts.

## Overall results

In 3,485 resuscitation attempts ROSC was restored at the scene in 593 cases (17%). By far the greatest proportion of these came from the 1451 patients (41.6%) in a shockable rhythm. It is known that 191 patients (5.5% overall) survived to hospital discharge. The final outcome could not be determined for many patients who reached hospital alive, and the total number of survivors is undoubtedly larger.

## Age / sex

The age / sex distribution of the patients is shown in tables 1 and 2 and figure1. The average (mean) age for men was 66.6 years and for females 72.9 years. Men outnumbered women by 2.3 : 1.

The results show that at most ages, a substantial proportion of patients (33 - 50%) are in a shockable rhythm although the proportion falls at the extremes of the age range. The tables show that overall ROSC and survival showed an inverted U shaped relationship with age with highest survival at ages 40 - 80 and poorer outcome in both younger and older patients.

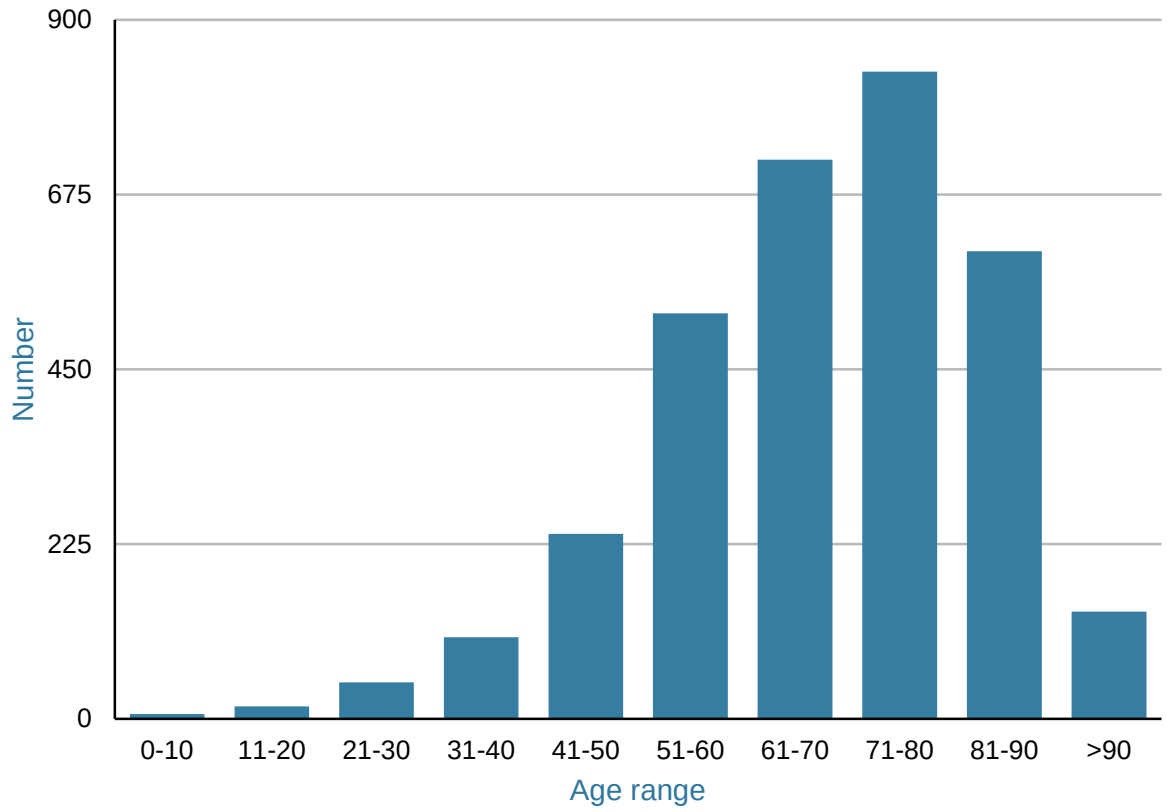



**Figure 1. Frequency of resuscitation attempts with age.**

| Age range | Male | Female | Total | Shock given No (%) | ROSC No (%) |
|---|---|---|---|---|---|
| 0-10 | 3 | 3 | 6 | 1 (17) | 1 (17) |
| 11-20 | 11 | 5 | 16 | 8 (50) | 5 (31) |
| 21-30 | 35 | 12 | 47 | 13 (35) | 5 (11) |
| 31-40 | 77 | 28 | 105 | 35 (33) | 13 (12) |
| 41-50 | 188 | 49 | 237 | 116 (49) | 47 (20) |
| 51-60 | 410 | 103 | 513 | 277 (54) | 115 (22) |
| 61-70 | 570 | 147 | 717 | 345 (48) | 152 (21) |
| 71-80 | 571 | 257 | 828 | 326 (39) | 135 (16) |
| 81-90 | 326 | 270 | 596 | 152 (25) | 66 (11) |
| 91 and over | 48 | 90 | 138 | 14 (10) | 10 (7) |
| **Total** | 2239 | 964 | 3203 | 1287 (40) | 549 (17) |

