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Description of Emergency Medical Services, treatment of cardiac arrest patients and cardiac arrest registries in Europe

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Abstract

Background: Variation in the incidence, survival rate and factors associated with survival after cardiac arrest in Europe is reported. Some studies have tried to fill the knowledge gap regarding the epidemiology of out-of-hospital cardiac arrest in Europe but were unable to identify reasons for the reported differences. Therefore, the purpose of this study was to describe European Emergency Medical Systems, particularly from the perspective of country and ambulance service characteristics, cardiac arrest identification, dispatch, treatment, and monitoring.

Methods: An online questionnaire with 51 questions about ambulance and dispatch characteristics, on-scene management of cardiac arrest and the availability and dataset in cardiac arrest registries, was sent to all national coordinators who participated in the European Registry of Cardiac Arrest studies. In addition, individual invitations were sent to the remaining European countries.

Results: Participants from 28 European countries responded to the questionnaire. Results were combined with official information on population density. Overall, the number of Emergency Medical Service missions, level of training of personnel, availability of Helicopter Emergency Medical Services and the involvement of first responders varied across and within countries. There were similarities in team training, availability of key resuscitation equipment and permission for ongoing performance of cardiopulmonary resuscitation during transported. The quality of reporting to cardiac arrest registries varied, as well as the data availability in the registries.

Conclusions: Throughout Europe there are important differences in Emergency Medical Service systems and the response to out-of-hospital cardiac arrest. Explaining these differences is complicated due to significant variation in how variables are reported to and used in registries.

Keywords: Emergency Medical Services (EMS), Out-of-hospital cardiac arrest, Cardiac arrest registries, Dispatch, Epidemiology of cardiac arrest

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Background

Epidemiology of cardiac arrest and the systems that care for out-of-hospital cardiac arrest (OHCA) patients have been described in many studies. Regional and inter-country variation in survival is a consistent finding in epidemiological studies. In a study from the Resuscitation Outcomes Consortium (ROC), variation between sites was 4.7 to 20% [1]. In 2015, across the seven ambulance services that contribute to the Australian and New Zealand Resuscitation Outcomes Consortium, survival ranged from 9 to 17% [2]. Similarly, from 2009 to 2012, the Pan Asian Resuscitation Outcomes Study (PAROS) observed survival ranging from 0.5 to 8.5% across seven countries [3]. In Europe, the European Registry of Cardiac Arrests (EuReCa) studies showed that between-country OHCA survival ranged from 1.1 to 31% over a 1-month period in 2014 [4], and from 0 to 18% over a 3-month period in 2017 [5].

Identifying the factors that contribute to this variation in OHCA survival is important. The consensus-based Utstein template provides a dataset of patient-level variables associated with survival [6]. Some factors that influence survival are well known i.e. witnessed collapse, bystander cardiopulmonary resuscitation, initial shockable cardiac arrest rhythm and achieved return of spontaneous circulation (ROSC) [7]. It has been estimated in a single city (Toronto) that patient-level Utstein variables accounted for 89% of variability in OHCA survival [8]. In a study from ROC, it was estimated that Utstein variables accounted for 72% of variability across North American sites [9]. However, in a study using international data from 232 Emergency Medical Services (EMS) agencies in 12 countries, the proportion of survival variability accounted for by Utstein variables fell to 51% [10]. The more international the study sites, the greater the variation in interpretation, system, organisation and culture. Hence, the less variation that is explained by patient-level Utstein variables.

Variability in EMS organisation is a common theme across international cardiac arrest registries and epistries [11–14]. It is likely that differences in EMS systems in Europe account for at least some of the differences in OHCA survival. Other factors that might account for the observed variability in survival after OHCA are differences in the links in the chain of survival e.g. the first link (early call for help) [15], or in the fourth link (post-resuscitation care) [16]. Development of different "first responder systems" may also explain part of the variability in survival [17].

