

Available online at [ScienceDirect](https://www.sciencedirect.com)

Resuscitation

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

Practice Guideline

European Resuscitation Council Guidelines 2025 Epidemiology in Resuscitation



Enrico Baldi^{a,b,*,1}, **Jan Wnent**^{c,d,e,1}, **Maria Luce Caputo**^{f,g,h}, **Kirstie L Haywood**ⁱ, **Gisela Lilja**^{j,k}, **Siobhan Masterson**^{l,m,n}, **Ziad Nehme**^{o,p}, **Gavin D Perkins**^{i,q,r}, **Fernando Rosell-Ortiz**^s, **Anneli Strömsöe**^{t,u,v}, **Ingvild B.M. Tjelmeland**^w, **Jan-Thorsten Graesner**^{c,d,e}

Abstract

These European Resuscitation Council Guidelines 2025 on epidemiology of resuscitation provides key information about incidence, patients' characteristics, system organisation and outcomes for both out-of-hospital and in-hospital cardiac arrest in Europe and beyond. Information regarding patients' post survival experience and causes of cardiac arrest, including genetic factors, are also reported. Recommendations are provided to support the development of cardiac arrest registries, and improve out-of-hospital cardiac arrest (OHCA) follow-up with an emphasis on quality of life, and perform autopsy including genetic analysis in young individuals.

Keywords: Cardiac arrest, Epidemiology, Incidence of cardiac arrest, Genetics, OHCA, IHCA, Registries

Introduction

Cardiac arrest is one of the leading causes of death worldwide.^{1,2} Whether cardiac arrest occurs outside the hospital (i.e. out-of-hospital cardiac arrest – OHCA) or inside the hospital (in-hospital cardiac arrest – IHCA), differences in incidence and outcome have been reported over the years across countries.^{3–5} These differences are due to several reasons, including variations in population characteristics (e.g. age, socio-economic status, co-morbidities), in system organisation (e.g. different emergency medical services (EMS) systems or differences in teams responding to IHCA; geographical variation; implementation of first responders network), and treatment provided by the system of care (e.g. quality of CPR, interventions, decisions on when initiate or terminate resuscitation, post-resuscitation care).⁶ Differences also arise from variation in data collection practices (e.g. case definition, ascertainment methods and outcome verification).

For these reasons, since the early 1990s, the Utstein recommendations on outcome reports for OHCA and IHCA have been published and periodically updated to provide researchers with a single template to facilitate and harmonise data collection.^{7–9} This enables inter-system and intra-system comparisons to identify gaps in knowledge, and to support clinical research.^{8,9} Understanding the epidemiology of cardiac arrest as accurately as possible is a step towards understanding its causes, improving treatments and patients' outcomes.¹⁰ This chapter provides an overview of incidence, patient characteristics, system organisation and outcomes of OHCA and IHCA. It also focuses on post-survival recovery and underlying causes of cardiac arrest (SCA), including genetic factors (Fig. 1).

The chapter focuses mainly on epidemiology in European countries; however, reference is also made to non-European countries. A section on epidemiology in lower resourced countries and remote areas is also included.

Individual search strategies were constructed for each section of these Guidelines. Searches were conducted using PubMed,

Abbreviations: AED, Automated External Defibrillator, COSCA, Core Outcome Set for Cardiac Arrest, CPC, Cerebral Performance Category, CPR, cardiopulmonary resuscitation, EDTA, Ethylenediaminetetraacetic acid, EMS, emergency medical services, ERC, European Resuscitation Council, IHCA, in-hospital cardiac arrest, ILCOR, International Liaison Committee on Resuscitation, OHCA, out-of-hospital cardiac arrest, ROSC, Return of spontaneous circulation, VF, ventricular fibrillation

* Corresponding author.

E-mail address: enrico.baldi@unipv.it (E. Baldi).

¹ Joint first co-authorship.

<https://doi.org/10.1016/j.resuscitation.2025.110733>

0300-9572/© 2025 European Resuscitation Council. Published by Elsevier B.V.

EPIDEMIOLOGY OF RESUSCITATION KEY MESSAGES

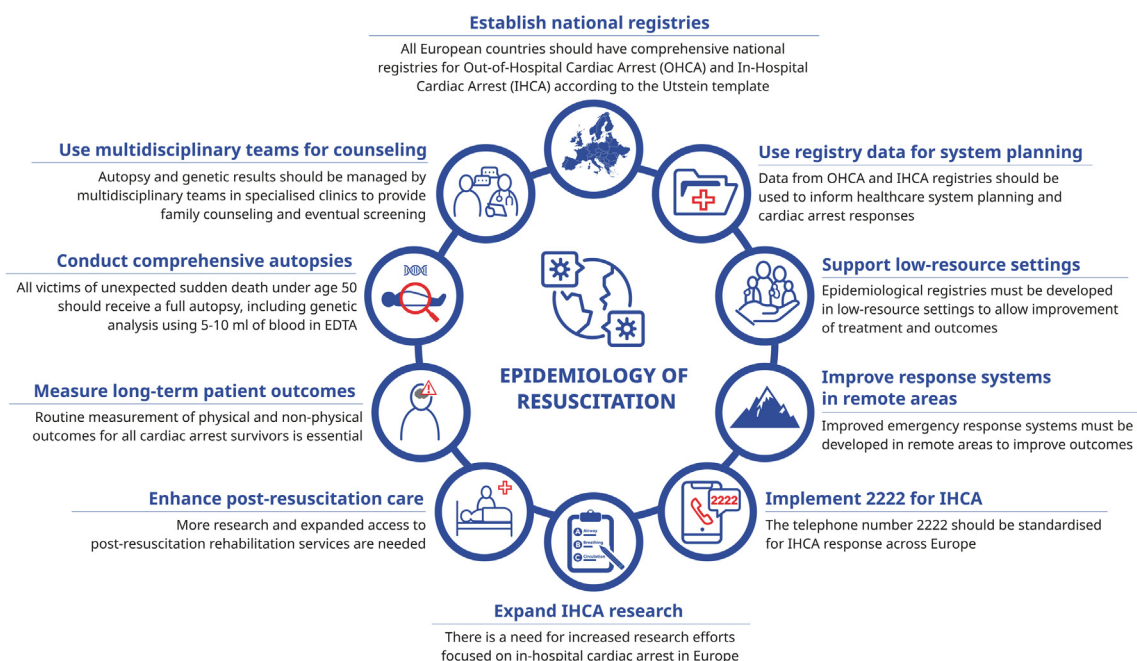


Fig. 1 – Epidemiology of resuscitation – key messages.

Embase and Cochrane. Only publications in English from the last 10 years were included, unless there was limited literature available or in the case of particularly relevant articles (i.e. articles with key information not included in subsequent studies). Abstracts were reviewed by at least two authors and relevant articles were read in full-text.

These Guidelines were drafted, discussed and agreed upon by the European Resuscitation Council (ERC) Epidemiology in Resuscitation Writing Group and the ERC Guidelines 2025 Steering Committee. This Guideline was posted for public comment between 5 and 30. May 2025. A total of 21 individuals submitted 22 comments, leading to 10 changes in the final version. Subsequently, the feedback was reviewed by the writing group, and the Guideline was then updated where relevant. The Guideline was presented to and approved by the ERC Board and the ERC General Assembly in June 2025. The methodology used for guideline development is presented in the executive summary.¹¹

Summary of facts on epidemiology in resuscitation

Out-of-hospital cardiac arrest

- The annual incidence of EMS-treated OHCA in Europe is 55 per 100,000 inhabitants.
- The mean age of patients is of 67.2 ± 17.3 years.
- Male subjects account for 65 %.
- Seventy percent occur in private locations.

- A shockable rhythm is the initial presentation in 20 % of cardiac arrests; 91 % have a medical aetiology.
- Nine European countries have an OHCA registry with full population coverage and 17 countries have a first responder system at least at a local level.
- The bystander CPR rate in Europe is 58 % with significant regional variations (from 13 % to 82 %).
- The use of an AED before EMS arrival varies from 2.6 % to 59 % in different European countries.
- Survival after OHCA in Europe is 7.5 % with a range in European countries from 3.1 % to 35 %.

In-hospital cardiac arrest

- The annual incidence of IHCA in Europe is 1.5 to 2.8 per 1000 hospital admissions.
- The proposed standard internal telephone number to alert the emergency team (2222) for IHCA in Europe is implemented in 2 % of countries only.

Long term survival and return to societal participation

- In European countries where withdrawal of life sustaining treatment is practised, poor neurological outcomes occur in less than 10 % of cardiac arrest survivors, whilst in situations where withdrawal of life sustaining treatment is not practised survival with poor neurological outcome is more common.
- The majority of OHCA survivors indicate the need for post-discharge follow-up with access to a multi-disciplinary team.

- One out of three OHCA survivors receive cardiac rehabilitation and only one out of ten receive brain injury rehabilitation.

Genetic variants and autopsy in cardiac arrest patients

- A clinically actionable pathogenic or likely pathogenic variant in a gene potentially related to the cause of sudden cardiac arrest is identified in up to 25 % of OHCA cases younger than 50 years.
- Autopsy in young sudden cardiac arrest victims is currently not routinely performed in many European countries.

Low-resource settings and remote areas

- The rate of bystander CPR and AED use is lower in low-resource settings compared to high-resource settings.
- Lower resourced countries tend to lack OHCA registries according to the Utstein template and based on a reference territory
- Early BLS and rapid response by an EMS are crucial and determines the prognosis of an OHCA patient also in remote areas.

Evidence informed guideline

Out-of-hospital cardiac arrest

Incidence

The incidence of OHCA has been reported in multiple studies including the three major EuReCa studies.^{2,12,5} Across all EuReCa studies, the incidence of cardiac arrest per 100,000 inhabitants demonstrated significant inter-country variation. In the 2022 three-month EuReCa-3 study, the annualised incidence ranged from 31 to 243 per 100,000 inhabitants, with an overall average of 82 per 100,000. Similarly, the incidence of EMS-treated OHCA varied significantly with an overall incidence of 55 per 100,000 (range from 17 per 100,000 to 104 per 100,000).⁵ The mean incidence of cardiac arrest remained consistent throughout the 8 years of the EuReCa studies. (Table 1).^{2,5,12}

Accurately estimating the true incidence of OHCA remains challenging because of reporting limitations—most notably, the restriction to cases treated by emergency medical services (EMS), which likely underestimates the overall burden of disease. The proportion of patients with cardiac arrest where no resuscitation was started may differ systematically because of cultural norms or religious beliefs, bystanders' willingness to start CPR and variations in how and when the EMS are alerted.¹³ As highlighted by the EuReCa THREE study, only EMS-treated OHCA are reported in many Euro-

pean countries, meaning the reasons for not initiating CPR are missing from a significant portion of the population.⁵ Given that dispatch centres serve a gatekeeping role for ambulance services and that most use a standardised dispatch protocol,¹⁴ it should be feasible in the future to systematically collect data on true incidence of cardiac arrest. This aligns with the recent Utstein update on data collection from dispatch centres.⁸

The number of reported OHCA in Europe has increased in recent years when compared with one or two decades ago.^{5,12,15} Whether these differences reflect an increased number of OHCA or simply a more comprehensive reporting is unclear. It is unknown if this can be partly explained by improved case ascertainment methods and increased coverage by regional and national registries or by an increase in intervention initiated before EMS arrival.

European OHCA incidence appears consistent with non-European settings. EMS-treated OHCA rates range from 44 to 56 per 100,000 population in Australia, New Zealand, Singapore, and South Korea, to 62–76 in the United States, and up to 97–100 in Japan—illustrating a similar degree of international variation.^{16–18}

The incidence of OHCA was impacted by the COVID-19 pandemic. During the early stages of the outbreak, regions severely affected by the virus, such as Northern Italy and the Paris region in France, reported an increase in OHCA incidence of up to 187 % compared with the same period in the previous year.^{19,20} Further analysis confirmed that OHCA incidence increased significantly in regions with high weekly COVID-19 incidence, returning to previous values after the end of the outbreak.^{21,22}

Patients' characteristics and presenting rhythms

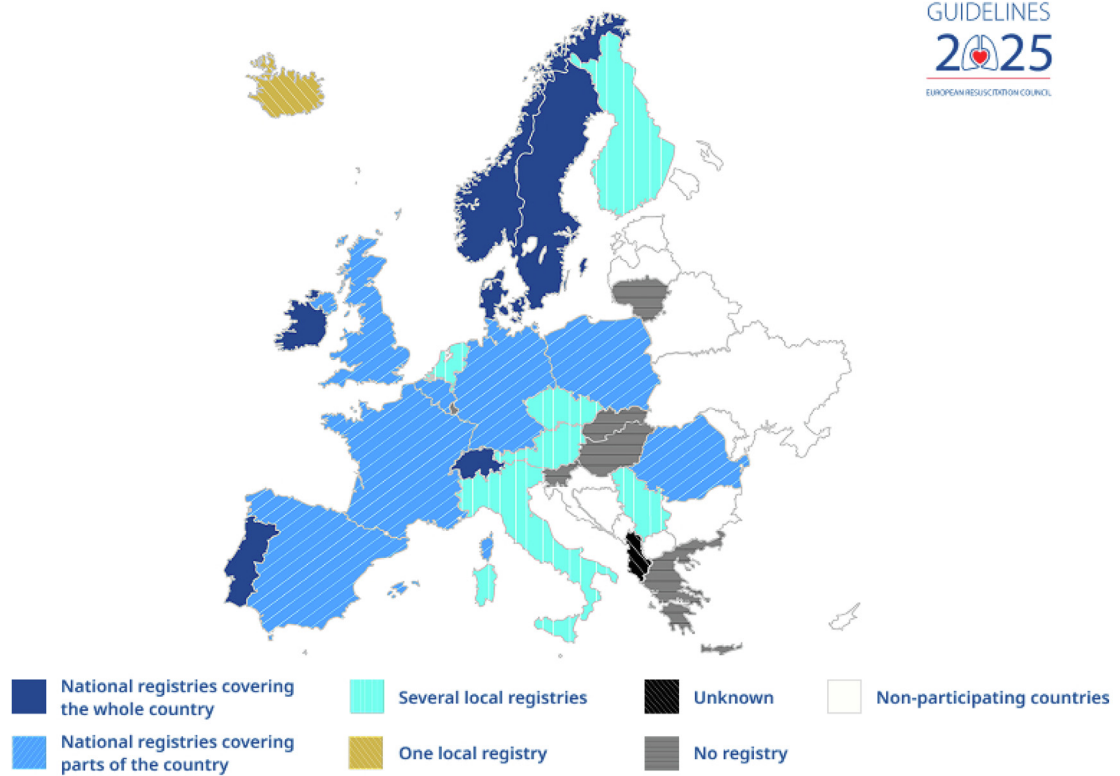
Patient characteristics,^{23–26} event circumstances,^{27–30} underlying aetiology and presenting rhythms significantly influence survival outcomes.³¹ Therefore, differences in these characteristics across European countries must be considered to understand regional variation in outcomes and opportunities for improvement.

The mean age of EMS-treated OHCA was reported as 67.6 ± 17.5 year.² This aligns with findings from the third ILCOR report on OHCA, where the mean age ranged from 62 to 76 years, across different countries.¹⁸ These patterns mirror the mean age of the general population in Europe³² with similar trend in the United States, Australia and New Zealand.^{17,33} Global comparisons reveal wider variability, patients from the middle east and Asia tend to be younger with a mean age of 50 years in United Arab Emirates and 57 years in

Table 1 – The mean incidence of OHCA in the three EuReCa surveys.

	Overall OHCA		EMS-treated OHCA	
	Mean incidence per 100,000	Range of incidence per 100,000 across countries	Mean incidence per 100,000	Range of incidence per 100,000 across countries
EuReCa ONE ¹²	84	28–160	49	19–104
EuReCa TWO ²	89	53–166	56	27–91
EuReCa THREE ⁵	82	31–243	55	17–104

(A)



(B)

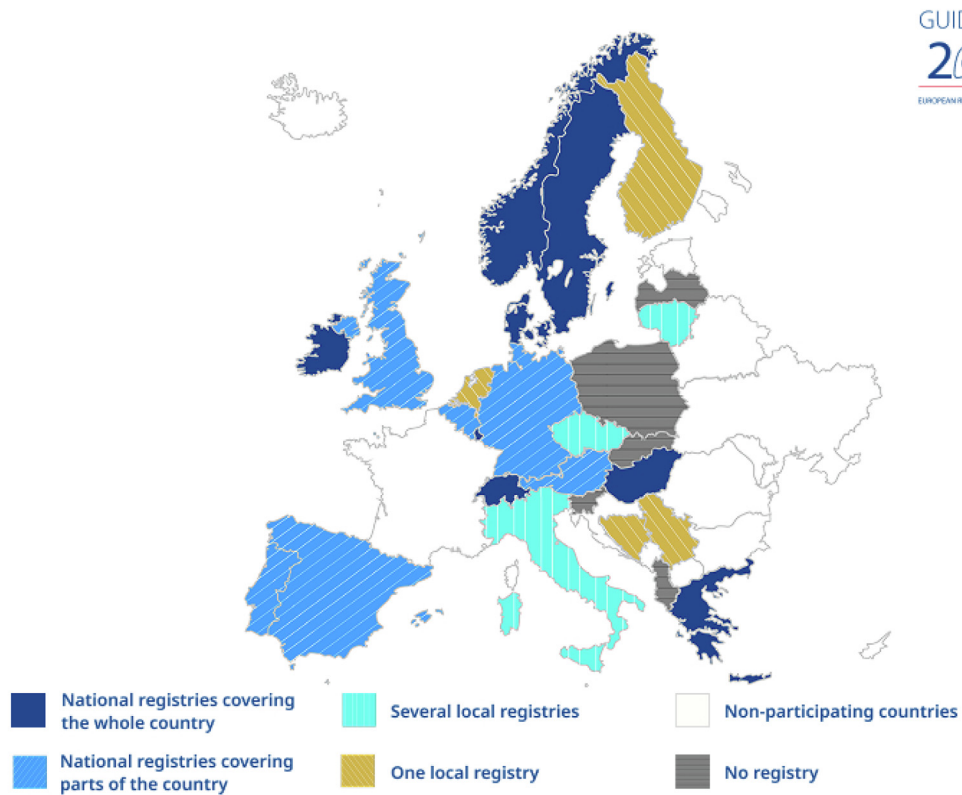
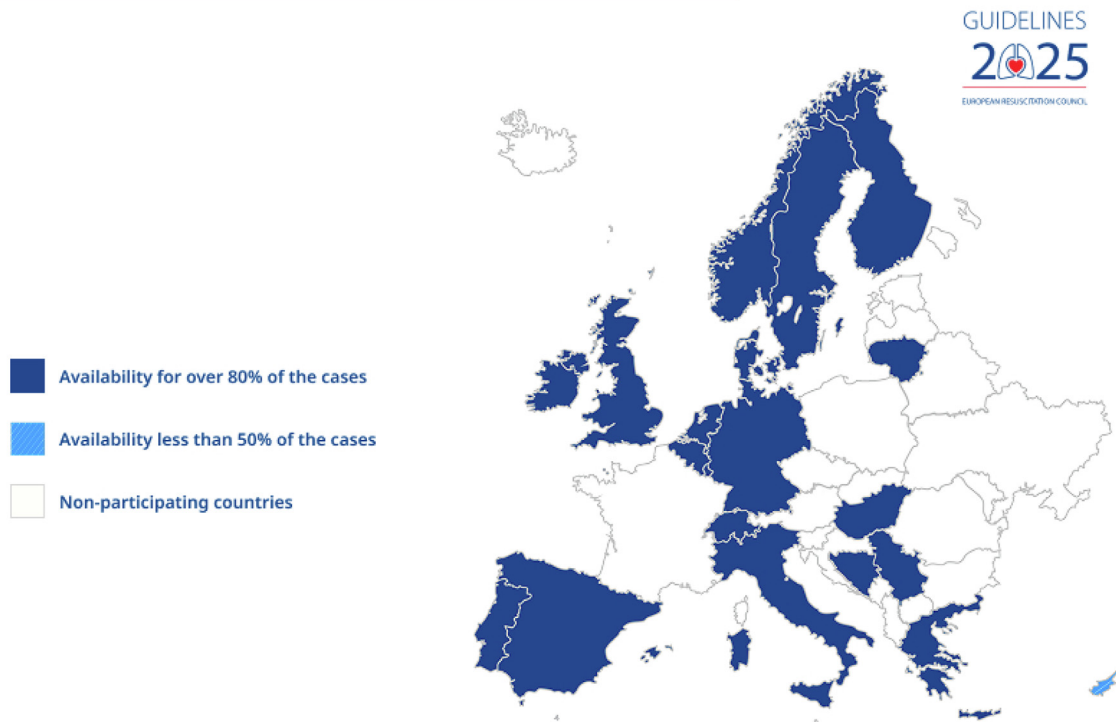


Fig. 2 – Coverage of OHCA registries in European countries in 2019 (2A) and in 2025 (2B). Countries not participating are left white.