**Table 1. Age and sex distribution**

Table 2 shows that shockable rhythms were more common in men (48% vs 22%). This is an important reason why successful resuscitation was more common in men (19% vs 11%). If a woman was in a shockable rhythm however, the chances of resuscitation were as good, if not better, than for men. In 2239 men, 1075 (48%) were in a shockable rhythm; ROSC was restored in 438. 212 (22%) of 964 females were in a shockable rhythm with ROSC restored in 111 (52%).

| Age range | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | No | Shocked | ROSC | No | Shocked | ROSC |
| **0 - 10** | 3 | 1 (33%) | 1 | 3 | 0 | 0 |
| **11 - 20** | 11 | 6 (54) | 3 | 5 | 2 (40%) | 2 |
| **21 - 30** | 35 | 8 (23) | 2 | 12 | 5 (42) | 3 |
| **31 - 40** | 77 | 31 (40) | 10 | 28 | 4 (14) | 3 |
| **41 - 50** | 188 | 103 (55) | 41 | 49 | 13 (26) | 6 |
| **51 - 60** | 410 | 244 (59) | 97 | 103 | 33 (32) | 18 |
| **61 - 70** | 570 | 308 (54) | 134 | 147 | 37 (25) | 18 |
| **71 - 80** | 571 | 258 (45) | 102 | 257 | 68 (26) | 33 |
| **81 - 90** | 326 | 106 (32) | 43 | 270 | 46 (17) | 23 |
| **91 and over** | 48 | 10 (21) | 5 | 90 | 4 (4) | 5 |
| **Totals** | **2239** | **1075 (48%)** | **438 (19%)** | **964** | **212 (22%)** | **111 (11%)** |

**Table 2. Prevalence of shockable rhythms with age for men and women**

Age and/or sex was not recorded in 282 cases.

## The two strategies – AEDs 'On-site' and first responders

In the UK, public access defibrillation has followed two different strategies. In the first an AED is placed at a location where it might be needed, often a busy public place where appreciable numbers of the public are present or pass through. Staff working at these locations were trained to recognise the features of cardiac arrest, perform basic life support and to use the AED. The important principle is that the AED is placed in close proximity to where it will be used with the intention that delay in providing a shock is kept to a minimum.

The second strategy is the 'first responder' where a lay volunteer trained by the ambulance service in resuscitation techniques and equipped with an AED is dispatched by ambulance control to medical emergencies in their locality when there is a good chance that they can reach a patient more quickly than a conventional ambulance (which is also dispatched at the same time). Members of other uniformed emergency services (the fire service or police) also act in this role in some areas. It is necessary for the responder to travel to the patient however, so there is usually a greater delay in providing a shock compared to the first strategy where the AED is situated near the site of the arrest.

There are pros and cons for each strategy. When the AED is 'on-site' quicker treatment is usually possible, but more operators must be trained, and the strategy usually requires more AEDs to cover a relatively modest area. It is also important to ensure that a trained staff member is always on duty. The first responder strategy however, only requires a single rescuer with one AED to cover a relatively large area. This would include both public locations and private premises. The home is the commonest place for cardiac arrest to occur, so the first responder is one of the few strategies that can provide treatment for patients who arrest at home.

## Headline results

Tables 3 and 4 show the headline results for the two methods - on-site AEDs vs First responders.

| Arrests | | Shocked | | ROSC | | Survived* | |
|---|---|---|---|---|---|---|---|
| No | % | No | % | No | % | No | % |
| 2795 | 100 | 858 | 31 | 322 | 11.5 | 54 | 1.9 |

**Table 3. Results of AEDs used by first responders**

| Arrests | | Shocked | | ROSC | | Survived* | |
|---|---|---|---|---|---|---|---|
| No | % | No | % | No | % | No | % |
| 690 | 100 | 593 | 82 | 271 | 39 | 137 | 19.8 |

**Table 4. Results from AEDs placed 'on-site' at a fixed location**

* The figures in the survived columns are those *known* to have survived to hospital discharge. Because outcome could not be determined in many cases this is a minimum survival figure.

