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Clinical paper

European registry of cardiac arrest study THREE (EuReCa- THREE) – EMS response time influence on outcome in Europe

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Abstract

Background: Throughout Europe there are important differences in the structure and characteristics of Emergency Medical Services (EMS) and their response to out-of-hospital cardiac arrest (OHCA). The primary aim of EuReCa-THREE was to examine the epidemiology of cardiac arrest in Europe and explore the association between EMS response time and survival.

Methods: EuReCa-THREE was an international, prospective, registry-based, cohort study, for which data were collected from 1 September to 30 November 2022 from 28 countries. Primary research questions were focused on assessing time intervals and their impact on outcomes.

Results: Of the 45,251 confirmed OHCA cases, 32,033 were treated by the EMS i.e. resuscitation started or continued. The mean response time was 12.2 min (range 6.4–22.8), with 25% of patients were reached within 7 min. For all cases where resuscitation was started or continued by EMS, the rate of any ROSC was 31.2% (range 17.0–42.7), ROSC sustained until arrival at the emergency department and transfer of care (survived event) was 22.5%(range 12.3–25.5) and overall survival was 7.5% (range 3.1–35.0), (incidence 4.0 per 100,000 inhabitants, range 1.7–24.6).

Conclusion: The results of EuReCa-THREE highlight continuing variation in the incidence, management and outcomes from OHCA across Europe. For patients who were EMS-treated, results indicate clear associations between response times and the likelihood of survival.

Keywords: Out-of-hospital cardiac arrest, Resuscitation, Epidemiology, EuReCa, Time intervals, Response time, Survival

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Introduction

Atwood *et al* estimated that Emergency Medical Services (EMS) in Europe treat approximately 275,000 people for out of hospital cardiac arrests (OHCA) each year, of which approximately 29,000 patients would survive.[1] This estimate was based on a systematic review of peer-reviewed articles published between 1980 and 2004 from which they identified 18,105 cardiac arrests giving an overall incidence of 38 per 100,000 inhabitants per year. More recent studies showed large variations in incidence of and survival from OHCA in European countries.[2–7] The European Registry of Cardiac Arrest (EuReCa) network was established in 2007.[2,5–8] In 2014 the first EuReCa study was conducted over one month, collecting information on the epidemiology of OHCA in 27 countries. The EuReCa-TWO study, which included 28 European countries (2017) extended the study period from one to three months and focused on better understanding the role of the bystander. As well as data on OHCA incidence and outcomes, data were reported on OHCA treatment, as well as EMS system characteristics and performance.[2,5,7,8]

The primary aim of EuReCa-THREE was to examine the epidemiology of cardiac arrest in Europe and explore the association between EMS response time and survival. Secondary aims were to examine the association between other EMS time intervals and different survival outcomes.[9–12]

Material and methods

EuReCa-THREE was an international, multi centre, prospective, registry-based, cohort study.[13] All resuscitation registries that were able to deliver the core data set were invited to participate in the study. Every participating country was represented by one national coordinator. The national coordinator was responsible for data collection, data transfer, and the accuracy of the data from the respective country. The full EuReCa-THREE study protocol has previously been published.[13]

Patients who sustained an OHCA between 1st September and 30th November 2022 and had a resuscitation attempt (chest compressions and/or defibrillation) by bystanders, first responders and/or by EMS were included. An OHCA was defined by EMS personnel when a patient (any age) was unconscious and not breathing normally. In addition, patients who had a resuscitation attempted before EMS arrival and were alive when EMS arrived were included if EMS confirmed the cardiac arrest. This included patients who were shocked by an AED and regained a pulse before EMS arrival.

Data collection was based on a pre-defined data dictionary which was similar to the dataset of EuReCa-ONE and TWO studies.[2,5,7] A Microsoft Excel data sheet was provided for each participating country. Where a resuscitation registry already existed locally or nationally, data were extracted from that registry and entered on to the Excel data sheet. Two countries with existing registries (United Kingdom, Sweden) provided only cases where EMS confirmed cardiac arrest and started or continued CPR. All other countries also reported the number of cases where CPR was not started/continued by EMS. Data were checked for completeness, plausibility, and double entries by the study statistician. Data errors or inconsistencies were flagged to the national coordinator who reviewed and if necessary, amended the initial submission data. The national coordinators also provided data about the population covered by the registry to enable calculation of incidences per 100,000 population and year.

All data were then merged into a single database for further analysis.

In line with the Utstein definition, CPR performed by a person who was not responding as part of an organised EMS system was defined as bystander-CPR. According to the Utstein definition, any person alerted to the scene by the dispatch centre is not a bystander and was defined in our study as “a person sent to help“. A person sent to help was e.g. a lay volunteer, police officer, firefighter, off-duty clinician, who is alerted by the emergency-dispatch system (e.g. SMS, pager, smartphone app) to provide a community-based response before EMS arrival.

Data for twelve time points were collected in the EuReCa-THREE study: time of arrest; time of call; start of telephone CPR; start of CPR by bystander, helper, and EMS; arrival of EMS on scene; shock; time of first ROSC; end of CPR; left scene; and arrival at hospital. As per study protocol, if the time of arrest was not recorded the time of start of CPR by bystander was used as a surrogate measure. If neither of these time points was available, time of call was used as the surrogate measure.