(A)



(B)

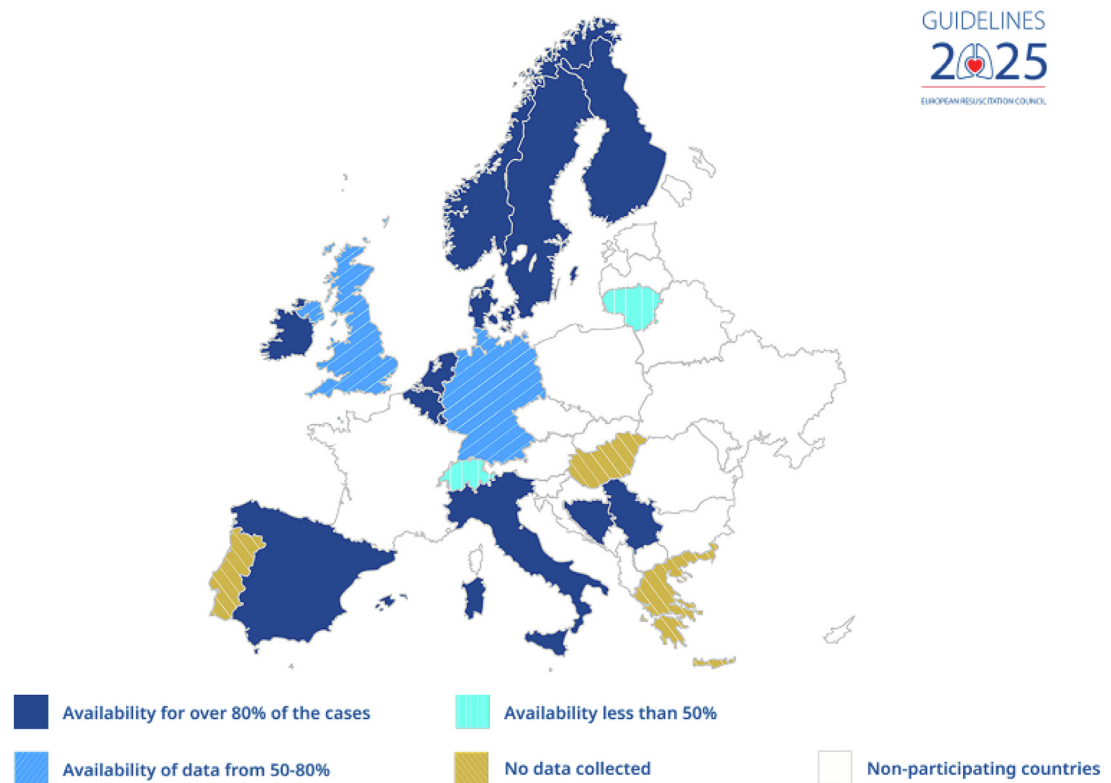
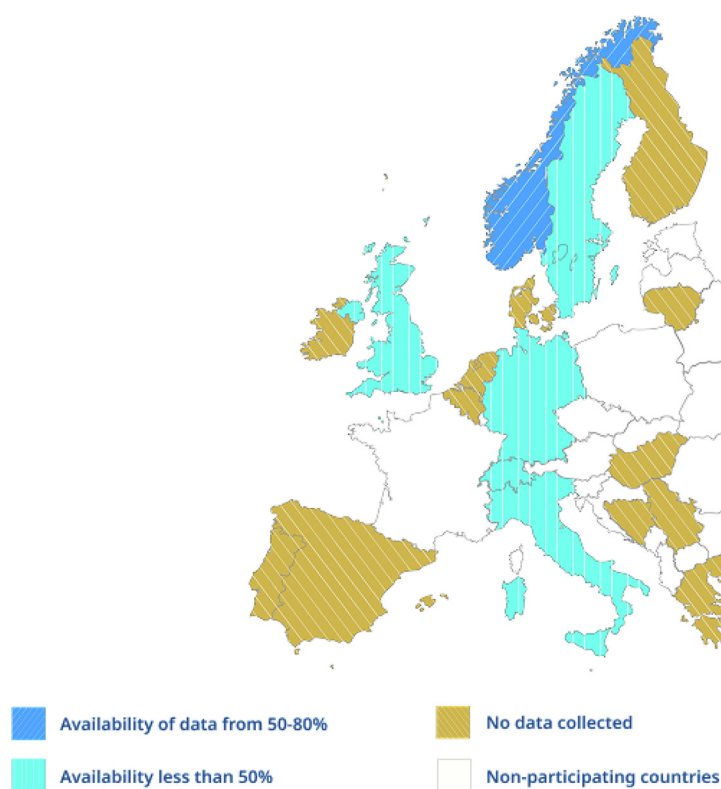


Fig. 3 – Availability of data in out-of-hospital cardiac arrest registries in Europe. Fig. 3A is ambulance data, Fig. 3B is hospital data and Fig. 3C is patient-reported quality of life data. Countries not participating are left white.

(C)

**Fig 3. (continued)**

Thailand. Conversely older ages have been reported in Japan (75 years) and Taiwan (76 years).³⁴ Interestingly, the mean age of the OHCA patients in whom the resuscitation was not started was higher than in patients in whom CPR was started (71.5 ± 17.4 years versus 67.6 ± 17.5 year).²

Sex distribution among OHCA patients is similar across Europe, with males representing about 65 % of patients overall,² e.g. 68 % in Norway and France, and just under 60 %, in Italy.^{17,18} This pattern is largely in line with international data,^{33,35} although lower in some countries, e.g. 57 % in Japan^{17,18,34} and higher in others, e.g. 82.7 % in the United Arab Emirates.³⁴

Approximately one-third of OHCA cases in Europe are unwitnessed OHCA, ranging from 17.3 % in France to 46 % in Denmark.¹⁷ Bystanders represent the largest group of witnesses, ranging from 44 % in Germany and Denmark to 69 % in France. EMS personnel are present at the time of arrest less frequently, ranging from 8 % in Ireland to 16 % in Switzerland.¹⁷ Outside Europe, unwitnessed OHCA exceed 50 % in the United States, Canada, Japan, South Korea, Singapore, Taiwan and United Arab Emirates,^{17,18,34} whilst EMS-witnessed events seem to be similar globally.^{17,33,34}

In Europe, the majority (70 %) of OHCA occur in private residences such as the patient's home with reported rates ranging from 61.5 % in Switzerland to 76.3 % in Italy.² The proportion of cardiac arrests which occurred in a private residence increased during the COVID-19 pandemic.^{21,36} Around 10 % of OHCA occur in public places or in nursing homes, with fewer cases occurring in schools, sport facilities and workplaces.^{17,18} These findings are consistent

with data reported from United States, Australia and Japan,¹⁶ although OHCA in nursing homes are less common in some Asian countries (about 2–5 %).^{16,18,34}

The initial rhythm of arrest is one of the most important prognostic factors for short- and long-term survival. In Europe, approximately one in five patients with an EMS-attempted resuscitation experience a 'shockable rhythm' (ventricular fibrillation (VF) or pulseless ventricular tachycardia) as the first monitored rhythm of cardiac arrest.² However, the rate of first monitored shockable rhythms varies three-fold across European countries from 11.4 % to 36.8 %. This may partly explain regional differences in outcomes.² Similar variability has been reported in other continents, such as Asia (from 4.1 % to 19.8 % in different regional areas) and Australia (22.9–44.0 %).^{33,34} Emerging data suggest that the proportion of first monitored shockable rhythms may be declining over time, giving rise to a higher proportion of OHCA with initial asystole and pulseless electrical activity.^{37–41} For example, in Sweden, the proportion of OHCA with an initial shockable rhythm declined from 39.5 % in 1990 to 17.4 % in 2020, with a larger difference in women (35.9 % in 1990 to 11.4 % in 2020).³⁸ Similar findings have been reported in other regions.^{39–41}

An important consideration is that the initial rhythm reported depends on the time interval between the cardiac arrest and the first rhythm analysis. Large population studies highlighted that the odds of a shockable first monitored rhythm declined with each additional minute of no-flow time as VF degenerates into a non-shockable rhythm, and that bystander CPR significantly mitigates the degradation of shockable rhythms over time.^{42–44}

Arrest aetiology strongly correlates with the initial rhythm and patient age. Medical causes precipitated 91.1 % of OHCA, while trauma, asphyxia, drug overdose, drowning and electrocution made up the remaining cases.² The leading cause of medical-related OHCA's include underlying cardiac aetiologies. In Sweden, the proportion of cardiac arrests caused by heart disease have declined for both men and women, from 80.5 % in 1990 to 58.7 % in 2020,³⁸ with similar declines observed in other high resource countries.⁴¹ The German Resuscitation Registry reported increasing OHCA of presumed cardiac aetiology between 2006 and 2020, but with values that have risen from just below to just over 60 %.³⁹ Most OHCA's in adults ≥ 40 years are from cardiac cause.³⁸ Drug overdose and suicide represents the leading cause in young adults and adolescents, and this is an increasing trend in some parts of Europe (e.g. in Sweden).⁴⁵

EMS organisation

A 2025 survey of EMS system characteristics gathered data from 27 European countries about EMS dispatch, on scene management, and coverage by cardiac arrest registries.¹⁴ Compared with a previous survey in 2019,⁴⁶ there were changes in the countries reporting a median EMS response interval of less than ten minutes in urban areas. Austria, Cyprus, the Netherlands, Slovakia and Slovenia reported improvement, whilst Belgium, Italy, Luxembourg, Norway, Poland and Switzerland reported a deterioration.¹⁴ Variation was noted in how response intervals are calculated according to start (e.g. starting of the call, ambulance alerting) and end points.

Early recognition and early initiation of CPR is crucial to improve survival.⁴⁷ To achieve that, several first responder systems have been established.^{48,49} Only 17 countries reported having established first responder system without changes over time.^{14,46}

Several countries established a new OHCA registry or expanded an already existing OHCA registry in the last five years (Fig. 2).^{14,46} Currently, nine countries report having an OHCA registry with national coverage (Cyprus, Denmark, Greece, Hungary, Ireland, Luxembourg, Norway, Sweden, Switzerland).¹⁴

Case ascertainment and data completeness are key drivers of how representative a registry is of the population it covers.^{50,51} As can be seen in Fig. 3, data completeness levels are high for EMS treatments and survival to hospital (>80 % data completeness). By contrast, data are less complete for hospital treatments. For health-related quality of life only one registry manages to capture information from more than 50 % of the survivors (Norway). Healthcare systems need reliable and accurate information if they are to be used for quality improvement purposes.⁸ This highlights that there is still much room for improvement across Europe.¹⁴

Community response

Dispatching community first responders to cardiac arrest

A systematic review identified that eight mobile phone systems from seven countries in Europe are used to alert community first responders for OHCA.⁴⁸ This includes text messages or specially designed smartphone applications.⁵² Activation radii (i.e. the distance from the scene that first responders are activated), prioritising volunteers to reach the scene, exclusion criteria (e.g. unsafe environment, patient's age) and methods for retrieval of AEDs tend to vary between systems. A recent survey of EMS systems suggests there are more systems being used across Europe than have been published in recent literature.⁴⁶

A meta-analysis on the impact of dispatching community first responders to cardiac arrest including six European countries,

reported higher CPR and AED use with community first responders compared with the conventional emergency response.⁴⁹ The activation of community first responders also improved the rate of defibrillation before EMS arrival, particularly in private homes.⁵³

Risks for dispatched community first responders are rarely reported.⁵⁴ In Denmark, the rate of injury was only 26/7334 (0.35 %), with one ankle fracture reported.⁵⁵ The psychological impact of a volunteer responding to cardiac arrest was also investigated; 24.7 %, 5.5 % and 1.2 % of 5395 respondents reported low, moderate, or severe impact, respectively.⁵⁶ More severe impact was associated with lack of CPR training, younger age and female sex. Dispatching first responders seems to be equally safe in both public and private locations.⁵⁷ Taking care in terms of psychological safety, continuing motivation and standardised debriefing needs to be included in first responder systems.⁵⁸

Bystander CPR and defibrillation rates

Bystander CPR rates vary across Europe with a mean bystander CPR rate of 58 %, but with a very wide range (13 % to 82 %).^{2,59} A common barrier to starting bystander CPR is a lack of knowledge (29.9 %). In a survey, even among those who reported that they knew what to do during an OHCA and how an AED works, few were able to mention specific actions required.⁶⁰ A meta-analysis including 23 studies (10 from European countries) reported advanced age, lower socioeconomic and educational status, and marginalisation groups (due to race or language differences) were barriers to lay persons participating in resuscitation training.⁶¹ Enablers identified were having previously witnessed a collapse, awareness of AEDs locations, certain occupations, and legal requirements for training.⁶¹ The rate of bystander CPR appears to be influenced by the population awareness about OHCA. Community interventions such as 'Restart a Heart' may contribute to improved bystander CPR rates.⁶²

Database analyses suggests that bystanders are more likely to perform chest compression-only CPR than standard CPR, but with a wide variability across European countries.^{15,63} Socioeconomic status affects the probability of receiving bystander CPR and socially deprived areas in a country have a lower probability of bystander CPR.⁶⁴ A review of 29 studies across 35 countries (including 9 studies from Europe) also reported higher rates of bystander CPR in countries with a higher Gross Domestic Product per capita.^{65,66}

Unwitnessed OHCA at home and among older people are less often resuscitated by bystanders.⁶⁷ In contrast, in the case of exercise-related cardiac arrest, although representing a minority of all OHCA's, there is a much higher rate of bystander CPR reported than for other OHCA's (95 % vs 77.4 % in Denmark).⁶⁸ Similarly, bystander AED use was higher for exercise-related OHCA compared with the general OHCA population (38.3 % vs 7.5 % in a Danish population).⁶⁸

The rate of AED use remains variable in European countries, ranging from 2.6 % to 59 % of cases, although an increase has been observed in some countries in the last decade.⁶⁹ Bystander defibrillation is reported as less likely in urban settings, at home, and in women.⁷⁰

Community response during COVID-19 pandemic

According to a meta-analysis including approximately 50,000 OHCA's from around the world, the reduction in bystander CPR rate was directly related to the weekly COVID-19 incidence in each area.²¹ Bystander CPR and bystander AED use rates fell during

the COVID-19 period, particularly in public places, and particularly during the first COVID-19 wave in different European areas.^{71,72} European first responder systems reacted differently to the COVID-19 pandemic and this led to different results in different countries.⁷³ Community first responder engagement and bystander defibrillation rates did not differ significantly during lockdown and non-lockdown periods in two Danish regions. However, compression-only CPR was more often performed during the lockdown period than previously (79 % versus 59 %).⁷⁴ Similar findings were observed in a worldwide registry-based study that included data from several European countries^{75,76} and in a large study in the UK.⁷⁷ There was a reduction in CPR initiated by first responders during the pandemic in Switzerland (45.3 % during pandemic vs 62.2 % before pandemic), but no difference in defibrillation rates by first responders (15.9 % during pandemic vs 23.9 % after pandemic), probably because alerting for community first responders was deactivated, but maintained for on-duty first responders.⁷⁸

Outcome

The ERC recommends registries report outcomes according to the Utstein template to improve comparability between health systems. Registries should prioritise collecting information about survived event, ROSC, transport to hospital, survival and neurological outcome at discharge or at 30 days.⁸

There is substantial international variation in survival rates and neurological outcomes. ILCOR reported survival to hospital discharge or 30-day survival ranged from 3.4 % to 15.6 %.¹⁸ Some areas reported even lower values (e.g. China 2.8 %).^{79,80} Unfortunately, resuscitation outcome is unknown in many countries particularly among those with developing emergency systems.^{81,82}

Prognostic factors for cardiac arrest outcome are age,^{23,24} gender,^{83,84} aetiology, initial arrest rhythm,^{27,85–87} previous and existing comorbidities,^{88,89} location of the cardiac arrest,^{90,91} whether the arrest was witnessed,^{27,28} socioeconomic status,^{92,93} and ethnicity.⁹⁴ Also the way health systems are organised,⁹⁵ available post-resuscitation care facilities (e.g. percutaneous coronary inter-

vention,^{96–99} temperature control,^{98,100–102} cardiac arrest centres^{103,104}) are contributing factors on the variability in patient survival. Furthermore, a significant variability in OHCA outcome may be observed in the same region or country, despite the same health system organisation, because of differences in demographics and the community response,^{105–108} which can change over time.¹⁰⁹ Differences in decisions on when to terminate resuscitation in the field will influence the denominator, which will affect outcome rate.¹¹⁰

Unfortunately, these aspects are not always captured by current data collection systems.¹¹¹ However, despite their inaccuracies and limitations, data from registries constitute the standard for knowing the outcomes from OHCA. These registries should enable annual updates that describe trends in outcomes and compare different areas of the world. For example, in 2024 the US Cardiac Arrest Registry to Enhance Survival (CARES) documented a survival to hospital discharge rate of 10.2 % for all EMS-treated non-traumatic adult OHCA cardiac arrests and 8.1 % for survival with good neurological function.¹ The Australian Aus-ROC Epistry captures data from Australia and New Zealand and reported survival to hospital discharge/30-days as 13 % with a range across different EMS from 9.9 % to 20.7 %.³³ The Swedish OHCA Registry has reported on the evolution in the treatment of OHCA during more than 30 years.³⁸

In Europe, the European Registry of Cardiac Arrest (EuReCa) has performed 3-monthly cross-sectional studies including about 30 countries, providing the data source on OHCA for the Atlas of Cardiovascular Diseases in Europe.¹¹² Over the years of these studies the average survival has changed from 10.3 % [range 1.1–30.8 %] in 2014 to 8 % [0–18 %] in 2017, and 7.5 % [3.1–35 %] in 2022.⁵ These results correlate well with annual reports from national registries.^{113–119} (Table 2).

The Utstein comparator group (bystander witnessed OHCA with a first monitored shockable rhythm) represents the recommended subgroup for system comparison on survival. Reported survival rates are higher than the general population of OHCA patients: 20 % in England,¹¹³ 27.1 % in Spain,¹¹⁵ and 30 % in Europe in 2022.⁵ Several European countries (Denmark, the Netherlands, Sweden, Czech

Table 2 – Outcome reported for OHCA in different European countries.

Country	Type of outcome	Rate
England	Survival at hospital discharge	7.9 %
France	Survival at hospital discharge	4.9 %
Spain	Survival at hospital discharge	11.5 %
Ireland	Survival at hospital discharge	6 %
Spain	Survival at hospital discharge with CPC 1 or 2	9.8 %
Germany	Survival at hospital discharge with CPC 1 or 2	10.5 % (males) –7.1 % (females)
Sweden	Survival at 30 days	12.3 %
Denmark	Survival at 30 days	14.4 %
Norway	Survival at 30 days	15 %

Republic and Norway) exceeded 40 % survival for this benchmark in 2022.⁵

A peculiar sub-group of patients are those with a traumatic cardiac arrest, for whom resuscitation was considered futile in the past.¹²⁰ However, recent data suggest that a good outcome can also be achieved in these patients, as the reported good neurological status at discharge ranged between 2.0 % in Germany¹²¹ and 6.6 % in Spain.¹²²

During the first wave of the COVID-19 pandemic, the outcome of OHCA patients was worse regardless of known predictors of outcome and regardless of the incidence of COVID-19 in a region.²¹ This highlights how the pandemic profoundly affected the management and survival of cardiac arrest patients worldwide.

