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Are there disparities in the location of automated external defibrillators in England?

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Abstract

Background: Early defibrillation is an essential element of the chain of survival for out-of-hospital cardiac arrest (OHCA). Public access defibrillation (PAD) programmes aim to place automated external defibrillators (AED) in areas with high OHCA incidence, but there is sometimes a mismatch between AED density and OHCA incidence.

Objectives: This study aimed to assess whether there were any disparities in the characteristics of areas that have an AED and those that do not in England.

Methods: Details of the location of AEDs registered with English Ambulance Services were obtained from individual services or internet sources. Neighbourhood characteristics of lower layer super output areas (LSOA) were obtained from the Oce for National Statistics. Comparisons were made between LSOAs with and without a registered AED.

Results: AEDs were statistically more likely to be in LSOAs with a lower residential but higher workplace population density, with people predominantly from a white ethnic background and working in higher socio-economically classified occupations ($p < 0.05$). There was a significant correlation between AED coverage and the LSOA Index of Multiple Deprivation (IMD) ($r = 0.79$, $p = 0.007$), with only 27.4% in the lowest IMD decile compared to about 45% in highest. AED density varied significantly across the country from 0.82/km^2 in the north east to 2.97/km^2 in London.

Conclusions: In England, AEDs were disproportionately placed in more auent areas, with a lower residential population density. This contrasts with locations where OHCAs have previously occurred. Future PAD programmes should give preference to areas of higher deprivation and be tailored to the local community.

Keywords: Public access defibrillation, Automated external defibrillators, Health inequality, Out-of-hospital cardiac arrest, Basic life support, Neighbourhood characteristics

Introduction

English ambulance services attend around 80,000 out-of-hospital cardiac arrests (OHCA) every year of which emergency medical staff (EMS) attempt resuscitation on about 31,000 (38.8%).[1] When resuscitation is commenced, approximately one third (30%) achieve a return of spontaneous circulation by the time of hospital handover and almost one in ten (9.5%) survive to hospital discharge.[2] Early defibrillation is an essential element of the chain of survival and prompt treatment with a defibrillator, within 3–5 min of collapse, can lead to survival rates in excess of 50%.[3–7] As time passes, the effectiveness of defibrillation declines and the likelihood of survival decreases, as the heart rhythm degenerates from a shockable rhythm to a non-shockable rhythm, which is largely unresponsive to treatment. Each minute of delay of defibrillation reduces the probability of survival to discharge by 10%.[8] Of those who survive an OHCA, approximately 85% present in a shockable rhythm[9] meaning that early defibrillation has the potential to make a disproportionate improvement on overall survival.

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Public access defibrillation (PAD) describes the use of automatic external defibrillators (AED) by members of the public. PAD programmes allow the community access to this life saving intervention while waiting for an ambulance to arrive. The importance of PAD is recognised by ILCOR guidelines[10] and national strategies[11] but even with renewed focus on ambulance response times in the UK, median response times to cardiac arrest are seven minutes and significantly longer in more rural areas. However, at present, only a small proportion of all UK patients (around 5%), where EMS attempt resuscitation, have been treated by PAD prior to their arrival,[2,12] leaving a large number of patients not potentially benefitting from PAD.

A fundamental, structural barrier, which limits opportunity for the use of AEDs is their location in the community, as only a minority of OHCAs occur in locations near a public-access AED.[13–18] There is a notably poor correlation between OHCA and AED locations,[14] and the ability to match sites of OHCA and AED locations is a necessary step toward improving PAD.[15]

The American Heart Association and European Resuscitation Council guidelines state that an AED should be in an area where an OHCA has occurred in the past 3–5 years.[19,20] There is also sufficient evidence to recommend AED placement in specific locations wherever large numbers of people congregate resulting in a high incidence of OHCA, e.g. bus/railway stations, airports, sports stadiums/arenas,[13,21–24] but not at other public sites e.g. with a lower footfall.