Time stamps were transformed into time intervals (one country directly provided intervals instead of time stamps). For each time interval, implausible intervals were checked for typing errors midnight change, and use of 12 or 24 h format. Remaining times which were outside a predefined range of plausible values were considered missing. From these time points, the following time intervals were calculated: Response time from call to EMS arrival at scene if collapse was not witnessed by EMS (valid interval 1–70 min); EMS treatment time from EMS arrival/start until end of CPR due to ROSC or cessation (valid interval 1–119 min); and Travel Time from scene to hospital in cases with hospital admission. It should be noted that, in France, OHCA response includes medical and non-medical response units. The Service Mobile d’Urgence et de Réanimation (SMUR) provide the medical response units, and consists of advanced life support ambulances staffed by physicians and specialised personnel. In addition to SMUR, emergency transport and basic life support are provided by fire services and private ambulance companies. In the data provided for EuReCa-THREE for France, only SMUR is considered an EMS response. Response times are therefore calculated based on the time of arrival at scene of a SMUR unit.

Study outcomes were calculated for the EMS-treated cohort and included (i) any ROSC during resuscitation; (ii) ROSC sustained until arrival at the emergency department and transfer of care to medical staff at the receiving hospital (i.e. survived event) and (iii) survival. Survival is primarily reported based on survival to hospital discharge unless this was unavailable, in which case 30 day survival was used. Survival was missing for 11.4 % of those admitted to hospital. Overall survival rate was calculated based on all cases with CPR by EMS and outcome data available.

Statistical analysis

Data analysis was performed with the Statistical Package for Social Sciences (SPSS, version 29, IBM Inc., Armonk, NY, USA). Categorical data were presented as numbers with percentages, and metric data as mean with standard deviation (SD). In case of skewed data, if appropriate, median and inter-quartile range (IQR) were provided

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in addition. Time intervals were compared using Mann-Whitney *U* test. Overall incidences were calculated as an average of incidences per country.

A generalised mixed linear model was used to examine the effect of response time on whether the patient was classified as having a survived event adjusted for age, location, presumed aetiology (medical, trauma, and other non-medical like asphyxia etc.), whether the collapse was witnessed, bystander CPR, initial shockable rhythm, and response time (7 categories, plus unknown). Results are presented as adjusted odds ratios (aOR) with 95 % confidence intervals (95 %CI). Country served as a random factor. Cases of EMS-witnessed cardiac arrest or where ROSC was achieved before EMS arrival were excluded from this analysis.

Ethical approval

EuReCa-THREE was approved by the University of Kiel Ethics Committee (reference number D422/22). The study was registered with the German Registry of Clinical Trials, Registration Number: DRKS00028591, searchable via WHO meta-registry (http://apps.who.int/trialsearch/). National co-ordinators were responsible for obtaining ethical approval at country level or providing written confirmation if local ethical approval was not required. Due to the observational nature of the study and use of routinely collected, anonymised data, patient consent was not expected to be required. If national regulations required consent to be sought, this was the responsibility of the national co-ordinator.

Results

EuReCA-THREE data were contributed by 28 countries, representing 64 % of European countries, and over 230 million individuals. Population coverage ranged from 4.0 % to 100 % (average: 44.6 %; 10 countries reported complete population coverage).

There were 47,973 suspected OHCAs reported, of which 45,251 were coded as confirmed. For the remaining cases, OHCA confirmation was assumed if EMS started CPR, or an initial shockable rhythm was detected. Based on this assumption, the total number of confirmed cases rose to 47,440 (98.9 %), and non-confirmed cases (n = 533) were excluded from further analysis. The incidence of OHCA per 100,000 population per year was 82.3 (range: 31–243).

In 32,033 cases, CPR was started or continued by the EMS. In addition, in 2,816 cases CPR was started by someone else before arrival of EMS but not continued. The cohort of 32,033 cases was used as the main denominator for the EuReCa-THREE study (see Flow Sheet Fig. 1, Box 1) giving an incidence of 55.6 per 100,000 population per year (range: 17–104). For this cohort, the overall ROSC rate was 31.1 % (incidence 17.2 per 100,000 population/year), and the overall survival rate was 7.5 % (incidence: 4.0 per 100,000 population/year; Table 1).

Patient characteristics

As shown in Table 1, 64.5 % of patients were male and the mean age was 67.2 years (SD 17.3). There was variation in the mean age between countries (range 57.9–74.3 years). On average, females were older than males (70.1 years versus 65.9 years).

Most incidents occurred in a private residence (71.3 %) or long-term care facilities (4.2 %). For public settings, 8.7 % incidents occurred on the street 6.9 % in public buildings; 1.9 % at work/ in an office; 0.7 % in sport facilities; and 5.4 % in other public places. Further descriptive information is included in Table 1, and details of country values are provided in a Supplementary Table.

CPR before EMS arrival

Excluding EMS-witnessed OHCA, the rate of bystander CPR was 61.1 % (14,567/26,844). In 1,606 cases (6.7 %) CPR was started by a person who was “sent to help” by the EMS. In 32.2 % of all cases (n = 7,671), EMS was the first to initiate resuscitation. EMS