Scientific consensus⁸ and policies from the European Parliament¹²³ have highlighted the importance of knowing local outcome data about OHCA in each country to issues guidance how to improve the response system and to enhance survival. The ERC recommends that maintenance of registries with high-quality data and adhering to the Utstein template should be an integrated part of each EMS service. This will help to improve their services and their patients' outcome.

Diversity, equity, equality & inclusion (DEEI) discrepancies on outcome

Studies show that racial, gender, and socioeconomic disparities influence cardiac arrest outcomes. Women receive 27 % less bystander CPR than men and survival is lower for women compared with men.^{124–127} Black and Hispanic patients in the USA tend to have lower survival rates and to receive fewer interventions before EMS arrival.^{128,129} Hispanic patients in the USA had poorer survival outcomes, even after accounting for medical history.^{130,131} Lower-income and rural areas have longer EMS response times, fewer public AEDs and lower survival rates.^{108,132–134} These disparities among these groups are reflected by their under-representation in resuscitation science.^{124,135} Ethnicity, gender, socioeconomic status, geographic location, sexual orientation, and disability are all characteristics that contribute to differences in healthcare outcomes.¹³⁶ Equitable resuscitation science requires mitigating barriers that contribute to survival rates, training accessibility, and clinical decision-making. This includes ensuring diverse representation among authors and researchers who can then create culturally competent approaches to guideline development. Recently, the Women's International Group to Inspire, Support, and Empower Women in Resuscitation (WISER) was founded to promote gender equality within resuscitation research community.¹³⁷

Epidemiology of paediatric resuscitation

Resuscitation in children is rare and most challenging presentation in OHCA. Most of the data on paediatric OHCA comes from North America and Asia.¹³⁸ While age-definitions and eligibility criteria differ across reports, data from Italy, Spain, Sweden, Norway, Germany, Denmark and the Netherlands indicates that the incidence of EMS-treated paediatric OHCA varies between 3.1 and 9.0 cases per 100,000 person-years.^{139–145} The incidence of paediatric OHCA has a U-shaped relationship with age, with the highest incidence observed in infancy and adolescence.^{139,141,142,144} The aetiology of OHCA also correlates with age: sudden infant death syndrome (SIDS) is the leading cause of death in children under 12 months of age, while hypoxia, trauma and cardiac causes are more prevalent in adolescent children.^{45,140,142,145,146} Recent data from Sweden

indicate that overdose and suicide are common in adolescent children and may be increasing.⁴⁵ The vast majority of cases, particularly in young children, are unwitnessed, occur in the home and have an initial non-shockable rhythm.^{140–143,147} In adolescents, initial shockable rhythms are common and a third of all events are precipitated by physical activity.¹⁴⁴ Bystander CPR occurs in 41 % to 88 % of cases, although the provision of defibrillation before EMS arrival remains infrequent (<10 %).^{140–142,144,147,148} Rates of survival and neurologically favourable survival are low in paediatric OHCA, but these outcomes may also be influenced by age, aetiology and initial rhythm.^{141,143,146} Overall survival to hospital discharge or 30-day survival varies between 7 % and 40 %, while neurologically favourable survival varies between 4 % and 15 %.^{141,142,144,145,147,148}

Treatment by bystanders using public access defibrillation can result in survival rates exceeding 80 %.¹⁴¹ Data from Sweden and Netherlands also indicates that both short-term survival outcomes and neurologically favourable survival are increasing over time.^{45,143,148} Despite limited reports from Europe examining the long-term quality-of-life and functional recovery of children survivors of OHCA, the available data suggests survivors maintain good neurological outcomes at longer-term follow-up.^{145,149}

Although synthesised data on the incidence and outcomes of paediatric OHCA are lacking, existing reports indicate some differences and similarities across regions. In Australia, the incidence of EMS-treated paediatric OHCA was 4.9 cases per 100,000 person-years (6.7 per 100,000 in EMS-treated cases) and 8.1 % of patients survived to hospital discharge.¹⁵⁰ In North American regions contributing to the Resuscitation Outcomes Consortium, the incidence of EMS-treated paediatric cases was 6.8 cases per 100,000 person-years (8.3 per 100,000 in EMS attended cases) with 10.2 % surviving to hospital discharge.¹⁵¹ In comparison, Asian regions contributing to the Pan Asian Resuscitation Outcomes Study reported a pooled survival to hospital discharge rate of 8.6 %, although the incidence was not reported.¹⁵² A recent systematic review exploring the influence of sociodemographic factors on paediatric OHCA indicates that the incidence of paediatric OHCA and the presence of bystander CPR were strongly associated with race and ethnicity, with minority populations being disproportionately impacted.¹⁵³ These factors may contribute to global differences in the outcome of paediatric OHCA.

In-hospital cardiac arrest (IHCA)

Incidence

There is wide variation in the incidence of treated IHCA in Europe.^{154,155} The ERC continues to recommend the adoption across Europe of the Utstein recommendations for reporting in-hospital cardiac arrest.⁹ The Utstein recommendations advocate reporting incidence as the number of treated in-hospital cardiac arrests per 1000 hospital admissions (excluding cardiac arrests which occur in the emergency department). A few studies on this topic have been published recently (Table 3 and Supplementary Table 1).^{3,4,91,156–161} They confirm previous European studies, which showed an incidence of 1.5 to 2.8 per 1000 admissions.^{162–166} Patients are aged 67 to 75 years and most are male (60 %–69 %), which is very consistent across different studies and countries.^{3,4,156–158,160,161} However, outcome data show significant variations

Table 3 – IHCA incidence, characteristics and outcome in published studies from 2020 to 2024.

Reviewed published studies (2020-2024) focusing on IHCA	IHCA Utstein's Core Elements [*] reported	Age (Mean)	Sex (Male)	Number of treated IHCA per year	Incidence of IHCA per 1000 admission per year ^{**}	Location in hospital	Monitored (M)/ non-monitored (NM) area	AnyROSC%	Survival to discharge%	30-day survival%	Neurological outcome CPC 1-2%	DNAR reported
Adielsson – 2020 – Sweden ³	Yes	72.6	61.4	23,950	N/A	All	M/NM	N/A	N/A	32.5%	N/A	No
Albert - 2023- Sweden ¹⁵⁶	Yes	74	63.1	4,324 ^A	N/A	All	M/NM	65.3/49.9% ^A	N/A	48.4/ 18.7% ^B	89.8/ 72.8% ^B	No
Andersson – 2022 – Sweden ⁹¹	No	N/A	N/A	245	N/A	All	M/NM	N/A	N/A	49.8%	40%	Yes
Bruchfeld – 2024 – Sweden ¹⁵⁷	No	75	60	5,788 ^C	N/A	All	M/NM	45%	21%	N/A	16%	No
Creutzburg - 2021 – Denmark ¹⁵⁸	Yes	67	69	444/494 ^D	1.13/1.11 ^D	General ward	NM	N/A	N/A	N/A	N/A	No
Flam – 2024 – Sweden ¹⁵⁹	No	N/A	N/A	3,737	16.1 ^E	ICU	M	N/A	N/A	N/A	N/A	No
Silverplats - 2024 – Sweden ¹⁶⁰	Yes	73	65	745/254 ^F	2.9/12.4 ^G	All	M/NM	63/72% ^F	N/A	40/ 39% ^F	92/ 91% ^F	Yes
Yonis -2020 – Denmark ⁴	No	74	65	1,892	N/A	All	M/NM	N/A	N/A	27.3%	N/A	No
Yonis - 2022 – Denmark ¹⁶¹	No	74	63.1	8,727	N/A	All	M/NM	53.1%	N/A	62% ^H	N/A	No

DNAR: Do Not Attempt Resuscitation.

^{*} Hospital/Patient/Pre-event/Cardiac Arrest Process/Postresuscitation Process/Outcome.^{**} Non-Utstein Core Elements.^A Cardiac/non-cardiac cause.^B Cardiac/non-cardiac group.^C Non-shockable IHCA.^D Pre-Implementation Early Warning Score/Post-Implementation Early Warning Score group.^E Intensive Care Unit (ICU) cardiac arrest events.^F Prospectively/retrospectively registered.^G Total/ICU admissions.^H <5 min resuscitation duration.

between the different studies, also depending on differences in the denominator, but ranging between 27.3 % and 62 %.
[3,4,91,156,160,161](#) (Table 3).[3,4,91,156–161](#)

Response organization

The ERC was a key stakeholder in the development of the 10 steps toward improving IHCA quality of care and outcomes recommenda-

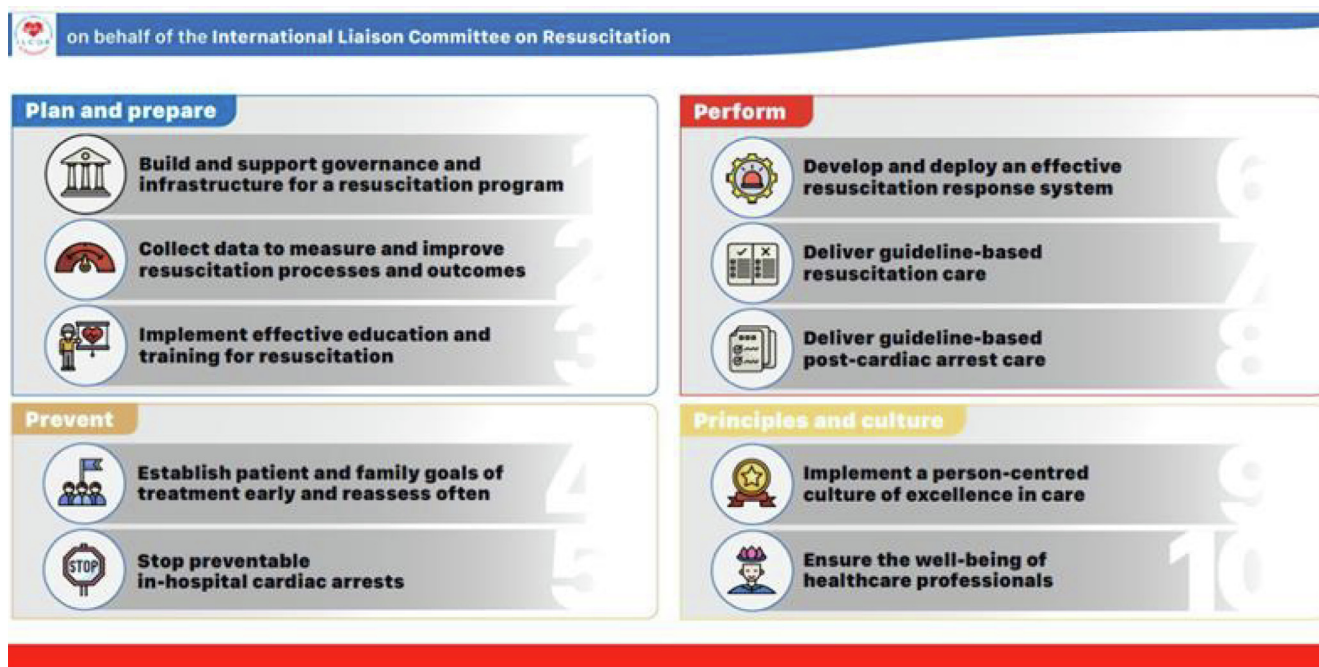
**Fig. 4 – 10 Steps to improve in-hospital cardiac arrest quality of care and outcomes.**

Table 4 – Summary of use of 2222 emergency call number for IHCA in European Countries.

Country	Survey date	Hospitals	Use of 2222 (%)
Belgium	2021	Flemish Hospitals	2/19 (11 %)
Denmark	2017	Hospitals	9/40 (29 %)
France	2019	Military Hospitals	2/8 (25 %)
Ireland	2019	Public and Private Hospitals	52/67 (78 %)
ERC guideline survey	2025	14 countries	2/14 (13 %)

tions from ILCOR.¹⁶⁷ The programme highlights the importance of planning and preparation, systems to prevent IHCA and inappropriate resuscitation, optimal organisation of the emergency response to IHCA including delivery of guideline-based care and principles of person-centred culture (Fig. 4).

Develop and deploy an effective resuscitation response system

Step 6 of the ILCOR initiative on improving IHCA describes the importance of a hospital-wide resuscitation response system that is easily and rapidly activated. It highlights the importance of a high-quality resuscitation team that includes preassigned, experienced, and interdisciplinary health care professionals.¹⁶⁷ A survey amongst guideline writing group authors ($n = 14$, 100 % response) covering 14 countries (Austria, Croatia, Denmark, France, Germany, Greece, Italy, Netherlands, Norway, Serbia, Spain, Sweden, Switzerland, United Kingdom) explored the characteristics of the response to IHCA. Most countries used a designated cardiac arrest team (78 %). Team roles were pre-assigned before cardiac arrest in nine countries (60 %), at the time of the cardiac arrest in two (20 %), and there was no consistent approach in two (20 %). The use of multi-professional teams was almost universal (93 %) – just one country included physicians only. Some form of standardised advanced life support training was provided in all but one country. The ERC Advanced Life Support Course was used in 6 countries (40 %), local advanced life support courses in 6 countries (40 %) or no consistent approach in 2 countries (13 %). Use of a defibrillator was permitted by physicians (all countries) and nurses in ten countries (73 %).

The ERC continues to recommend the use of a standard internal telephone number (2222) for IHCA in Europe.¹⁶⁸ Despite these recommendations being made in 2016, penetration across Europe is limited. (Table 4) Forward citation tracking of the publications recommending implementation of 2222 as the standard number to alert the in-hospital resuscitation team demonstrates variable penetration across Europe.^{169–172}

Outcome

Outcome data should be reported consistently to enable comparisons. Core outcome data should include reasons for CPR termination, ROSC, survival and neurological outcome at discharge and/or at 30-days.⁹

There are far fewer studies reporting outcomes from IHCA compared with those reporting outcomes from OHCA. Data identified by the ERC writing group are summarised in Table 3 and show that varying rates of ROSC (range 45–72 %), survival (range 27.3–62 %) and neurological outcome (range 16–92 %). There is also evidence that IHCAs in monitored areas, younger age, shockable rhythm, with less comorbidity are associated with best outcomes,⁹ whilst IHCAs occurring early in the morning are associated with worse outcomes.¹⁷³ The ERC therefore strongly advocates for the roll out of IHCA registries in accordance with Utstein recommendations.

Long term survival and return to societal participation

Measurement of outcome and recovery

Long term survival and outcome

Severe hypoxic-ischaemic brain injury is a devastating outcome for cardiac arrest survivors. In most European countries where withdrawal of life sustaining treatment is routinely practiced, a poor neurological outcome is seen in less than 10 % of cardiac arrest survivors.¹⁷⁴ In situations where withdrawal of life sustaining treatment is not applied, survivors with severe hypoxic-ischaemic brain injury are substantially more common. Even among survivors classified with a good outcome, the effects of hypoxic-ischaemic brain injury may impact everyday life. The most frequently reported neurological sequela is neurocognitive impairment, affecting most survivors in the early phase and up to 50 % over the longer term, where it is mostly mild-to-moderate.^{174,175}

When assessed at group level, the use of generic measures of health-related quality-of-life suggests comparable levels of health with the general population.^{175,176} However, more nuanced analyses reveal that several health-related quality-of-life sub-domains are poorer in cardiac arrest survivors, and that cognitive, physical, emotional problems and fatigue are common.^{174,177–180}

Families of cardiac arrest patients (also known as ‘co-survivors’) are also at significant risk of emotional problems including anxiety, increased care-giver burden, and post-traumatic stress.^{181–183} Being a witness to a relation’s cardiac arrest increased the risk for emotional problems,¹⁸¹ and cognitive impairment in the survivor was associated with increased caregiver strain.^{183,184} Logistical and ethical challenges with collecting detailed information beyond hospital

discharge remains a critical issue for long-term recovery reporting.^{8,175}

A recent review of recovery and survivorship following paediatric cardiac arrest describes the commonality of cognitive impairment, including difficulties with memory, language, attention, communication, and executive functioning, impaired physical functioning, and activities of daily living.¹⁸⁵ Emotional problems, such as anxiety, depression, or behavioural problems, may manifest as somatic complaints or attention difficulties. Changes in family social functioning are also described. Few studies capture long-term outcomes beyond 2–3 years post hospital discharge.¹⁸⁵

Registries

The Utstein template defines core and supplementary outcome variables and recoding methodologies to be collected in the event of OHCA.⁸ Since its introduction, patient survival and neurological status have received increasing focus. Utstein guidance directs that neurological outcome is reported using the Cerebral Performance Category (CPC) and/or modified Rankin Scale (mRS) for adults and the Paediatric Cerebral Performance Category for children at hospital discharge or at 30 days.⁸ Because the collection of post-discharge survival status and health-related quality-of-life data requires extensive resources they are identified as supplementary outcomes. Recommended health-related quality-of-life assessments are in line with the Core Outcome Set for Cardiac Arrest (COSCA) outcome reporting recommendations: that is, the Short-Form 36-item Health Status Survey (SF-36), EuroQoL EQ-5D-5L, or the Health Utility Index version 3 (HUI3) for adult survivors at 90-days¹⁸⁶ and the Pediatric Quality of Life Scale (PEDQL) for children at 6-months.¹⁸⁷ However, a recent review of studies citing Utstein guidance found that the supplementary outcomes were rarely used, with fewer than 3.3 % assessing health-related quality-of-life.⁸

Research

The introduction of the COSCA guidance has contributed to an improvement in outcome reporting:¹⁸⁸ 82 % (45/55) of recent trials reported neurological function, of which 19 of 45 adopted the modified Rankin Scale as a measure of functional outcome; 33 % (18/55) of trials reported health-related quality-of-life, with most (16 of 18) including recommended assessments. The EuroQoL EQ-5D-5L was most frequently used. However, continued heterogeneity in the reporting of health-related quality-of-life is hindering data synthesis.^{176,179}

Recognising the limitation of generic assessments, COSCA highlights the complementarity of domain-specific assessment, for example, of cognition, fatigue, anxiety, and participation. However, without specific assessment guidance, further heterogeneity in domain-based outcome reporting has been described.^{177–180} For example, a review of 43 studies described more than 50 measures and a range of different cut-points used to assess neurocognitive function following OHCA.¹⁷⁷ Similarly, 16 different measures of anxiety or depression across 32 studies of cardiac arrest survivors were reported in another review.¹⁸⁰ Variation in measurement choice and cut points impacts prevalence reporting; standardisation is urgently required to support greater transparency in the assessment of symptom incidence.