Various UK organisations promote the placement of AEDs outdoors in public places so that they are always available, but despite several campaigns to raise public awareness and make PAD more available, many public areas have no AED.[18,25] There has been no clear strategy in the UK on where AEDs should be placed; the choice of where to install AEDs in public places has been driven mainly by local ad-hoc initiatives. Their placement has been questioned and they are not necessarily located to match OHCA incidence. The strategies for the deployment of AEDs in public places in the UK remain somewhat arbitrary, and if these approaches are driven by local and/or political initiatives, there is a risk of paradoxical AED placement in the community, with placement being primarily in affluent areas with low OHCA incidence,[13,21] increasing health inequalities. It is clear that there is a need for an evidence-based strategy.[21,26]

Previously we have shown that OHCA incidence is higher in deprived areas of England,[27] and one might therefore expect AED density to be greater in these areas. This study aimed to assess whether there were any disparities in the neighbourhood characteristics of areas that have an AED and those that do not in England.

Methods

AED location

Details of the locations of 32,332 registered AEDs were obtained for 10 of the 11 English ambulance service regions. Services maintain lists of publicly available defibrillators so they can direct 999 callers to them in the event of an OHCA. Some services make the list available on their website, whilst others were contacted directly to share the information after setting up a data sharing agreement. For those that had not provided the information at the time of writing this paper an OpenStreetMap project on the internet was identified, where the required information were obtained by using Freedom of Information legislation (https://osm.mathmos.net/defib/).. Information provided, where available, included: location address and postcode; location details; geographic coordinates; and availability. Where possible we asked services to provide information on AEDs registered with them as of 31st December 2019, or as close to that date as possible.

The location information provided was validated by geocoding, on an ambulance service basis, the address and postcode provided using Geocode, a Google Sheets add-on by Awesome Table.[28] Obvious mistakes by the software were checked manually. A random 10% sample of addresses was also checked manually. The generated coordinates were also checked against those provided by the ambulance service.

The geographic coordinate of each AED was allocated to the relevant lower layer super output area (LSOA) using a lookup table.[29] LSOAs have been developed by the Office for National Statistics, and are a geographic hierarchy designed to improve the reporting of small area statistics.[30] They are built from clusters of contiguous output areas, which are made up of adjacent unit postcodes, and are designed to have similar population sizes and be as socially homogenous as possible based on household tenure and dwelling type. There are 32,844 LSOAs in England with a population range of 1,000–1,500, and household number of 400–1,200.

Neighbourhood characteristics

Information on neighbourhood characteristics (2011 Census) was obtained from the Office for National Statistics via the https://www.nomisweb.co.uk website, the definitions for which can be found on the website (data was downloaded on 1st February 2021). Information obtained included: residential, workday and workplace population density; proportion of people from different ethnic groups in the resident population (white, mixed, non-white); proportion of people with higher educational qualifications (A-level and above); proportion of people living with a long-term health problem or disability where day-to-day activities are significantly limited; proportion of people in different socio-economic groups based on occupation (management/professional; intermediate; routine/manual; unemployed/not classified); proportion of people not living as a couple; proportion of people living in households classified as being deprived in none, or one to four dimensions (employment, education, health and disability, and household overcrowding); and proportion of people aged over 65 years. The Rural/Urban classification for each LSOA was also obtained: urban (major conurbation, minor conurbation, city and town, city and town in a sparse setting) and rural (town and fringe, town and fringe in a sparse setting, village and dispersed (hamlets & isolated dwellings), village and dispersed (hamlets & isolated dwellings) in a sparse setting).

The Index of Multiple Deprivation (IMD) for each LSOA was obtained.[31] IMD ranks every LSOA in England from 1 (most deprived) to 32,844 (least deprived) and is the official measure of relative deprivation for small areas (or neighbourhoods) in England. It combines information from seven domain indices: income; employment; education; skills and training; health deprivation and disability; crime; barriers to housing and services; and living environment. Deciles were created by ranking these areas from most to least deprived (lowest decile is most deprived).

Statistical analysis

Comparisons were made between the neighbourhood characteristics where AEDs are located and not located, and with the national and regional averages for these characteristics using *t*-test to compare means and Mann-Whitney test to compare medians, using Stata SE version 17.0; a p-value less than 0.05 was considered statistically significant.