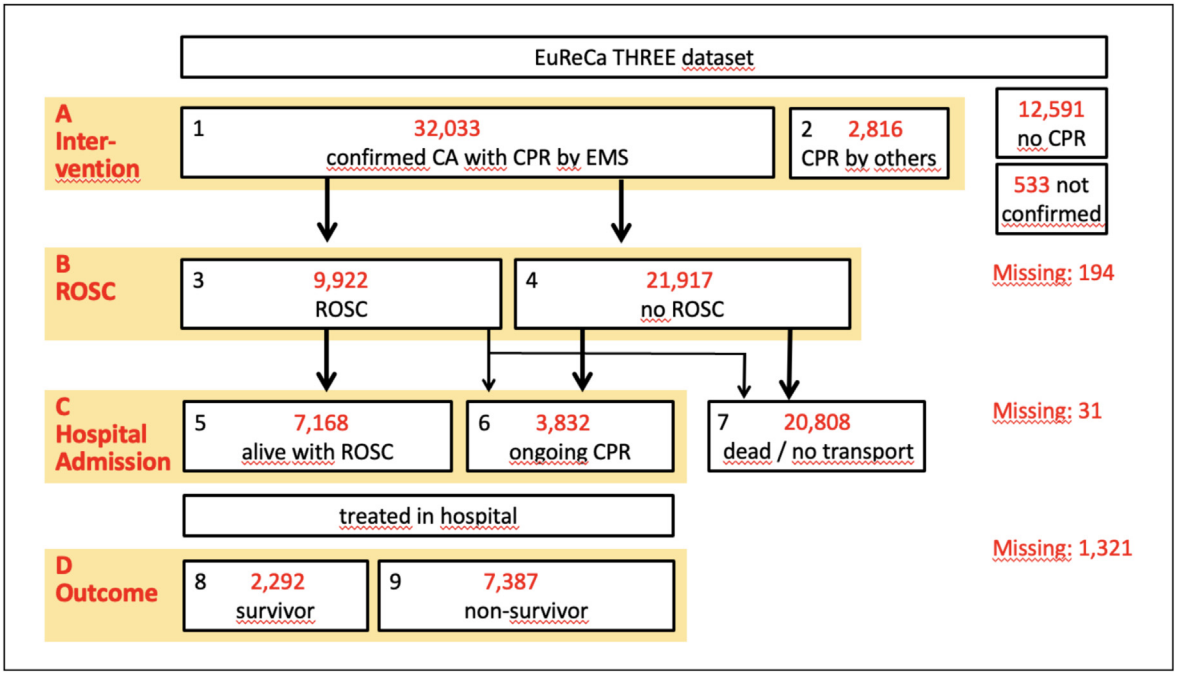

Fig. 1 – Flow chart (CA = cardiac arrest, CPR = cardio pulmonary resuscitation, EMS = emergency medical service, ROSC = return od spontaneous circulation).

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Table 1 – Descriptive data and outcome of patients with OHCA, overall and range of country values for EMS-treated OHCA.

	Data available N (%)	Overall average or rate	Range of country values
Confirmed CA and CPR by EMS	32,033		23–6971
Mean age (years)	31,803 (99.3 %)	68.5 (17.5)	57.9–74.3
Male sex (%)	30,618 (95.6 %)	61.7	43.9–78.3
Cause: medical (%)		85.1	64.6–97.3
traumatic (%)	32,033 (100 %)	4.5	0–11.5
other non-medical (%)		10.4	1.8–32.9
Initial shockable rhythm (%)	30,611 (95.6 %)	20.6	8.3–39.1
Location: at residence (%)	31,763 (99.2 %)	71.3	47.8–84.3
Collapse witnessed by EMS (%)		17.8	0–33.9
by bystander (%)	28,990 (90.5 %)	54,8	41.6–92.9
Bystander CPR (%)	31,759 (99.1 %)	52.5	16.9–78.3
Any ROSC (%)	31,893 (99.4 %)	31.2	17.0–42.7
Hospital arrival status (%):		22.5	12.3–35.5
survived event ongoing CPR	31,808 (99.3 %)	12.0	1.5–69.8
dead on scene		65.5	8.7–80.0
Patients admitted to hospital, with ROSC or ongoing CPR (n)	11,000(34.5 %)		12–2152
Hospital outcome available (%)	9,679(88.0 %)		38.9–100
Survival after hospital admission (%)	9,726	23.6	12.7–58.3
Overall survival: Discharged alive (or at 30 days) based on all CPR started by EMS (%)	30,534 (95.3 %)	7.5	3.1–35.0
Survivor per 100,000 population per year	2292	4.0	1.7–24.6

(OHCA = out of hospital cardiac arrest, CA = cardiac arrest, CPR = cardio pulmonary resuscitation, EMS = emergency medical service, ROSC = return od spontaneous circulation).

crews also started resuscitation in all EMS-witnessed cases (n = 5,146). Overall, EMS started resuscitation in 45.2 % of all cases (n = 14,494).

The bystander CPR rate was calculated for all cases with CPR started (box 1 + 2 in the flow sheet, Fig. 1). Excluding EMS-witnessed OHCA (n = 5185, plus 166 cases with missing data regarding who stated) the rate of bystander CPR was 59.4 % (17,518 of 29,498). In 2,452 cases (8.3 %) CPR was started by a person who was "sent to help" by the EMS. In 32.3 of all cases (n = 9,528), EMS was the first to initiate resuscitation.

Survival

Amongst the EMS-treated cohort, outcomes for those admitted to hospital was available for 9,679 patients (88.0 %). Amongst this group 2,292 (23.6 %) survived representing an overall survival rate of 7.5 %, (incidence 4.0 per 100,000 inhabitants) (Table 1). Based on the 30-days definition, overall survival would be 7.1 % (n = 2,166).

Time intervals

Response time from call to EMS arrival at scene (excluding EMS-witnessed OHCA) could be calculated for 95.1 % of cases (n = 25,567). The average response time was 12.2 min (SD 8.0, median 10, IQR 7–15). Ten percent of cases had a response time of ≤5 min, 25 % had a response time of ≤7 min, while 50 % of cases had a response time of ≤10 min. Seventy-five percent of patients were attended within 14 min and 90 % were attended within 21 min. The median response time ranged from 5 to 20 min per country (Fig. 2).