Recent evidence suggests that the Montreal Cognitive Assessment (MoCA) is an acceptable measure of cognitive screening following cardiac arrest,^{189,190} further underpinning recommendations for its use in this population.¹⁹¹ The measure is usually administered

face-to-face or via a digital meeting. Whilst a telephone version is available, the psychometric properties are less known, and hence this version should be applied with caution.¹⁹²

Despite the Hospital Anxiety and Depression Scale (HADS) being widely used as a measure of anxiety and depression in cardiac arrest survivors,¹⁸⁰ there are few psychometric evaluations of its use with this population.¹⁹³ However, there is strong evidence supporting its use in the general population and in patients with cardiac disease. For example, evidence from a large Danish population of cardiac patients suggests acceptable evidence of essential measurement properties, in keeping with earlier studies.¹⁹⁴

Fatigue assessment guidance following cardiac arrest is not available. Whilst the most widely used measures in cardiac arrest are the Fatigue Severity Scale (FSS)^{195–197} and the Modified Fatigue Impact Scale (MFIS),^{197–199} information of psychometric properties is limited in this population. Evidence from other patient groups (e.g. multiple sclerosis) suggest they are comparable when measuring physical aspects of fatigue in populations with mild to moderate fatigue.²⁰⁰ However, where both physical and cognitive aspects are important, and where higher levels of fatigue might be anticipated, the somewhat longer Modified Fatigue Impact Scale is preferable.²⁰⁰

Guidance for the assessment of activities and participation following cardiac arrest does not exist. However, functional outcome scales and health-related quality-of-life assessments, such as the modified Rankin Scale and Short-Form 36-item Health Status Survey, commonly include these domains; the value of reporting health-related quality-of-life outcomes at a domain-level has been demonstrated.²⁰¹ Whilst overall physical and mental component summary scores on the Short-Form 36-item Health Status Survey suggested health status comparable to the general population, at the domain level impairment was substantial. This was particularly noted where people experienced difficulties engaging in roles related to work and other activities due to physical (50 % impaired) and emotional (35 %) limitations.²⁰¹

Variation in outcome assessment following paediatric cardiac arrest (what is assessed, when, and by whom) is described, which may further contribute to the reported heterogeneity in post-arrest problems described and our understanding of long-term outcomes.¹⁸⁵ Moreover, the widespread use of blunt global assessments such as the Paediatric Cerebral Performance Category (PCPC) may inadequately capture change in patient and family important outcomes such as ability to engage with friends, school, and society. Introduction of the Paediatric-COSCA guidance in 2020¹⁸⁷ is expected to contribute to improvements in outcome reporting and our understanding of the long-term recovery and survival of children.¹⁸⁵

Routine practice

Measures to use during follow-up in clinical practice are detailed in the ERC Guidelines 2025 Post-resuscitation care, and includes guidance for screening of cognitive, emotional challenges, and fatigue and exploring limitations in physical activity and physical function.²⁰²

Rehabilitation and return to societal participation

Follow-up and screening

The 2021 ERC Post-resuscitation Guidelines recommended the assessment of physical and non-physical impairments both before and within 3-months of hospital discharge to identify rehabilitation needs and the provision of timely and targeted care through appro-

appropriate referrals.¹⁹¹ An early follow-up assessment, including screening for cognitive and emotional challenges, is supported by an RCT from the Netherlands.^{203–205} This cost-effective intervention contributed to a positive impact on mental health and an earlier return to work at one year.^{205,206} Several European national guidelines and quality standards now recommend early follow-up following cardiac arrest – for example, Sweden,²⁰⁷ France,²⁰⁸ United Kingdom,^{209,210} Scotland,²¹¹ and the Netherlands.²¹² To what extent cardiac arrest survivors in Europe are assessed before discharge and/or at follow-up is unknown.

Most cardiac arrest survivors who responded to a UK survey (95 of 123 (77 %); median 2 yrs since cardiac arrest) reported being followed-up, typically by a cardiologist (62 %). The majority (99 %) indicated the need for post-discharge follow-up with access to a multi-disciplinary team; more than half (61 %) preferring early follow-up within one month of discharge. Prioritised topics included: medical issues (as the cause of the cardiac arrest and heart disease), mental fatigue/sleep and screening for emotional and cognitive challenges.²¹³

Almost all respondents to a survey of French ICUs reported providing oral information to cardiac arrest survivors prior to discharge (136/145, 94 %).²⁰⁸ However, just half noted the OHCA survivors' neurological and functional outcome in medical records or organized a post ICU follow-up which included cognitive and emotional screening. Described barriers to provision of follow-up appointments included: lack of awareness and knowledge; limited resources, including limited interdisciplinary collaboration; limited evidence to justify the cost; and an absence of practical recommendations.^{208,212}

Informed by previous experiences^{203–206} and European guidelines²¹⁴ the Essex Cardiothoracic centre started the UK's first dedicated follow-up clinic for cardiac arrest.²¹⁵ Cardiac arrest survivors (approximately 70 per year) are assessed by an ICU nurse and cardiologist before discharge and provided with multiple information sources, ranging from contact details to a peer support group. A post-discharge telephone call is organized within 48-hours, with follow-ups at 2-, 6- and 12-months for survivors and their carers.²¹⁵ A hub-and-spoke sub-regional model with a single lead cardiac arrest centre performing patients' assessment both in-person and remotely is being implemented in Italy. Such an approach may reduce disparities in care allowing this type of follow-up even in hospitals with limited resources.²¹⁶

The 'Copenhagen Framework'²¹⁷ provides a further example of guideline translation^{191,214} into clinical practice. A stepwise multidisciplinary approach to organise and manage follow-up and rehabilitation, implemented through two high-volume cardiac arrest centres (approximately 200 survivors a year), it includes: in-patient assessments; early follow-up 1–2 weeks post-discharge; and a more extensive follow-up at 2-months for both survivors and their family members.

Rehabilitation

The 2021 guidelines recommend that, where indicated, cardiac arrest survivors should be referred for specialist rehabilitation.¹⁹¹ However, there remains a lack evidence for rehabilitation after cardiac arrest.²¹⁸ Current evidence based clinical practice recommendations for rehabilitation after cardiac arrest are discussed in the ERC Guidelines 2025 Post-resuscitation care.²⁰² Here we explore and describe available European rehabilitation pathways for cardiac arrest survivors. Participants in a large trial including mainly European OHCA survivors described their experience of rehabilitation

within the first six-months post-arrest.¹⁹² Just 29 % out of 836 patients participated in cardiac rehabilitation, with fewer than 12 % receiving brain injury rehabilitation (in-hospital: 12 %; outpatient: 5 %).¹⁹² In a smaller Danish study of OHCA survivors who had been in employment before their arrest ($n = 38$), 100 % had a rehabilitation plan at time of discharge.²¹⁹ The most frequently accessed rehabilitation interventions involved psychologists addressing psychological issues (78 %) and physiotherapists supporting exercise capacity (68 %). Although rehabilitation participation was high, almost half of survivors reported unmet rehabilitation needs at 6-months, including support for existential issues, speech problems, return to work, fatigue and energy management.²¹⁹

Whilst many cardiac arrest survivors are eligible for cardiac rehabilitation, engaging in these programmes alongside other patients who have experienced an acute cardiac/coronary event, those survivors whose cardiac arrest was idiopathic or due to non-ischaemic causes are generally excluded.^{174,175,215} A survey of Danish cardiac rehabilitation facilities suggests that cardiac arrest survivors received less specialised cardiac rehabilitation than myocardial infarction patients. This included less patient education, exercise training, screening for anxiety and depression and nutritional counselling.²²⁰

Commencing at three-months post-arrest for survivors who had been discharged to home, a small Danish pilot study tested a combination of residential and home-based rehabilitation including education, physical activity training, and psychosocial support.¹⁹⁸ Carers were invited to attend the residential group sessions. Whilst this small pilot study is unable to provide sufficient evidence to support a change in practice, patient and clinician satisfaction was high. However, the specialised residential component may not be feasible in many settings.

Due to the prevalence of cognitive impairment in cardiac arrest survivors, a potential knowledge gap in care delivery by cardiology-based healthcare professionals has been described,^{212,221} with a greater need for interdisciplinary collaboration proposed.^{215,221,222} By example, a combined cardiac and cognitive rehabilitation programme is provided to cardiac arrest survivors at a single centre in the Netherlands.²²³ More specifically, whilst those without cognitive impairment follow a traditional cardiac rehabilitation programme, those with impairment participate in smaller cardiac rehabilitation groups with the addition of a cognitive rehabilitation programme. This pathway has not been evaluated, but 23 % of cardiac arrest survivors referred for cardiac rehabilitation had cognitive problems.²²⁴

Brain injury rehabilitation is often provided to cardiac arrest survivors with severe hypoxic-ischaemic brain injury, with care provided alongside other patients with acquired brain injury – e.g., traumatic brain injury.²²⁵ Whilst guidance on brain injury rehabilitation following cardiac arrest is not available in the European context, insight can be gained from several retrospective studies (e.g., patient records) from the last decade. A retrospective review of patients admitted to a Turkish brain injury in-patient rehabilitation facility between 2011 and 2015, reported anoxic brain injury following cardiac arrest in 5 % of patients.²²⁵ Patients with anoxic brain injury received the same intense rehabilitation programme as patients with traumatic brain injury, including physiotherapy, occupational therapy, cognitive rehabilitation and speech-language therapy for 5 h a day, for 20 days. In a small Dutch study of patients hospitalised and institutionalised because of unresponsive wakefulness syndrome (most due to cardiac arrest), more than half (54 %) had not received any rehabilitation.²²⁶ By contrast, a larger German study on 93 patients describes early, daily interdisciplinary neurological rehabilitation for patients with severe hypoxic-ischaemic brain injury (34 % of cardiac causation), which

continued until improvement ceased or complications were observed (including death).²²⁷ Following a mean duration of 109 days, 41 % were discharged to a nursing facility, 23 % were referred for additional rehabilitation, 18 % returned home, 10 % needed further acute-care and 8 % died. Of those comatose at admission, 82 % remained comatose at discharge. A single French centre describes a six-month therapeutic intervention for institutionalised patients with anoxic brain injury ($n=11/20$ caused by cardiac arrest; mean 8-years post-event).²²⁸ Consisting of medication, psychotherapy, support group, and physical, cultural and/or artistic therapeutic activities, it positively impacted quality of life and social participation.

Genetic variants and autopsy in cardiac arrest patients

The cause of cardiac arrest is known to be different according to the age of the victim. Coronary artery disease indeed represents the cause of cardiac arrest in most people over 50 years, but it explains only a minority of cases in young people. In young victims, most of the sudden cardiac deaths are attributable to other diseases, of which the majority are genetically determined structural or arrhythmogenic myocardial pathologies.^{229,230} Differences in the cause of cardiac arrest become more pronounced at younger ages.^{231,232} In young victims of sudden cardiac disease, the most common causes are hypertrophic cardiomyopathy—which is particularly prevalent in athletes—and arrhythmogenic cardiomyopathy. Other significant contributors include dilated cardiomyopathy and primary arrhythmogenic disorders, such as familial long-QT syndrome, catecholaminergic polymorphic ventricular tachycardia, and Brugada syndrome.^{231,232} The identification of such an aetiology in the deceased may have important implications for families, allowing their arrhythmic risk to be defined and potentially preventing further sudden death events. In concordance with other European Societies the ERC recommends that a full post-mortem examination, including heart dissection, sampling for genetic and toxicological analysis, should be done in all the young sudden cardiac disease victims. However, although this recommendation is endorsed by numerous scientific societies in Europe and beyond, the post-mortem examination of young sudden cardiac disease victims is currently not routinely performed in many European countries.^{233,234}

Genetic post-mortem analysis (so-called 'molecular autopsy') is important because about one third of the sudden cardiac disease remains unexplained after autopsy.^{235–237} For this reason, the collection of 5–10 mL of blood in Ethylenediaminetetraacetic acid (EDTA) is recommended during post-mortem examination or whenever possible, even on the OHCA scene.^{235,238,239} Modern techniques of DNA evaluation (e.g. multi-gene panels using next-generation sequencing) enable identification of a clinically actionable pathogenic or likely pathogenic variant in a gene potentially related to the cause of sudden cardiac death in up to 25 % of cases, with significant implications for the care of their families.^{231,240–247} Considering genetic data together with the phenotype provides much more informative data at a clinical level than using genetic data alone. Molecular and familial analysis together enable increased diagnostic yield.²⁴⁸ The clinical data, including information about the deceased, the context and the triggers of the event, and the families, are all important.^{249–251} Modern DNA analysis techniques enable the identification of a considerable percentage of

variants of uncertain significance (VUS) on genes of interest. However, unlike pathogenic or likely pathogenic variants, these types of variants present significant challenges when explaining their significance to family members of the deceased and, if still alive, to the patients themselves.²⁵⁰ The ERC recommends that genetic and clinical testing should be undertaken only by multidisciplinary teams including professionals with skills to counsel on the implications and the uncertainty of results and to decide about the appropriateness of extending the screening to the first-degree relatives of the victims, and experienced cardiologists able to direct testing to the correct phenotype.²⁵² These teams should ideally be based in tertiary centres that offer comprehensive professional expertise and can receive patient referrals from a wide region. These centres should also be capable of periodically reanalysing and reclassifying variants as new data on pathogenicity become available.^{247,253} There has been consensus that the autopsy and genetic testing should be performed in those under the age of 40 years,^{250,254} however, other studies suggest that the age range should be extended up to 50 years.^{255,236,251,256} This wider age range is supported by two recent expert consensus statements on genetic evaluation of patients with unexplained sudden cardiac arrest.^{252,257} These statements represent the official views of the European Society of Cardiology (ESC) and numerous arrhythmia scientific societies worldwide (European Heart Rhythm Association, Heart Rhythm Society, Asia Pacific Heart Rhythm Society and Latin American Heart Rhythm Society). Therefore, the ERC strongly recommends performing a comprehensive post-mortem examination (including heart dissection and toxicological analysis) and a molecular autopsy on all victims of unexpected sudden death under 50 years old.

Low-resource settings and remote areas

Out-of-hospital cardiac arrest and IHCA occur worldwide, regardless of a country's available resources, population density, or remoteness. Although responding to cardiac arrest may not be a primary focus of emergency services in lower-resourced countries, the fundamental principles of resuscitation still apply. However, the epidemiology, organisation of response and treatment, and both short- and long-term outcomes differ significantly in these settings and in remote areas. Therefore, it is important to consider the treatment of OHCA and IHCA in less-resourced countries and remote regions separately. The response to OHCA in remote areas of high-resourced countries involves entirely different strategies and resource allocation compared to those in lower-resourced settings.

Low-resource settings

The only available data on OHCA in low-resourced countries in Europe concern Serbia and Bosnia and Herzegovina,^{258,259} two of the most low-resourced countries in Europe, where an incidence of OHCA of 85.6 per 100,000 and 54 per 100,000 inhabitants/year respectively is reported, which aligns with the median reported incidence of 55 per 100,000 inhabitants/year in Europe.⁵ Some characteristics of OHCA in those countries are similar to other European countries, such as the majority of events occurring at home, but other aspects are significantly different. In particular, the rate of first monitored shockable rhythm reported in Bosnia and Herzegovina is consistently higher than in other European countries, representing

45.6 % of OHCA.^{258,259} The rate of bystander CPR (15.3 % among bystander witnessed in Serbia and 3.3 % among all OHCA in Bosnia and Herzegovina) and AED use (0 % in Bosnia and Herzegovina) is lower compared with the European average value.^{258,259} This reflects on the outcome, as the ROSC and survival rates in both countries are lower than the median value in Europe.^{2,5}

The differences between low- and high-resourced countries become even more apparent outside Europe, where there is a reporting bias because of a lack of OHCA registries adapted to the Utstein template and based on a reference territory,²⁶⁰ both of which are essential for reliably understanding the phenomenon. Most reports are derived from hospital-based registries that do not follow the Utstein template, and often describe cases where patients in cardiac arrest are transported to the Emergency Department without EMS activation,^{261–265} leading to clear delays in treatment, compromised care, and poorer outcomes.

Estimating the incidence of OHCA is only feasible in a few countries with functioning registries, such as South Africa and Argentina—both classified as ‘upper-middle income’ countries. Reported incidence rates are 23.2 per 100,000 inhabitants per year in Cape Town and 53 per 100,000 inhabitants per year in the city of Bariloche, although the latter figure includes all OHCA, not just those treated by EMS.^{266,267} No incidence data are available from other countries.

The available data suggest that the mean age of OHCA patients in low-resourced countries is lower than in high-resourced settings, ranging from 55 years in Pakistan²⁶⁵ to 63 years in South Africa.²⁶⁶ This likely reflects both a younger general population and differing attitudes toward resuscitation in elderly individuals. The location of OHCA, though difficult to interpret because of reporting limitations, varies considerably. The proportion of OHCA occurring at home ranges from 56.1 % in China⁸⁰ to 79.7 % in South Africa.²⁶⁶

A first monitored shockable rhythm is found in only a small fraction of patients—approximately 1 % in both Pakistan²⁶³ and South Africa.²⁶⁶ Bystander intervention is also rare, with CPR rates ranging from 2.3 % in Pakistan and 5.1 % in Iran,^{263,268} to 18.7 % in China and 22 % in Vietnam,^{80,269} underscoring the strong correlation between bystander CPR and gross domestic product.⁶⁵ Outcomes for OHCA patients in these settings are generally poor: in cohorts with presumed lower reporting bias, ROSC is about 1 %, ²⁶⁶ and survival to hospital discharge ranges from 0 % to 4 %.^{263,265,266,268} There are no data on IHCA in low-resourced countries in Europe. Existing data from non-European countries are limited and typically based on small patient cohorts. The reported incidence in Egypt is 1.77 per 1000 patients discharged,²⁷⁰ while the median age in Uganda is 40 years.²⁷¹ ROSC rates range from 49.3 %²⁷² to 62.2 %, ²⁷¹ and survival rates from 14.9 %²⁷¹ to 35.5 %, ²⁷² with improved outcomes reported following the implementation of in-hospital Rapid Response Teams.^{270,273} In summary, for both OHCA and IHCA in low-resourced countries, the establishment of robust registries is of paramount importance to accurately define the epidemiology and to monitor progress in treatment and patient outcomes.

Remote areas

Regarding OHCA in remote areas, available European data are limited to mountain regions, which represent the most remote settings within the European context. Studies from the French,²⁷⁴ Polish,²⁷⁵ and Austrian Alps²⁷⁶ reveal some common features—such as a mean age of OHCA victims around 60 years and a predominance of male patients—but also highlight significant differences in bystander

intervention and outcomes. French data suggest a key reason for this variation: OHCA that occur on ski slopes are more likely to receive bystander CPR and AED use, leading to better survival rates, compared with those that occur off the slopes or in other mountain settings, including typical Utstein-defined locations such as homes, public spaces, or workplaces.²⁷⁴ This emphasises that the response to the arrest, rather than the location itself, is the critical factor in determining patient outcomes. Remote areas are more widespread outside Europe, and informative data on OHCA in these contexts come from Canada,²⁷⁷ the United States,²⁷⁸ and Australia.^{279,280} In these countries, OHCA patients in rural and remote settings tend to be younger, and bystander CPR and AED use are more common than in urban areas. However, significantly longer EMS response times in remote regions consistently reduce the likelihood of ROSC and survival in all three countries, underlining the particular challenges of managing OHCA in geographically isolated areas.

Declaration of competing interest

Declarations of competing interests for all ERC Guidelines authors are displayed in a COI table which can be found online at <https://doi.org/10.1016/j.resuscitation.2025.110733>.

Acknowledgement

The ERC would like to thank Tommaso Scquizzato for creating the infographic on the 10 Steps to improve in-hospital cardiac arrest quality of care and outcomes – Fig. 4.

Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.resuscitation.2025.110733>.