In the last European-wide study, EuReCa TWO, the mean incidence rate of started resuscitations was 56 per 100,000 inhabitants per year, ranging from 27 to 91 per 100,000 inhabitants per year [5]. This wide range in national incidence estimates may have been caused by differences in how key variables were interpreted. However, much of this variation is likely to be attributable to patient and system level differences. To date, there has been no comprehensive description of EMS systems in Europe. Therefore, the objective of this study is to describe European EMS systems, particularly from the perspective of ambulance service characteristics, cardiac arrest identification, dispatch, treatment, and monitoring.

Methods

A structured questionnaire was developed through a review of published literature on previous international ambulance surveys [11–14, 18] and by consensus among members of the European Resuscitation Council (ERC) Guidelines 2020 Epidemiology Writing Group (Writing Group). The questionnaire was designed to investigate the following five categories: (Additional file 1; EMS survey):

1. Country and EMS baseline characteristics
2. Ambulance Service characteristics
3. Dispatch characteristics
4. On-Scene Management of Out-of-Hospital Cardiac Arrest by the EMS
5. Cardiac Arrest Registries

The survey was piloted with the members of the Writing Group. The questionnaire was shared with participants using the online tool Questback, licensed to Oslo University Hospital. All information is stored on an approved area at Oslo University Hospital.

The survey was distributed between October 2019 and January 2020. All national coordinators of the EuReCa ONE or EuReCa TWO studies were asked to participate ($n = 31$). Representatives from other European countries were invited to participate using the ERC network and the individual networks of the Writing Group ($n = 3$). In total the survey was sent to 34 different countries. Participants were asked to provide information for the entire country.

After completion of the survey, results were returned to each participant, who was asked to validate responses with at least one other national expert. Countries that did not confirm their response were excluded from the survey. In case of inconsistencies or critical missing data, participants were again contacted to maximise data quality. After all the data had been merged into a result section, the tables were again shared with the participants, who then confirmed the results. All participants were asked for consent to be acknowledged in publications and reports. Participants were entitled to withdraw from the study at any time up to submission of the article.

Descriptive analysis of data was carried out using Statistical Package for Social Sciences (SPSS, Inc., IL, USA) version 23. Results are presented as frequencies and proportions.

Results

Country information and baseline characteristics

Survey responses from 33 out of 39 (85%) respondents were received. Three responses were excluded as results

related to only one region ($n = 2$) or validation of results was not received ($n = 1$). For the United Kingdom, separate answers were received for England, Scotland and Northern Ireland and the answers were merged. A total of 28 countries were included in the analysis.

For participating countries, national populations varied from 375,000 in Iceland to over 83 million in Germany [19]. Population density ranged from 3.6 to almost 510 population/km^2 (Fig. 1). Data on the number of EMS missions per 1000 inhabitants per year were available for 19 countries and varied from 12 in France to 268 in Lithuania. In 75% of countries the EMS was described as publicly funded. Germany had the greatest number of hospitals per million inhabitants while Finland had the lowest (23 vs 3.6 respectively). Only Albania and Cyprus did not operate bypass protocols to bring patients directly to a Percutaneous Coronary Intervention (PCI)-capable hospital. The majority of respondents ($n = 25$) also reported that there were "Cardiac Arrest" hospitals in their country i.e. hospitals capable of providing all of the following post-resuscitation interventions: 24/7 primary PCI, targeted temperature management and neuro-prognostication. Data on the median response times for urban and rural areas is presented in Table 1.

Ambulance service characteristics

In 15 countries, the majority of EMS personnel were reported as paramedics or Emergency Medical Technicians (EMTs) with at least 2 years of specialist training (Fig. 2). It was reported that all ambulance personnel were trained in Advanced Life Support (ALS) in 19 countries (i.e. at least ERC ALS level or similar), and at least some were trained in the remaining countries. In 12 countries, non-physician ambulance personnel were allowed to perform ALS procedures in the absence of a physician (see Table 2).