A valid EMS treatment time (i.e. from EMS arrival/start until end of CPR) was available for 19,681 cases (61.4 %, range per country 8–98 %, 27 countries). The overall mean EMS treatment time was 29.6 min (SD 8.2, median 27, IQR 16–38). For the subgroup of patients where the first rhythm was shockable, the average EMS treatment time was 30.0 min (SD 20.9, median 27, IQR 13–42). For those patients who had ROSC at scene, the mean EMS treatment time was almost 10 min shorter (20.8 min, SD 16.7, median 17, IQR 10–27). If the OHCA was witnessed by the EMS, the average EMS treatment time was 35.5 min (SD 21.6, median 33, IQR 20–48, Fig. 3).

Transport time was defined as the time interval from leaving the scene until hospital arrival for patients with ROSC or with ongoing CPR. Transport time was considered valid if it was within the range from 2 to 119 min. A valid transport time interval was available for 4,129–11,000 cases (37.5 %, country range 54.7–100 %, 19 countries). The mean transport time was 14.9 min (SD 12.5, median 11, IQR 7–19).

Relation between times and outcomes

The mean EMS response time was 12.2 min for all patients. For the group of patients who achieved ROSC, the mean response time was 11.2 min compared to 12.6 min in the group of patients who never achieved ROSC ($p < 0.001$). The relationship between response time and survival per country is presented in Fig. 4.

The mean EMS treatment time was with 32.7 min in the group of patients that never achieved ROSC compared to 20.8 min in the patients with ROSC, 18.0 min with patients with survived event,

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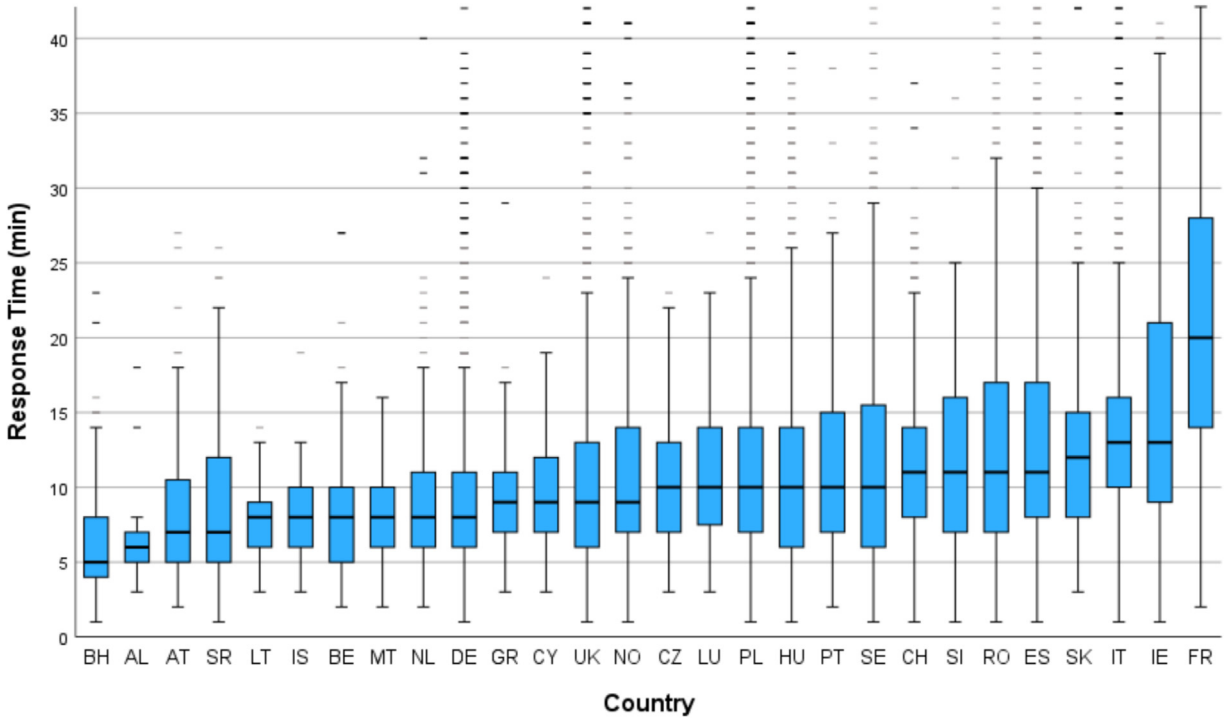

Fig. 2 – Box plot of EMS response times by country, sorted by increasing median in EMS treated OHCA. EMS witnessed cardiac arrests were excluded from calculation of the EMS response time. Abbreviations: Albania (AL), Austria (AT), Belgium (BE), Bosnia & Herz. (BH), Switzerland (CH), Cyprus (CY), Czech Rep. (CZ), Germany (DE), Spain (ES), France (FR), Greece (GR), Hungary (HU), Ireland (IE), Iceland (IS), Italy (IT), Lithuania (LT), Luxembourg (LU), Malta (MT), The Netherlands (NL), Norway (NO), Poland (PL), Portugal (PT), Romania (RO), Sweden (SE), Slovenia (SI), Slovakia (SK), Serbia (SR), United Kingdom (UK).

and 14.8 min in the group of survivors. All time intervals are shown in Table 2.

In patients with extended treatment times, ROSC was rarely observed. Fig. 5 includes only patients with ROSC and describes the cumulative rate of ROSC within the first 100 min of CPR. From the time that CPR was started, ROSC was achieved for 50 % of cases within 17 min, for 90 % within 38 min, and for 99 % within 62 min.