Author details

^aDivision of Cardiology, Fondazione IRCCS Policlinico San Matteo, Pavia, Italy ^bCardiac Arrest and Resuscitation Research Team (RESTART), Fondazione IRCCS Policlinico San Matteo, Pavia, Italy ^cInstitute for Emergency Medicine, University Hospital Schleswig-Holstein, Kiel, Germany ^dDepartment for Anaesthesiology and Intensive Medicine, University Hospital Schleswig-Holstein, Kiel, Germany ^eGerman Resuscitation Registry, Nuernberg, Germany ^fDepartment of Cardiology, Cardiocentro Ticino Institute, Ente Ospedaliero Cantonale, Lugano, Switzerland ^gFondazione Ticino Cuore, Lugano, Switzerland ^hFaculty of Biomedical Sciences, Università della Svizzera Italiana, Lugano, Switzerland ⁱWarwick Medical School, University of Warwick, Coventry, United Kingdom ^jNeurology, Department of Clinical Sciences Lund, Lund University, Lund, Sweden ^kNeurology, Skåne University Hospital, Lund, Sweden ^lClinical Directorate, HSE National Ambulance Service, Dublin, Ireland ^mDiscipline of General Practice, University of Galway, Ireland ⁿSchool of Medicine, University College Cork, Cork, Ireland ^oCentre for Research and Evaluation, Ambulance Victoria, Victoria, Australia ^pSchool of Public Health and Preventive Medicine, Monash University, Victoria, Australia ^qUniversity Hospitals Birmingham, Birmingham, United Kingdom ^rUniversity Hospitals Coventry and

Warwickshire, Coventry, United Kingdom ^aServicio de Emergencias Sanitarias 061, La Rioja, Spain ^bSchool of Health and Welfare, Dalarna University, Falun, Sweden ^cCentre for Clinical Research Dalarna, Uppsala University, Falun, Sweden ^dDepartment of Pre-hospital Care, Region of Dalarna, Falun, Sweden ^eDivision of Prehospital Services, Oslo University Hospital, Oslo, Norway

REFERENCES

- Martin SS, Aday AW, Allen NB, et al. 2025 Heart disease and stroke statistics: a report of US and global data from the American heart association. *Circulation* 2025;151(8):e41–e660. <https://doi.org/10.1161/CIR.0000000000001303>.
- Grasner JT, Wnent J, Herlitz J, et al. Survival after out-of-hospital cardiac arrest in Europe – Results of the EuReCa TWO study. *Resuscitation* 2020;148:218–26. <https://doi.org/10.1016/j.resuscitation.2019.12.042>.
- Adielsson A, Djarv T, Rawshani A, Lundin S, Herlitz J. Changes over time in 30-day survival and the incidence of shockable rhythms after in-hospital cardiac arrest – A population-based registry study of nearly 24,000 cases. *Resuscitation* 2020;157:135–40. <https://doi.org/10.1016/j.resuscitation.2020.10.015>.
- Yonis H, Ringgren KB, Andersen MP, et al. Long-term outcomes after in-hospital cardiac arrest: 30-day survival and 1-year follow-up of mortality, anoxic brain damage, nursing home admission and in-home care. *Resuscitation* 2020;157:23–31. <https://doi.org/10.1016/j.resuscitation.2020.10.003>.
- Gräsner J-T, Wnent J, Lefering R, et al. European Registry of Cardiac Arrest Study Three (EuReCa- THREE) – EMS response time influence on outcome in Europe. *Resuscitation*. doi: 10.1016/j.resuscitation.2025.110704.
- Perkins GD, Brace-McDonnell SJ, Group OP. The UK out of hospital cardiac arrest outcome (OHCAO) project. *BMJ Open* 2015;5(10):e008736. <https://doi.org/10.1136/bmjopen-2015-008736>.
- Douglas Chamberlain ROC, Norman Abramson, Mervyn Allen, et al. Recommended guidelines for uniform reporting of data from out-of-hospital cardiac arrest: the 'Utstein style': Prepared by a Task Force of Representatives from the European Resuscitation Council, American Heart Association, Heart and Stroke Foundation of Canada, Australian Resuscitation Council. *Resuscitation* 1991; 22 (1): 1–26.
- Grasner JT, Bray JE, Nolan JP, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: 2024 update of the Utstein out-of-hospital cardiac arrest registry template. *Resuscitation* 2024;201:110288. <https://doi.org/10.1016/j.resuscitation.2024.110288>.
- Nolan JP, Berg RA, Andersen LW, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update of the utstein resuscitation registry template for in-hospital cardiac arrest: a consensus report from a task force of the international liaison committee on resuscitation (American heart association, european resuscitation council, Australian and New Zealand council on resuscitation, heart and stroke foundation of Canada, Inter American Heart Foundation, Resuscitation Council of Southern Africa, Resuscitation Council of Asia). *Resuscitation* 2019;144:166–77. <https://doi.org/10.1016/j.resuscitation.2019.08.021>.
- Soreide E, Morrison L, Hillman K, et al. The formula for survival in resuscitation. *Resuscitation* 2013;84(11):1487–93. <https://doi.org/10.1016/j.resuscitation.2013.07.020>.
- Greif R, Lauridsen KG, Djarv T, et al. European Resuscitation Council Guidelines 2025: Executive Summary. *Resuscitation* 2025;215 (Suppl 1):110770.
- Grasner JT, Lefering R, Koster RW, et al. EuReCa ONE-27 nations, ONE Europe, ONE registry: a prospective one month analysis of out-of-hospital cardiac arrest outcomes in 27 countries in Europe. *Resuscitation* 2016;105:188–95. <https://doi.org/10.1016/j.resuscitation.2016.06.004>.
- Milling L, Kjaer J, Binderup LG, et al. Non-medical factors in prehospital resuscitation decision-making: a mixed-methods systematic review. *Scand J Trauma Resusc Emerg Med* 2022;30 (1):24. <https://doi.org/10.1186/s13049-022-01004-6>.
- Tjelmeland IBM, Strömsöe A, Masterson S. Emergency Medical Services, treatment of cardiac arrest patients and cardiac arrest registries in Europe – update on systems. *Resusc Plus* 2025. <https://doi.org/10.1016/j.resplu.2025.100960>.
- Wnent J, Tjelmeland I, Lefering R, et al. To ventilate or not to ventilate during bystander CPR – A EuReCa TWO analysis. *Resuscitation* 2021;166:101–9. <https://doi.org/10.1016/j.resuscitation.2021.06.006>.
- Kiguchi T, Okubo M, Nishiyama C, et al. Out-of-hospital cardiac arrest across the world: first report from the International Liaison Committee on Resuscitation (ILCOR). *Resuscitation* 2020;152:39–49. <https://doi.org/10.1016/j.resuscitation.2020.02.044>.
- Nishiyama C, Kiguchi T, Okubo M, et al. Three-year trends in out-of-hospital cardiac arrest across the world: second report from the International Liaison Committee on Resuscitation (ILCOR). *Resuscitation* 2023;186:109757. <https://doi.org/10.1016/j.resuscitation.2023.109757>.
- Nishiyama C, Kiguchi T, Okubo M, et al. Characteristics of Out-of-hospital Cardiac Arrest from 2018 to 2021 across the World: Third Report from the International Liaison Committee on Resuscitation (ILCOR) Research and Registries Committee. *Resuscitation* 2025; XXX:110852.
- Baldi E, Sechi GM, Mare C, et al. Out-of-hospital cardiac arrest during the covid-19 outbreak in Italy. *N Engl J Med* 2020;383 (5):496–8. <https://doi.org/10.1056/NEJMc2010418>.
- Marijon E, Karam N, Jost D, et al. Out-of-hospital cardiac arrest during the COVID-19 pandemic in Paris, France: a population-based, observational study. *Lancet Public Health* 2020;5(8): e437–43. [https://doi.org/10.1016/S2468-2667\(20\)30117-1](https://doi.org/10.1016/S2468-2667(20)30117-1).
- Baldi E, Klersy C, Chan P, et al. The impact of COVID-19 pandemic on out-of-hospital cardiac arrest: an individual patient data meta-analysis. *Resuscitation* 2024;194:110043. <https://doi.org/10.1016/j.resuscitation.2023.110043>.
- Baldi E, Primi R, Gentile FR, et al. Out-of-hospital cardiac arrest incidence in the different phases of COVID-19 outbreak. *Resuscitation* 2021;159:115–6. <https://doi.org/10.1016/j.resuscitation.2020.12.020>.
- Al-Dury N, Ravn-Fischer A, Hollenberg J, et al. Identifying the relative importance of predictors of survival in out of hospital cardiac arrest: a machine learning study. *Scand J Trauma Resusc Emerg Med* 2020;28(1):60. <https://doi.org/10.1186/s13049-020-00742-9>.
- Libungan B, Lindqvist J, Stromsoe A, et al. Out-of-hospital cardiac arrest in the elderly: a large-scale population-based study. *Resuscitation* 2015;94:28–32. <https://doi.org/10.1016/j.resuscitation.2015.05.031>.
- Bougouin W, Mustafic H, Marijon E, et al. Gender and survival after sudden cardiac arrest: a systematic review and meta-analysis. *Resuscitation* 2015;94:55–60. <https://doi.org/10.1016/j.resuscitation.2015.06.018>.
- Kim C, Fahrenbruch CE, Cobb LA, Eisenberg MS. Out-of-hospital cardiac arrest in men and women. *Circulation* 2001;104 (22):2699–703. <https://doi.org/10.1161/hc4701.099784>.

27. Sasson C, Rogers MA, Dahl J, Kellermann AL. Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis. *Circ Cardiovasc Qual Outcomes* 2010;3(1):63–81. <https://doi.org/10.1161/CIRCOUTCOMES.109.889576>.
28. Grasner JT, Meybohm P, Lefering R, et al. ROSC after cardiac arrest—the RACA score to predict outcome after out-of-hospital cardiac arrest. *Eur Heart J* 2011;32(13):1649–56. <https://doi.org/10.1093/eurheartj/ehr107>.
29. Baldi E, Caputo ML, Savastano S, et al. An Utstein-based model score to predict survival to hospital admission: the UB-ROSC score. *Int J Cardiol* 2020;308:84–9. <https://doi.org/10.1016/j.ijcard.2020.01.032>.
30. Caputo ML, Baldi E, Burkart R, et al. Validation of Utstein-based score to predict return of spontaneous circulation (UB-ROSC) in patients with out-of-hospital cardiac arrest. *Resuscitation* 2024;197:110113. <https://doi.org/10.1016/j.resuscitation.2024.110113>.
31. Baldi E, Contri E, Burkart R, Bywater D, Duschl M. The three dimension model of the out-of-hospital cardiac arrest. *Resuscitation* 2019;138:44–5. <https://doi.org/10.1016/j.resuscitation.2019.02.042>.
32. Eurostat. Demography of Europe. (<https://ec.europa.eu/eurostat/web/interactive-publications/demography-2024#population-structure>).
33. Bray J, Howell S, Ball S, et al. The epidemiology of out-of-hospital cardiac arrest in Australia and New Zealand: a binational report from the Australasian Resuscitation Outcomes Consortium (Aus-ROC). *Resuscitation* 2022;172:74–83. <https://doi.org/10.1016/j.resuscitation.2022.01.011>.
34. Ong ME, Shin SD, De Souza NN, et al. Outcomes for out-of-hospital cardiac arrests across 7 countries in Asia: the Pan Asian Resuscitation Outcomes Study (PAROS). *Resuscitation* 2015;96:100–8. <https://doi.org/10.1016/j.resuscitation.2015.07.026>.
35. Odom E, Nakajima Y, Vellano K, et al. Trends in EMS-attended out-of-hospital cardiac arrest survival, United States 2015–2019. *Resuscitation* 2022;179:88–93. <https://doi.org/10.1016/j.resuscitation.2022.08.003>.
36. Fothergill RT, Smith AL, Wrigley F, Perkins GD. Out-of-hospital cardiac arrest in London during the COVID-19 pandemic. *Resusc plus* 2021;5:100066. <https://doi.org/10.1016/j.resplu.2020.100066>.
37. Oving I, de Graaf C, Karlsson L, et al. Occurrence of shockable rhythm in out-of-hospital cardiac arrest over time: a report from the COSTA group. *Resuscitation* 2020;151:67–74. <https://doi.org/10.1016/j.resuscitation.2020.03.014>.
38. Jerkeman M, Sultanian P, Lundgren P, et al. Trends in survival after cardiac arrest: a Swedish nationwide study over 30 years. *Eur Heart J* 2022;43(46):4817–29. <https://doi.org/10.1093/eurheartj/ehac414>.
39. Hubar I, Fischer M, Monaco T, Grasner JT, Westenfeld R, Bernhard M. Development of the epidemiology and outcomes of out-of-hospital cardiac arrest using data from the German resuscitation register over a 15-year period (EpiCPR study). *Resuscitation* 2023;182:109648. <https://doi.org/10.1016/j.resuscitation.2022.11.014>.
40. Holmstrom L, Chugh H, Uy-Evanado A, Jui J, Reinier K, Chugh SS. Temporal trends in incidence and survival from sudden cardiac arrest manifesting with shockable and nonshockable rhythms: a 16-year prospective study in a large US community. *Ann Emerg Med* 2023;82(4):463–71. <https://doi.org/10.1016/j.annemergmed.2023.04.001>.
41. Alqahtani S, Nehme Z, Williams B, Bernard S, Smith K. Changes in the incidence of out-of-hospital cardiac arrest: differences between cardiac and non-cardiac aetiologies. *Resuscitation* 2020;155:125–33. <https://doi.org/10.1016/j.resuscitation.2020.07.016>.
42. Tanguay-Rioux X, Grunau B, Neumar R, Tallon J, Boone R, Christenson J. Is initial rhythm in OHCA a predictor of preceding no flow time? Implications for bystander response and ECPR candidacy evaluation. *Resuscitation* 2018;128:88–92. <https://doi.org/10.1016/j.resuscitation.2018.05.002>.
43. Hara M, Hayashi K, Hikoso S, Sakata Y, Kitamura T. Different Impacts of time from collapse to first cardiopulmonary resuscitation on outcomes after witnessed out-of-hospital cardiac arrest in adults. *Circ Cardiovasc Qual Outcomes* 2015;8(3):277–84. <https://doi.org/10.1161/CIRCOUTCOMES.115.001864>.
44. Cournoyer A, Chauny JM, Paquet J, et al. Electrical rhythm degeneration in adults with out-of-hospital cardiac arrest according to the no-flow and bystander low-flow time. *Resuscitation* 2021;167:355–61. <https://doi.org/10.1016/j.resuscitation.2021.07.021>.
45. Fovaeus H, Holmen J, Mandalenakis Z, Herlitz J, Rawshani A, Castellheim AG. Out-of-hospital cardiac arrest: Survival in children and young adults over 30 years, a nationwide registry-based cohort study. *Resuscitation* 2024;195:110103. <https://doi.org/10.1016/j.resuscitation.2023.110103>.
46. Tjelmeland IBM, Masterson S, Herlitz J, et al. Description of Emergency Medical Services, treatment of cardiac arrest patients and cardiac arrest registries in Europe. *Scand J Trauma Resusc Emerg Med* 2020;28(1):103. <https://doi.org/10.1186/s13049-020-00798-7> (In eng).
47. Travers S, Jost D, Gillard Y, et al. Out-of-hospital cardiac arrest phone detection: those who most need chest compressions are the most difficult to recognize. *Resuscitation* 2014;85(12):1720–5. <https://doi.org/10.1016/j.resuscitation.2014.09.020>.
48. Scquizzato T, Pallanch O, Belletti A, et al. Enhancing citizens response to out-of-hospital cardiac arrest: a systematic review of mobile-phone systems to alert citizens as first responders. *Resuscitation* 2020;152:16–25. <https://doi.org/10.1016/j.resuscitation.2020.05.006>.
49. Scquizzato T, Belloni O, Semeraro F, et al. Dispatching citizens as first responders to out-of-hospital cardiac arrests: a systematic review and meta-analysis. *Eur J Emerg Med* 2022;29(3):163–72. <https://doi.org/10.1097/MEJ.0000000000000915>.
50. Stromsoe A, Afzelius S, Axelsson C, et al. Improvements in logistics could increase survival after out-of-hospital cardiac arrest in Sweden. *J Intern Med* 2013;273(6):622–7. <https://doi.org/10.1111/joim.12041>.
51. Alm-Kruse K, Tjelmeland I, Kongsgard H, Kvale R, Kramer-Johansen J. Case completeness in the Norwegian cardiac arrest registry. *Resusc plus* 2021;8:100182. <https://doi.org/10.1016/j.resplu.2021.100182>.
52. Marks T, Metelmann B, Gamberini L, et al. Smartphone-based alert of community first responders: a multinational survey to characterise contemporary systems. *Resuscitation Plus* 2025;24. <https://doi.org/10.1016/j.resplu.2025.100988>.
53. Andelius L, Malta Hansen C, Jonsson M, et al. Smartphone-activated volunteer responders and bystander defibrillation for out-of-hospital cardiac arrest in private homes and public locations. *Eur Heart J Acute Cardiovasc Care* 2023;12(2):87–95. <https://doi.org/10.1093/ehjacc/zuac165>.
54. Metelmann B, Elschenbroich D, Auricchio A, et al. Proposal to increase safety of first responders dispatched to cardiac arrest. *Resusc Plus* 2023;14:100395. <https://doi.org/10.1016/j.resplu.2023.100395>.
55. Andelius L, Malta Hansen C, Tofte Gregers MC, et al. Risk of physical injury for dispatched citizen responders to out-of-hospital cardiac arrest. *J Am Heart Assoc* 2021;10(14):e021626. <https://doi.org/10.1161/JAHA.121.021626>.
56. Kragh AR, Andelius L, Gregers MT, et al. Immediate psychological impact on citizen responders dispatched through a mobile application to out-of-hospital cardiac arrests. *Resusc Plus* 2021;7:100155. <https://doi.org/10.1016/j.resplu.2021.100155>.
57. Metelmann C, Metelmann B, Herzberg L, et al. More patients could benefit from dispatch of citizen first responders to cardiac arrests. *Resuscitation* 2021;168:93–4. <https://doi.org/10.1016/j.resuscitation.2021.09.026>.
58. Schnaubelt S, Orlob S, Veigl C, et al. Out of sight – Out of mind? The need for a professional and standardized peri-mission first