Results

Across the country AED locations are in areas with a significantly ($p < 0.001$) lower residential population density, but higher workplace population density (Table 1). These locations had significantly greater proportion of people aged 65 years and over, and are predominantly from a white ethnic background, with fewer people identifying themselves as mixed race or from non-white ethnic backgrounds. The locations with an AED also had a significantly larger population in management/professional occupations, but a smaller proportion in routine and manual occupations, unemployed and unclassified occupations. The proportion of people with higher educational qualifications was also significantly higher, and the proportion of people not living as a couple significantly lower.

Areas containing at least one AED were also more affluent, as indicated by the lower proportion of households that were not deprived in any dimension and greater proportion deprived in 2 or 3 dimensions, and the greater mean/median IMD rank and IMD decile (Table 1; $p < 0.001$). There was a significant correlation between AED coverage and LSOA IMD decile ($r = 0.79$, $p = 0.007$). The most deprived LSOAs (IMD deciles 1/2) had the lowest coverage with registered AEDs; 27.4% (899/3284) contained a device (Fig. 1). The highest AED coverage was observed in the deciles 6 (50.5%) and 7 (50.2%).

AED density

There is significant variation ($p < 0.001$) in the proportion of LSOAs covered by an AED in each ambulance service, ranging from 19.5% in North-East to 63.7% in East Midlands (Table 2). There is also significant regional variation ($p < 0.001$), with 30% of LSOAs in the North with a registered AED, 50.4% in the Midlands and 47.4% in the South. Consequently, the AED density varies considerably between the services and regions from 0.08/km^2 in North-East to 2.97/km^2 in London. In the LSOAs that contain an AED the density also varies significantly from 0.08/km^2 to 5.29/km^2 between the services; the median density in the LSOAs ranging from 0.38/km^2 to 6.59/km^2, overall 1.98/km^2. The number of AEDs per 10,000 resident population also differs significantly, from 2.1 in the North-East to 12.3 in East Midlands (overall: 6.1/10,000).

Table 1 – Comparison of neighbourhood characteristics of automatic external defibrillator (AED) locations with the national lower layer super output area (LSOA) average, and in LSOAs where AED was present/absent.

Characteristic	AED locations (n = 32,234)		National LSOA average (n = 32,844)		LSOA AED present (n = 14,215)	LSOA AED absent (n = 18,629)
	Mean (sd)	Median	Mean (sd)	Median	Mean (sd)	Mean (sd)
Population density (N/hectare):						
• Residential	27.6 (36.8)*	15.5	42.6 (42.3)	34.5	33.2 (40.9)*	49.8 (41.9)
• Working day	55.7 (147.1)*	19.1	38.6 (53.1)	28.7	37.7 (69.9)$	39.3 (35.2)
• Workplace	41.1 (142.4)*	6.9	16.1 (42.2)	7.2	20.5 (59.9)*	12.8 (19.5)
Proportion of population ≥ 65y (%)	18.0 (7.6)*	18.1	16.6 (7.2)	16.1	17.8 (7.4)*	15.8 (7.0)
Ethnic group (%):						
• White	88.4 (16.8)*	96.3	86.2 (18.7)	94.8	87.7 (17.7)*	85.1 (19.4)
• Mixed	2.0 (1.8)*	1.3	2.2 (1.9)	1.5	2.1 (1.9)*	2.3 (1.9)
• Non-white	9.6 (15.5)*	2.4	11.6 (17.5)	3.6	10.3 (16.4)*	12.6 (18.2)
Socio-Economic Classification (%):						
• Management/Professional	34.2 (12.1)*	34.4	31.3 (12.2)	30.5	33.6 (11.9)*	29.5 (12.2)
• Intermediate	29.6 (6.3)	30.7	29.4 (5.5)	30.2	29.8 (5.7)	29.1 (5.4)
• Routine/Manual	23.0 (9.9)*	21.5	25.4 (10.1)	24.6	23.6 (9.7)*	26.7 (10.3)
• Unemployed/Not classified	13.2 (10.2)*	9.6	14.0 (9.2)	10.8	13.0 (9.2)*	14.7 (9.2)
Not living as a couple (%)	41.1 (11.6)$	38.0	42.1 (10.8)	40.4	40.7 (10.9)*	43.1 (10.5)
Education, A-level+ (%)	48.0 (13.7)*	47.0	44.8 (13.7)	43.3	46.8 (13.1)*	43.2 (13.9)
Long term health	8.1 (3.4)	7.6	8.4 (3.5)	7.9	8.1 (3.3)	8.6 (3.6)
No. of dimensions households are deprived (%):						
• None	44.6 (11.5)*	45.9	42.7 (12.2)	43.4	44.4 (11.7)*	41.4 (12.5)
• 1	32.9 (4.0)	32.6	32.6 (3.7)	32.6	32.6 (3.8)	32.6 (3.7)
• 2	17.7 (6.6)*	16.8	19.1 (7.0)	18.5	18.0 (6.7)*	19.9 (7.2)
• 3	4.4 (3.4)*	3.3	5.1 (3.8)	4.0	4.5 (3.4)*	5.5 (3.9)
• 4	0.5 (0.6)	0.2	0.5 (0.6)	0.3	0.46 (0.59)*	0.55 (0.62)
Index of multiple deprivation:						
• Rank	17,434 (8618)*	17,855	16,423 (9481)	16,423	17,698 (8933)*	15,459 (9768)
• Decile	5.8 (2.6)*	6.0	5.5 (2.9)	5.5	5.9 (2.7)*	5.2 (3.0)

