

INITIAL RESULTS OF THE SCOTTISH OUT-OF-HOSPITAL CARDIAC ARREST DATA LINKAGE PROJECT



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PREFACE

THE PROBLEM

Out-of-hospital cardiac arrest (OHCA) is a significant health issue in Scotland. The shape of the problem is that around 3,000 patients each year will have resuscitation attempted after a sudden cardiac arrest in the community, but only around 6% will survive to hospital discharge. In the best performing comparable settings around the world survival is as high as 25%⁽¹⁾.

In response to this challenge, in 2015 Scotland launched a National Strategy for out-of-hospital cardiac arrest⁽²⁾. In an unprecedented collaboration, all of Scotland's emergency services, Scottish Government, Third Sector, NHS and Academic partners have come together intent to achieve together what would be too difficult to accomplish separately: to optimise the 'chain of survival' after OHCA thereby saving 1000 additional lives in Scotland by 2020. The aim is that Scotland becomes an international leader in OHCA resuscitation over the next four years.

THE SOLUTION

Solving the problem of OHCA is difficult, but in broad terms it is not complicated. There is a high level of international consensus about the steps required^(3, 4). The first of these is to create a registry. To build a mechanism to measure current system performance, identify areas for improvement and track progress. This is not a straightforward process, as the system delivering care to victims of OHCA spans multiple agencies and so assembling meaningful data requires the synthesis of information from a range of 'silos'. This is a tractable problem which has been overcome in centres of excellence around the world and marks a foundational step for all those attempting to improve OHCA survival⁽⁵⁻¹³⁾. This is a challenge which Scotland's health data architecture should make Scotland well placed to overcome.

LINKING THE DATA

In order to know how many patients fall victim to OHCA each year we begin with details of emergency calls to the Scottish Ambulance Service (SAS). This gives us the number of incidents where Ambulance Service personnel attempted resuscitation for OHCA. Ambulance Service data collection ceases when the patient is delivered to hospital, and so to calculate the proportion of OHCA survivors we need information about in-hospital care. Information about this part of the patients' journeys are accessible via their Community Health Index (CHI) number. The CHI number uniquely identifies everyone registered with the healthcare system in Scotland. The backbone of the data included in this report is derived from the linkage of Ambulance Service cases with the patient's CHI number. This transforms 'incidents' into CHI-linked patient records. Once linked, use of the data is restricted to a highly controlled 'safe haven' environment in order to preserve patient confidentiality. We will describe how this linkage process throws up its own challenges, but once complete delivers a rich picture of the way Scotland responds to OHCA (see Figure 14).

THANKS

We would like to thank the following people for their hard work and persistence in facilitating this report:

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SUMMARY OF THE MAIN FINDINGS

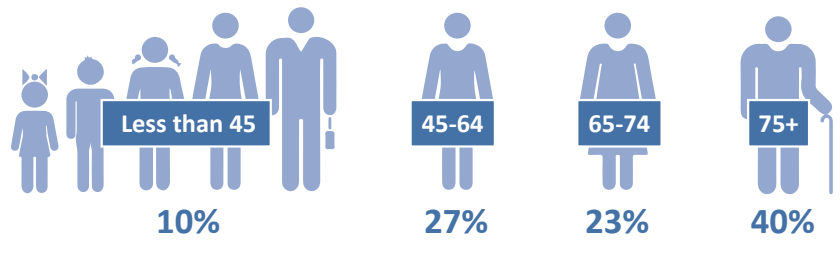
Improving Outcomes from OHCA The Starting Point

Average number of OHCA
3,000 per year



38% 62%

OHCA can affect people of all ages at any time

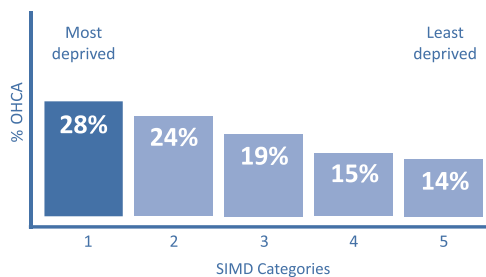


Only around
1 in 20
survive to leave
hospital

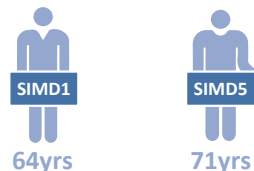


People who live in
rural areas are
32% less likely
to survive to leave
hospital

People in the most deprived areas
are **twice as likely** to have an OHCA.



The **average age** of the people who
have an OHCA in these deprived
areas is **7 years lower**.



People from most deprived areas are
**43% less likely to survive to leave
hospital compared to those from
least deprived areas**

INITIAL RESULTS OF THE SCOTTISH OUT-OF-HOSPITAL CARDIAC ARREST DATA LINKAGE PROJECT

INTERPRETATION OF RESULTS AND COMPARISONS

BOX 1

The Utstein Template

In June 1990, an international multidisciplinary meeting held at the Utstein Abbey in Norway has led to the development of uniform terms and definitions for out-of-hospital resuscitation. The ultimate goal of this 'Utstein style' was to improve health care and quality improvement through better understanding of the epidemiology of cardiac arrest and enable comparisons within and between systems and countries.

An important part of the Utstein style is a standardised template for reporting outcomes for OHCA⁽¹⁵⁾. Based on this template OHCA cases can be classified in different groups based on characteristics of the OHCA case and circumstances (such as resuscitation attempted or not, initial heart rhythm, witnessed or not).

One of the groups which can be identified using this Utstein standardised template is the Utstein comparator group. This group is formed by OHCA cases who are most likely to survive (presenting with shockable heart rhythms, have witnessed arrests and where prompt bystander CPR is started). Outcomes within Utstein comparator group are increasingly used by researchers and registries to standardise the reporting of OHCA. This enables comparisons between geographical regions in terms of system efficacy and short-term and long-term outcomes ⁽¹¹⁾.

This report presents initial results of the Scottish OHCA data linkage project. This innovative work has linked complex datasets for the first time in order to report on OHCA in Scotland. As such, the results should be treated as provisional while the data and methodology are still in development. Throughout the report interpretations of the figures are given, and any assumptions are explained, with additional detail in the 'methods and assumptions' section (page 34) of this report. Our results are compared, where possible, with data from other OHCA registries and academic publications.

We have taken this approach as international commentators have suggested that a large part of the variation in published OHCA outcomes may be due to the use of a broad range of population and outcome definitions^(11, 15,16). This problem was recognised some time ago and led to the introduction of specific guidelines for the uniform reporting on OHCA outcomes in 1991; the Utstein Template⁽¹⁵⁾. These definitions can be used to help identify a more homogeneous and comparable cohort of OHCA cases (see Box 1 above for a description of the Utstein criteria). International registries and research groups often report survival percentages based on these criteria. To enable comparability this report includes results based on the Utstein comparator group.

DEFINING OUR STUDY COHORT: IDENTIFYING PEOPLE WHO HAD AN OHCA

Our findings are based on a dataset including information about OHCA patients of all ages in Scotland between the 1 January 2011 until the launch of the National Strategy for OHCA for Scotland on the 28 March 2015⁽²⁾. OHCA due to traumatic causes, including hanging and drowning, are not included in our study cohort. All other cases of OHCA where resuscitation was attempted by the SAS are included.

Of the 14,895 people in Scotland who had an OHCA between the 1 January 2011 and the 28 March 2015 where resuscitation was attempted, 75.7% are included in the dataset. For the other 24.3%, data linkage was not possible because of missing personal identifiers (see Figure 14 in the 'methodology' section for further information about the data linkage on page 32). All analysis is based on the OHCA cases which could be linked with other data sources (including survival outcome) unless otherwise specified. Importantly, this means it is likely that incidences and other absolute estimates will be underestimates of the true values. Future analysis is planned to investigate this assumption in more detail.

BOX 2

What's the difference between a 'heart attack' and 'cardiac arrest'?

A heart attack is a sudden interruption to the blood supply to part of the heart muscle. It is likely to cause chest pain and permanent damage to the heart. The heart is still sending blood around the body and the person remains conscious and is still breathing.

A cardiac arrest occurs when the heart suddenly stops pumping blood around the body. Someone who is having a cardiac arrest will suddenly lose consciousness and will stop breathing or stop breathing normally. Unless immediately treated by CPR this always leads to death within minutes.

A person having a heart attack is at high risk of experiencing a cardiac arrest.

Both a heart attack and a cardiac arrest are life-threatening medical emergencies and require immediate medical help. Call 999 if you think you are having a heart attack or if you witness someone having a cardiac arrest.

Source: <https://www.bhf.org.uk/hearthealth/conditions/cardiac-arrest.aspx>

INCIDENCE OF OHCA

NUMBER OF PATIENTS WITH OHCA IN SCOTLAND

On average 3,000 people per year suffer from an OHCA where resuscitation is attempted by the responding ambulance crews. This translates to 58 per 100,000 resident population. This is a slightly higher figure than both the 53 per 100,000 resident population published by the English OHCA registry based on data from 2014⁽¹⁷⁾ and the 49 patients per 100,000 resident population reported by the European Registry of Cardiac Arrest (EuReCa ONE)⁽¹¹⁾.

Worldwide there is variation in the reported incidence of OHCA with some other countries reporting similar numbers to Scotland, for example 58 per 100,000 of resident population in Finland⁽¹¹⁾ and 56 per 100,000 per resident population in North America.

It is important to note that although the incidence of OHCA for Scotland quoted above is derived from all OHCA where resuscitation was attempted, all other analysis is based on a slightly smaller dataset. Throughout the remainder of this report, the 'denominator' number used to calculate proportions - for example, the proportion of survivors after OHCA - refers to OHCA where resuscitation was attempted by SAS, and which we were able to link via CHI to ascertain survival outcome (see 'Linking the Data' on page 3).

SEX AND AGE DISTRIBUTION OF OHCA PATIENTS

Of all patients who had an OHCA, 62% were males and 38% were females. These results are in line with published data from other countries across the world describing higher proportions of OHCA among males⁽¹⁷⁻²⁰⁾.

Figure 1 shows the age distribution (each age group is expressed as a percentage of all OHCA cases in our dataset) of OHCA patients across five-year age groups for males and females. Due to the very small number of OHCA cases in the lowest and highest age bands, some of these groups have been combined further to protect patient confidentiality. This figure also illustrates that OHCA is more common among males compared with females. Of note, the proportion of OHCA cases is lowest in children between 5 and 10 years old, however, all age groups - including very young children - are at some risk of OHCA. To illustrate this further, 10% of all OHCA patients are less than 45 years old.

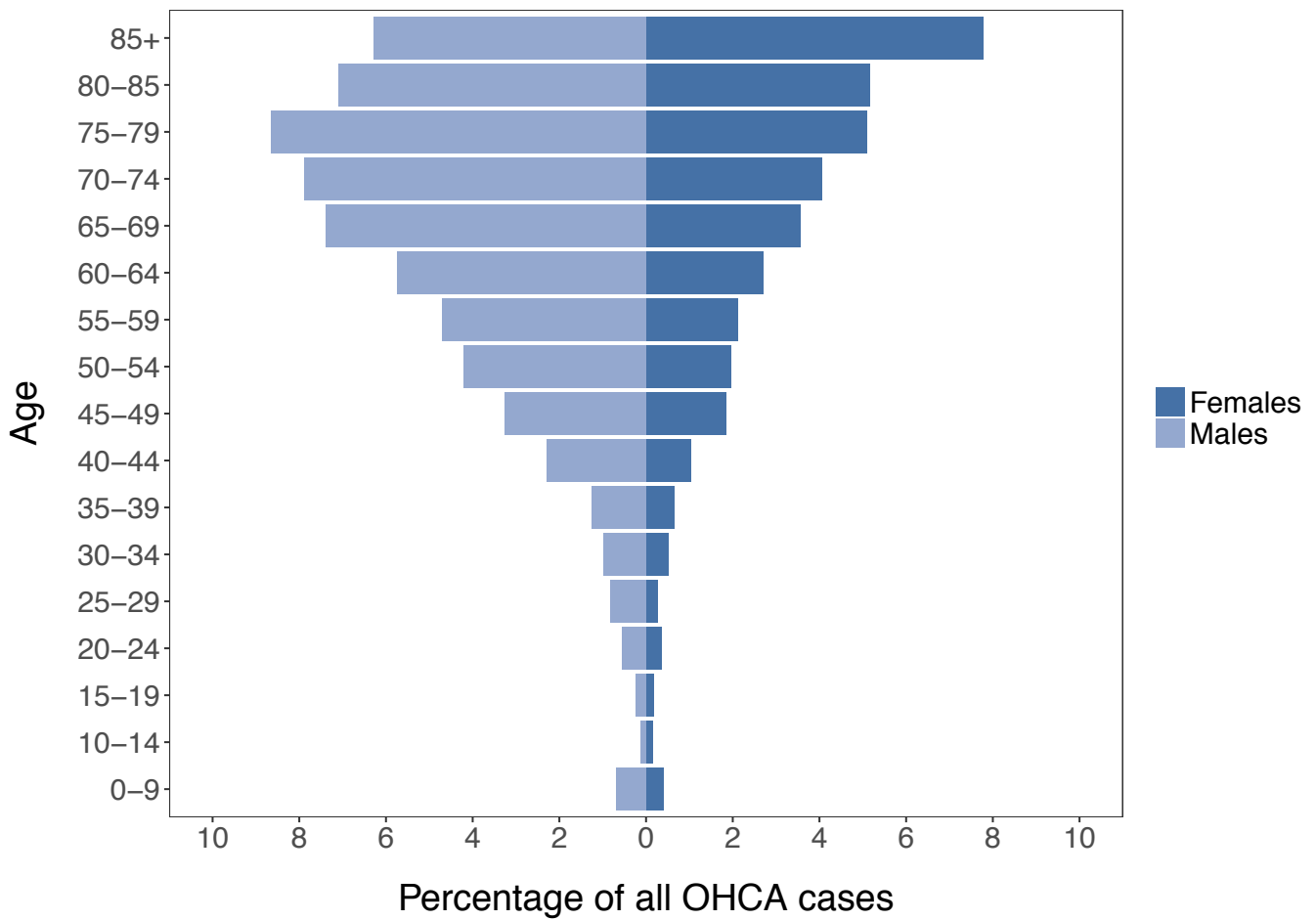


Figure 1: Distribution of OHCA cases by age and sex expressed as a percentage of the total number of OHCA between January 2011 and March 2015