A Helicopter EMS (HEMS) was available in 24 countries. Cyprus, Iceland, Lithuania and Serbia reported that

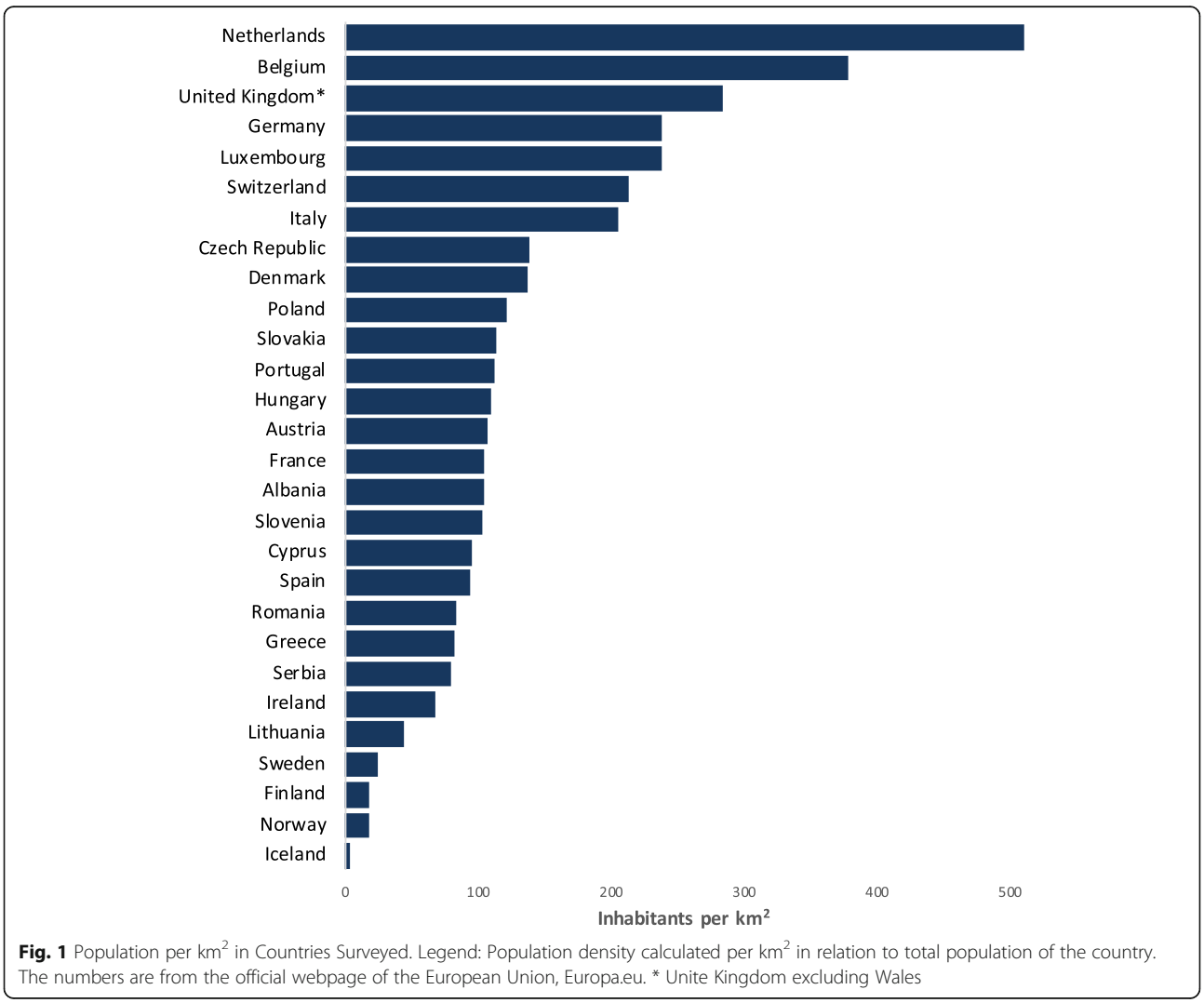

Fig. 1 Population per km^2 in Countries Surveyed. Legend: Population density calculated per km^2 in relation to total population of the country. The numbers are from the official webpage of the European Union, Europa.eu. * Unite Kingdom excluding Wales