* $p < 0.001$.
$ $p < 0.01$.

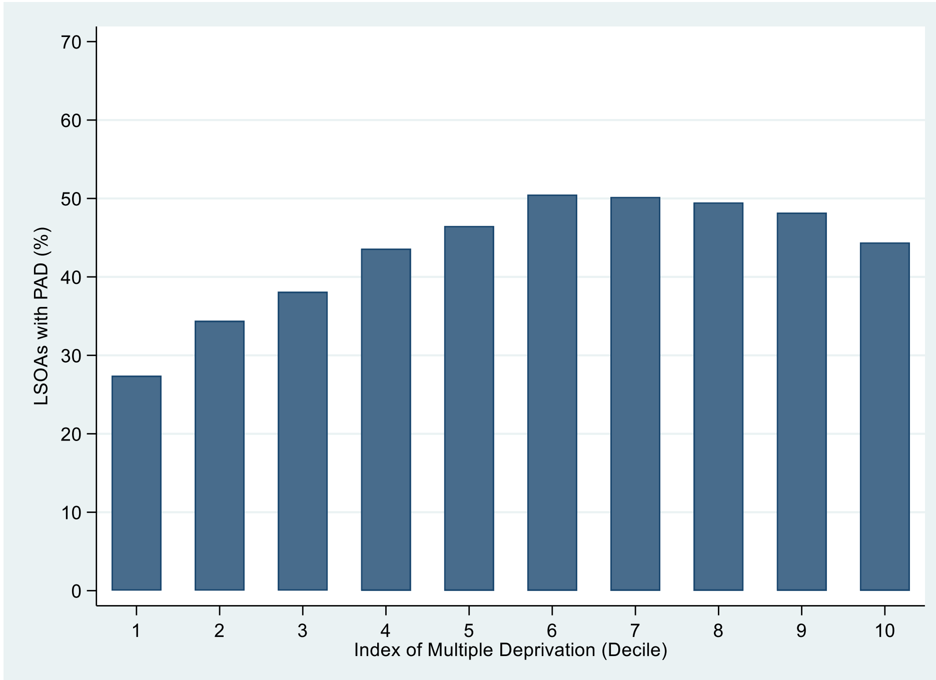

Fig. 1 – The percentage of lower layer super output areas (LSOA) within each deprivation decile that contain a public access defibrillator (PAD) in 2019 (1 = most deprived, 10 = least deprived).

Table 2 – Distribution of automatic external defibrillators (AED) by ambulance service and regional lower layer super output area (LSOA).