Figure 2 shows the incidence of OHCA - number of cases per 100,000 resident population - for the different age groups and for males and females separately. Mid-year population estimates of the Scottish population published by National Records Scotland are used to estimate incidence⁽²¹⁾.

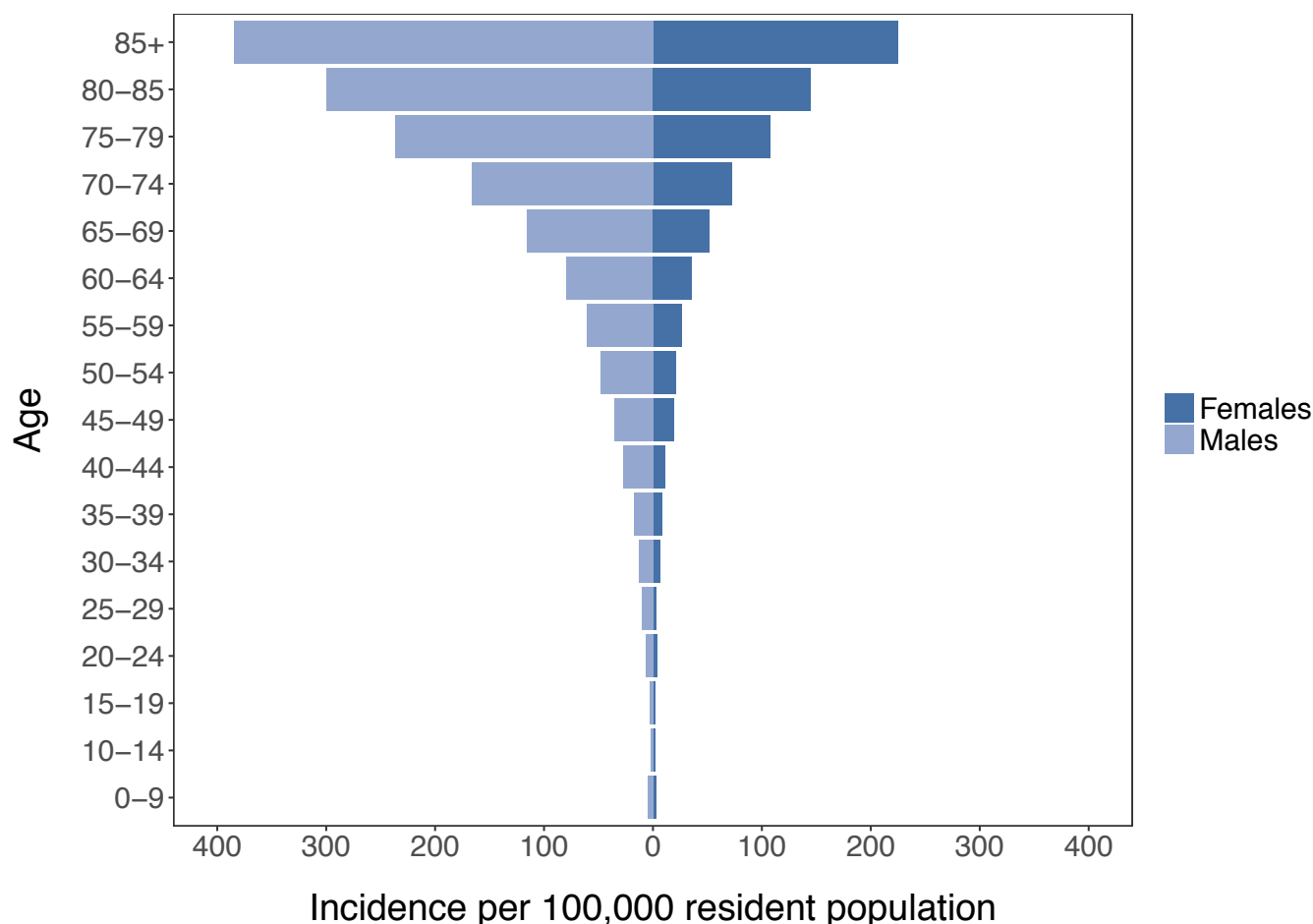


Figure 2: Incidence of OHCA by age and gender, expressed per 100,000 resident population between January 2011 and March 2015

A comparison of the distributions for males and females indicates that male OHCA patients are on average younger. This is also reflected in an average (mean) age of 66.1 years for males and 69.8 years for females. The results shown in Figures 1 and 2 are consistent with reports from other countries about the age and sex distribution of OHCA^(9, 17, 22-24).

SIMD STATUS OF OHCA PATIENTS

The Scottish Index of Multiple Deprivation (SIMD) is a measure designed to identify area concentrations of multiple markers of deprivation. For the purpose of disseminating data, Scotland is divided into areas called ‘datazones’, each with a population of around 500 to 1,000 residents. The SIMD ranks the 6,505 datazones that cover Scotland from most deprived (ranked 1) to least deprived (ranked 6,505). Ranking is based upon markers including current income, employment, health, education, skills and training, housing, geographic access and crime. These SIMD-ranked datazones can then be split into quintiles reflecting the most deprived 20% of the population (SIMD1) up to the least deprived 20% (SIMD5)⁽²⁵⁾.

In our linked dataset, the SIMD quintile was available for over 97% of OHCA cases included in the analysis (no information was available for 207 patients). Figure 3 shows the proportion of OHCA patients in each SIMD quintile. The proportion of OHCA involving people living in the most deprived SIMD quintile was twice as high as the proportion of people in the least deprived SIMD quintile (28% versus 14%). The majority of relevant academic literature has shown that a low socio-economic status is associated with a higher incidence of OHCA^(26, 27).

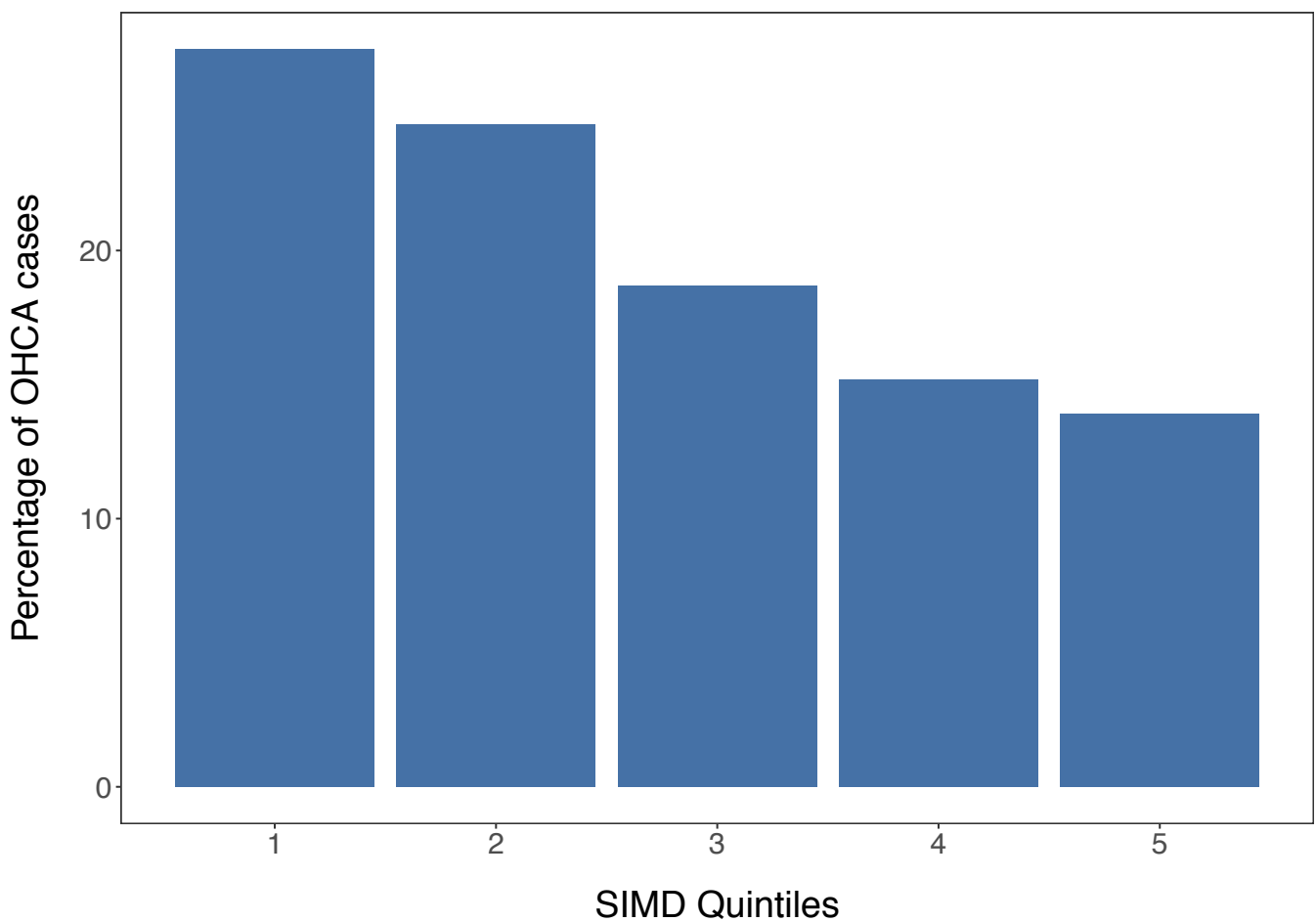


Figure 3: Percentage of OHCA cases across the SIMD quintiles. SIMD1: most deprived, SIMD5: least deprived

Figure 4 shows the (mean) average age at which patients suffered an OHCA in each SIMD quintile. For both males and females the mean age increases across the SIMD quintiles. This indicates that people who live in a more deprived area who have an OHCA are younger than people who live in less deprived areas who have an OHCA (average age for males in SIMD1 and SIMD5 is 62.5 and 70.3 respectively, and for females 66.6 and 72.6). The age difference across the SIMD quintiles is most pronounced for males and the mean age at which males suffer OHCA is consistently younger than for females.