Table 1 Baseline characteristics of participating countries

Country	Population	EMS Missions per 1000 inhabitants	Public or Private EMS funding?	Hospitals per million population	"Cardiac Arrest" hospitals	PCI bypass protocol	Rural areas - median ambulance response time < 10 min?	Urban - median ambulance response time < 10 min?
Albania	2,862,400		Public		Some areas	No	Some areas	Some areas
Austria	8,858,800		Public	10.4	All areas	Yes	Some areas	Some areas
Belgium	11,467,900	77.0	Public and private	10.9	All areas	Yes	Some areas	All areas
Cyprus	875,900	62.8	Public	8.0	All areas	No	Some areas	Some areas
Czech Republic	10,649,800	103.9	Public		Some areas	Yes	Some areas	All areas
Denmark	5,806,100	68.9	Public	3.8	Some areas	Yes	Some areas	All areas
Finland	5,517,900	140.1	Public	3.6	Some areas	Yes	Some areas	Some areas
France	67,028,000	11.9	Public	9.8	Some areas	Yes	No	Some areas
Germany	83,019,200	172.2	Public	22.9	Some areas	Yes	Some areas	Some areas
Greece	10,722,300		Public		None	Yes	Some areas	Some areas
Hungary	9,772,800		Public	5.9	Some areas	Yes	Some areas	Some areas
Iceland	357,000	117.6	Public	14.0	Some areas	Yes	Some areas	All areas
Ireland	4,693,460	95.9	Public	6.2	Some areas	Yes	No	Some areas
Italy	60,359,500		Public	4.7	Some areas	Yes	Some areas	All areas
Lithuania	2,794,200	268.4	Public and private	14.3	None	Yes	No	No
Luxembourg	613,900	72.5	Public	4.9	Some areas	Yes	Some areas	All areas
Netherlands	17,282,200	57.6	Public and private	5.0	All areas	Yes	Some areas	Some areas
Norway	5,323,933	136.2	Public	9.4	Some areas	Yes	Some areas	All areas
Poland	37,972,800		Public	8.6	Some areas	Yes	No	All areas
Portugal	10,276,600	114.2	Public	4.3	Some areas	Yes	No	Some areas
Romania	19,401,700	172.1	Public and private	6.7	Some areas	Yes	Some areas	Some areas
Serbia	6,963,800	43.7	Public	7.0	Some areas	Yes	No	Some areas
Slovakia	5,450,400	26.6	Public and private	13.8	None	Yes	Some areas	Some areas
Slovenia	2,080,900		Public	5.3	All areas	Yes	Some areas	Some areas
Spain	46,934,600		Public	4.9	Some areas	Yes	No	Some areas
Sweden	10,230,200	97.7	Public and private	7.2	Some areas	Yes	Some areas	Some areas
Switzerland	8,542,300	58.5	Public and private	11.9	Some areas	Yes	Some areas	All areas
United Kingdom[a]	63,298,819		Public		Some areas	Yes	Some areas	Some areas

For country population official numbers from EU were used. (eurpoa.eu)
Abbreviations: *EMS* Emergency Medical Services, *PCI* Percutaneous Coronary Intervention, "*Cardiac arrest hospitals*" - hospitals capable of providing all of the following post-resuscitation interventions: 24/7 primary PCI, targeted temperature management and neuro-prognostication
[a]United Kingdom excluding Wales

they did not operate HEMS. Denmark, the Netherlands, Norway, Portugal, Slovakia, and Switzerland reported having 24/7 HEMS availability in all areas (Fig. 3).

In 18 countries there were established first responder systems (where volunteers were alerted to OHCA by the dispatch centre) in some or all areas. Countries that were reported not to have first responder systems were Albania, Belgium, Cyprus, Finland, Greece, Poland, Portugal, Serbia and Slovakia (no information received about Italy). In eight countries, volunteers were reported to staff ambulances in the EMS (i.e. Austria, Belgium, Germany, Hungary, Italy, Luxembourg, Portugal and Romania).