	AEDs				LSOAs		
	Number	Proportion of total (%)	Density (/10,000 population)	Density (/km^2)	Number (%) with an AED	Density in LSOAs with an AED (/km^2)[a]	Median density (/km^2)
Ambulance service							
East of England	2407	7.5	4.1	0.13	1369 (37.9)	0.16	0.38
East Midlands	5591	17.3	12.3	0.36	1768 (63.7)	0.39	1.84
London	4661	14.5	5.7	2.97	2186 (45.2)	5.29	6.59
North East	535	1.7	2.1	0.08	323 (19.5)	0.10	0.87
North West	3869	12.0	5.5	0.27	1551 (34.5)	0.44	2.86
South Central	2592	8.0	6.2	0.26	1227 (47.0)	0.31	1.46
South East Coast	3226	10.0	7.2	0.35	1528 (55.1)	0.43	1.72
South West	3105	9.6	7.2	0.13	1456 (44.4)	0.14	0.43
West Midlands	4452	13.8	7.9	0.34	1839 (52.7)	0.37	2.30
Yorkshire	1796	5.6	3.4	0.12	968 (29.2)	0.15	0.83
All	32,234		6.1	0.25	14,215 (43.3)	0.30	1.98
Region[b]							
North	6200	19.2	4.2	0.17	2842 (30.0[$])	0.24	1.85
Midlands	12,450	38.6	7.8	0.26	4976 (50.4)	0.30	1.51
South	13,584	42.2	6.4	0.30	6397 (47.4)	0.36	2.53

[$] Significant difference between proportions ($p < 0.001$): Midlands > South > North.
[a] Density = Total number of AEDs/Total area of LSOAs with AED.
[b] North: North East, North West, Yorkshire; Midlands: East of England, East Midlands, West Midlands; South: South West, South Central, South East Coast, London.

Urban/Rural pattern

As expected, a significant majority of the registered AEDs were in urban areas (63.8%; $p < 0.001$) compared to rural areas (36.2%) (Table 3). These figures vary significantly around the country, the proportion in urban areas ranging from 31.0% in the South-West to 99.7% in London (Appendix 1). However, a greater proportion of rural LSOAs (76.4%; $p < 0.001$) have an AED compared to urban areas (36.5%), the proportion increasing with degree of rurality. Excluding London as a special situation, the proportion of AEDs that are in rural areas increases the further south one goes (North – 30.3%; Midlands – 43.6%; South – 48.7%; Appendix 1).

Discussion

AEDs registered with English ambulance services in 2019 were in neighbourhoods that had characteristics that were significantly different from those where AEDs were not located. Access to AEDs was lowest in the most deprived LSOAs in England (IMD decile 1; Figure 1). The proportion of LSOAs in each region with an AED varied significantly and was lower in the north of the country.

Although many AEDs are available in England, there is disparity in their distribution, with populations at higher need having lowest access. There is a social gradient in cardiovascular disease mortality with more deprived areas experiencing higher mortality rates,[32] and cardiovascular disease is the largest cause of premature mortality in deprived areas[33] due to health inequalities. In deprived areas, people spend more time in poor health[34] and multimorbidity is more common.[35] We have shown previously that they also have a higher incidence of OHCA.[27] This study was informed by data collected at the last census and the index of multiple deprivation (IMD). The IMD is a robust measure of deprivation using six weighted components as outlined in the methods.

These findings are not unique to England. A recent study in Scotland also showed the proportion of existing AEDs differed significantly across quintiles of IMD, the proportion being highest in quintile 3 (equivalent to deciles 5/6 in this study).[36] A mismatch between proportions of AED locations and suspected OHCA across IMD quintiles was also shown. In New Zealand the most socioeconomically deprived communities had the highest incidence of OHCA and the least availability of AEDs.[37] In the USA Zip codes that had high-access to AEDs also tended to have a higher median household income with a slightly higher proportion of the population being high school graduates,[16] and also a lower median residential population and a higher proportion of unemployed residents. In Seoul, more affluent neighbourhoods exhibit higher per capita AEDs, even when accounting for OHCA risk, with 4.92 AEDs per 10,000 in the lowest socio-economic status quartile and 12.66 per 10,000 in highest.

AED locations had a higher mean working day and workplace population density, and LSOAs with an AED had a significantly greater workplace population density. Guidance states that AEDs should be in busy public places, and areas with a high working day and workplace population density could be interpreted as places with a high movement during the working day. The benefits of PAD in public places were demonstrated in England by the National Defibrillator Programme, when AEDs were placed in busy public places where OHCAs were more liable to occur. It found that the implementation of PAD programmes could double survival from OHCA.[38–41] However, despite several campaigns to raise public awareness and make AEDs more available many public areas have no recorded AED available, and where there is one it was only used in a minority of cases before the EMS arrival.[25] In the present study, we observed that 63.8% of registered AEDs were in urban areas, however, we did see that a significant proportion of LSOAs classified as urban (about 65%) did not contain an AED.