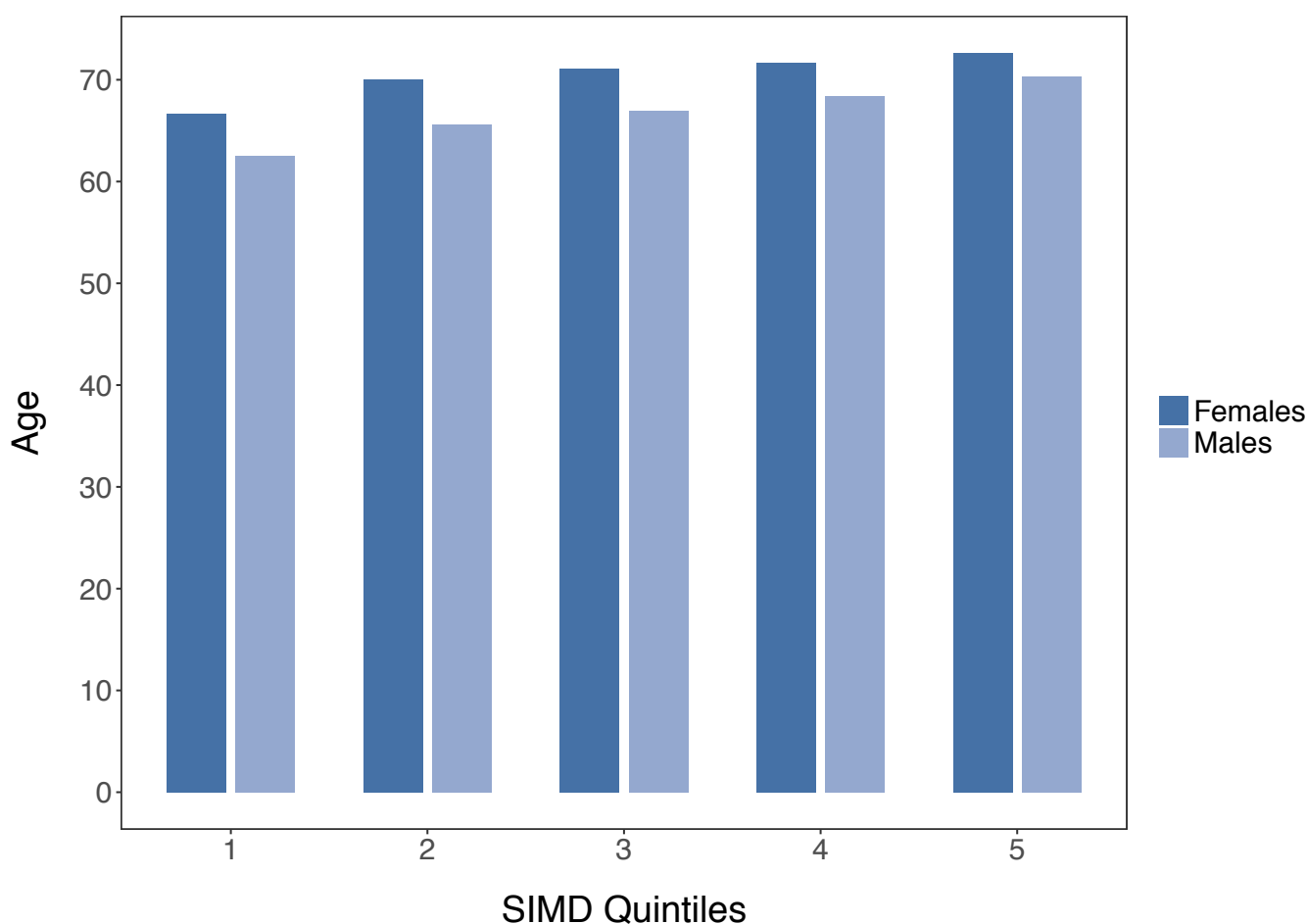


Figure 4: (Mean) Average age of OHCA cases across the SIMD quintiles by sex

NUMBER OF PATIENTS WITH OHCA IN URBAN AND RURAL AREAS

The Scottish Government Urban Rural Classification⁽²⁸⁾ is based on two key criteria - settlement size and drive time to major settlements. The six categories distinguish between urban, rural and remote areas (see Table 1). Table 1 shows the proportions of all people who live in Scotland across the categories and the proportion of OHCA patients who lived in the different urban rural categories. Over 73% of all OHCA patients live in an urban area. The last column of the table shows the incidence per 100,000 population by the six categories. This shows that the incidence is highest in the large urban areas and lowest in remote rural areas. Note that these are crude incidences not adjusted for age, sex or SIMD. Furthermore, the urban rural classification is based on patients' home addresses, not necessarily the locations where the OHCA happened. In contrast, data from the Irish OHCA registry showed no difference in incidence between urban and rural areas⁽²⁹⁾. For practical reasons in some analysis a simpler urban (combining categories 1 and 2) or rural (combining categories 3-6) classification is used instead of the six categories. More detailed analysis is planned to investigate regional and urban/rural differences in incidence and outcome of OHCA in Scotland.

Table 1: Description of urban and rural classification and proportions and incidence of OHCA cases

Category	Description	Proportion of total population of Scotland	Percentage of OHCA's	Incidence per 100,000 population
1. Large urban areas	Settlements of over 125,000 people	34.7	34.7	41.0
2. Other urban areas	Settlements of 10,000-125,000 people	35.2	38.4	44.6
3. Accessible small towns	Settlements of between 3,000 and 10,000 people and <30 min drive of a settlement of >10,000 people	9.4	8.9	38.7

Category	Description	Proportion of total population of Scotland	Percentage of OHCA's	Incidence per 100,000 population
4. Remote small towns	Settlements of between 3,000 and 10,000 people and with a drive time of >30 min to a settlement of >10,000 people	3.5	3.1	36.2
5. Accessible rural	Settlements of <3,000 people and within 30 min drive of a settlement of >10,000 people	11.3	10.3	37.2
6. Remote rural	Settlements of <3,000 people and with a drive time of >30 min to a settlement of >10,000 people	5.9	4.6	31.9

RESUSCITATION FOLLOWING OHCA

PRESENTING HEART RHYTHMS

When the heart rhythm is first monitored after OHCA a patient may present with a shockable rhythm (ventricular fibrillation or ventricular tachycardia - treated by delivering an electric shock using a defibrillator) or non-shockable rhythm (asystole or pulseless ventricular activity and bradycardia) on the electrocardiogram (ECG)⁽¹⁴⁾. The treatment and prognosis depend on presenting heart rhythm with better survival after OHCA with shockable rhythm^(30, 31).

Information about presenting heart rhythm was available for 91.1% of our cohort. The proportion of OHCA cases with a shockable presenting heart rhythm was 25.1% (Figure 5). Other OHCA registries and academic studies have reported a similar proportion of shockable rhythms⁽¹⁸⁾. Some report lower proportions of shockable rhythms and also a trend towards diminishing proportions of patients with shockable rhythms over recent years⁽¹⁷⁾. Part of the reason for our relatively high proportion of shockable presenting rhythms may be the fact that survivors are likely to be over-represented in our linked dataset.

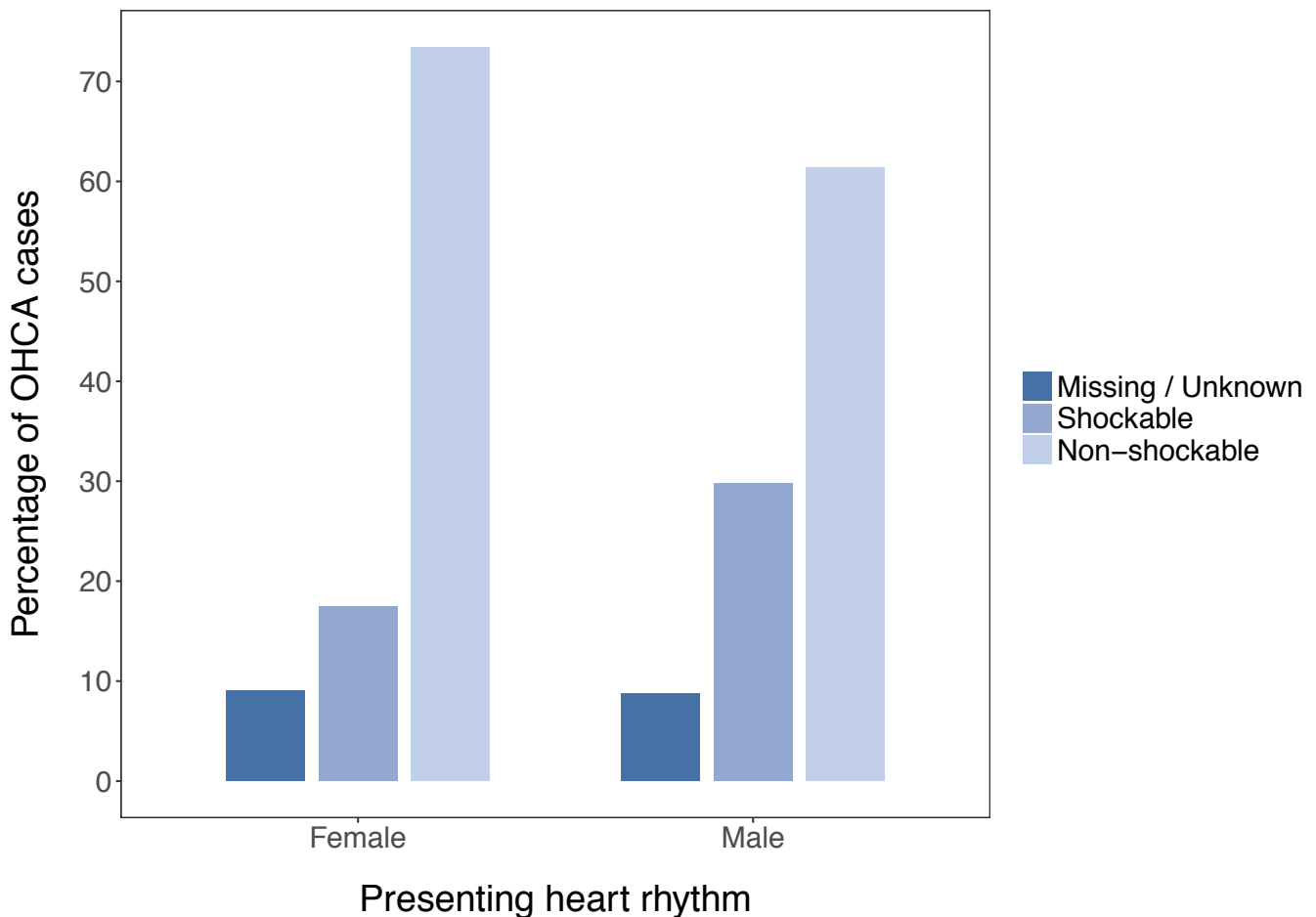


Figure 5: Distribution shockable and non-shockable heart rhythms by gender

Figure 5 also shows that a larger proportion of males present with a shockable heart rhythm during their OHCA. This is in agreement with earlier published figures⁽¹⁸⁾. In our dataset both males and females between 45 and 65 years of age were most likely to present with a shockable rhythm.

BYSTANDER CARDIOPULMONARY RESUSCITATION

The positive effect on survival of the early start of cardiopulmonary resuscitation (CPR) is well established⁽³²⁻³⁵⁾. In the ideal situation, a bystander starts performing chest compressions on the OHCA victim as soon as possible.

Figure 6 shows that in just over 40% of OHCA cases where the Scottish Ambulance Service attempted resuscitation it is recorded that a bystander started CPR before arrival of the ambulance service. It is an idiosyncrasy of the way CPR data is collected on the electronic patient report form used by the Scottish Ambulance Service that it is unclear whether in the remaining 60% of cases there was no bystander CPR observed or the data is simply missing or unknown.

Scotland's 40% bystander CPR rate is low compared with the numbers published for other centres, including some parts of England⁽¹⁷⁾. For example it is substantially lower than the 60% bystander CPR reported by the London Ambulance Service in their 2015/2016 annual report⁽³⁶⁾. The relatively low overall survival rate in Scotland during the period our data was collected, lends plausibility to the suggestion that our bystander CPR rate is substantially lower than other parts of Europe with better survival outcomes. It is also possible that because our 2011-15 dataset bystander CPR information was often missing or ambiguous, the actual percentage of bystander CPR may be higher, and our findings simply reflect significant under-reporting.

A fundamental tenet of Scotland's OHCA Strategy is that increasing bystander CPR rate is crucial to increasing survival. It is therefore a priority to improve completeness of information about bystander CPR. Work is underway to capture baseline bystander CPR data for the period 2011-2015 by extracting additional data relating to telephone guided CPR initiated by emergency call handlers from the Scottish Ambulance Service control centres ([see section about future work on page 36 for more details](#)).