Patients with an EMS-witnessed arrest had better outcomes than those where the arrest occurred prior to EMS arrival (any ROSC in 39.0 % compared to 29.7 % and survived event in 28.1 % compared to 21.5 %, respectively).

Excluding EMS-witnessed OHCA there was 25,711 patients, of which 5,733 (21.5 %) survived event. Positive predictors of survived event in the adjusted multivariate analysis were: initial shockable rhythm (aOR 3.27; 95 %CI 3.04–3.52); OHCA witnessed by bystander (aOR 2.01; 95 %CI 1.87–2.17); aetiology other than medical or trauma (aOR 1.98; 95 %CI 1.79–2.19); bystander CPR including ventilations (aOR 1.20; 95 %CI 1.06–1.25) and; location in a public place (aOR 1.28; 95 %CI 1.14–1.45). There was a negative influence of an extended response time when compared to the reference of 1–5 min. Compared to a response time of 1–5 min, a response time of 6–10 min conferred no significant survival advantage (OR 0.93 [95 % CI 0.84–1.02]]) There was a clear and significant negative association between a response time of 11 min or more when compared to a response time of 1–5 min. and other negative factors are presented in Fig. 6. Patients with a missing response time (n = 1.287) were included as a separate category in the model, with an average effect (aOR 0.82, 95 %CI 0.69–0.97).

Discussion

EuReCa-THREE represents the largest prospective observational study of OHCA that has been conducted in Europe to date. While the number of countries included has remained at 28, the size of the European population covered increased from 178,879,118 for the EuReCa-TWO study to 230,032,635.[7] The principal aim of the EuReCa project is to encourage high quality OHCA data collection which, in turn, will drive quality improvement in OHCA management and subsequently improve OHCA survival.[3–4,6] Comprehensive data capture is an important dimension of data quality therefore it is highly encouraging to note that ten countries achieved national data whole-country coverage in EuReCa-THREE, a substantial increase from four countries in EuReCa-TWO. It is also of note that at least two countries that participated in EuReCa-TWO were unable to participate in the EuReCa-THREE due to data protection considerations, despite all European data protection legislation being based on the same General Data Protection Regulation,[14] a fact that highlights the diversity and individuality of European countries, despite their many commonalities.

For analyses of EMS response time influence, we continued with cases where EMS confirms cardiac arrest and started or continued CPR. Based on the main denominator used in this study i.e. con-

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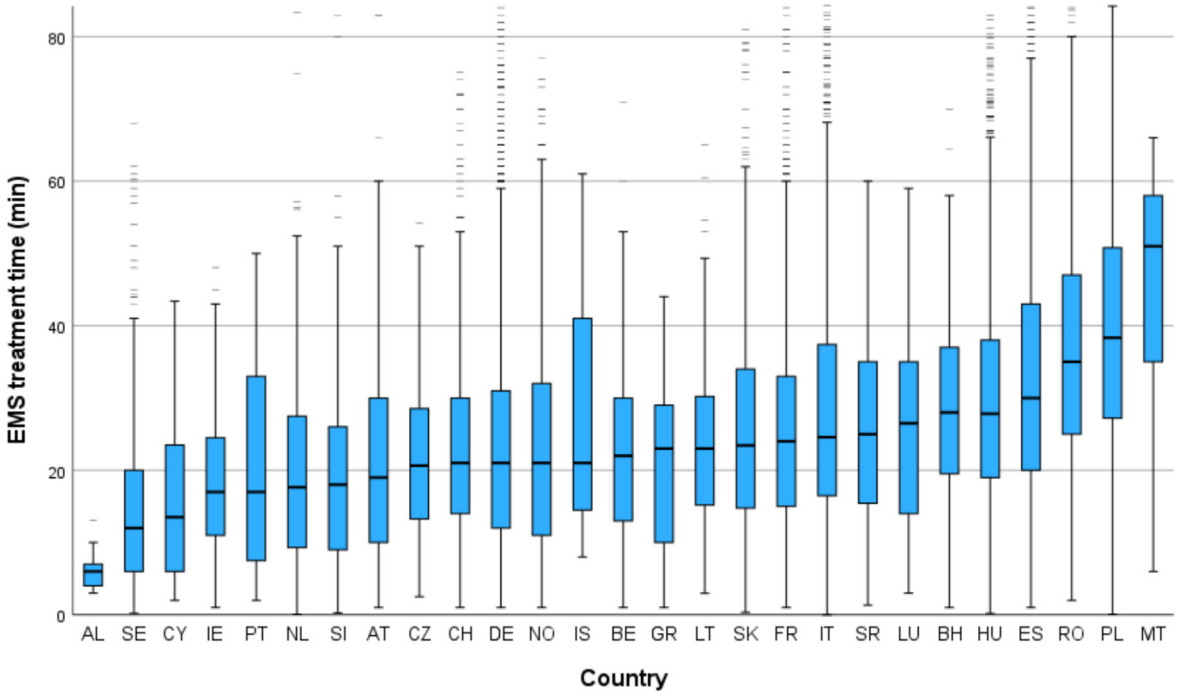

Fig. 3 – Box plot of EMS treatment time by county. Abbreviations: Albania (AL), Austria (AT), Belgium (BE), Bosnia & Herz. (BH), Switzerland (CH), Cyprus (CY), Czech Rep. (CZ), Germany (DE), Spain (ES), France (FR), Greece (GR), Hungary (HU), Ireland (IE), Iceland (IS), Italy (IT), Lithuania (LT), Luxembourg (LU), Malta (MT), The Netherlands (NL), Norway (NO), Poland (PL), Portugal (PT), Romania (RO), Sweden (SE), Slovenia (SI), Slovakia (SK), Serbia (SR), United Kingdom (UK).