LSOAs with an AED had significantly lower residential population density compared to those that do not. Previously, the placement of AEDs in homes has been determined as not cost-effective,[42] and does not improve long-term survival among a high-risk population.[43] However, although it may not be effective to place AEDs in homes, it does not mean that they should not be placed in residential areas. In Copenhagen, researchers observed that combining two or more demographic characteristics could identify residential areas suitable for AED placement.[44] These characteristics included population density, low income, low education, and high average age. Targeting residential areas has also recently been shown to be effective in increasing coverage of both in-home and public OHCAs,[44–49] and that they need to be considered priority targets for AED installation.[50] The guidelines suggest that neighbourhood characteristics should guide AED placement in residential areas but do not specify which ones are of importance.

It was encouraging to see that the proportion of LSOAs with an AED increased with the increasing degree of rurality, and that three quarters of all LSOAs had at least one AED located within its bound-

Table 3 – Distribution of automatic external defibrillators by rural/urban classification (RUC) of the lower layer super output area (LSOA).

Rural/Urban classification of LSOA	AEDs*		LSOAs		
	Number	Proportion of total	Number (%) with an AED	Number (%) without an AED	Proportion of RUC LSOAs with an AED
Urban:	(20,568)	(63.8)	(9,937)	(17,309)	(36.5)
• major conurbation	8,547	26.5	4,153 (29.2)	7,370 (39.6)	36.0
• minor conurbation	806	2.5	359 (2.5)	849 (4.6)	29.7
• city & town	11,129	34.5	5389 (37.9)	9,067 (48.7)	37.3
• city & town, sparse	86	0.3	36 (0.3)	23 (0.1)	61.0
Rural:	(11,666)	(36.2)	(4,278)	(1,320)	(76.4)
• town & fringe	4293	13.3	1930 (13.6)	1,007 (5.4)	65.7
• town & fringe, sparse	243	0.8	94 (0.7)	25 (0.1)	79.0
• rural village & dispersed.	6458	20.0	2082 (14.7)	279 (1.5)	88.2
• rural village & dispersed, sparse	672	2.1	172 (1.2)	9 (0.1)	95.0

* Automatic external defibrillator.

aries: 95% of the most rural LSOAs. Previous studies have shown that AEDs are located significantly further away from OHCAs in rural areas,[51] and that AED usage drops significantly as the locations become more remote due to inadequate availability and education.[52] However, the introduction of AED programmes into rural areas results in a decrease in collapse-to-defibrillation times and better survival of OHCA patients.[53] This is important because a higher need for AEDs must be considered especially in rural areas, based on substantially longer ambulance response times.[54] A higher density of AED placement in rural areas is likely to have additional benefit in that there is a high commitment of lay-person AED use.[55]

AED density varied significantly across the country, in respect of both population and land area of the LSOA (Table 2). Overall, coverage around the country was significantly greater than that seen in South Korea (0.61/10,000)[56] and Hong Kong (1.94/10,000),[57] similar to that in Toronto (6.68/10,000),[58] but lower than in Copenhagen (9.2/10,000).[59] However, in terms of area, the coverage was significantly lower than that in Copenhagen (5.7/km^2) and Toronto (2.6/km^2), apart from London (6.59/km^2). Increasing AED coverage, and in particular those that are registered, along with an improvement in accessibility, significantly increases use by a bystander, which then leads to an increase in 30-day survival.[60]

Black, Asian and minority ethnic communities are at substantially higher risk of poor health and early death.[61] A high OHCA incidence has been reported amongst London's South Asian community,[62] and we have also shown that postcode districts with a greater proportion of non-white ethnic groups have a greater than median OHCA incidence (127/100,000) and lower than median bystander CPR rate (<60%). High risk areas (OHCA incidence > 127/100,000 plus bystander CPR rate < 60%) had significantly greater proportion of people from mixed and non-white ethnic groups.[27] Recently, during the first wave of the Covid-19 pandemic in London, OHCA incidence was high amongst these groups.[63] However, even though OHCA risk is higher in these communities, we have shown they are less likely to have access to an AED. Any future CPR training and PAD programmes should focus on these areas.