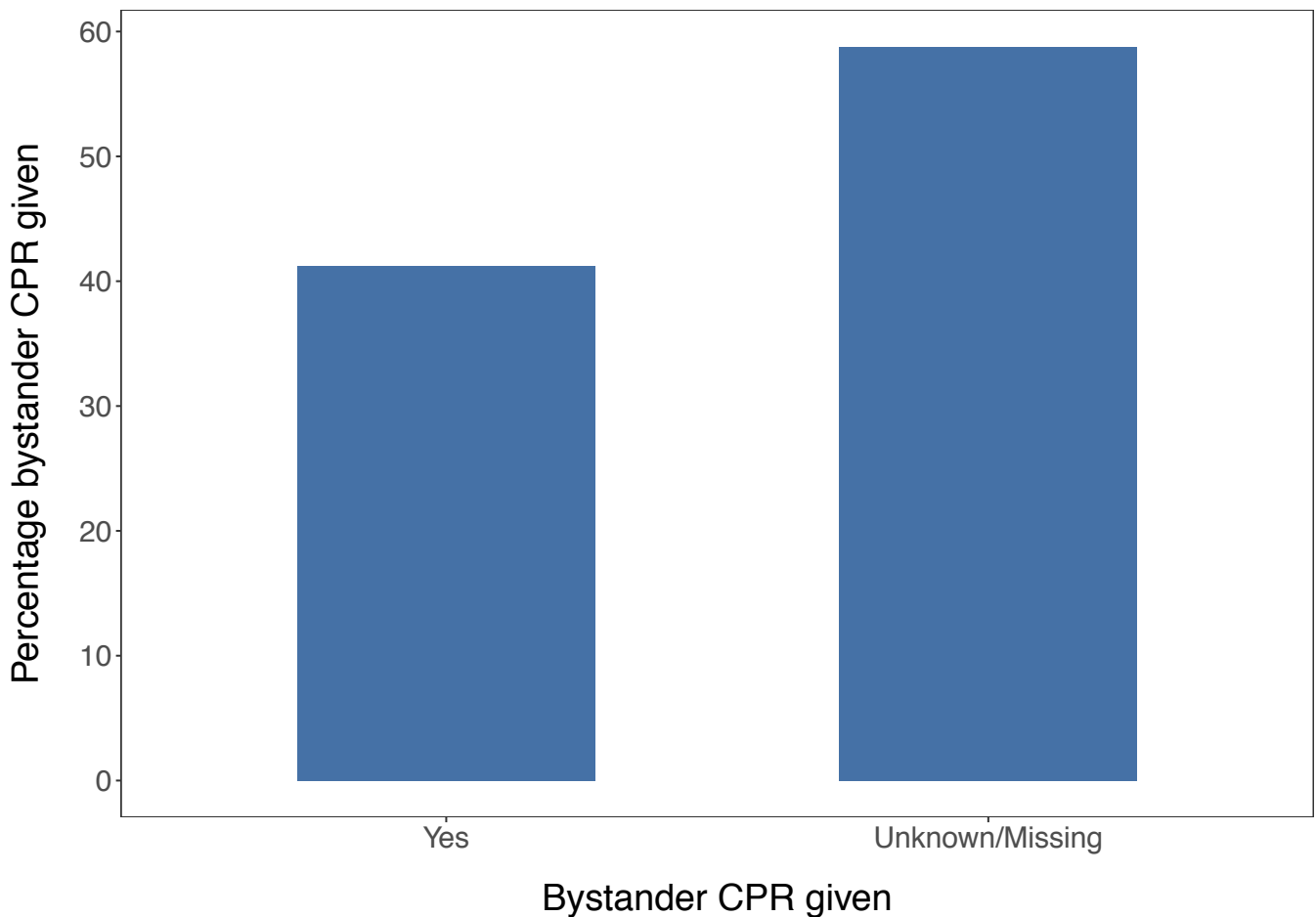


Figure 6: Total proportions of known and unknown/missing bystander CPR given

More detailed analysis show that the likelihood of receiving bystander CPR differs between subgroups of people in the dataset. The upper left panel of Figure 7 shows that the likelihood of receiving bystander CPR is higher among males. This data conflicts with some of the current literature reporting higher bystander CPR rates in witnessed OHCA among females⁽²⁰⁾, but are in line with other published findings⁽³⁷⁾. The current literature describing bystander CPR rates across age groups is inconsistent. Some authors report higher proportions receiving bystander CPR among younger patients while others report higher proportions among older patients^(38, 39). Our data show the highest proportions with a record of bystander CPR among the youngest age groups (Figure 7, left upper panel). Figure 7, bottom left panel, shows that patients from deprived areas (SIMD1) are less likely to receive bystander CPR. This is in line with a recently published study from Taiwan showing that patients who suffer from an OHCA in a low socio-economic status area are less likely to receive bystander CPR compared with more affluent areas⁽⁴⁰⁾. The figure in the right bottom panel shows a trend towards increasing proportions of records of bystander CPR over time. This trend towards more bystander CPR in Scotland in the years before the launch of the Scottish OHCA strategy might be partly explained by an international increase in emphasis on the importance

of bystander CPR. It is also likely that the recording of bystander CPR has improved in recent years. Our overall increase in bystander CPR over time is concordant with observations from other centres^(32, 41).

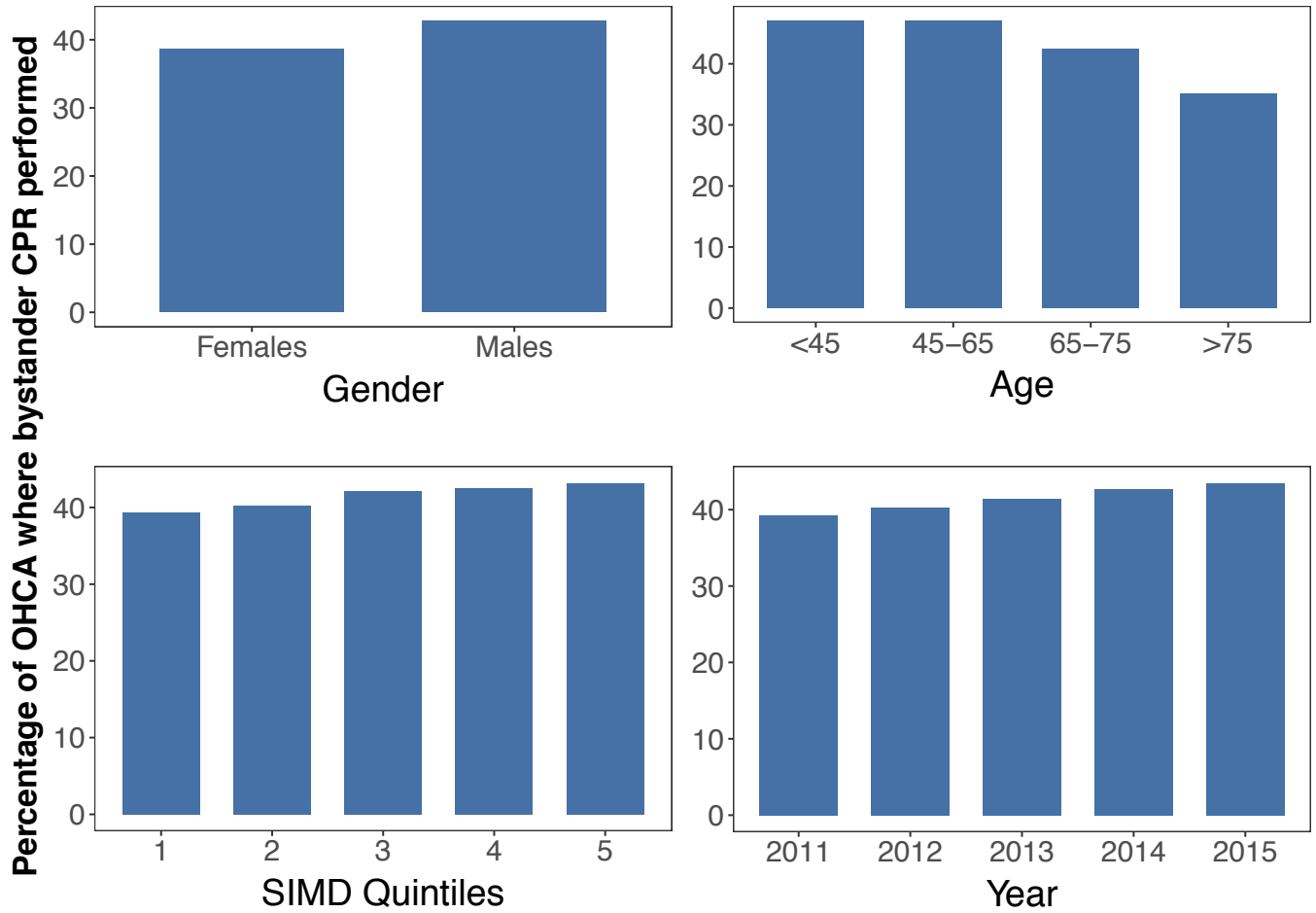


Figure 7: Percentages of OHCA with a record of receiving bystander CPR by age, sex, SIMD quintiles and year of OHCA

SURVIVAL FOLLOWING OHCA

Survival figures for OHCA where resuscitation was attempted are shown in table 2. The percentage of patients alive at 24 hours, 30 days and 1 year is given. In addition, return of spontaneous circulation (ROSC) is an outcome measure frequently reported in other OHCA registries and publications and therefore we have included it here for comparison. Definitions for ROSC vary. The Scottish Ambulance Service record ROSC if a patient regains a palpable pulse which is sustained until arrival at the Emergency Department, a proxy for the Utstein definition of ‘sustained ROSC’ (palpable pulse for greater than 20 minutes).

Table 2 shows survival figures after OHCA in Scotland based on two different sets of assumptions in analysis of the data. In column A, we have used only patients where data could be linked (ie around 75%) in the denominator, yielding an overall 30 day survival of 8.4%. For the column B, the assumption has been made that patients who were not part of the linked dataset died shortly after their OHCA, which gives a lower 30-day survival figure of 6.2%. The presupposition here is that patients pronounced dead in the community without being transported to hospital are more likely to have insufficient data recorded for probabilistic data linkage (see the methodology section for further information). The actual 30-day survival percentage will lie between the two figures, but is probably closer to that reported in column B.

Table 2: Outcomes after OHCA

Outcome	A: Proportion based on linked dataset as denominator(%)	B: Proportion using all arrests as denominator and assumption that insufficient data for linkage = death(%)
ROSC	16.7	12.2
Alive at 24hrs	12.7	9.3
Alive at 30 days	8.4	6.2
Alive at 1 year	8.0	5.9

In line with other published reports, 30-day survival is used as a proxy for survival to discharge from hospital. Detailed data for hospital discharges will be available for analysis in the future.

In the dataset, just over 800 (8.6%) cases fulfilled criteria for inclusion in the ‘Utstein comparator group’ meaning that the OHCA cases are witnessed, presented with a shockable presenting heart rhythm and bystander CPR was started. The 30 day survival in this group was 23.2%, substantially higher than for the whole cohort. The international literature reports survival to hospital discharge in this group between 18.5% and 52%^(1, 33, 42).

COMPARISON OF SCOTLAND'S SURVIVAL RATES WITH OTHER REGISTRIES

The results of the EuReCa ONE project were mentioned earlier - this project demonstrated significant differences in the incidence of OHCA, and also survival rates across Europe. The percentage who had ROSC among the 27 included countries ranged from less than 10% to over 40%. The percentage with ROSC in Scotland is at the lower end of this spectrum. Similarly, our 30-day survival sitting between 6.2% - 8.4% (see Table 2) puts Scotland among the countries with the lowest survival rates, lower than the overall European survival rate of 10.3% reported by EuReCa ONE. Substantially higher 30 day survival rates are found in Finland, the Netherlands and Switzerland^(11, 43). Comparable proportions of people who survived 30 days were found in Denmark and other parts of the United Kingdom^(17, 19). It is important to reflect on these differences in the context of the different population included in different datasets (eg some studies or registries only include OHCA cases with a cardiac origin, while others include cases with other aetiologies such as drugs-related cases or cases due to trauma, some report only witnessed OHCA cases, and others also include unwitnessed cases), and the differences in data collection and data processing (eg handling of missing data)⁽¹⁵⁾. The EuReCa ONE project collaborators themselves also identified sources of variability in data processing and collection.

USING LOGISTIC REGRESSION TO MAKE LIKE-FOR-LIKE COMPARISONS

In addition to overall survival figures we have made a series of comparisons of OHCA survival between different groups using logistic regression techniques. This makes it possible to adjust for factors - for example age, sex and deprivation - that might differ between sub-groups and confound any associations. Logistic regression techniques adjust for these factors enabling us to make like-for-like comparisons.

The results of this type of modelling should be interpreted as relative measures. For example when the survival between males and females is compared using logistic regression, the risk of death for males is used as the reference category and the estimated risk for females is expressed relative to that of males.

(Technical note: we recognise that odds ratios over-estimate relative risks when outcomes are common, ie occur in greater than 15% of the study population⁽⁴⁴⁾. For accessibility, the results here are described in terms of higher and lower risk but are actually calculated as higher and lower odds. We plan further analysis to compare the results of both approaches⁽⁴⁵⁾. Using logistic regression models is in line with the majority of published papers in this research field thus enabling comparisons.)