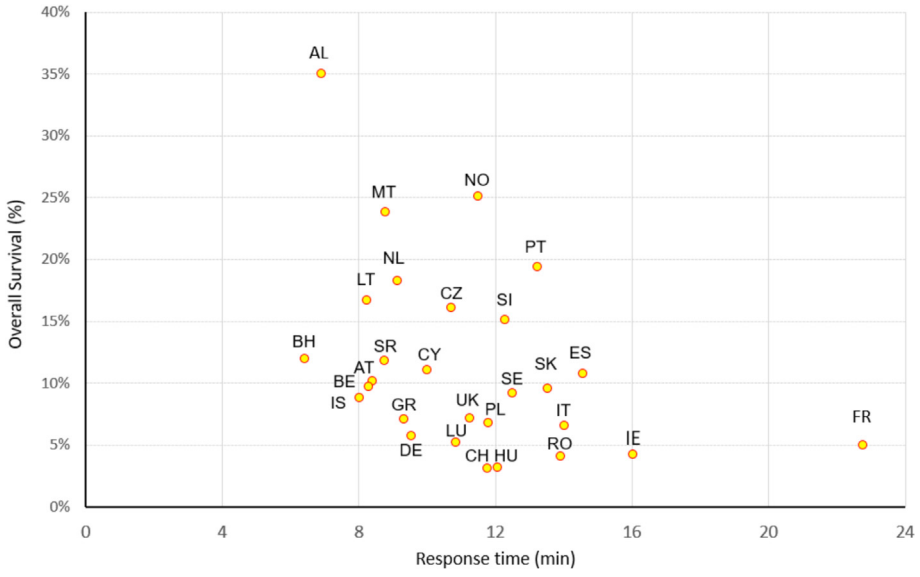

Fig. 4 – Overall survival versus mean response time per country, in 25,567 patients with collapse not witnessed by EMS. Abbreviations: Albania (AL), Austria (AT), Belgium (BE), Bosnia & Herz. (BH), Switzerland (CH), Cyprus (CY), Czech Rep. (CZ), Germany (DE), Spain (ES), France (FR), Greece (GR), Hungary (HU), Ireland (IE), Iceland (IS), Italy (IT), Lithuania (LT), Luxembourg (LU), Malta (MT), The Netherlands (NL), Norway (NO), Poland (PL), Portugal (PT), Romania (RO), Sweden (SE), Slovenia (SI), Slovakia (SK), Serbia (SR), United Kingdom (UK).

firmed cardiac arrest with CPR by EMS (n = 32,033), average percentage OHCA survival in Europe is low at 7.5 % and is lower than reported in EuReCa-TWO at 8.0 %. It is of particular note that the range in percentage survival has widened from 0–18.7 % in EuReCa-TWO, to 3.1–35.0 % in this study, and exceeds the variation reported by Kiguchi *et al.* who described results from nine

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Table 2 – Time intervals in minutes, for specific subgroups of cases. Results are presented as mean (SD) in row 1 and median with quartiles in row 2. * cases *.

Subgroup	No. of cases	Response time*	EMS treatment time	Travel time to hospital
Time available		n = 25,567*	n = 19,681	n = 4,129
All patients	32,033	12.2 (8.0)10 (7–15) n = 25,567	29.5 (18.1)27 (16–39) n = 19,681	14.9 (12.5)11 (7–19) n = 4,129
Never ROSC	21,917	12.6 (8.0) 11 (7–15) n = 17,968	32.7 (17.6) 30 (21–42)n = 14,321	––
Any ROSC	9,922	11.2 (7.7) 9 (6–13) n = 7,451	20.8 (16.7) 17 (10–27) n = 5,314	15.7 (12.9)12 (7–20) n = 3,166
Survived event	7,168	11.0 (7.7)9 (6–13) n = 5,439	18.0 (13.9)15 (8–24) n = 3,799	15.8 (12.9)12 (7–20) n = 2,661
Survivor	2,292	10.4 (7.7)9 (6–12) n = 1,639	14.08 (14.0)11 (5–19) n = 1,196	16.4 (13.7)12 (7–21) n = 858

Response time is based on un-witnessed/bystander witnessed arrests with EMS witnessed excluded. **Survived event is defined as ROSC sustained until arrival at the emergency department and transfer of care to medical staff at the receiving hospital.