The NHS Long Term Plan recognises that a key priority is to tackle health inequalities and sets out a plan for "stronger NHS action on health inequalities" including a commitment to reduce unjustified variation in performance and access to health care.[61] This includes a defined objective to improve variation in outcomes from OHCA. Similarly, the UK Cardiovascular Disease Outcome Strategy aims to save 1,000 extra lives every year by improving OHCA survival and highlights the importance of improved prehospital care, with the wider availability of AEDs potentially saving additional lives.[32] However, if we are to improve outcomes it is important not to just consider the placement of AEDs in areas that most need them. The whole chain of survival needs to be considered: early recognition, early bystander cardiopulmonary resuscitation, early defibrillation, and post resuscitation care. In addition, it is important to consider the allocation and availability of EMS resources[64] and their rapid dispatch,[65] and also access to specialised cardiac arrest centres.[66]

Limitations

The study used information from ambulance service registries of AEDs, as these are the devices that ambulance service call operators and the NHS have access to when a call operator receives a 999-emergency call for an OHCA close by. These are maintained by the services; however, their resources are limited, and the information is not checked regularly, and they do not contain information on every AED in the country. Not every AED 'owner/guardian' registers the AED they have purchased with the ambulance service as they are not legally required to do so. Although there is no evidence to suggest it, this registration could be disproportionately lower in LSOAs with a lower IMD. We have assumed that as the owner/guardian of the AED has registered its location and other information with the local ambulance service it is available for anyone to access at any time if an OHCA has occurred nearby. This may not be the case as there might be physical barriers that prevent access to them, and this information was not available to include in the analysis. To improve the situation, the British Heart Foundation have developed 'The Circuit' and are planning a comprehensive map of AEDs across the country. The NHS Long Term Plan also hopes that a national network of AEDs, along with one of community first responders, would help save up to 4,000 lives each year by 2028.[61] Strategies to improve the placement and registration of AEDs may help enhance coverage.

Conclusions

Whilst almost 80% of all OHCAs occur in residential areas, public access AEDs are located less frequently in these areas. However, they are also disproportionately placed in more affluent areas with lower proportions of population from non-white ethnic groups. Future PAD programmes should give preference to areas where OHCAs are more likely to occur. In addition, any programme should also include publicising their benefits and ease of use. The results of this study provide impetus for targeted PAD programmes in areas of higher deprivation, with these programmes being tailored to local community needs.

CRediT authorship contribution statement

Terry P. Brown: Funding acquisition, Project administration, Data curation, Study design, Data analysis, Data interpretation, Writing - original draft, Writing reviewing & editing. **Gavin D. Perkins:** Funding acquisition, Project administration, Data interpretation, Writing - original draft. **Christopher M. Smith:** Data interpretation, Writing - reviewing & editing. **Charles D. Deakin:** Data interpretation, Writing - reviewing & editing. **Rachael Fothergill:** Data interpretation, Writing - reviewing & editing

Declaration of Competing Interest

Terry Brown and Gavin Perkins are affiliated to the National Institute for Health Research (NIHR) Applied Research Collaboration (ARC) West Midlands. The views expressed are those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care.

Gavin Perkins is co-chair of International Liaison Committee for Resuscitation, Director of Science and Research at European Resuscitation Council, and Chair of Community and Ambulance Research Committee of Resuscitation Council UK.

Charles Deakin is a trustee of the Resuscitation Council UK, domain leader for defibrillation with the International Liaison Committee for Resuscitation, and member of the Advanced Life Support Working Group at European Resuscitation Council.

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Ethical considerations

The NHS Health Research Authority deemed the project as Service Evaluation, considering it not to be research and did not require review by an NHS Research Ethics Committee. No personal information is stored with regards to the AED location. The study is part of a National Institute for Health Research funded project that has received ethics approval from the Biomedical and Scientific Research Ethics Committee of the University of Warwick.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resuscitation.2021.10.037.

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