- responder support model. *Resusc Plus* 2023;15:100449. <https://doi.org/10.1016/j.resplu.2023.100449>.
59. Lafrance M, Recher M, Javaudin F, et al. Bystander basic life support and survival after out-of-hospital cardiac arrest: a propensity score matching analysis. *Am J Emerg Med* 2023;67:135–43. <https://doi.org/10.1016/j.ajem.2023.02.028>.
 60. Dew R, Norton M, Aitken-Fell P, et al. Knowledge and barriers of out of hospital cardiac arrest bystander intervention and public access automated external defibrillator use in the Northeast of England: a cross-sectional survey study. *Intern Emerg Med* 2024;19(6):1705–15. <https://doi.org/10.1007/s11739-024-03549-z>.
 61. Ko YC, Hsieh MJ, Schnaubelt S, Matsuyama T, Cheng A, Greif R. Disparities in layperson resuscitation education: a scoping review. *Am J Emerg Med* 2023;72:137–46. <https://doi.org/10.1016/j.ajem.2023.07.033>.
 62. Lockey AS, Brown TP, Carlyon JD, Hawkes CA. Impact of community initiatives on non-EMS bystander CPR rates in West Yorkshire between 2014 and 2018. *Resusc Plus* 2021;6:100115. <https://doi.org/10.1016/j.resplu.2021.100115>.
 63. Petravic L, Miklic R, Burger E, et al. Enhancing bystander intervention: insights from the utstein analysis of out-of-hospital cardiac arrests in Slovenia. *Medicina (Kaunas)* 2024;60(8). <https://doi.org/10.3390/medicina60081227>.
 64. Reuter PG, Baert V, Colineaux H, et al. A national population-based study of patients, bystanders and contextual factors associated with resuscitation in witnessed cardiac arrest: insight from the french ReAC registry. *BMC Public Health* 2021;21(1):2202. <https://doi.org/10.1186/s12889-021-12269-4>.
 65. Shekhar A, Narula J. Globally, GDP per capita correlates strongly with rates of bystander CPR. *Ann Glob Health* 2022;88(1):36. <https://doi.org/10.5334/aogh.3624>.
 66. Kate Keeping C, Adam WG. Deprivation links to bystander cardiopulmonary resuscitation and defibrillation rates. *J Paramedic Practice* 2024;16(8):318–27. <https://doi.org/10.12968/jpar.2024.0024>.
 67. Ballesteros-Pena S, Jimenez-Mercado ME. Epidemiological characteristics and factors associated with out-of-hospital cardiac arrest attended by bystanders before ambulance arrival. *An Sist Sanit Navar* 2021;44(2):177–84. <https://doi.org/10.23938/ASSN.0944>.
 68. Wolthers SA, Jensen TW, Blomberg SN, et al. Out-of-hospital cardiac arrest related to exercise in the general population: incidence, survival and bystander response. *Resuscitation* 2022;172:84–91. <https://doi.org/10.1016/j.resuscitation.2022.01.021>.
 69. Baldi E, Grieco NB, Ristagno G, et al. The automated external defibrillator: heterogeneity of legislation, mapping and use across Europe. *New Insights from the ENSURE Study*. *J Clin Med* 2021;10(21). <https://doi.org/10.3390/jcm10215018>.
 70. Barry T, Kasemiire A, Quinn M, et al. Bystander defibrillation for out-of-hospital cardiac arrest in Ireland. *Resusc Plus* 2024;19:100712. <https://doi.org/10.1016/j.resplu.2024.100712>.
 71. Baldi E, Sechi GM, Mare C, et al. COVID-19 kills at home: the close relationship between the epidemic and the increase of out-of-hospital cardiac arrests. *Eur Heart J* 2020;41(32):3045–54. <https://doi.org/10.1093/eurheartj/ehaa508>.
 72. Barry T, Kasemiire A, Quinn M, et al. Health systems developments and predictors of bystander CPR in Ireland. *Resusc Plus* 2024;19:100671. <https://doi.org/10.1016/j.resplu.2024.100671>.
 73. Metelmann C, Metelmann B, Muller MP, Bottiger BW, Trummer G, Thies KC. First responder systems can stay operational under pandemic conditions: results of a European survey during the COVID-19 pandemic. *Scand J Trauma Resusc Emerg Med* 2022;30(1):10. <https://doi.org/10.1186/s13049-022-00998-3>.
 74. Gregers MCT, Andelius L, Malta Hansen C, et al. Activation of citizen responders to out-of-hospital cardiac arrest during the COVID-19 outbreak in Denmark 2020. *J Am Heart Assoc* 2022;11(6):e024140. <https://doi.org/10.1161/JAHA.121.024140>.
 75. Krawczyk A, Kurek K, Nucera G, et al. Effect of COVID-19 on the prevalence of bystanders performing cardiopulmonary resuscitation: a systematic review and meta-analysis. *Cardiol J* 2025;32(1):9–18. <https://doi.org/10.5603/cj.98616>.
 76. Tjelmeland IBM, Wnent J, Masterson S, et al. Did lockdown influence bystanders' willingness to perform cardiopulmonary resuscitation? A worldwide registry-based perspective. *Resuscitation* 2023;186:109764. <https://doi.org/10.1016/j.resuscitation.2023.109764>.
 77. Hawkes CA, Kander I, Contreras A, et al. Impact of the COVID-19 pandemic on public attitudes to cardiopulmonary resuscitation and publicly accessible defibrillator use in the UK. *Resusc Plus* 2022;10:100256. <https://doi.org/10.1016/j.resplu.2022.100256>.
 78. Baldi E, Caputo ML, Auricchio A, Vanetta C, Cresta R, Benvenuti C. A quantitative assessment of the contribution of "citizen first responder" in the adult out-of-hospital chain of survival during COVID-19 pandemic. *Resuscitation* 2021;166:41–2. <https://doi.org/10.1016/j.resuscitation.2021.07.024>.
 79. Zheng J, Lv C, Zheng W, et al. Incidence, process of care, and outcomes of out-of-hospital cardiac arrest in China: a prospective study of the BASIC-OHCA registry. *Lancet Public Health* 2023;8(12):e923–32. [https://doi.org/10.1016/S2468-2667\(23\)00173-1](https://doi.org/10.1016/S2468-2667(23)00173-1).
 80. Li S, Qin C, Zhang H, et al. Survival after out-of-hospital cardiac arrest before and after legislation for bystander CPR. *JAMA Netw Open* 2024;7(4):e247909. <https://doi.org/10.1001/jamanetworkopen.2024.7909>.
 81. van Rensburg L, Majiet N, Geldenhuys A, King LL, Stassen W. A resuscitation systems analysis for South Africa: a narrative review. *Resusc Plus* 2024;18:100655. <https://doi.org/10.1016/j.resplu.2024.100655>.
 82. Kabongo D, Issa M, Diango K, Bilomba P, Simbi C, Nsambi AD. Evaluation of resuscitation systems in the Democratic Republic of Congo: a narrative review. *Resusc Plus* 2024;18:100656. <https://doi.org/10.1016/j.resplu.2024.100656>.
 83. Blom MT, Oving I, Berdowski J, van Valkengoed IGM, Bardai A, Tan HL. Women have lower chances than men to be resuscitated and survive out-of-hospital cardiac arrest. *Eur Heart J* 2019;40(47):3824–34. <https://doi.org/10.1093/eurheartj/ehz297>.
 84. Nehme Z, Andrew E, Bernard S, Smith K. Sex differences in the quality-of-life and functional outcome of cardiac arrest survivors. *Resuscitation* 2019;137:21–8. <https://doi.org/10.1016/j.resuscitation.2019.01.034>.
 85. Andrew E, Nehme Z, Lijovic M, Bernard S, Smith K. Outcomes following out-of-hospital cardiac arrest with an initial cardiac rhythm of asystole or pulseless electrical activity in Victoria, Australia. *Resuscitation* 2014;85(11):1633–9. <https://doi.org/10.1016/j.resuscitation.2014.07.015>.
 86. Dumas F, Rea TD. Long-term prognosis following resuscitation from out-of-hospital cardiac arrest: role of aetiology and presenting arrest rhythm. *Resuscitation* 2012;83(8):1001–5. <https://doi.org/10.1016/j.resuscitation.2012.01.029>.
 87. Mader TJ, Nathanson BH, Millay S, et al. Out-of-hospital cardiac arrest outcomes stratified by rhythm analysis. *Resuscitation* 2012;83(11):1358–62. <https://doi.org/10.1016/j.resuscitation.2012.03.033>.
 88. Andrew E, Nehme Z, Bernard S, Smith K. The influence of comorbidity on survival and long-term outcomes after out-of-hospital cardiac arrest. *Resuscitation* 2017;110:42–7. <https://doi.org/10.1016/j.resuscitation.2016.10.018>.
 89. Hirlekar G, Jonsson M, Karlsson T, Hollenberg J, Albertsson P, Herlitz J. Comorbidity and survival in out-of-hospital cardiac arrest. *Resuscitation* 2018;133:118–23. <https://doi.org/10.1016/j.resuscitation.2018.10.006>.
 90. Herlitz J, Eek M, Holmberg M, Engdahl J, Holmberg S. Characteristics and outcome among patients having out of hospital cardiac arrest at home compared with elsewhere. *Heart* 2002;88(6):579–82. <https://doi.org/10.1136/heart.88.6.579>.

91. Andersson A, Arctadius I, Cronberg T, et al. In-hospital versus out-of-hospital cardiac arrest: Characteristics and outcomes in patients admitted to intensive care after return of spontaneous circulation. *Resuscitation* 2022;176:1–8. <https://doi.org/10.1016/j.resuscitation.2022.04.023>.
92. Brown TP, Booth S, Hawkes CA, et al. Characteristics of neighbourhoods with high incidence of out-of-hospital cardiac arrest and low bystander cardiopulmonary resuscitation rates in England. *Eur Heart J Qual Care Clin Outcomes* 2019;5(1):51–62. <https://doi.org/10.1093/ehjqcco/qcy026>.
93. Jonsson M, Harkonen J, Ljungman P, et al. Survival after out-of-hospital cardiac arrest is associated with area-level socioeconomic status. *Heart* 2019;105(8):632–8. <https://doi.org/10.1136/heartjnl-2018-313838>.
94. Zhao D, Post WS, Blasco-Colmenares E, et al. Racial differences in sudden cardiac death. *Circulation* 2019;139(14):1688–97. <https://doi.org/10.1161/CIRCULATIONAHA.118.036553>.
95. Chocron R, Loeb T, Lamhaut L, et al. Ambulance density and outcomes after out-of-hospital cardiac arrest. *Circulation* 2019;139(10):1262–71. <https://doi.org/10.1161/CIRCULATIONAHA.118.035113>.
96. Rosell Ortiz F, Mellado Vergel F, Lopez Messa JB, et al. Survival and neurologic outcome after out-of-hospital cardiac arrest. Results of the andalusian out-of-hospital cardiopulmonary arrest registry. *Rev Esp Cardiol (Engl Ed)* 2016;69(5):494–500. <https://doi.org/10.1016/j.rec.2015.09.022>.
97. Tranberg T, Lippert FK, Christensen EF, et al. Distance to invasive heart centre, performance of acute coronary angiography, and angioplasty and associated outcome in out-of-hospital cardiac arrest: a nationwide study. *Eur Heart J* 2017;38(21):1645–52. <https://doi.org/10.1093/eurheartj/ehx104>.
98. Wyckoff MH, Greif R, Morley PT, et al. 2022 International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations: summary from the basic life support; advanced life support; pediatric life support; neonatal life support; education, implementation, and teams; and first aid task forces. *Resuscitation* 2022;181:208–88. <https://doi.org/10.1016/j.resuscitation.2022.10.005>.
99. Byrne RA, Rossello X, Coughlan JJ, et al. 2023 ESC guidelines for the management of acute coronary syndromes. *Eur Heart J* 2023;44(38):3720–826. <https://doi.org/10.1093/eurheartj/ehad191>.
100. Granfeldt A, Holmberg MJ, Nolan JP, Soar J, Andersen LW. International Liaison Committee on Resuscitation Advanced Life Support Task F. Targeted temperature management in adult cardiac arrest: Systematic review and meta-analysis. *Resuscitation* 2021;167:160–72. <https://doi.org/10.1016/j.resuscitation.2021.08.040>.
101. Dankiewicz J, Cronberg T, Lilja G, et al. Hypothermia versus normothermia after out-of-hospital cardiac arrest. *N Engl J Med* 2021;384(24):2283–94. <https://doi.org/10.1056/NEJMoa2100591>.
102. Arrich J, Schutz N, Oppenauer J, et al. Hypothermia for neuroprotection in adults after cardiac arrest. *Cochrane Database Syst Rev* 2023;5(5):CD004128. <https://doi.org/10.1002/14651858.CD004128.pub5>.
103. Balian S, Buckler DG, Blewer AL, Bhardwaj A, Abella BS, Group CS. Variability in survival and post-cardiac arrest care following successful resuscitation from out-of-hospital cardiac arrest. *Resuscitation* 2019;137:78–86. <https://doi.org/10.1016/j.resuscitation.2019.02.004>.
104. Stub D, Schmicker RH, Anderson ML, et al. Association between hospital post-resuscitative performance and clinical outcomes after out-of-hospital cardiac arrest. *Resuscitation* 2015;92:45–52. <https://doi.org/10.1016/j.resuscitation.2015.04.015>.
105. Beck B, Bray J, Cameron P, et al. Regional variation in the characteristics, incidence and outcomes of out-of-hospital cardiac arrest in Australia and New Zealand: results from the Aus-ROC Epistry. *Resuscitation* 2018;126:49–57. <https://doi.org/10.1016/j.resuscitation.2018.02.029>.
106. Moller SG, Wissenberg M, Moller-Hansen S, et al. Regional variation in out-of-hospital cardiac arrest: incidence and survival – A nationwide study of regions in Denmark. *Resuscitation* 2020;148:191–9. <https://doi.org/10.1016/j.resuscitation.2020.01.019>.
107. Ruiz-Azpiazu JI, Daponte-Codina A, Fernandez Del Valle P, et al. Regional variation in the incidence, general characteristics, and outcomes of prehospital cardiac arrest in Spain: the out-of-hospital Spanish cardiac arrest registry. *Emergencias* 2021;33(1):15–22. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/33496395>.
108. Garcia RA, Girotra S, Jones PG, et al. Variation in out-of-hospital cardiac arrest survival across emergency medical service agencies. *Circ Cardiovasc Qual Outcomes* 2022;15(6):e008755. <https://doi.org/10.1161/CIRCOUTCOMES.121.008755>.
109. Wissenberg M, Lippert FK, Folke F, et al. Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. *JAMA* 2013;310(13):1377–84. <https://doi.org/10.1001/jama.2013.278483>.
110. Shiozumi T, Matsuyama T, Nishioka N, et al. Evaluation of interventions in prehospital and in-hospital settings and outcomes for out-of-hospital cardiac arrest patients meeting the termination of resuscitation rule in Japan: a nationwide database study (the JAAM-OHCA Registry). *Resuscitation* 2025;208:110530. <https://doi.org/10.1016/j.resuscitation.2025.110530>.
111. Masterson S, Stromsoe A, Cullinan J, Deasy C, Vellinga A. Apples to apples: can differences in out-of-hospital cardiac arrest incidence and outcomes between Sweden and Ireland be explained by core Utstein variables? *Scand J Trauma Resusc Emerg Med* 2018;26(1):37. <https://doi.org/10.1186/s13049-018-0505-2>.
112. Timmis A, Aboyans V, Vardas P, et al. European society of cardiology: the 2023 atlas of cardiovascular disease statistics. *Eur Heart J* 2024;45(38):4019–62. <https://doi.org/10.1093/eurheartj/ehae466>.
113. Hawkes C, Booth S, Ji C, et al. Epidemiology and outcomes from out-of-hospital cardiac arrests in England. *Resuscitation* 2017;110:133–40. <https://doi.org/10.1016/j.resuscitation.2016.10.030>.
114. Luc G, Baert V, Escutnaire J, et al. Epidemiology of out-of-hospital cardiac arrest: a French national incidence and mid-term survival rate study. *Anaesth Crit Care Pain Med* 2019;38(2):131–5. <https://doi.org/10.1016/j.accpm.2018.04.006>.
115. Ruiz Azpiazu JI, Fernandez Del Valle P, Escriche MC, et al. Incidence, treatment, and factors associated with survival of out-of-hospital cardiac arrest attended by Spanish emergency services: report from the out-of-hospital Spanish cardiac arrest registry for 2022. *Emergencias* 2024;36(2):131–9. <https://doi.org/10.5563/s3me/014.2024>.
116. Vasko P. SWEDEHEART Annual report 2023. 2024. (<https://www.ucr.uu.se/swedeheart/dokument-sh/arsrapporter-sh/01-swedeheart-annual-report-2023-english-2/viewdocument/3657>).
117. DANSK HJERTESTOPREGISTER. 2023. (<https://hjerTESTOPregister.dk/wp-content/uploads/2024/05/Aarsrapport-fra-Dansk-HjerTESTOPregister-2023.pdf>).
118. Tjelmeland IBM, Alm-Kruse K, Grasner JT, et al. Importance of reporting survival as incidence: a cross-sectional comparative study on out-of-hospital cardiac arrest registry data from Germany and Norway. *BMJ Open* 2022;12(2):e058381. <https://doi.org/10.1136/bmjopen-2021-058381>.
119. Bockler B, Preisner A, Bathe J, et al. Gender-related differences in adults concerning frequency, survival and treatment quality after out-of-hospital cardiac arrest (OHCA): an observational cohort study from the German resuscitation registry. *Resuscitation* 2024;194:110060. <https://doi.org/10.1016/j.resuscitation.2023.110060>.
120. Rosemurgy AS, Olson SM, Hurst JM, Albrink MH. Prehospital traumatic cardiac arrest: the cost of futility. *J Trauma* 1993;35(3):468–73.

121. Grasner JT, Wnent J, Seewald S, et al. Cardiopulmonary resuscitation traumatic cardiac arrest—there are survivors. An analysis of two national emergency registries. *Crit Care* 2011;15(6):R276. <https://doi.org/10.1186/cc10558>.
122. Leis CC, Hernandez CC, Blanco MJ, Paterna PC, Hernandez Rde E, Torres EC. Traumatic cardiac arrest: should advanced life support be initiated? *J Trauma Acute Care Surg* 2013;74(2):634–8. <https://doi.org/10.1097/TA.0b013e31827d5d3c>.
123. Parliament E. Declaration of the European Parliament of 14 June 2012 on establishing a European cardiac arrest awareness week.
124. Blewer AL, McGovern SK, Schmicker RH, et al. Gender disparities among adult recipients of bystander cardiopulmonary resuscitation in the public. *Circ Cardiovasc Qual Outcomes* 2018;11(8):e004710. <https://doi.org/10.1161/CIRCOUTCOMES.118.004710>.
125. Shen CP, Bhavnani SP, Rogers JD. New innovations to address sudden cardiac arrest. *US Cardiol* 2024;18:e09. <https://doi.org/10.15420/usc.2023.25>.
126. Damuth E, Baldwin C, Schmalbach N, Green A, Puri N, Jones CW. Sex disparity in extracorporeal membrane oxygenation clinical trial enrollment. *Crit Care Med* 2025;53(2):e424–8. <https://doi.org/10.1097/CCM.0000000000006539>.
127. Amacher SA, Zimmermann T, Gebert P, et al. Sex disparities in ICU care and outcomes after cardiac arrest: a Swiss nationwide analysis. *Crit Care* 2025;29(1):42. <https://doi.org/10.1186/s13054-025-05262-5>.
128. Lupton JR, Schmicker RH, Aufderheide TP, et al. Racial disparities in out-of-hospital cardiac arrest interventions and survival in the pragmatic airway resuscitation trial. *Resuscitation* 2020;155:152–8. <https://doi.org/10.1016/j.resuscitation.2020.08.004>.
129. Gupta K, Raj R, Asaki SY, Kennedy K, Chan PS. Comparison of out-of-hospital cardiac arrest outcomes between Asian and white individuals in the United States. *J Am Heart Assoc* 2023;12(18):e030087. <https://doi.org/10.1161/JAHA.123.030087>.
130. Huebinger R, Power E, Del Rios M, et al. Factors mediating community race and ethnicity differences in initial shockable rhythm for out-of-hospital cardiac arrests in Texas. *Resuscitation* 2024;200:110238. <https://doi.org/10.1016/j.resuscitation.2024.110238>.
131. Anderson ML, Cox M, Al-Khatib SM, et al. Rates of cardiopulmonary resuscitation training in the United States. *JAMA Intern Med* 2014;174(2):194–201. <https://doi.org/10.1001/jamainternmed.2013.11320>.
132. Lane-Fall MB. Why Diversity, Equity, and Inclusion Matter for Patient Safety. *ASA Monitor* 2021;85(11):42.
133. Lilley R, Davie G, Dicker B, et al. Rural and ethnic disparities in out-of-hospital care and transport pathways after road traffic trauma in New Zealand. *West J Emerg Med* 2024;25(4):602–13. <https://doi.org/10.5811/westjem.18366>.
134. Dicker B, Todd VF, Tunnage B, et al. Ethnic disparities in the incidence and outcome from out-of-hospital cardiac arrest: a New Zealand observational study. *Resuscitation* 2019;145:56–62. <https://doi.org/10.1016/j.resuscitation.2019.09.026>.
135. Garcia RA, Spertus JA, Girotra S, et al. Racial and ethnic differences in bystander CPR for witnessed cardiac arrest. *N Engl J Med* 2022;387(17):1569–78. <https://doi.org/10.1056/NEJMoa2200798>.
136. Nagaraja V, Burgess S. The importance of equity in health care. *J Soc Cardiovasc Angiogr Interv* 2023;2(5):101065. <https://doi.org/10.1016/j.jscv.2023.101065>.
137. Bray J, Dainty K, Haywood K, Morrison LJ, Castren M, Sasson C. WISER: a women's international group to inspire, support and empower women in resuscitation. *Resusc Plus* 2024;19:100693. <https://doi.org/10.1016/j.resplu.2024.100693>.
138. Abate SM, Nega S, Basu B, Mesfin R, Tadesse M. Global burden of out-of-hospital cardiac arrest in children: a systematic review, meta-analysis, and meta-regression. *Pediatr Res* 2023;94(2):423–33. <https://doi.org/10.1038/s41390-022-02462-5>.
139. Pireddu R, Ristagno G, Gianquintieri L, et al. Out-of-hospital cardiac arrest in the paediatric patient: an observational study in the context of national regulations. *J Clin Med* 2024;13(11). <https://doi.org/10.3390/jcm13113133>.
140. Katzenschlager S, Kelpandides IK, Ristau P, et al. Out-of-hospital cardiac arrest in children: an epidemiological study based on the German Resuscitation Registry identifying modifiable factors for return of spontaneous circulation. *Crit Care* 2023;27(1):349. <https://doi.org/10.1186/s13054-023-04630-3>.
141. Holgersen MG, Jensen TW, Breindahl N, et al. Pediatric out-of-hospital cardiac arrest in Denmark. *Scand J Trauma Resusc Emerg Med* 2022;30(1):58. <https://doi.org/10.1186/s13049-022-01045-x>.
142. Kelpandides IK, Katzenschlager S, Skogvoll E, et al. Out-of-hospital cardiac arrest in children in Norway: a national cohort study, 2016–2021. *Resusc Plus* 2024;18:100662. <https://doi.org/10.1016/j.resplu.2024.100662>.
143. Gelberg J, Stromsoe A, Hollenberg J, et al. Improving survival and neurologic function for younger age groups after out-of-hospital cardiac arrest in Sweden: a 20-year comparison. *Pediatr Crit Care Med* 2015;16(8):750–7. <https://doi.org/10.1097/PCC.0000000000000503>.
144. Bardai A, Berdowski J, van der Werf C, et al. Incidence, causes, and outcomes of out-of-hospital cardiac arrest in children. A comprehensive, prospective, population-based study in the Netherlands. *J Am Coll Cardiol* 2011;57(18):1822–8. <https://doi.org/10.1016/j.jacc.2010.11.054>.
145. de Vicente CD, Ruiz Frias A, Fernandez Del Valle P, Gomez Jimenez J, Rosell OF. Long-term survival after out-of-hospital cardiac arrest in children: outcomes in Andalusia in 2008–2019. *Emergencias* 2024;36(4):290–7. <https://doi.org/10.55633/s3me/047.2024>.
146. Herlitz J, Svensson L, Engdahl J, et al. Characteristics of cardiac arrest and resuscitation by age group: an analysis from the Swedish cardiac arrest registry. *Am J Emerg Med* 2007;25(9):1025–31. <https://doi.org/10.1016/j.ajem.2007.03.008>.
147. Albargi H, Mallett S, Berhane S, et al. Bystander cardiopulmonary resuscitation for paediatric out-of-hospital cardiac arrest in England: an observational registry cohort study. *Resuscitation* 2022;170:17–25. <https://doi.org/10.1016/j.resuscitation.2021.10.042>.
148. Albrecht M, de Jonge RCJ, Nadkarni VM, et al. Association between shockable rhythms and long-term outcome after pediatric out-of-hospital cardiac arrest in Rotterdam, the Netherlands: an 18-year observational study. *Resuscitation* 2021;166:110–20. <https://doi.org/10.1016/j.resuscitation.2021.05.015>.
149. Ng ZHC, Ho SJ, Caleb T, et al. Long-term outcomes after non-traumatic out-of-hospital cardiac arrest in pediatric patients: a systematic review. *J Clin Med* 2022;11(17). <https://doi.org/10.3390/jcm11175003>.
150. Nehme Z, Namachivayam S, Forrest A, Butt W, Bernard S, Smith K. Trends in the incidence and outcome of paediatric out-of-hospital cardiac arrest: a 17-year observational study. *Resuscitation* 2018;128:43–50. <https://doi.org/10.1016/j.resuscitation.2018.04.030>.
151. Fink EL, Prince DK, Kaltman JR, et al. Unchanged pediatric out-of-hospital cardiac arrest incidence and survival rates with regional variation in North America. *Resuscitation* 2016;107:121–8. <https://doi.org/10.1016/j.resuscitation.2016.07.244> (In eng).
152. Tham LP, Wah W, Phillips R, et al. Epidemiology and outcome of paediatric out-of-hospital cardiac arrests: a paediatric sub-study of the Pan-Asian resuscitation outcomes study (PAROS). *Resuscitation* 2018;125:111–7. <https://doi.org/10.1016/j.resuscitation.2018.01.040>.
153. Idrees S, Abdullah R, Anderson KK, Tijssen JA. Sociodemographic factors associated with paediatric out-of-hospital cardiac arrest: a systematic review. *Resuscitation* 2023;192:109931. <https://doi.org/10.1016/j.resuscitation.2023.109931>.