Dispatch characteristics

The number of dispatch centres per million population ranged from 3.3 in Germany to 0.3 in Albania. Dispatch centres were part of the EMS in 18 countries, while four countries had some dispatch centres as part of the EMS. It was reported that all countries, with the exception of Serbia, operated a standardised dispatch protocol in all or some of the country (no data available for Greece). Dispatch-assisted Cardio Pulmonary Resuscitation (DA-CPR) instructions were offered in all countries except Greece, but a standardised DA-CPR protocol was not reported to be in use in Poland and Serbia. The type of DA-CPR that was offered was compressions only in ten

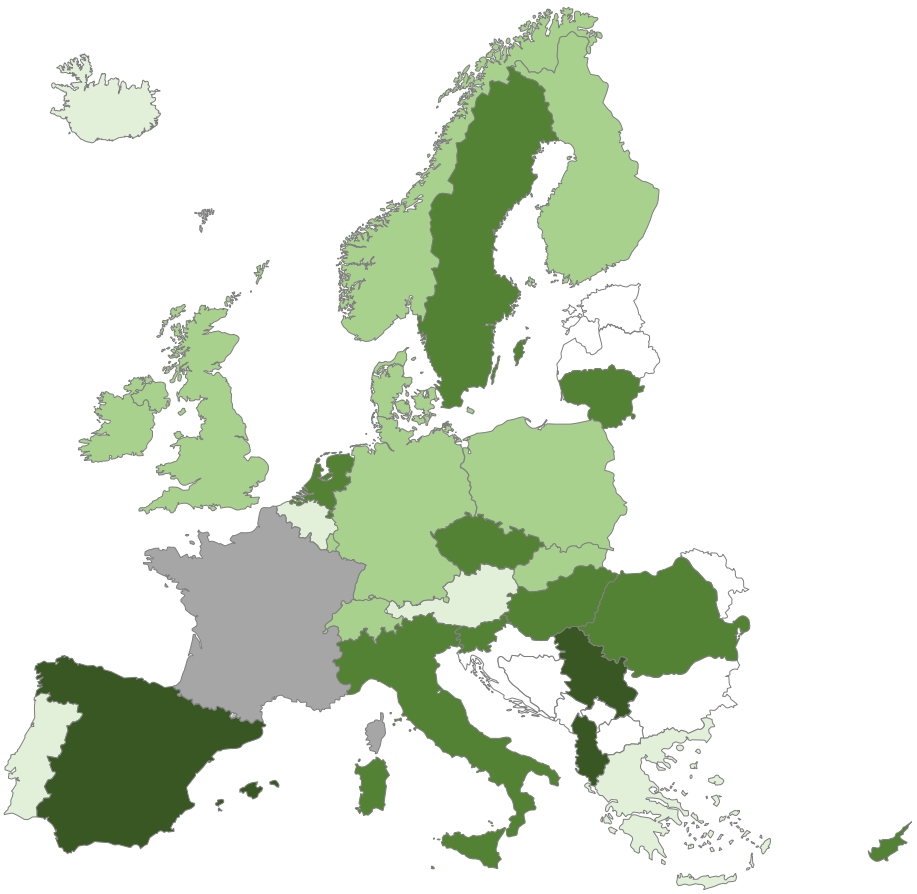

Fig. 2 Occupation of the majority of employees in the EMS. Legend: The darkest colour indicates countries where the majority of employees are medical doctors, the second darkest colour emergency nurses/nurses, light green indicates paramedics, very light indicates emergency medical technicians and grey is other. White colour indicates the country did not participate in the survey

countries, situation dependent in 15 countries and full CPR with compression and ventilation in two countries. Dynamic deployment, meaning sending the nearest available ambulance/EMS resource, was reported in all countries. However, this was only in some areas of Germany, Romania, Serbia, Slovenia, Spain, Switzerland and the United Kingdom. In 21 countries there were registries of publicly available Automated External Defibrillators (AED) in at least some areas (see Table 3).

On-scene management of out-of-hospital cardiac arrest by Emergency Medical Services

Team training in CPR involving all EMS personnel was reported in 27 countries, but only 12 countries had this in all areas. Defibrillators were available in all EMS vehicles dispatched to OHCA, with the exception of Albania. Real-time CPR performance data was collected for feedback and debriefing purposes in 17 countries, but used in all areas in Cyprus only. Mechanical CPR was used in 24 countries, and transport with ongoing CPR was permitted in all countries except Luxembourg. However, 23 respondents described specific circumstances in which transport with ongoing CPR may be considered. Eighteen countries were reported to use thrombolysis in OHCA. Availability of more advanced resuscitation interventions on-scene was limited, with extracorporeal membrane oxygenation (ECMO) reported as being used in five countries (France, Germany, Italy, Poland and Portugal), and resuscitative endovascular balloon occlusion of the aorta (REBOA) reported in three countries only (Germany, Italy, and Norway) On-scene management of OHCA is presented in Table 4.