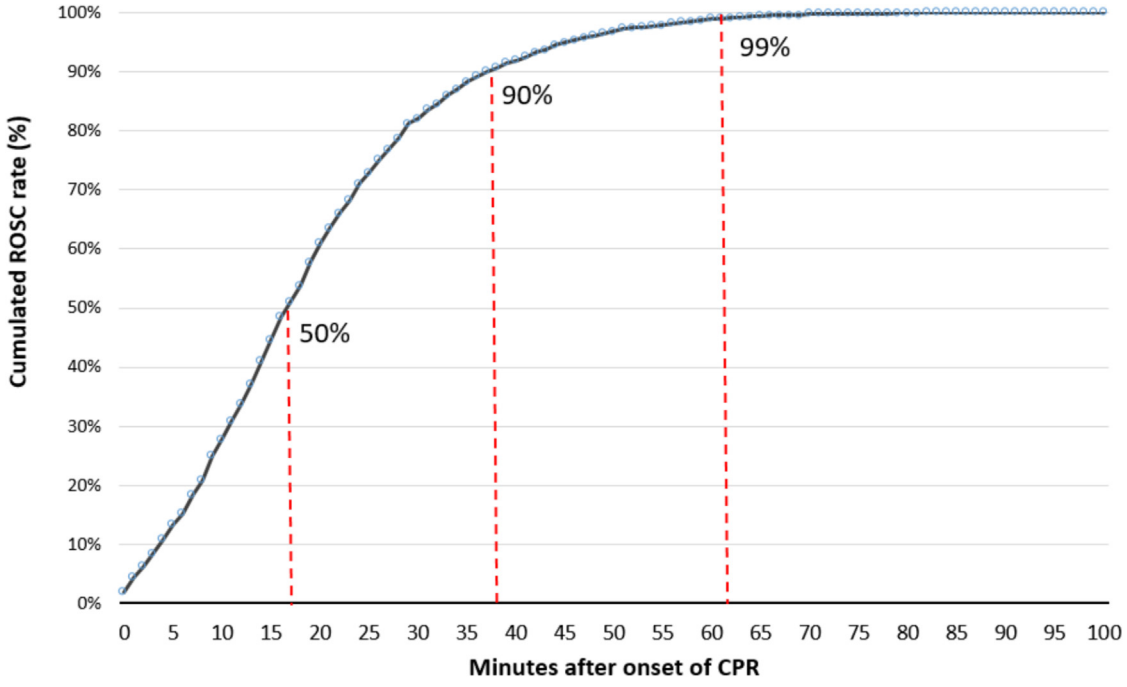

Fig. 5 – Cumulative rate of ROSC within the first 100 min after initiation of CPR. Predictors of ROSC sustained until arrival at the emergency department and transfer of care to medical staff at the receiving hospital (survived event).

national and seven regional registries across the world.[15] While some of this variation is associated with case selection in individual countries, there is substantial inequity regarding the chance of surviving OHCA across Europe. The availability of survival data after hospital admission increased considerably from 75.7 % (EuReCa-TWO) to 88.4 % in EuReCa-THREE.

A known independent predictor of OHCA survival is EMS response time[10,16,17] and this study investigated the impact of key EMS time intervals on OHCA outcomes in the pan-European context. Results of the logistic regression analysis showed that a longer response time is associated with a deceased chance to achieve ROSC sustained until arrival at the emergency department and transfer of care to medical staff (survived event). A response time greater than 15 min reduced the chance of survived event by about half (OR 0.55). The known predictors of improved survival were all significant for this study, including younger age, public location, witnessed collapse, bystander CPR and initial shockable rhythm.

At a country level, even when limitations of selection bias are considered, comparison between Fig. 2 and Fig. 3 would suggest that this study validates EMS response time as an independent predictor of OHCA survival in Europe. Achieving effective EMS response times is challenging for many reasons. There are inherent challenges to providing a timely response, such as geography, road and health system infrastructure and population settlement patterns.[18–21] In most countries, increases in EMS capacity have not kept pace with increasing demand on EMS.[22] For many years, there

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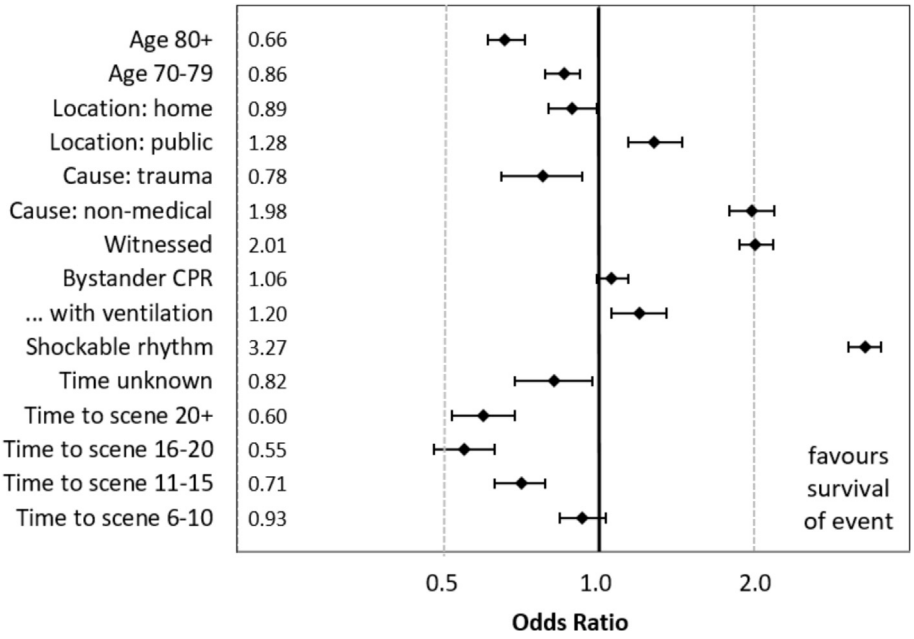

Fig. 6 – Predictors of survived event (ROSC sustained until arrival at the emergency department and transfer of care to medical staff at the receiving hospital); n = 25,711 cases without those witnessed by EMS. Results of regression analysis are presented as adjusted Odds Ratios with 95 % confidence intervals.

has been an appropriate emphasis on the first three links of the Chain of Survival, which focuses on improving community response to cardiac arrest across many European countries, with advances such as dispatch-assisted CPR, public access defibrillation programs, mass CPR training, and an ever-proliferating number of community first response models developing.[23–27] These developments have undoubtedly improved OHCA outcomes across individual countries.