154. Penketh J, Nolan JP. In-hospital cardiac arrest: the state of the art. *Crit Care* 2022;26(1):376. <https://doi.org/10.1186/s13054-022-04247-y>.
155. Grasner JT, Herlitz J, Tjelmeland IBM, et al. European resuscitation council guidelines 2021: epidemiology of cardiac arrest in Europe. *Resuscitation* 2021;161:61–79. <https://doi.org/10.1016/j.resuscitation.2021.02.007>.
156. Albert M, Herlitz J, Rawshani A, et al. Aetiology and outcome in hospitalized cardiac arrest patients. *Eur Heart J Open* 2023;3(4) oead066. <https://doi.org/10.1093/ehjopen/oead066>.
157. Bruchfeld S, Ullemarck E, Riva G, Ohm J, Rawshani A, Djarv T. Aetiology and predictors of outcome in non-shockable in-hospital cardiac arrest: a retrospective cohort study from the Swedish registry for cardiopulmonary resuscitation. *Acta Anaesthesiol Scand* 2024;68(10):1504–14. <https://doi.org/10.1111/aas.14496>.
158. Creutzburg A, Isbye D, Rasmussen LS. Incidence of in-hospital cardiac arrest at general wards before and after implementation of an early warning score. *BMC Emerg Med* 2021;21(1):79. <https://doi.org/10.1186/s12873-021-00469-5>.
159. Flam B, Andersson Franko M, Skrifvars MB, et al. Trends in incidence and outcomes of cardiac arrest occurring in Swedish ICUs. *Crit Care Med* 2024;52(1):e11–20. <https://doi.org/10.1097/CCM.0000000000006067>.
160. Silverplats J, Ang B, Kallestedt MS, Stromsoe A. Incidence and case ascertainment of treated in-hospital cardiac arrest events in a national quality registry – A comparison of reported and non-reported events. *Resuscitation* 2024;195:110119. <https://doi.org/10.1016/j.resuscitation.2024.110119>.
161. Yonis H, Andersen MP, Mills EHA, et al. Duration of resuscitation and long-term outcome after in-hospital cardiac arrest: a nationwide observational study. *Resuscitation* 2022;179:267–73. <https://doi.org/10.1016/j.resuscitation.2022.08.011>.
162. Radeschi G, Mina A, Berta G, et al. Incidence and outcome of in-hospital cardiac arrest in Italy: a multicentre observational study in the piedmont region. *Resuscitation* 2017;119:48–55. <https://doi.org/10.1016/j.resuscitation.2017.06.020>.
163. Nolan JP, Soar J, Smith GB, et al. Incidence and outcome of in-hospital cardiac arrest in the United Kingdom national cardiac arrest audit. *Resuscitation* 2014;85(8):987–92. <https://doi.org/10.1016/j.resuscitation.2014.04.002>.
164. Hessulf F, Karlsson T, Lundgren P, et al. Factors of importance to 30-day survival after in-hospital cardiac arrest in Sweden - a population-based register study of more than 18,000 cases. *Int J Cardiol* 2018;255:237–42. <https://doi.org/10.1016/j.ijcard.2017.12.068>.
165. Andersen LW, Holmberg MJ, Lofgren B, Kirkegaard H, Granfeldt A. Adult in-hospital cardiac arrest in Denmark. *Resuscitation* 2019;140:31–6. <https://doi.org/10.1016/j.resuscitation.2019.04.046>.
166. Adamski J, Nowakowski P, Gorynski P, Onichimowski D, Weigl W. Incidence of in-hospital cardiac arrest in Poland. *Anaesthesiol Intensive Ther* 2016;48(5):288–93. <https://doi.org/10.5603/AIT.a2016.0054>.
167. Chan PS, Greif R, Anderson T, et al. Ten steps toward improving in-hospital cardiac arrest quality of care and outcomes. *Resuscitation* 2023;193:109996. <https://doi.org/10.1016/j.resuscitation.2023.109996>.
168. Whitaker DK, Nolan JP, Castren M, Abela C, Goldik Z. Implementing a standard internal telephone number 2222 for cardiac arrest calls in all hospitals in Europe. *Resuscitation* 2017;115:A14–5. <https://doi.org/10.1016/j.resuscitation.2017.03.025>.
169. Verborgh H, degrèVe W, Foubert L. Alerting and organisation of the flemish resuscitation teams. *Acta Anaesth Belg* 2021;72:267–73.
170. Madsen JL, Lauridsen KG, Lofgren B. In-hospital cardiac arrest call procedures and delays of the cardiac arrest team: a nationwide study. *Resusc Plus* 2021;5:100087. <https://doi.org/10.1016/j.resplu.2021.100087>.
171. Py N, Prunet B, Lamblin A, et al. European standard internal telephone number 2222 for in-hospital emergency calls: a national survey in all French military training hospitals. *Resusc Plus* 2022;10:100228. <https://doi.org/10.1016/j.resplu.2022.100228>.
172. A H, O G, B K. Standardising the Use of “2222” for In-Hospital Cardiac Arrest Calls. *Irish Med J* 2020;113(8):1–4.
173. McGuigan PJ, Edwards J, Blackwood B, et al. The association between time of in hospital cardiac arrest and mortality; a retrospective analysis of two UK databases. *Resuscitation* 2023;186:109750. <https://doi.org/10.1016/j.resuscitation.2023.109750>.
174. Cronberg T, Greer DM, Lilja G, Moulart V, Swindell P, Rossetti AO. Brain injury after cardiac arrest: from prognostication of comatose patients to rehabilitation. *Lancet Neurol* 2020;19(7):611–22. [https://doi.org/10.1016/S1474-4422\(20\)30117-4](https://doi.org/10.1016/S1474-4422(20)30117-4).
175. Perkins GD, Callaway CW, Haywood K, et al. Brain injury after cardiac arrest. *Lancet* 2021;398(10307):1269–78. [https://doi.org/10.1016/S0140-6736\(21\)00953-3](https://doi.org/10.1016/S0140-6736(21)00953-3).
176. Chin YH, Yaow CYL, Teoh SE, et al. Long-term outcomes after out-of-hospital cardiac arrest: a systematic review and meta-analysis. *Resuscitation* 2022;171:15–29. <https://doi.org/10.1016/j.resuscitation.2021.12.026>.
177. Zook N, Voss S, Blennow Nordstrom E, et al. Neurocognitive function following out-of-hospital cardiac arrest: a systematic review. *Resuscitation* 2022;170:238–46. <https://doi.org/10.1016/j.resuscitation.2021.10.005>.
178. Yaow CYL, Teoh SE, Lim WS, et al. Prevalence of anxiety, depression, and post-traumatic stress disorder after cardiac arrest: a systematic review and meta-analysis. *Resuscitation* 2022;170:82–91. <https://doi.org/10.1016/j.resuscitation.2021.11.023>.
179. Pek PP, Fan KC, Ong MEH, et al. Determinants of health-related quality of life after out-of-hospital cardiac arrest (OHCA): a systematic review. *Resuscitation* 2023;188:109794. <https://doi.org/10.1016/j.resuscitation.2023.109794>.
180. Chen X, Li D, He L, et al. The prevalence of anxiety and depression in cardiac arrest survivors: a systematic review and meta-analysis. *Gen Hosp Psychiatry* 2023;83:8–19. <https://doi.org/10.1016/j.genhosppsych.2023.03.013>.
181. Rojas DA, DeForge CE, Abukhadra SL, Farrell L, George M, Agarwal S. Family experiences and health outcomes following a loved ones' hospital discharge or death after cardiac arrest: a scoping review. *Resusc Plus* 2023;14:100370. <https://doi.org/10.1016/j.resplu.2023.100370>.
182. Hermansen AS, Joshi VL, Wagner MK, et al. Caregiver strain among relatives of out-of-hospital cardiac arrest survivors; the DANCAS relative survey. *Resuscitation* 2024;201:110298. <https://doi.org/10.1016/j.resuscitation.2024.110298>.
183. Joshi VL, Borregaard B, Mikkelsen TB, et al. Observer-reported cognitive decline in out-of-hospital cardiac arrest survivors and its association with long-term survivor and relative outcomes. *Resuscitation* 2024;197:110162. <https://doi.org/10.1016/j.resuscitation.2024.110162>.
184. Bohm M, Cronberg T, Arestedt K, et al. Caregiver burden and health-related quality of life amongst caregivers of out-of-hospital cardiac arrest survivors. *Resuscitation* 2021;167:118–27. <https://doi.org/10.1016/j.resuscitation.2021.08.025>.
185. Pinto NP, Scholefield BR, Topjian AA. Pediatric cardiac arrest: a review of recovery and survivorship. *Resuscitation* 2024;194:110075. <https://doi.org/10.1016/j.resuscitation.2023.110075>.
186. Haywood K, Whitehead L, Nadkarni VM, et al. COSCA (Core outcome set for cardiac arrest) in adults: an advisory statement from the international liaison committee on resuscitation. *Resuscitation* 2018;127:147–63. <https://doi.org/10.1016/j.resuscitation.2018.03.022>.
187. Topjian AA, Scholefield BR, Pinto NP, et al. P-COSCA (Pediatric core outcome set for cardiac arrest) in children: an advisory

- statement from the international liaison committee on resuscitation. *Resuscitation* 2021;162:351–64. <https://doi.org/10.1016/j.resuscitation.2021.01.023>.
188. Le Brun Powell J, Haywood K. Assessing the uptake of core outcome sets in adult and paediatric cardiac-arrest research: a review of randomised controlled trials. *Resuscitation* 2024;203S1: S11–S238.
 189. Blennow Nordstrom E, Evald L, Mion M, et al. Combined use of the montreal cognitive assessment and symbol digit modalities test improves neurocognitive screening accuracy after cardiac arrest: a validation sub-study of the TTM2 trial. *Resuscitation* 2024;202:110361. <https://doi.org/10.1016/j.resuscitation.2024.110361>.
 190. van Gils P, van Heugten C, Hofmeijer J, Keijzer H, Nutma S, Duits A. The montreal cognitive assessment is a valid cognitive screening tool for cardiac arrest survivors. *Resuscitation* 2022;172:130–6. <https://doi.org/10.1016/j.resuscitation.2021.12.024>.
 191. Nolan JP, Sandroni C, Bottiger BW, et al. European resuscitation council and european society of intensive care medicine guidelines 2021: post-resuscitation care. *Resuscitation* 2021;161:220–69. <https://doi.org/10.1016/j.resuscitation.2021.02.012>.
 192. Lilja G, Ullen S, Dankiewicz J, et al. Effects of hypothermia vs normothermia on societal participation and cognitive function at 6 months in survivors after out-of-hospital cardiac arrest: a predefined analysis of the TTM2 randomized clinical trial. *JAMA Neurol* 2023;80(10):1070–9. <https://doi.org/10.1001/jamaneurol.2023.2536>.
 193. Arestedt K, Israelsson J, Djukanovic I, et al. Symptom prevalence of anxiety and depression in older cardiac arrest survivors: a comparative nationwide register study. *J Clin Med* 2021;10(18). <https://doi.org/10.3390/jcm10184285>.
 194. Christensen AV, Dixon JK, Juel K, et al. Psychometric properties of the danish hospital anxiety and depression scale in patients with cardiac disease: results from the DenHeart survey. *Health Qual Life Outcomes* 2020;18(1):9. <https://doi.org/10.1186/s12955-019-1264-0>.
 195. Wimmer H, Lundqvist C, Saltyte Benth J, et al. Health-related quality of life after out-of-hospital cardiac arrest – A five-year follow-up study. *Resuscitation* 2021;162:372–80. <https://doi.org/10.1016/j.resuscitation.2021.01.036>.
 196. Moolaert VRM, van Heugten CM, Gorgels TPM, Wade DT, Verbunt JA. Long-term outcome after survival of a cardiac arrest: a prospective longitudinal cohort study. *Neurorehabil Neural Repair* 2017;31(6):530–9. <https://doi.org/10.1177/1545968317697032>.
 197. Kim YJ, Rogers JC, Raina KD, et al. An intervention for cardiac arrest survivors with chronic fatigue: a feasibility study with preliminary outcomes. *Resuscitation* 2016;105:109–15. <https://doi.org/10.1016/j.resuscitation.2016.05.020>.
 198. Joshi VL, Tang LH, Kim YJ, et al. Promising results from a residential rehabilitation intervention focused on fatigue and the secondary psychological and physical consequences of cardiac arrest: the SCARF feasibility study. *Resuscitation* 2022;173:12–22. <https://doi.org/10.1016/j.resuscitation.2022.02.002>.
 199. Joshi VL, Tang LH, Mikkelsen TB, et al. Does time heal fatigue, psychological, cognitive and disability problems in people who experience an out-of-hospital cardiac arrest? Results from the DANCAS survey study. *Resuscitation* 2023;182:109639. <https://doi.org/10.1016/j.resuscitation.2022.11.005>.
 200. Amtmann D, Bamer AM, Noonan V, Lang N, Kim J, Cook KF. Comparison of the psychometric properties of two fatigue scales in multiple sclerosis. *Rehabil Psychol* 2012;57(2):159–66. <https://doi.org/10.1037/a0027890>.
 201. Bohm M, Lilja G, Finnbogadottir H, et al. Detailed analysis of health-related quality of life after out-of-hospital cardiac arrest. *Resuscitation* 2019;135:197–204. <https://doi.org/10.1016/j.resuscitation.2018.10.028>.
 202. Nolan JPSC, Cariou A, Cronberg T, et al. European resuscitation council and european society of intensive care medicine guidelines 2025: post-resuscitation care. *Resuscitation* 2025.
 203. Moolaert VR, Verbunt JA, Bakx WG, et al. 'Stand still, and move on', a new early intervention service for cardiac arrest survivors and their caregivers: rationale and description of the intervention. *Clin Rehabil* 2011;25(10):867–79. <https://doi.org/10.1177/0269215511399937>.
 204. Moolaert VR, van Haastregt JC, Wade DT, van Heugten CM, Verbunt JA. 'Stand still, and move on', an early neurologically-focused follow-up for cardiac arrest survivors and their caregivers: a process evaluation. *BMC Health Serv Res* 2014;14(1):34. <https://doi.org/10.1186/1472-6963-14-34>.
 205. Moolaert VR, van Heugten CM, Winkens B, et al. Early neurologically-focused follow-up after cardiac arrest improves quality of life at one year: a randomised controlled trial. *Int J Cardiol* 2015;193:8–16. <https://doi.org/10.1016/j.ijcard.2015.04.229>.
 206. Moolaert VR, Goossens M, Heijnders IL, Verbunt JA, Heugten CM. Early neurologically focused follow-up after cardiac arrest is cost-effective: a trial-based economic evaluation. *Resuscitation* 2016;106:30–6. <https://doi.org/10.1016/j.resuscitation.2016.06.015>.
 207. Johan I, Gisela L. Post cardiac arrest follow-up – Swedish guidelines available. *Lakartidningen* 2019;116:FIIP.
 208. Paul M, Paquereau J, Legriel S, Cariou A. Follow up of cardiac arrest survivors: survey of French intensivists practices. *Resuscitation* 2024;199:110208. <https://doi.org/10.1016/j.resuscitation.2024.110208>.
 209. Bradfield M, Haywood KL, Mion M, Kayani A, Leckey S. Rcuq quality standards group for care RoCASKS. Not just surviving: towards a quality standard which meets the care and rehabilitation needs of cardiac arrest survivors and their key supporters. *Resuscitation* 2024;198:110182. <https://doi.org/10.1016/j.resuscitation.2024.110182>.
 210. Mion M, Simpson R, Johnson T, et al. British cardiovascular intervention society consensus position statement on out-of-hospital cardiac arrest 2: post-discharge rehabilitation. *Interv Cardiol* 2022;17:e19. <https://doi.org/10.15420/icr.2022.08>.
 211. Government S. Out-of-Hospital Cardiac Arrest: A Strategy for Scotland. (www.gov.scot/Publications/2015/03/7484).
 212. van Til JA, Hemels MEW, Hofmeijer J. Cognitive screening and rehabilitation after cardiac arrest: only a few hurdles to take. *Neth Heart J* 2024;32(1):63–6. <https://doi.org/10.1007/s12471-023-01838-4>.
 213. Mion M, Case R, Smith K, et al. Follow-up care after out-of-hospital cardiac arrest: a pilot study of survivors and families' experiences and recommendations. *Resusc Plus* 2021;7:100154. <https://doi.org/10.1016/j.resplu.2021.100154>.
 214. Nolan JP, Soar J, Cariou A, et al. European resuscitation council and European society of intensive care medicine guidelines for post-resuscitation care 2015: section 5 of the European resuscitation council guidelines for Resuscitation 2015. *Resuscitation* 2015;95:202–22. <https://doi.org/10.1016/j.resuscitation.2015.07.018>.
 215. Mion M, Al-Janabi F, Islam S, et al. Care after REsuscitation: implementation of the United Kingdom's first dedicated multidisciplinary follow-up program for survivors of out-of-hospital cardiac arrest. *Ther Hypothermia Temp Manag* 2020;10(1):53–9. <https://doi.org/10.1089/ther.2018.0048>.
 216. Mandrini A, Mion M, Primi R, et al. The REVIVE project: from survival to holistic recovery—A prospective multicentric evaluation of cognitive, emotional, and quality-of-life outcomes in out-of-hospital cardiac arrest survivors. *J Clin Med* 2025;14(11):3631. <https://doi.org/10.3390/jcm14113631>.
 217. Wagner MK, Christensen J, Christensen KA, et al. A multidisciplinary guideline-based approach to improving the sudden cardiac arrest care pathway: the Copenhagen framework. *Resusc Plus* 2024;17:100546. <https://doi.org/10.1016/j.resplu.2023.100546>.