Cardiac arrest registries

Six countries reported having an OHCA registry with full population coverage (Denmark, Ireland, Norway, Portugal, Sweden and Switzerland), while partial coverage was described for 14 countries. Seven countries were reported not to have a registry (data not available for Albania) (Fig. 4). Of the 20 countries reported to have full or partial registries, information on the types of outcome data collected was limited, and only Italy reported

Table 2 Ambulance service characteristics – training and occupation of EMS ambulance personnel

Country	Ambulance personnel ALS trained?	What is the occupation of the majority of EMS personnel?	Do physicians provide patient care as part of EMS?	Can ALS trained ambulance personnel perform the following interventions without a physician present on scene?			
				Secure airways with supraglottic or endotracheal tubes	Intravenous or intraosseous drug therapy	Manual defibrillation	Semi-automatic defibrillation
Albania	Some	Emergency physician	Sometimes	No	Yes	Yes	Yes
Austria	All	EMT	Routinely	Yes	Yes	No	Yes
Belgium	Some	EMT	Routinely	No	No	No	Yes
Cyprus	All	Emergency nurse / nurse	No	Yes	Yes	Yes	Yes
Czech Republic	Some	Emergency nurse / nurse	Routinely	Yes	Yes	Yes	Yes
Denmark	All	Paramedic	Routinely	Yes	Yes	Yes	Yes
Finland	Some	Paramedic	Routinely	Yes	Yes	Yes	Yes
France	Some	Other	Routinely	Yes	Yes	Yes	Yes
Germany	All	Paramedic	Routinely	Yes	Yes	Yes	Yes
Greece	Some	EMT	Sometimes	No	No	No	No
Hungary	Some	Emergency nurse / nurse	Routinely	Yes	Yes	Yes	Yes
Iceland	Some	EMT	Sometimes	Yes	Yes	Yes	Yes
Ireland	All	Paramedic	Sometimes	Yes	Yes	Yes	Yes
Italy	Some	Emergency nurse / nurse	Routinely	Yes	Yes	No	Yes
Lithuania	Some	Emergency nurse / nurse	Sometimes	Yes	Yes	Yes	Yes
Luxembourg	Some	Paramedic	Routinely	Yes	No	No	Yes
Netherlands	All	Emergency nurse / nurse	Sometimes	Yes	Yes	Yes	Yes
Norway	All	Paramedic	Sometimes	Yes	Yes	Yes	Yes
Poland	All	Paramedic	Sometimes	Yes	Yes	Yes	Yes
Portugal	Some	EMT	Routinely	Yes	Yes	No	Yes
Romania	Some	Emergency nurse / nurse	Sometimes	Yes	Yes	Yes	Yes
Serbia	Some	Emergency physician	Routinely	No	No	No	No
Slovakia	All	Paramedic	Routinely	Yes	Yes	Yes	Yes
Slovenia	All	Emergency nurse / nurse	Routinely	Yes	Yes	Yes	Yes
Spain	All	Emergency physician	Routinely	No	Yes	Yes	Yes
Sweden	All	Emergency nurse / nurse	Sometimes	Yes	Yes	Yes	Yes
Switzerland	All	Paramedic	Routinely	Yes	Yes	Yes	Yes
United Kingdom[a]	Some	Paramedic	Sometimes	Yes	Yes	Yes	Yes

The answers are for the entire country which means that the answers "Some" and "Sometimes" indicate this is not implemented in all EMS services in the entire country

Abbreviations: *EMS* Emergency Medical Services, *EMT* Emergency Medical Technician, ALS – Advanced Life Support