Internationally EMS is under increasing pressure, primarily due to changing population demographics and increased reliance on EMS as a fall back due to decreased availability and pressure on other front-line services.[28] The role of EMS internationally is evolving, with more emphasis on hospital avoidance and community-based care.[29,30] This is entirely appropriate, as the European population ages and as it is increasingly recognized that hospital is not always the right destination for an ill or injured person. It is also entirely appropriate that actions to enhance community response to cardiac arrest are continued. However, where bystander CPR and defibrillation do not immediately lead to ROSC a timely EMS response to initiate other advanced life support treatments are critical to survival. In order for this link to be effective, EMS response must be timely. It is essential that ensuring continued improvements in OHCA survival remains prioritised as a key role of EMS. While additional EMS capacity is required, modelling studies have suggested that revised deployment models may also improve ambulance availability.[31–34] While there are local initiatives that may marginally improve response times, it remains critical that sufficient frontline EMS providers are available to support this link in the Chain of Survival in all European countries.

The impact of treatment time on OHCA outcomes was also a focus of this study. As may have been expected, treatment time was approximately 10 min shorter for patients who achieved ROSC at scene. Similarly, as shown in Fig. 5, when CPR duration extended beyond 62 min, less than 1 % of patients achieved ROSC. These findings are unsurprising, in that patients who are likely to achieve ROSC are likely to do so at an early stage of resuscitation.[35,36] However, they do show that a high proportion of ROSC will be achieved after the 5-minute and 8-minute intervals that are traditionally associated with cardiac arrest survival.[37]

Interestingly, patients with an aetiology other than medical or trauma had a higher odds of achieving ROSC sustained until arrival at the emergency department and transfer of care to medical staff at the receiving hospital (survived event – OR 1.88, 95 %CI [1.72–2.06]). This group accounted for 2,349 patients and included the following aetiologies: drowning; electrocution; asphyxiation; and drug overdose. At a national level, patients in this cohort generally account for a very small number of cases, and it can be difficult to draw conclusions regarding their survival prospects. To the best of our knowledge, this is the first European study to find that this group of aetiologies is independently associated with event survival when compared to presumed medical aetiology. This contrasts with previous studies, where patients in this cohort were found to fare more poorly.[38,39] An increase in drug overdose as the underlying aetiology to OHCA in young adults may be a contributing factor.[40]

Limitations

There are several limitations inherent in studies which combine data from individual registries as outlined previously.[2,3,5–7,41,42] Although larger than previous studies, EuReCa-THREE captured data from only 28 of 44 countries in Europe, with only 10 providing complete data for their country. Whilst attempts were made to standardise case ascertainment methods and data definitions based on the Utstein style for OHCA (5), variations likely persisted.[2–3,5–7,41–43] For example, the study observed a trend for countries with the smaller percentage of population to have the shortest EMS response times raising the possibility of selection bias.

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The study focused on treatments delivered by the EMS. Variation in hospital practices such as decisions to admit to intensive care, hospital-based post resuscitation care bundles and withdrawal of life sustaining treatments will have influenced outcomes but will not be captured in this study. The study adopted Utstein recommendations and included all patients where EMS attempted or continued CPR. This may explain difference with other international reports who have chosen to report a more limited cohort (e.g. those with a witnessed arrest only).[44]

As shown in our results, some countries have a high missing rate for information on hospital treatment and survival. We therefore calculated treatment rates and survival rates based on the patients where this information is known thereby excluding the cases from both the nominator and the denominator.

Conclusion

The results of EuReCa-THREE confirm and underline substantial variation in the incidence of OHCA, process and outcome parameters as shown in previous EuReCa studies. This study found strong association between longer EMS response time and decreased survival. The average response time throughout Europe was 12.1 min and only 25 % of patients were reached within 7 min. EuReCa-THREE data results reaffirm that there are clear predictors for surviving an OHCA event until hospital admission for the variables namely: location in public place, short response times, initial shockable rhythm, witnessed by bystander, cause other than medical or trauma, and bystander CPR including ventilation. While OHCA remains a major health burden across Europe, the EuReCa project contributes to a better understanding and management of cardiac arrest and underscores the importance of establishing continuously running registries.

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Declaration of competing interest

All national coordinators confirm that the local coordinators listed within the contributor section have seen and approved the final version of the document and fulfill the criteria to be listed as a contributor.

Jan-Thorsten Gräsner is member of the editorial board of resuscitation. He declares speaker fees and travel support from Weinmann:Emergency, Laerdal Foundation and Zoll.

Jan-Thorsten Gräsner and Jan Wnent reports travel was provided by German Society for Anesthesiology and Intensive Care Medicine - DGAI e.V. Jan-Thorsten Gräsner and Jan Wnent reports a relationship with German Society for Anestheisology and Intensive Care Medicine - DGAI e.V. that includes: board membership and travel reimbursement. Jan-Thorsten Gräsner and Jan Wnent are members of the steering committee of the German Resuscitation Registry. They declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Nikolaos Nikolaou declared Board Member, European Resuscitation Council Gavin D. Perkins declared research funding from National Institute for Health Research, British Heart Foundation, Resuscitation Council UK), Laerdal Foundation; Director European Resuscitation Council; President Resuscitation Council UK; Immediate past co-chair for ILCOR; Editor roles with Resuscitation and Resuscitation Plus.

Federico Semeraro is the Chair of the European Resuscitation Council, an Emeritus member of the ILCOR BLS Working Group, and a member of the Italian Resuscitation Council Foundation. He participated in the data safety monitoring or advisory board of CPAr - CardioPulmonary Resuscitation with Argon.

No conflict of interest was declared by all other co-authors.

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Appendix A. Supplementary data

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