EFFECT OF AGE AND SEX ON SURVIVAL OF OHCA PATIENTS

The previous section showed that overall, males in the cohort are more likely than females to be affected by an OHCA. In contrast, the percentage of females who survive after an OHCA is lower compared to males (see Figure 8, crude analysis). More detailed analysis of our data have shown that women are more likely to present with a less favourable heart rhythm (non-shockable). In the linked dataset, the proportion with shockable presenting heart rhythm was 17.5% among females and 29.8% among males. The adjusted analysis presented in Figure 8 show that taking these differences, and differences in age distribution into account (adjusted analysis), there is no longer any sex difference in survival. This finding is in line with other published work⁽⁴⁶⁾.

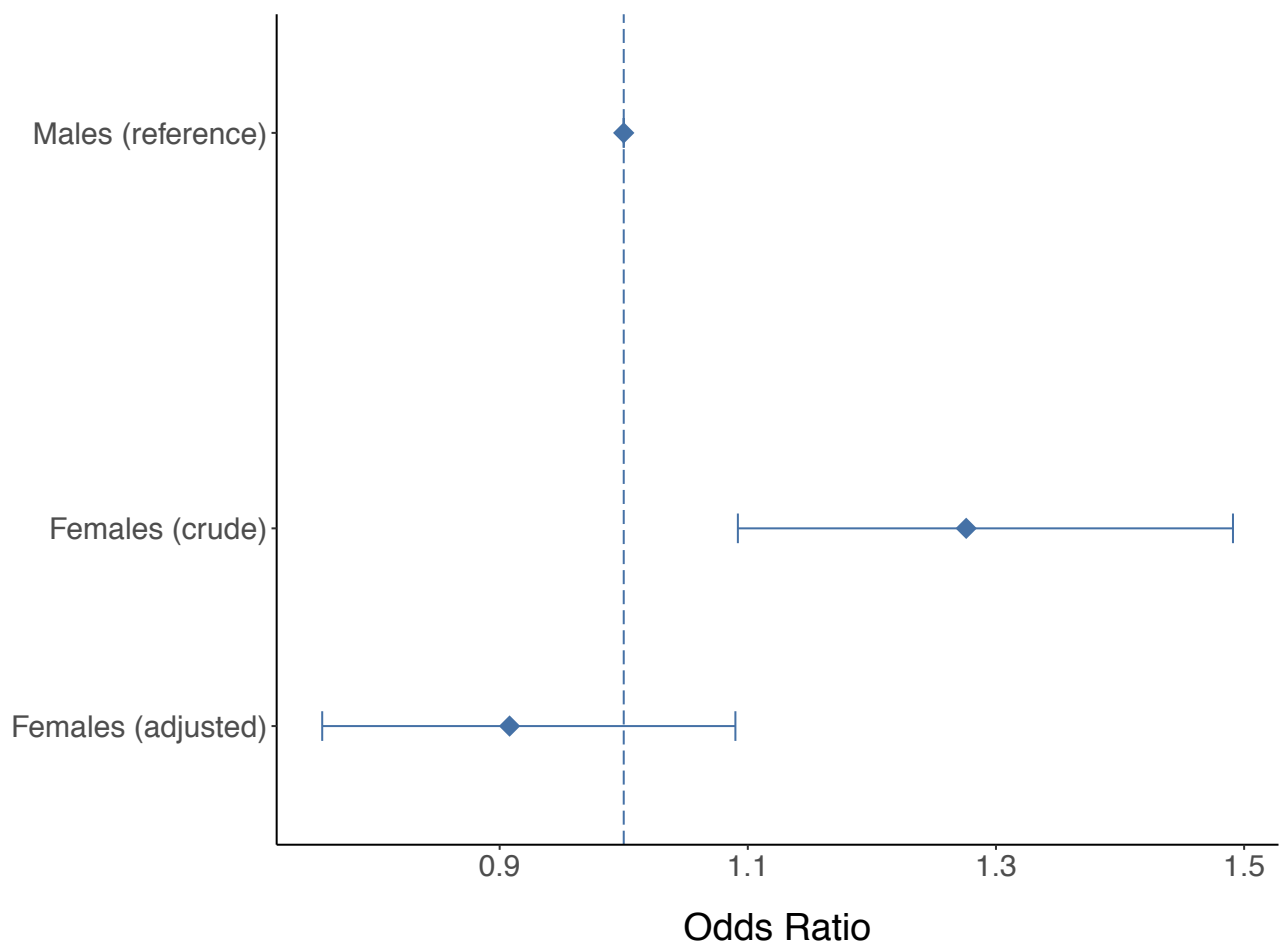


Figure 8: Results of logistic regression analysis examining the effect of sex on risk of death at 30 days after OHCA. The diamonds refer to the estimated odds ratios for 30 days mortality and the bars refer to the 95% confidence intervals. Males are the reference category. Values above 1 for the lower limit of the confidence interval suggest a statistically significant higher risk for 30 days mortality for women in the crude estimates that is not observed for the adjusted estimates.

In Figure 8, the crude data shows that a higher proportion of females die within 30 days of their OHCA. However the sex difference is no longer present after adjusting for age and presenting heart rhythm as illustrated by the fact that the 95% confidence intervals include the value of 1.

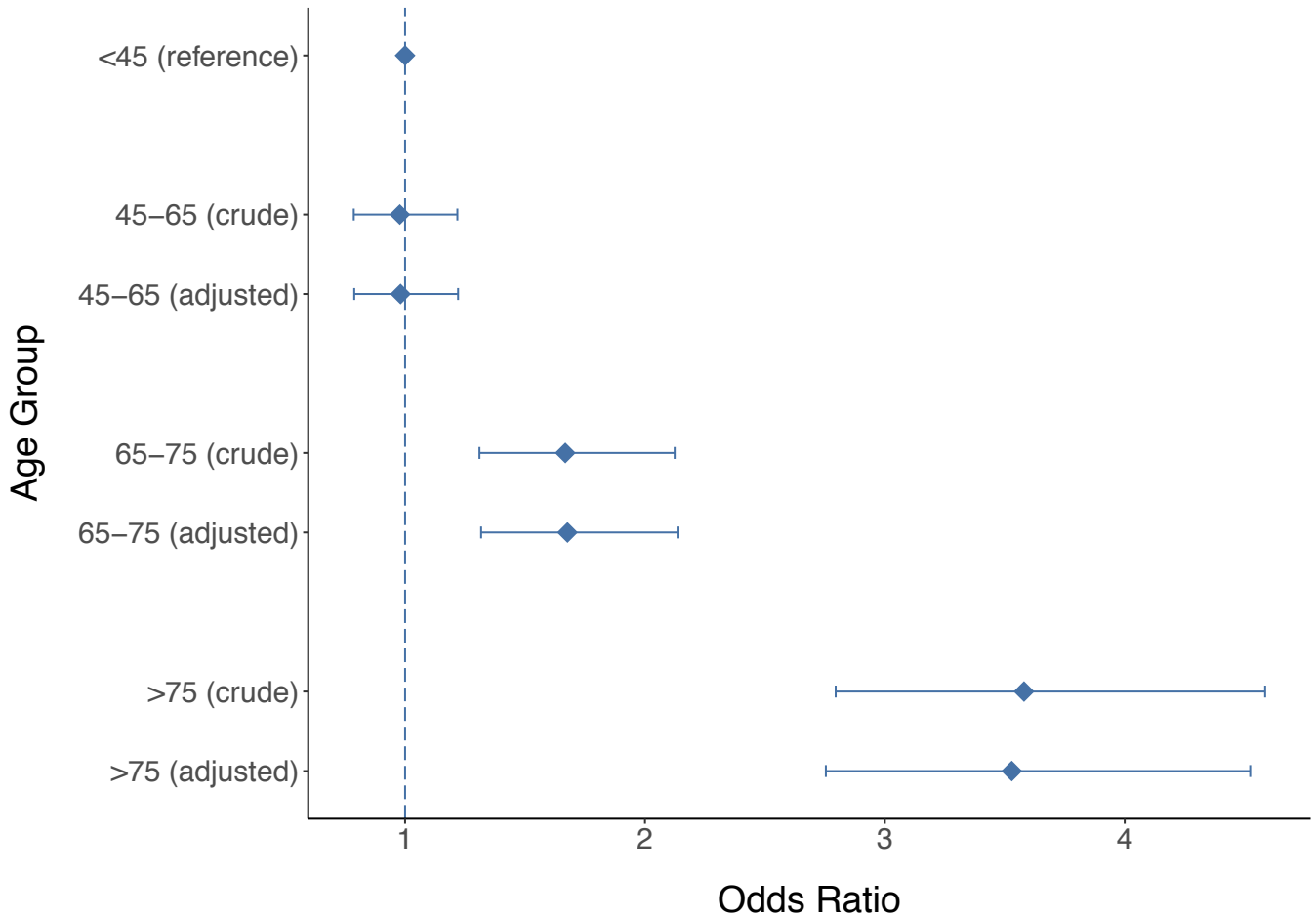


Figure 9: Results of logistic regression analysis examining the effect of age on risk of death at 30 days after OHCA. The age group <45 years is the reference category. The diamonds refer to the estimated odds ratios for 30 days mortality and the bars refer to the 95% confidence intervals. Values above 1 for the lower limit of the confidence intervals for the age groups 65-75 and >75 suggest a statistically significant higher risk for 30 days mortality patients older than 65 years compared with patients younger than 45 years. The adjusted analysis is adjusted for sex.

In Figure 9, both the crude and adjusted analysis show that patients from 65 years and older are more likely to die within 30 days after their OHCA compared with younger patients. This finding is consistent with other published figures⁽⁴⁶⁾.

EFFECT OF SIMD STATUS ON SURVIVAL OF OHCA PATIENTS

Figure 3 has already shown that people living in more deprived areas are more likely to experience an OHCA. Further analysis show that patients from deprived areas are also less likely to survive following OHCA. Figure 10 shows the likelihood of 30 day survival for each of the first four quintiles of SIMD compared with people from the least deprived areas (SIMD5). People who lived in the most deprived areas of Scotland (SIMD1) are 43% more likely to die within 30 days after their OHCA compared with people who lived in the least deprived areas in Scotland (SIMD5).

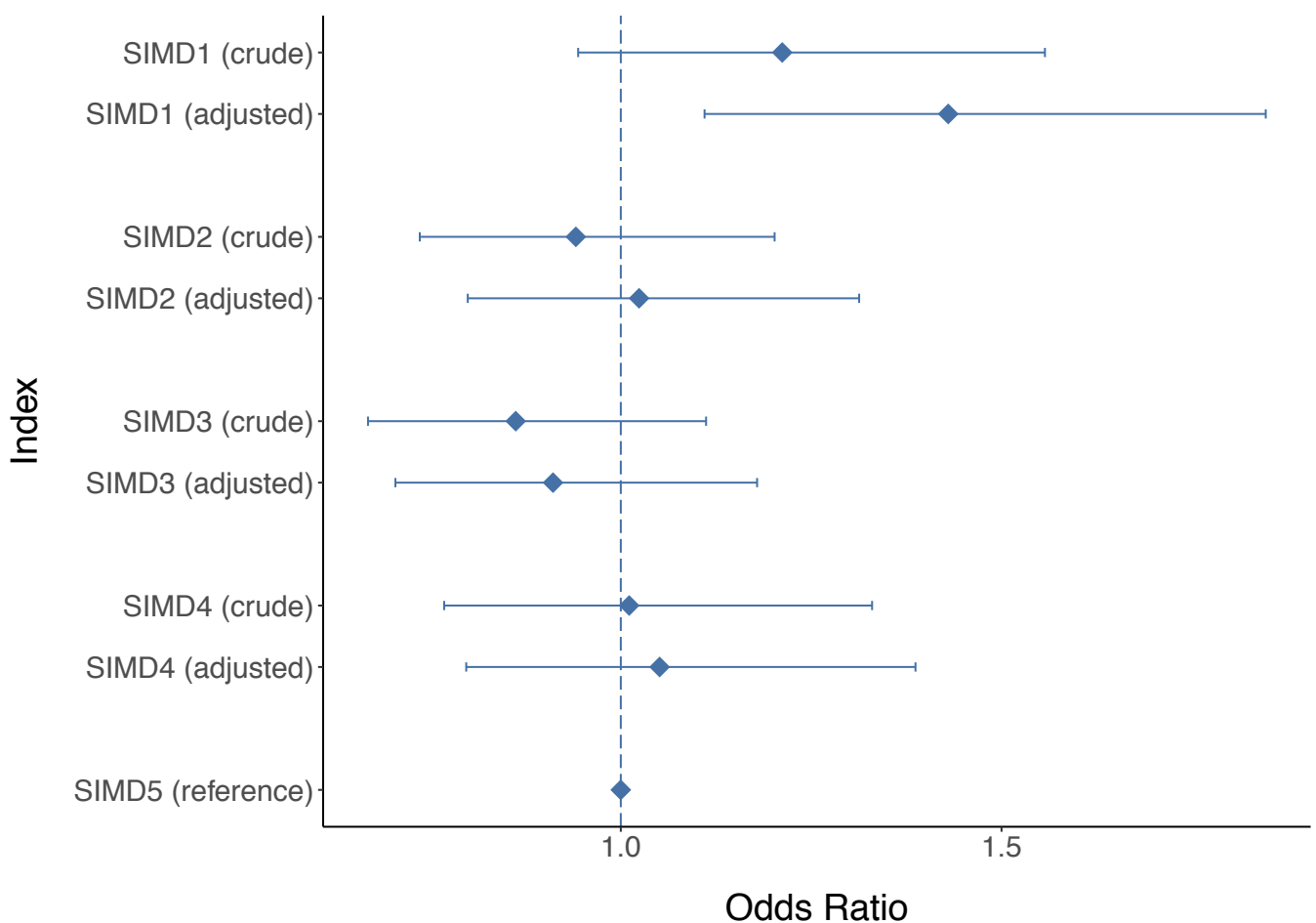


Figure 10: Results of logistic regression analysis examining the effect of SIMD quintiles on risk of death at 30 days after OHCA. SIMD5 (least deprived) is the reference category. The diamonds refer to the estimated odds ratios for 30 days mortality and the bars refer to the 95% confidence intervals. Values above 1 for the lower limit of the confidence intervals for SIMD1 suggest a statistically significant higher risk for 30 days mortality for patients in SIMD1 compared with patients from the least deprived areas. The adjusted analysis is adjusted for sex, age and urban rural classification.