## First responders

Further information about the first responders who contributed to this study is shown in tables 5 and 6.

| Responder | Number | Shocked | | ROSC | | Survived* | |
|---|---|---|---|---|---|---|---|
| | No | No | % | No | % | No | % |
| Ambulance FR | 2308 | 714 | 31 | 271 | 12 | 42 | 1.8 |
| Fire service | 458 | 138 | 30 | 45 | 10 | 9 | 1.9 |
| Police | 29 | 6 | 21 | 6 | 21 | 3 | 10 |
| Total | 2795 | 858 | 31 | 322 | 11.5 | 54 | 1.9 |

**Table 5. Organisations acting as first responders**

| | Number | Shocked | | ROSC | | Survived* | |
|---|---|---|---|---|---|---|---|
| | No | No | % | No | % | No | % |
| Home arrests | 2203 | 543 | 25 | 202 | 9 | 27 | 1.2 |
| Outside home<br>(Of which in street) | 592<br>(152) | 315<br>(98) | 53<br>(64) | 120<br>(40) | 20<br>(26) | 27<br>(13) | 4.5<br>(8.5) |
| Total | 2795 | 858 | 31 | 322 | 11.5 | 54 | 1.9 |

**Table 6. First responders: results for home arrests vs arrests outside home**

Considering the two strategies for delivering public access defibrillation, considerably more patients attended by on-site personnel achieved ROSC or survived to leave hospital. In those patients attended by first responders, results were considerably better when the arrest occurred outside the home; these patients received CPR and the AED was applied more quickly than was possible for home arrests.

Several factors could be identified that contributed to this difference. Compared to the patients treated by first responders, the patients treated with 'on-site' AEDs were:

1. More likely to be in a shockable rhythm.
2. The arrest was more frequently witnessed
3. The patients were younger
4. More were male
5. CPR was started more quickly, and more often before the AED arrived
6. The AED pads were applied more quickly.

Tables 7 and 8 show the longer time intervals after collapse before the start of CPR and the application of the AED pads. In most cases the difference is an inevitable result of the AED being close at hand in the case of on-site responders compared to the need for first responders to travel to the patient.

| **Organisation** | **No. of events** | **Time to start CPR (min)** | | **Time to apply AED pads (min)** | |
|---|---|---|---|---|---|
| | | Mean | Median | Mean | Median |
| Ambulance FR | 1935 | 9.6 | 6 | 11.5 | 8 |
| St John FR** | 373 | 13.3 | 4 | 11.4 | 8 |
| Fire service | 458 | 13.1 | 6.75 | 18.5 | 11 |
| Police | 29 | 6.5 | 4 | 12.7 | 10.5 |
| Home arrests | 2203 | 12.3 | 6 | 13.8 | 9 |
| Arrests in street | 152 | 4.2 | 3 | 7.45 | 6 |

**Table 7. Time intervals for first responders**

** Members of St John Ambulance acting as first responders for ambulance services

| **Location** | **No. of events** | **Time to start CPR (min)** | | **Time to apply AED pads (min)** | |
|---|---|---|---|---|---|
| | | Mean | Median | Mean | Median |
| Airport | 232 | 2.9 | 2 | 4.6 | 4 |
| Bus station | 13 | 2.9 | 2.5 | 5.2 | 5 |
| Exhibitions | 24 | 3.35 | 3 | 6.8 | 5 |
| Gym | 85 | 1.8 | 1.4 | 3.7 | 3 |
| Railway station | 104 | 3 | 2 | 4.3 | 4 |
| Shopping mall | 45 | 3 | 2 | 6.2 | 4.75 |
| Sporting event | 106 | 2.8 | 2 | 5.4 | 4.5 |
| Underground rly | 15 | 1.7 | 2 | 7 | 7 |

**Table 8. Time intervals for on-site AEDs**

The excellent results achieved at these sites (with 40% ROSC and at least 20% survival) reflect the speed with which CPR was started and the AED was used and are shown in table 9.

| Location | No. of events | Shocked | | ROSC | | Survived* | |
|---|---|---|---|---|---|---|---|
| | | No | % | No | % | No | % |
| Airport | 232 | 192 | 82 | 71 | 30.6 | 39 | 16.8 |
| Bus station | 13 | 10 | 77 | 5 | 38 | 2 | 15.4 |
| Exhibitions | 24 | 18 | 75 | 4 | 16 | 3 | 12.5 |
| Gym | 85 | 76 | 89 | 53 | 62 | 27 | 31.7 |
| Railway station | 104 | 79 | 76 | 41 | 39 | 29 | 27.9 |
| Shopping mall | 45 | 29 | 64 | 15 | 33 | 5 | 11.1 |
| Sporting event | 106 | 93 | 88 | 52 | 49 | 19 | 17.9 |
| Tube (LUL) | 15 | 12 | 80 | 8 | 53 | 6 | 40 |
| **Totals** | **624** | **509** | **82** | **249** | **40** | **130** | **21** |

**Table 9. On site use of AEDs: results by location**

* The figures in the survived columns are those *known* to have survived to hospital discharge. Because final outcome could not be determined in many cases this is a minimum survival figure.