218. Joshi VL, Christensen J, Lejsgaard E, Taylor RS, Zwisler AD, Tang LH. Effectiveness of rehabilitation interventions on the secondary consequences of surviving a cardiac arrest: a systematic review and meta-analysis. *BMJ Open* 2021;11(9):e047251. <https://doi.org/10.1136/bmjopen-2020-047251>.
219. Christensen J, Winkel BG, Eskildsen SJ, Gottlieb R, Hassager C, Wagner MK. Return-to-work and rehabilitation needs in cardiac arrest survivors: an exploratory cross-sectional study. *Eur J Cardiovasc Nurs* 2023;22(3):328–31. <https://doi.org/10.1093/eurjcn/zvac039>.
220. Tang LH, Joshi V, Egholm CL, Zwisler AD. Are survivors of cardiac arrest provided with standard cardiac rehabilitation? – Results from a national survey of hospitals and municipalities in Denmark. *Eur J Cardiovasc Nurs* 2021;20(2):115–23. <https://doi.org/10.1177/1474515120946313>.
221. Boyce LW, Goossens PH, Moulart VR, Pound G, van Heugten CM. Out-of-hospital cardiac arrest survivors need both cardiologic and neurologic rehabilitation! *Curr Opin Crit Care* 2019;25(3):240–3. <https://doi.org/10.1097/MCC.0000000000000609>.
222. Lilja G, Blennow NE. What you ask for is what you get: a practical approach for early cognitive screening and the potential for individualized support after cardiac arrest. *Resuscitation* 2017;116:A5–6. <https://doi.org/10.1016/j.resuscitation.2017.05.007>.
223. Boyce LW, Goossens PH. Rehabilitation after cardiac arrest: integration of neurologic and cardiac rehabilitation. *Semin Neurol* 2017;37(1):94–102. <https://doi.org/10.1055/s-0036-1593860>.
224. Boyce-van der Wal LW, Volker WG, Vliet Vlieland TP, van den Heuvel DM, van Exel HJ, Goossens PH. Cognitive problems in patients in a cardiac rehabilitation program after an out-of-hospital cardiac arrest. *Resuscitation* 2015;93:63–8. <https://doi.org/10.1016/j.resuscitation.2015.05.029>.
225. Adiguzel E, Yasar E, Kesikburun S, et al. Are rehabilitation outcomes after severe anoxic brain injury different from severe traumatic brain injury? A matched case-control study. *Int J Rehabil Res* 2018;41(1):47–51. <https://doi.org/10.1097/MRR.0000000000000261>.
226. van Erp WS, Lavrijsen JC, Vos PE, Bor H, Laureys S, Koopmans RT. The vegetative state: prevalence, misdiagnosis, and treatment limitations. *J Am Med Dir Assoc* 2015;16(1):85. <https://doi.org/10.1016/j.jamda.2014.10.014>. e9–85 e14.
227. Heinz UE, Rollnik JD. Outcome and prognosis of hypoxic brain damage patients undergoing neurological early rehabilitation. *BMC Res Notes* 2015;8(1):243. <https://doi.org/10.1186/s13104-015-1175-z>.
228. Tazopoulou E, Miljkovitch R, Truelle JL, et al. Rehabilitation following cerebral anoxia: an assessment of 27 patients. *Brain Inj* 2016;30(1):95–103. <https://doi.org/10.3109/02699052.2015.1113563>.
229. Meyer L, Stubbs B, Fahnenbruch C, et al. Incidence, causes, and survival trends from cardiovascular-related sudden cardiac arrest in children and young adults 0 to 35 years of age: a 30-year review. *Circulation* 2012;126(11):1363–72. <https://doi.org/10.1161/CIRCULATIONAHA.111.076810>.
230. Semsarian C, Ingles J, Wilde AA. Sudden cardiac death in the young: the molecular autopsy and a practical approach to surviving relatives. *Eur Heart J* 2015;36(21):1290–6. <https://doi.org/10.1093/eurheartj/ehv063>.
231. Bagnall RD, Weintraub RG, Ingles J, et al. A prospective study of sudden cardiac death among children and young adults. *N Engl J Med* 2016;374(25):2441–52. <https://doi.org/10.1056/NEJMoa1510687>.
232. Risgaard B, Winkel BG, Jabbari R, et al. Burden of sudden cardiac death in persons aged 1 to 49 years: nationwide study in Denmark. *Circ Arrhythm Electrophysiol* 2014;7(2):205–11. <https://doi.org/10.1161/CIRCEP.113.001421>.
233. Behr ER, Scrocco C, Wilde AAM, et al. Investigation on Sudden Unexpected Death in the Young (SUDY) in Europe: results of the European Heart Rhythm Association Survey. *Europace* 2022;24(2):331–9. <https://doi.org/10.1093/europace/euab176>.
234. Amin AS, Wilde AAM. The future of sudden cardiac death research. *Prog Pediatr Cardiol* 2017;45:49–54. <https://doi.org/10.1016/j.ppedcard.2017.02.008>.
235. Ackerman MJ, Priori SG, Willems S, et al. HRS/EHRA expert consensus statement on the state of genetic testing for the channelopathies and cardiomyopathies: this document was developed as a partnership between the Heart Rhythm Society (HRS) and the European Heart Rhythm Association (EHRA). *Europace* 2011;13(8):1077–109. <https://doi.org/10.1093/europace/eur245>.
236. Finocchiaro G, Radaelli D, Johnson D, et al. Yield of molecular autopsy in sudden cardiac death in athletes: data from a large registry in the UK. *Europace* 2024;26(2). <https://doi.org/10.1093/europace/eaue029>.
237. Isbister JC, Semsarian C. The role of the molecular autopsy in sudden cardiac death in young individuals. *Nat Rev Cardiol* 2024;21(4):215–6. <https://doi.org/10.1038/s41569-024-00989-0>.
238. Martinez-Barrios E, Grassi S, Brion M, et al. Molecular autopsy: twenty years of post-mortem diagnosis in sudden cardiac death. *Front Med (Lausanne)* 2023;10:1118585. <https://doi.org/10.3389/fmed.2023.1118585>.
239. Stanasiuk C, Milting H, Homm S, et al. Blood taken immediately after fatal resuscitation attempts yields higher quality DNA for genetic studies as compared to autopsy samples. *Int J Legal Med* 2023;137(5):1569–81. <https://doi.org/10.1007/s00414-023-02966-z>.
240. Campuzano O, Sanchez-Molero O, Allegue C, et al. Post-mortem genetic analysis in juvenile cases of sudden cardiac death. *Forensic Sci Int* 2014;245:30–7. <https://doi.org/10.1016/j.forsciint.2014.10.004>.
241. Chugh SS, Senashova O, Watts A, et al. Postmortem molecular screening in unexplained sudden death. *J Am Coll Cardiol* 2004;43(9):1625–9. <https://doi.org/10.1016/j.jacc.2003.11.052>.
242. Di Paolo M, Luchini D, Bloise R, Priori SG. Postmortem molecular analysis in victims of sudden unexplained death. *Am J Forensic Med Pathol* 2004;25(2):182–4. <https://doi.org/10.1097/01.paf.0000127406.20447.8a>.
243. Skinner JR, Crawford J, Smith W, et al. Prospective, population-based long QT molecular autopsy study of postmortem negative sudden death in 1 to 40 year olds. *Heart Rhythm* 2011;8(3):412–9. <https://doi.org/10.1016/j.hrthm.2010.11.016>.
244. Winkel BG, Holst AG, Theilade J, et al. Sudden unexpected death in infancy in Denmark. *Scand Cardiovasc J* 2011;45(1):14–20. <https://doi.org/10.3109/14017431.2010.538433>.
245. Tester DJ, Ackerman MJ. The molecular autopsy: should the evaluation continue after the funeral? *Pediatr Cardiol* 2012;33(3):461–70. <https://doi.org/10.1007/s00246-012-0160-8>.
246. Isbister JC, Nowak N, Butters A, et al. “Concealed cardiomyopathy” as a cause of previously unexplained sudden cardiac arrest. *Int J Cardiol* 2021;324:96–101. <https://doi.org/10.1016/j.ijcard.2020.09.031>.
247. Martinez-Barrios E, Sarquella-Brugada G, Perez-Serra A, et al. Reevaluation of ambiguous genetic variants in sudden unexplained deaths of a young cohort. *Int J Legal Med* 2023;137(2):345–51. <https://doi.org/10.1007/s00414-023-02951-0>.
248. Lahrouchi N, Raju H, Lodder EM, et al. Utility of post-mortem genetic testing in cases of sudden arrhythmic death syndrome. *J Am Coll Cardiol* 2017;69(17):2134–45. <https://doi.org/10.1016/j.jacc.2017.02.046>.
249. Schwartz PJ, Dagradi F. Management of survivors of cardiac arrest – The importance of genetic investigation. *Nat Rev Cardiol* 2016;13(9):560–6. <https://doi.org/10.1038/nrcardio.2016.104>.
250. Stiles MK, Wilde AAM, Abrams DJ, et al. 2020 APHRS/HRS expert consensus statement on the investigation of decedents with sudden unexplained death and patients with sudden cardiac arrest, and of

- their families. *Heart Rhythm* 2021;18(1):e1–e50. <https://doi.org/10.1016/j.hrthm.2020.10.010>.
251. Finocchiaro G, Radaelli D, D'Errico S, et al. Ethnicity and sudden cardiac death in athletes: insights from a large United Kingdom registry. *Eur J Prev Cardiol* 2024;31(12):1518–25. <https://doi.org/10.1093/euripr/zwae146>.
 252. Zeppenfeld K, Tfelt-Hansen J, de Riva M, et al. 2022 ESC guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death. *Eur Heart J* 2022;43(40):3997–4126. <https://doi.org/10.1093/eurheartj/ehac262>.
 253. Sarquella-Brugada G, Fernandez-Falgueras A, Cesar S, et al. Clinical impact of rare variants associated with inherited channelopathies: a 5-year update. *Hum Genet* 2022;141(10):1579–89. <https://doi.org/10.1007/s00439-021-02370-4>.
 254. Fellmann F, van El CG, Charron P, et al. European recommendations integrating genetic testing into multidisciplinary management of sudden cardiac death. *Eur J Hum Genet* 2019;27(12):1763–73. <https://doi.org/10.1038/s41431-019-0445-y>.
 255. Tiesmeier J, Gaertner A, Homm S, et al. The emergency medical service has a crucial role to unravel the genetics of sudden cardiac arrest in young, out of hospital resuscitated patients: interim data from the MAP-IT study. *Resuscitation* 2021;168:176–85. <https://doi.org/10.1016/j.resuscitation.2021.07.042>.
 256. de Noronha SV, Behr ER, Papadakis M, et al. The importance of specialist cardiac histopathological examination in the investigation of young sudden cardiac deaths. *Europace* 2014;16(6):899–907. <https://doi.org/10.1093/europace/eut329>.
 257. Wilde AAM, Semsarian C, Marquez MF, et al. European Heart Rhythm Association (EHRA)/Heart Rhythm Society (HRS)/Asia Pacific Heart Rhythm Society (APHRS)/Latin American Heart Rhythm Society (LAHRS) expert consensus statement on the state of genetic testing for cardiac diseases. *J Arrhythm* 2022;38(4):491–553. <https://doi.org/10.1002/joa3.12717>.
 258. Slijvo A, Jevtic T, Sirucic I, et al. Out-of-hospital cardiac arrest (OHCA) in Bosnia and Herzegovina in the period 2018–2022: current trends, usage of automated external defibrillators (AED) and bystanders' involvement. *Med Glas (Zenica)* 2024;21(2):267–73. <https://doi.org/10.17392/1719-21-2>.
 259. Randjelovic S, Nikolovski S, Selakovic D, et al. Time Is life: golden ten minutes on Scene-EuReCa_Serbia 2014–2023. *Medicina (Kaunas)* 2024;60(4). <https://doi.org/10.3390/medicina60040624>.
 260. Schnaubelt S, Monsieurs KG, Semeraro F, et al. Clinical outcomes from out-of-hospital cardiac arrest in low-resource settings – A scoping review. *Resuscitation* 2020;156:137–45. <https://doi.org/10.1016/j.resuscitation.2020.08.126>.
 261. Krishna CK, Showkat HI, Taktani M, Khatri V. Out of hospital cardiac arrest resuscitation outcome in North India - CARO study. *World J Emerg Med* 2017;8(3):200–5. <https://doi.org/10.5847/wjem.1920-8642.2017.03.007>.
 262. Raffee LA, Samrah SM, Al Yousef HN, Abeeleh MA, Alawneh KZ. Incidence, characteristics, and survival trend of cardiopulmonary resuscitation following in-hospital compared to out-of-hospital cardiac arrest in Northern Jordan. *Indian J Crit Care Med* 2017;21(7):436–41. https://doi.org/10.4103/ijccm.IJCCM_15_17.
 263. Mawani M, Kadir MM, Azam I, et al. Epidemiology and outcomes of out-of-hospital cardiac arrest in a developing country-a multicenter cohort study. *BMC Emerg Med* 2016;16(1):28. <https://doi.org/10.1186/s12873-016-0093-2>.
 264. Monsomboon A, Chantawatsharakorn P, Suksuriyayothin S, et al. Prevalence of emergency medical service utilisation in patients with out-of-hospital cardiac arrest in Thailand. *Emerg Med J* 2016;33(3):213–7. <https://doi.org/10.1136/emmermed-2015-204818>.
 265. Rahim Khan U, Baig N, Bhojwani KM, et al. Epidemiology and outcomes of out of hospital cardiac arrest in Karachi, Pakistan – A longitudinal study. *Resusc Plus* 2024;20:100773. <https://doi.org/10.1016/j.resplu.2024.100773>.
 266. Stassen W, Wylie C, Djarv T, Wallis LA. Out-of-hospital cardiac arrests in the city of Cape Town, South Africa: a retrospective, descriptive analysis of prehospital patient records. *BMJ Open* 2021;11(8):e049141. <https://doi.org/10.1136/bmjopen-2021-049141>.
 267. Trevisan M, Bocián J, Caminos M, et al. Out-of-hospital cardiac arrest in bariloche: incidence, distribution and context. evaluation of the potential usefulness of an automated external defibrillator program. *Revista Argentina de Cardiología* 2018;86(5):329–35. <https://doi.org/10.7775/rac.v86.i5.12640>.
 268. Navab E, Esmaeili M, Poorkhorshidi N, Salimi R, Khazaei A, Moghimbeigi A. Predictors of out of hospital cardiac arrest outcomes in pre-hospital settings; a retrospective cross-sectional study. *Arch Acad Emerg Med* 2019;7(1):e36.
 269. Xuan Dao C, Quoc Luong C, Manabe T, et al. Impact of bystander cardiopulmonary resuscitation on out-of-hospital cardiac arrest outcome in Vietnam. *West J Emerg Med* 2024;25(4):507–20. <https://doi.org/10.5811/westjem.18413>.
 270. Hosny R, Hussein RS, Hussein WM, Hakim SA, Habil IS. Effectiveness of rapid response team implementation in a tertiary hospital in Egypt: an interventional study. *BMJ Open Qual* 2024;13(3). <https://doi.org/10.1136/bmjog-2023-002540>.
 271. Alum RA, Kiwanuka JK, Nakku D, Kakande ER, Nyaiteera V, Ttendo SS. Factors associated with in-hospital post-cardiac arrest survival in a referral level hospital in Uganda. *Anesth Analg* 2022;135(5):1073–81. <https://doi.org/10.1213/ANE.0000000000006132>.
 272. De Silva AP, Sujeewa JA, De Silva N, et al. A retrospective study of physiological observation-reporting practices and the recognition, response, and outcomes following cardiopulmonary arrest in a low-to-middle-income country. *Indian J Crit Care Med* 2017;21(6):343–5. https://doi.org/10.4103/ijccm.IJCCM_136_17.
 273. Jamous SE, Kouatly I, Irani J, Badr LK. Implementing a rapid response team: a quality improvement project in a low- to middle-income country. *Dimens Crit Care Nurs* 2023;42(3):171–8. <https://doi.org/10.1097/DCC.0000000000000584>.
 274. Segond N, Viglino D, Duhem H, et al. Neurological outcome of cardiac arrest patients in mountain areas: an analysis of the Northern French Alps Emergency Network. *Am J Emerg Med* 2024;81:47–52. <https://doi.org/10.1016/j.ajem.2024.04.017>.
 275. Mikiewicz M, Polok K, Szczeklik W, Gorka A, Kosinski S. Sudden cardiac arrests in the polish Tatra mountains: a retrospective study. *Wilderness Environ Med* 2023;34(2):128–34. <https://doi.org/10.1016/j.wem.2022.11.005>.
 276. Strohle M, Vogele A, Neuhauser P, Rauch S, Brugger H, Paal P. Sudden cardiac arrest and cardiopulmonary resuscitation with automated external defibrillator in the Austrian mountains: a retrospective study. *High Alt Med Biol* 2019;20(4):392–8. <https://doi.org/10.1089/ham.2018.0134>.
 277. Connolly MS, Goldstein Pcp JP, Currie M, et al. Urban-rural differences in cardiac arrest outcomes: a retrospective population-based cohort study. *CJC Open* 2022;4(4):383–9. <https://doi.org/10.1016/j.cjco.2021.12.010>.
 278. Nikonowicz P, Huebinger R, Al-Araji R, et al. Rural cardiac arrest care and outcomes in Texas. *Am J Emerg Med* 2024;78:57–61. <https://doi.org/10.1016/j.ajem.2023.12.033>.
 279. Smith A, Ball S, Stewart K, Finn J. The reality of rurality: Understanding the impact of remoteness on out-of-hospital cardiac arrest in Western Australia – A retrospective cohort study. *Aust J Rural Health* 2024;32(6):1159–72. <https://doi.org/10.1111/ajr.13184>.
 280. Smith A, Finn J, Stewart K, Ball S. Dispelling the remoteness myth—a geospatial analysis of where out-of-hospital cardiac arrests are occurring in Western Australia. *Resusc Plus* 2024;20:100805. <https://doi.org/10.1016/j.resplu.2024.100805>.