Figure 10 shows that in both the crude and adjusted analysis patients who lived in SIMD1 are more likely to die within 30 days after their OHCA compared with patients who lived in the least deprived areas.

The effect of SIMD on survival is most pronounced among males. Furthermore for both males and females the effect is greatest among younger patients (younger than 45 for females and younger than 65 for males). Our data appear to show that the effect of deprivation may be explained by less bystander CPR and higher likelihood of comorbidities among young OHCA patients living in SIMD1 areas compared with people of similar age from less deprived areas (these results are not shown here).

The underlying explanation of these SIMD-related differences will be multifactorial, but lifestyle factors such as smoking are likely to play a significant role^(32, 47).

More in depth analysis focusing on the association between SIMD and the incidence and outcomes of OHCA are planned.

EFFECT OF URBAN AND RURAL ENVIRONMENT ON SURVIVAL OF OHCA PATIENTS

In Table 1 (page 13), the incidences of OHCA are shown for the six urban rural categories⁽²⁸⁾. Note, these percentages are based on only the patients in the linked dataset and are therefore subject to the caveats already stated. Patients from areas classified as remote accessible towns, large urban areas and other urban areas have the highest incidences of OHCA, and remote rural areas the lowest.

Given the small numbers in some groups, a dichotomous (two-category) urban-rural measure was created (Table 3) for the following analysis of differences in 30-day survival.

Table 3: Aggregation of urban and rural categories

Six categories	Two categories
Large urban areas	Urban
Other urban areas	Urban
Accessible small towns	Rural
Remote small towns	Rural
Accessible rural	Rural
Remote rural	Rural

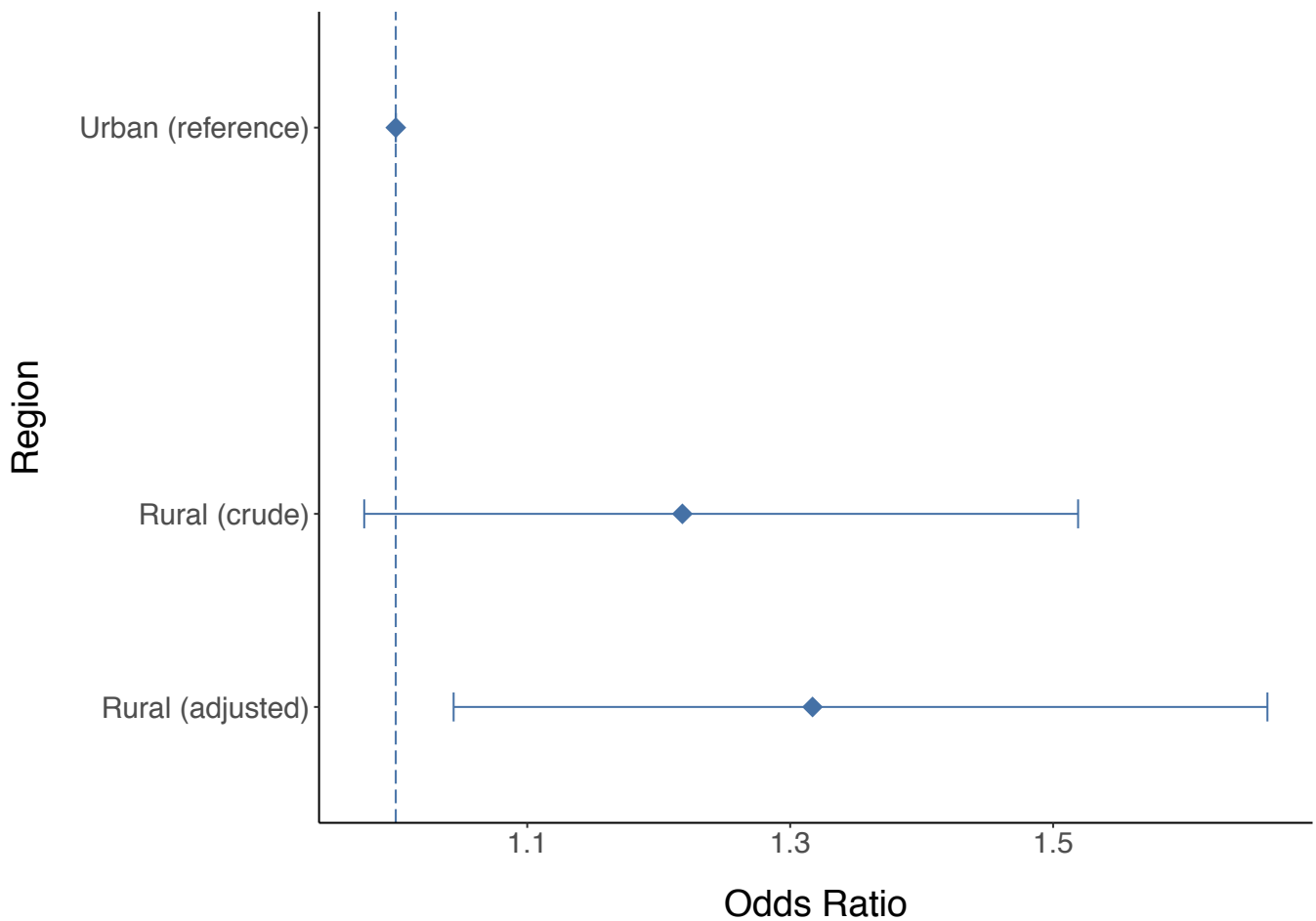


Figure 11: Results of logistic regression analysis examining the effect of living in urban or rural areas of Scotland on risk of death at 30 days after OHCA. Urban area is the reference category. The diamonds refer to the estimated odds ratios for 30 days mortality and the bars refer to the 95% confidence intervals. Values above 1 for the lower limit of the confidence intervals for rural category in the adjusted analysis suggest a statistically significant higher risk for 30 days mortality in patients who lived in rural areas compared with urban areas. The adjusted analysis is adjusted for sex, age and SIMD.

In Figure 11, the adjusted analysis shows that patients living in a rural area are more likely to have died 30 days after OHCA compared with patients living in an urban area. People living in rural areas are less likely to survive an OHCA. The adjusted analysis shows that this effect persists after taking into account the age, sex and SIMD distributions. Further analysis will investigate the effect of other potential factors such as heart rhythm and bystander CPR.

EFFECT OF INITIAL HEART RHYTHM ON SURVIVAL OF OHCA PATIENTS

As mentioned in the previous section, a shockable initial heart rhythm after OHCA is predictive of increased survival. Taking all patients with a known initial heart rhythm into account (91% of the total dataset), we found that people who present with a shockable initial heart rhythm are 88% more likely to survive until 30 days after the OHCA compared with patients with a non-shockable rhythm. These results are based on a logistic regression model adjusted for age and sex (adjusted odds ratio 0.12 (95% confidence interval 0.10-0.14, further adjustment for SIMD and urban rural category did not change the estimates).

EFFECT OF BYSTANDER CPR ON SURVIVAL OF OHCA PATIENTS

A positive effect of bystander CPR on survival was found in OHCA cases where the first ambulance arrived within eight minutes after one of the Ambulance Control Centres received an OHCA call. In figure 12, the likelihood of survival with and without bystander CPR is compared. This figure shows that on average, cases with bystander CPR are 32% more likely to be alive 30 days after the OHCA.

In Figure 12, both the crude and age, sex, SIMD and urban rural category adjusted analysis show that patients who receive bystander CPR are more likely to survive 30 days after OHCA compared with patients who do not receive bystander CPR.

As mentioned previously, we suspect that the available bystander CPR data is underreported. Therefore, it is likely that the true effect of bystander CPR on survival is even greater. Furthermore, not all CPR is equally effective. A limitation of the current available data is the lack of timing of the start of bystander CPR making it impossible to calculate how long before the arrival of the first ambulance a bystander started CPR. Chest compressions started earlier are likely to be more effective in preserving life than those started after a significant delay⁽³⁵⁾.

Currently work is underway to solve some data issues for arrival times. Therefore, only cases where the first ambulance arrived within eight minutes are included in the current analysis.

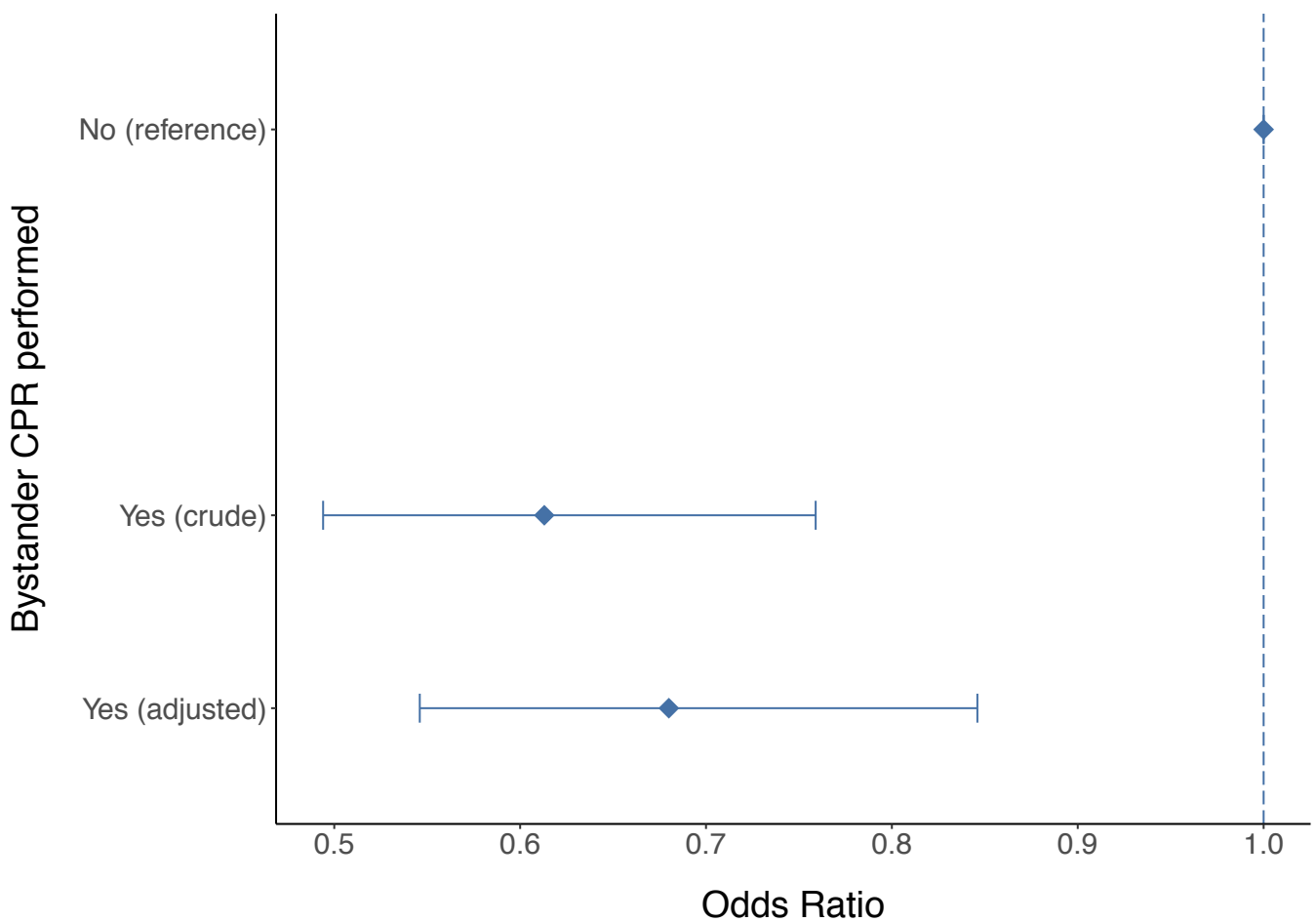


Figure 12: Results of logistic regression analysis examining the effect of bystander CPR on death at 30 days after OHCA within all cases where an ambulance arrived within eight minutes. The group where bystander CPR was unknown is reported as the reference category. The diamonds refer to the estimated odds ratios for 30 days mortality and the bars refer to the 95% confidence intervals. Values above 1 for the lower limit of the confidence intervals for the Yes category in the crude and adjusted analysis suggest a statistically significant lower risk for 30 days mortality in patients who received bystander CPR compared with the group for which the bystander CPR status is missing or unknown. The adjusted analysis is adjusted for age, sex, SIMD and urban rural category.