## Discussion

From a modest start in the late 1990s, public access defibrillation has now been incorporated into mainstream health service and first aid provision throughout England. Substantial progress has also been made in the other devolved countries of the United Kingdom.

This has been made possible by a National Health Service that includes a statutory ambulance service, and other bodies with national influence including the Resuscitation Council (UK), the British Heart Foundation (BHF), The British Red Cross and St. John Ambulance. The role of the Department of Health was crucial in coordinating the early implementation of what has since become a National Defibrillator Programme, now coordinated by the BHF and regional ambulance services.

The results are very much better when the AED was immediately available as part of an on-site strategy than when it had to be transported to the patient. As would be predicted, survival was positively associated with witnessed arrest, early CPR by bystanders and the presence of a shockable rhythm, all of which were more common in this group. The times between collapse and

the start of CPR and attempted defibrillation were also short and a major factor in the success of this strategy. It is only under exceptional circumstances that an ambulance crew or first responder who both have to travel to a victim can achieve these short response times.

The key principles of PAD - that lay responders can initiate CPR and attempt defibrillation sooner than conventional ambulance services - also apply to the community first responders (CFRs) reported here. The favourable prognostic factors noted above were less prevalent in their patients. They attended more unwitnessed arrests, CPR was administered less frequently, and when attempted was started later, the AED pads were applied later and fewer patients were shocked, especially at home. Many of the home arrests were unwitnessed making it likely that any prospect of resuscitation had passed in many cases. These patients were also older, with the likelihood of co-morbidity or inter-current illness. As might be expected, their results were not as good as with the on-site strategy, and were particularly poor in those who arrested at home. Outside the home, first responders achieved better results with 20% ROSC and higher survival.

The on-site strategy has now been proved to be very effective at sites where there is an appreciable risk of cardiac arrest occurring. The strategy is however, heavy on resources often with the need for several AEDs at any one site and an on-going commitment to train staff. More arrests were reported from airports than any other single location and the reported survival rates are impressive. Airports cover a large area however, and in large termini many AEDs were installed, for example Heathrow Terminal 4 had 108 individual AEDs. First responders schemes require fewer resources - a relatively small number of volunteers and only one or two AEDs, so the relative costs per life saved may be comparable.

The initial sites chosen by the DH to install AEDs were based on data from ambulance services about the location of cardiac arrests outside the home; transport facilities, especially airports and mainline railway stations were clearly the most common, and impressive results have been achieved. There was less evidence available to advise many other types of site to install AEDs and many have installed them on their own initiative often with advice from their local ambulance service. Gyms and leisure centres are one example and their results (62% ROSC and at least 31% survival) are particularly impressive. I hope these figures will inspire all such places where exercise is undertaken to consider implementing a PAD scheme.

To be a first responder requires considerable commitment and assumes great responsibility; they provide an approach to the treatment of sudden cardiac death for victims who would otherwise have no prospect of resuscitation. They treated more than four times as many patients than ‘on-site’ responders. Their results should be seen as a promising start to a strategy in the process of development; their results are already comparable to those reported by a conventional ambulance

response. They also have the potential to reach patients in the most common place for cardiac arrest to occur and where AEDs cannot generally be located - the home.

## Acknowledgements

Firstly I extend considerable thanks to all those who made this study possible by completing and returning the report forms; the study would have been impossible without your considerable efforts. By so doing helped greatly extend our knowledge of the possibilities of Public Access Defibrillation.

The author thanks Jane Turner for all her help throughout the project, and especially with data entry. He also thanks Sara Harris who coordinated the collection and supply of report forms by the Resuscitation Council (UK) and her husband Bob who designed the Access database. The author also thanks all those at the BHF, in ambulance services and other organisations that have supported the project over the years. He thanks Douglas Chamberlain for many helpful discussions over more than twenty years and Sian Davies for much information during the Defibrillators in Public Places Initiative co-ordinated by the DH.

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