DATA LINKAGE PROCESS

PERMISSIONS PROCESS

This project was dependent on securing a number of permissions before data could be shared and linked. The three stages of permissions were:

1. Approval from the Scottish Government's Analytical Leadership Group

The Scottish Government has provided funding for 60 Scottish Government/public sector linkage projects to be supported through SILC ([Scottish Informatics and Linkage Collaboration](#)). In order to be selected as one of the 60 projects by the Analytical Leadership Group, the project had to meet a number of criteria including:

- providing a proportionate balance between privacy, mitigating the risk of identification, and realising the public benefits
- demonstrating public benefit and the ethical and secure use of data
- demonstrating the data is processed lawfully
- demonstrating alignment with Scottish Government priorities
- feasibility (ie the project is likely to succeed)
- outlining appropriate methodology
- demonstrating how the project addresses the Guiding Principles for Data Linkage
- identifying potential for significant impact on Scottish Government policy

Further information about Scottish Government Funded Data Linkage projects can be found here: <http://www.gov.scot/Topics/Statistics/datalinkageframework/Funded-Linkage-Projects>.

The OHCA Data Linkage Project secured this permission in August 2015.

2. Approval from the Scottish Intensive Care Society Audit Group (SICSAG)

The Scottish Intensive Care Society Audit Group (SICSAG) authorises (in conjunction with the Public Benefit & Privacy Panel for Health and Social Care (PBPP) for national data requests) the use of intensive care and high dependency care data which is collected from Scottish health boards.

Further information about SICSAG is available here: <http://www.sicsag.scot.nhs.uk/research/main.html>.

The OHCA Data Linkage Project secured this permission in April 2016.

3. Public Benefit and Privacy Panel for Health & Social Care

The PBPP is a governance structure of NHS Scotland, exercising delegated decision-making on behalf of NHS Scotland Chief Executive Officers and the Registrar General. The panel assesses the public benefit, privacy, confidentiality, and information governance in relation to NHS Scotland or National Records of Scotland originated data.

Further information about the PBPP can be found here:

<http://www.informationgovernance.scot.nhs.uk/pbp-phsc/>

The OHCA Data Linkage Project secured this permission in May 2016.

DATA SOURCES

This first report of findings from the OHCA Data Linkage project relates to data from 2011-2014/15. Figure 13 and Table 4 provide information about the data sources included in the linked dataset:

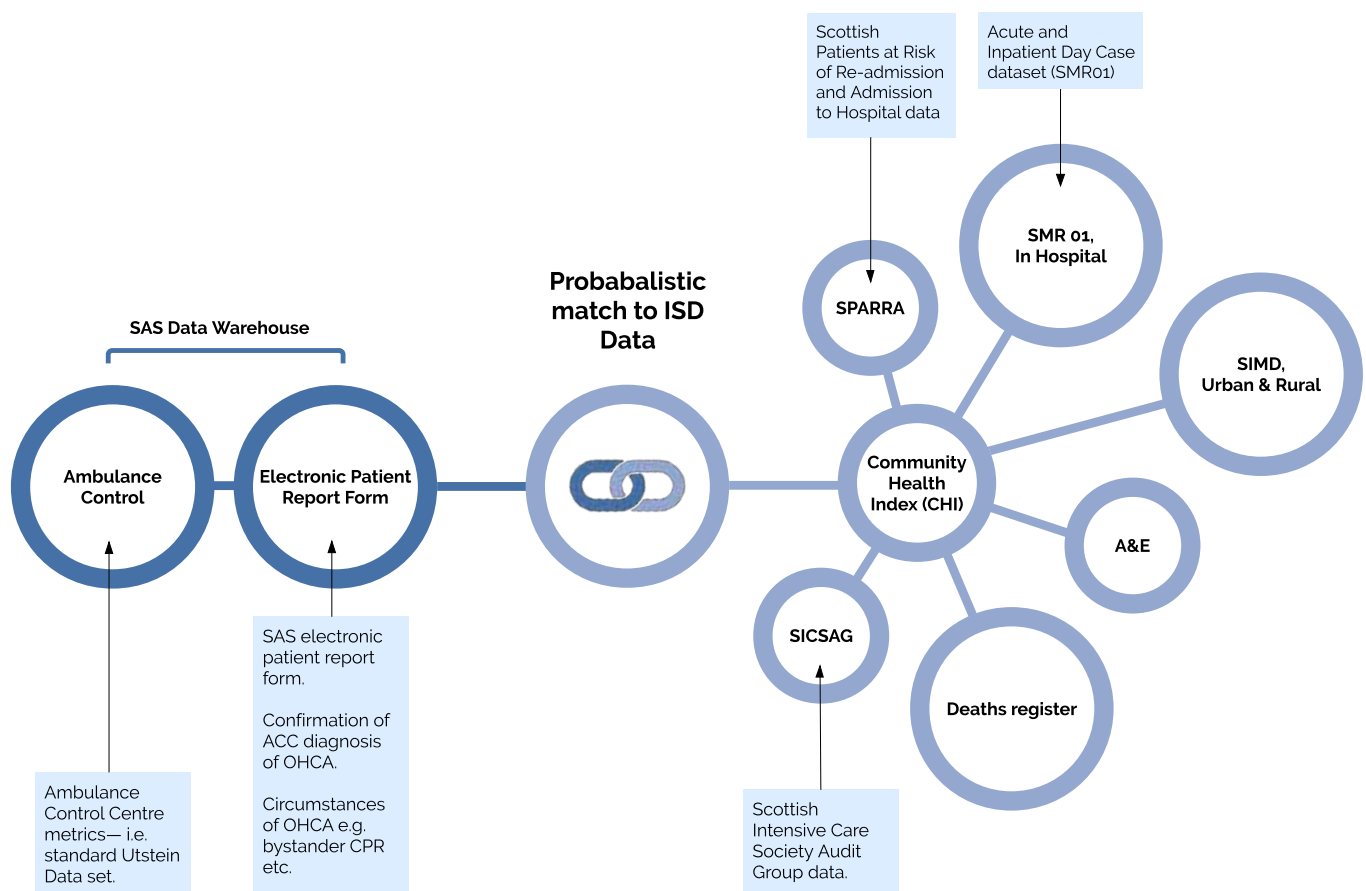


Fig 13: A schematic overview of the linkage process and data sources

Table 4: Data sources

Dataset	Time period	Source
Ambulance	2011-2014/15	Scottish Ambulance Service/ Unscheduled Care Datamart, NHS National Services Scotland
A&E	2011-2014/15	Unscheduled Care Datamart, National Services Scotland
Hospital inpatient data	2011-2014/15	Unscheduled Care Datamart, National Services Scotland
Intensive care	2011-2014/15	Scottish Intensive Care Society Audit Group
High dependency	2011-2014/15	Scottish Intensive Care Society Audit Group
Scottish patients at risk of readmission	2011-2014/15	National Services Scotland
Deaths	2011-2014/15	National Records of Scotland
Scottish Index of Multiple Deprivation	2012	Scottish Government

DATA LINKAGE PROCESS

Figure 14 gives a schematic overview of the data linkage process.

The starting point of this process is the list of 46,471 calls received by the Scottish Ambulance Service which were initially coded as possible OHCA. From this list, 14,895 OHCA cases between January 2011 and December 2015 were identified by SAS as OHCA cases where resuscitation was attempted ('worked arrests').

The next step is to convert the list of worked arrest ambulance service incidents into patient records by linking each patient with their Community Health Index (CHI). In this dataset only one OHCA had a CHI number immediately available.

For the other cases, SAS incidents were initially linked by interrogating the Unscheduled Care Datamart (UCD). The UCD is a collaboration between Public Health Information, Information Services Division (ISD) and unscheduled care providers NHS 24 and SAS. A probabilistic matching process was used to link unscheduled care records from NHS 24 and Scottish Ambulance Service to inpatient data (including Emergency Department, Acute, Mental Health and Deaths) by matching patient identifiers in incident data to those in CHI linked records.

Comparing the worked arrest list of incidents to the CHI linked incidents in the UCD, 66% of OHCA cases were found. For the remaining cases, additional probabilistic linkage was carried out. This type of linkage makes use of unique personal identifiers or combinations of unique personal identifiers. For this data linkage the following identifiers were used: parts of surname, first and second initial, sex, date of birth and postcode. A detailed description of the probabilistic linkage process, advantages and disadvantages can be found in reference 48. Using this process, an additional 9.7% of CHI numbers were retrieved. The probabilistic linkage was done in a trusted environment and all personal identifiers were removed before the datasets were made available for the researchers.

Following CHI linkage, the eData Research and Innovation Service team (eDRIS) at the Farr Institute (Scotland) were able to join the worked arrest data to the data sources outlined in Table 4. A diagram of the data linkage process can be found in Figure 14.

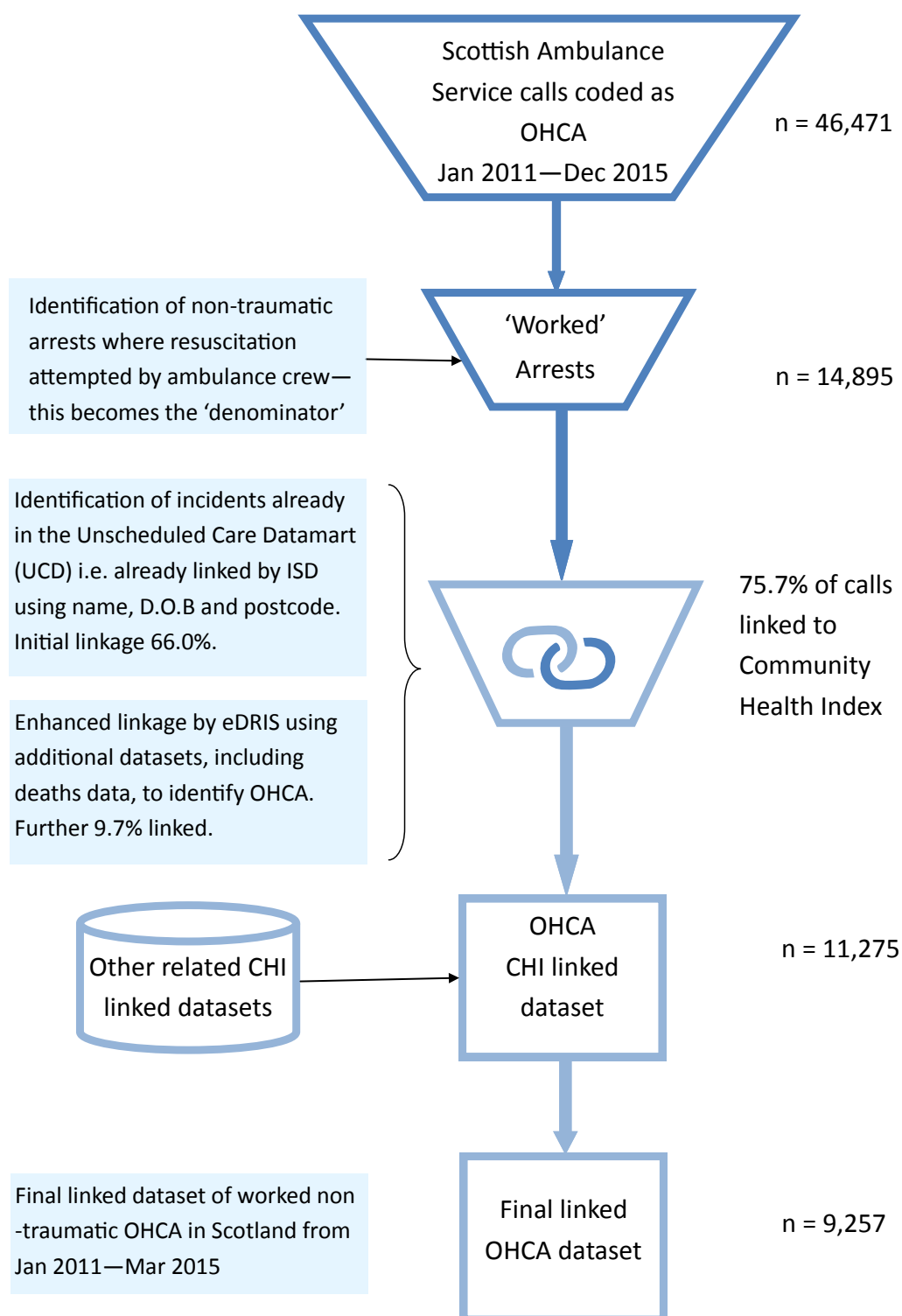


Figure 14: A flow chart of the linkage process.

DATA CONFIDENTIALITY AND SECURITY

The linked dataset was stored in the NHS National Services Scotland (NSS) safe haven environment and was accessible to authorised researchers only after compliance with specific information governance, data stewardship and system security requirements⁽⁴⁹⁾.

Statistical disclosure control has been applied to the analysis prior to any outputs leaving the safe haven environment. Statistical Disclosure Control (SDC) covers a range of ways of changing data which are used to control the risk of an intruder finding out confidential information about a person or unit (such as a household or business). This publication has used the following methods where there are under five patients in a particular category:

- Suppression of possibly disclosive cells (eg where the value is small) which means that the value for that cell in the table is not given and secondary suppression of cells which means at least one other value in the row or column is also not given to ensure that disclosive cells cannot be deduced through subtraction;
- Table redesign and recoding, where cells are grouped together to protect small value cells.

Further information about Statistical Disclosure Control is available here:
<http://www.gov.scot/Topics/Statistics/About/Methodology/Glossary>

METHODOLOGY

DESCRIPTION OF DATA USED

Unless otherwise specified, the analysis described in this report are based on all available data from 1 January 2011 until the launch of the OHCA Strategy for Scotland (28 March 2015).

- This will enable future analysis to assess the impact of the OHCA Strategy.
- Combining data from several consecutive years provides a more statistically robust baseline.

CALCULATION OF SURVIVAL - ASSUMPTIONS MADE ABOUT UNLINKED EPISODES

For the calculation of the survival percentages the assumption has been made that the OHCA cases which we were unable to link to their CHI number belonged to individuals pronounced dead at the scene of their cardiac arrest. It is relatively unusual for patients who are transported to hospital to have less than the minimum data required for linkage recorded in their SAS data. For this reason we have assumed that the majority of unlinked episodes represent patients who were not conveyed from the scene of their arrest by SAS.

LOGISTIC REGRESSION ANALYSIS

The majority of the results presented in the section describing survival after OHCA are based on logistic regression analysis. Firstly the results from univariable logistic regression models are presented which represent the crude associations. In addition, the results from multivariable (adjusted) regression analysis is presented. The advantage of this approach is the opportunity to calculate estimates of the independent effect of variables while adjusting for other factors.

The choice of the confounding factors is based on existing clinical knowledge, literature review and availability of data. An example of this is the association between living in an urban or rural area and 30-day survival presented in Figure 11. First, the crude results show an odds ratio of 1.22 and an accompanying 95% confidence interval of 0.98-1.52. Based on previous knowledge and descriptive analysis it is known that the age distribution between patients living in urban and rural populations is different. Furthermore, earlier results in Figure 9 show that age and 30-day survival are associated (younger patients are more likely to survive an OHCA) and age is not part of the causal pathway in the association of urban/rural and survival. Therefore, age is a potential confounder in the association between urban/rural and 30-day survival. For this reason, taking age into account as a possible confounder will yield a better reflection of the true association between urban/rural residence and 30-day survival. The multivariable logistic regression model, adjusting for age, gender and SIMD quintiles results in an odds ratio of 1.32 and an accompanying 95% confidence interval of 1.04-1.66.

ADJUSTMENTS FOR VARIABLES IN THE CAUSAL PATHWAY

Where appropriate for analysis included in this report, adjustment for variables on the causal pathway has been made. For example, in Figure 8 the association between sex and survival is presented. First, the crude results are given, showing a difference in survival between males and females. Thereafter, the association is adjusted for the presenting heart rhythm (shockable or non-shockable). This variable is likely to be part of the causal pathway. The adjusted results show no survival difference between males and females. This demonstrates that the fact that more females present with a non-shockable rhythm makes an important contribution to the explanation of sex differences in survival.

COMPLETENESS AND QUALITY OF DATA

This report describes initial work using this Scottish OHCA data with only a part of the linked dataset analysed in detail. The completeness of the variables used in this report is shown in table 5.

Table 5: completeness of the variables

Variable	Number of missing values
Age at time of OHCA	1
Sex	14
SIMD	207
Urban rural category	207
Shockable rhythm	823
Bystander CPR	Unknown

Table 5 shows that the majority of the data used for this report, with the exception of bystander CPR is reasonably complete. Completeness of the data varies between 91.1 and 99.9% for the variables in the dataset. As already mentioned the completeness and quality of bystander CPR data is poor and work is underway to improve this data.

Most of the datasets in these analysis are widely used in research (see Table 4) and the data quality is generally regarded as good. The SAS data used for this project is under-utilised and somewhat under-developed. One of the longer-term goals of this work is to identify mechanisms to improve the data quality of SAS data.

It is worth noting that in this report, location related characteristics of OHCA cases such as SIMD quintile and urban-rural classification are all based on the home address of the OHCA patient. For most analysis this will be valuable information, though some questions are better answered using the geographical data relating to the location where the OHCA occurred. This type of analysis will form part of future work.

FUTURE

This report is just a start. The process of assembling this baseline dataset has laid the foundations for an OHCA epistry (epidemiological registry) in Scotland. This will allow us to track the impact of Scotland's OHCA Strategy to 2020 and beyond. In addition, the OHCA Data Linkage Project Analytical Team are collaborating with others in the international community who share our aspiration to improve survival after OHCA (including the UK wide OHCA registry and the Global Resuscitation Alliance^(3, 17, 50, 51)) to share data and ideas for system improvement.

DATA DEVELOPMENT

One of the aims of the OHCA Data Linkage Project is to understand and improve data quality, particularly in datasets which have not been extensively analysed. The OHCA Data Linkage Project Analytical Team will work with data providers to improve data quality to enhance the use of the data locally as well as for research.

The linked dataset will be updated at least once a year to monitor the [‘Out-of-Hospital Cardiac Arrest: A Strategy for Scotland’](#). Subject to permissions, the linked dataset will be expanded to include:

- co-responder data from the Scottish Fire and Rescue Service,
- co-responder data from Police Scotland, and
- geographical data on Public Access Defibrillators (PADs) from the Scottish Ambulance Service.

The ‘Out of Hospital Cardiac Arrest: A Strategy for Scotland’ proposed that there should be an on-going OHCA Registry. The experiences from this data linkage project will inform the development of a long term OHCA epidemiological registry (‘epistry’).

Making this OHCA data available for the first time in Scotland has involved drawing together the expertise and organisational commitment of a range of key partners from organisations caring for critically ill and deteriorating patients. The power of providing key metrics and analysis in helping build a system that saves lives is evident. We hope to build on this project to develop a wider group of partners working towards improving outcomes for patients with a range of life-threatening emergency conditions requiring a time-critical response with both pre-hospital and in-hospital components - a Scottish Resuscitation Outcomes Consortium.

BOX 3

A vision for the future: Scottish Resuscitation Outcomes Consortium (Scot-ROC)

In order to ensure on-going improvements in OHCA outcomes, there is a need for a collaborative hub in Scotland around which ideas can be developed, research progressed, data analysed, information shared and support and expertise offered. Based on the experience in other countries^(6, 8, 22), it is proposed that a consortium – the Scottish Resuscitation Outcomes Consortium (or Scot-ROC) – should be developed.

- To work with key partners to put in place the ethical, data protection, statistical and IT frameworks required to assemble key datasets required to analyse systems of care, identify strategic research areas and drive quality improvement.
- To provide infrastructure and project support for clinical trials and other outcome-oriented research into cardiopulmonary arrest that will rapidly lead to evidence-based change in clinical practice and pathways of care in Scotland.
- To maintain a focus on pre-hospital and early hospital-based emergency interventions recognising the critical importance of this timeframe and the common challenges of data collection, research and service improvement in these clinical domains.
- Scot-ROC investigators could conduct collaborative trials and tests of change of variable size and duration leveraging the combined power of the member institutions and promoting the rapid translation of promising scientific and clinical advances for the public good.
- Scot-ROC would report regularly with information available to stakeholders, Scottish Government and the general public, present at relevant meetings and publish in the peer reviewed literature. The consortium could also act as an advisory group for Scottish Government and other organisations.

Excerpted from Scotland's Strategy for Out-of-hospital cardiac arrest⁽²⁾

REVIEWERS

This report was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. This process was carried out in order to provide candid and critical comments that assisted the production of a clear and accurate report. While we are grateful for their contributions, any inaccuracies or ambiguities which may remain are our own.

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GLOSSARY

ACC	Ambulance Control Centre
Arrhythmia	Abnormal heart rhythm
Aus-ROC	Australian Resuscitation Outcomes Consortium
BHF	British Heart Foundation - www.bhf.org.uk
Bystander	A lay person or non-Emergency Medical Service personnel
Can-ROC	Canadian Resuscitation Outcomes Consortium
Cardiac arrest	The heart suddenly stops pumping blood around the body.
CHI	Community Health Index
Co-responder	In Scotland this refers to schemes where the Scottish Fire & Rescue Service and the Scottish Ambulance Service work in partnership to provide an effective, rapid response to immediately life threatening medical emergencies, specifically in locations where the Fire Service will be able to get to the call more quickly.
CPR	Cardio-Pulmonary Resuscitation. Chest compressions and breaths delivered to a person who has suffered a cardiac arrest.
Data linkage	In this report we refer to matching a patient's ambulance service record to their CHI number to allow linkage to other parts of their health care record.
eDRIS	electronic Data Research and Innovation Service
ePRF	Electronic Patient Report Form
EuReCa	European Registry of Cardiac Arrest
EuReCa One	An international European project for collecting and analysing and reporting OHCA resuscitation events during October 2014.
GRA	Global Resuscitation Alliance
Heart attack	Damage to the heart caused by a clot in the coronary arteries—requires emergency treatment in hospital.
NHS	National Health Service
Non-shockable rhythm	Pulseless electrical activity or asystole - not treated with defibrillation.
NSS	NHS National Services Scotland
OHCA	Out-of-Hospital Cardiac Arrest

PBPP	Public Benefit and Privacy Panel (for Health & Social Care). The panel assesses the public benefit, privacy, confidentiality, and information governance in relation to NHS Scotland or National Records of Scotland-originated data.
Presenting Rhythm	The first ECG rhythm recorded at an OHCA.
ROC	Resuscitation Outcomes Consortium
ROSC	Return of Spontaneous Circulation
RRG	Resuscitation Research Group - www.rrg.scot
Safe Haven	Scotland has regional 'Safe Havens' located within Aberdeen, Dundee, Edinburgh and Glasgow, and a National Safe Haven at NSS. Operating independently to agreed standards they provide advice, support and a secure environment for access to a wide range of research datasets while protecting the confidentiality of the data.
SAS	Scottish Ambulance Service - www.scottishambulance.com
Scot-ROC	Scottish Resuscitation Outcomes Consortium
SDC	Statistical Disclosure Control - methods applied to datasets and/or analysis to protect confidentiality
Shockable rhythm	Ventricular fibrillation or ventricular tachycardia - treated by delivering an electric shock using a defibrillator.
SICSAG	Scottish Intensive Care Society Audit Group - www.sicsag.scot.nhs.uk
SIMD	Scottish Index of Multiple Deprivation
SMR01	Scottish Morbidity Record 01: a record of episodes of inpatient care.
SPARRA	Scottish Patients at Risk of Readmission and Admission is a risk prediction tool developed by NSS which predicts an individual's risk of being admitted to hospital as an emergency inpatient within the next year.
UCD	Unscheduled Care Datamart
Utstein	Internationally recognised criteria for uniform reporting of cardiac arrest.
VF	Ventricular Fibrillation: A condition in which there is uncoordinated contraction of the heart muscle, which can potentially be corrected by early defibrillation.

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