[a]United Kingdom excluding Wales

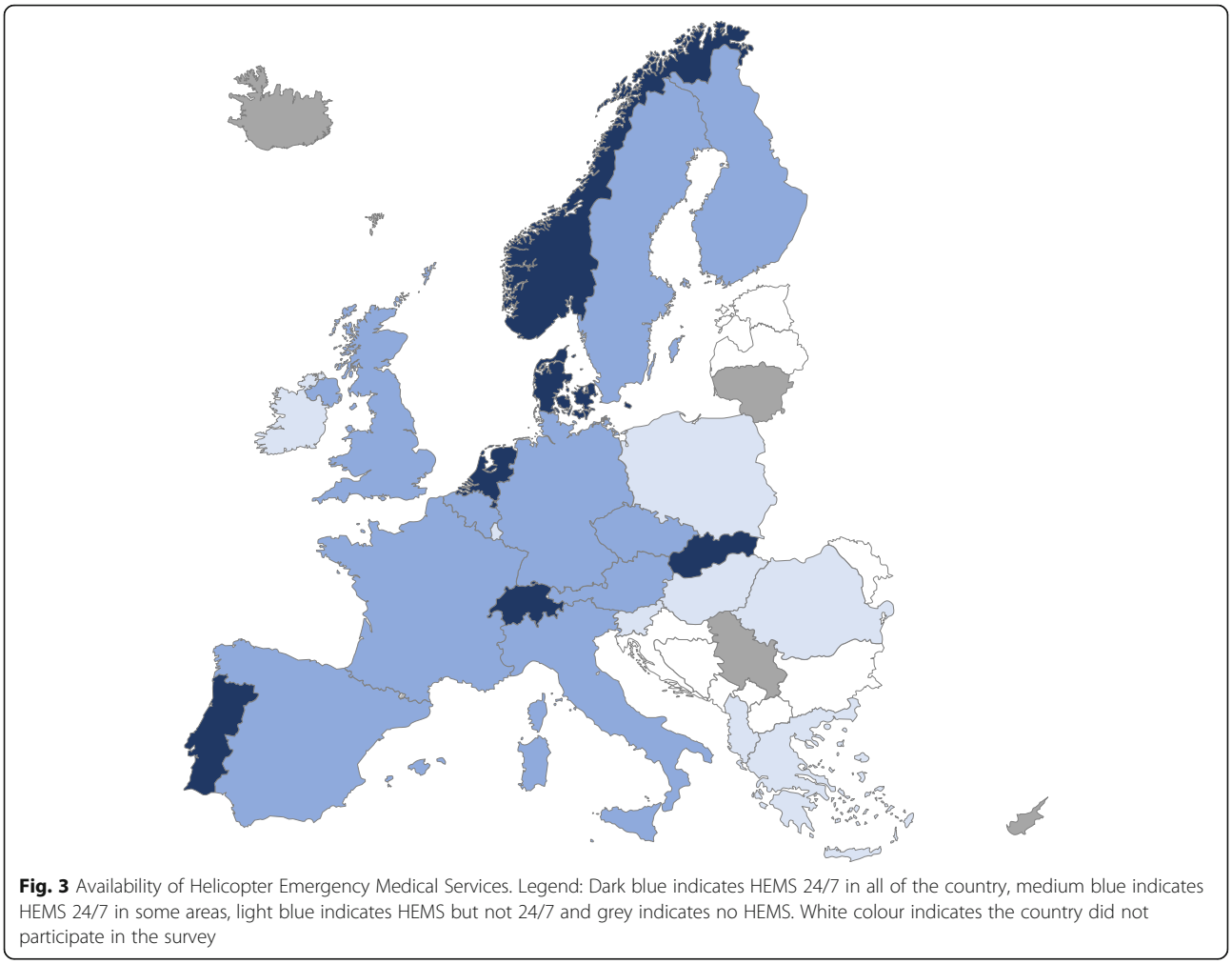

Fig. 3 Availability of Helicopter Emergency Medical Services. Legend: Dark blue indicates HEMS 24/7 in all of the country, medium blue indicates HEMS 24/7 in some areas, light blue indicates HEMS but not 24/7 and grey indicates no HEMS. White colour indicates the country did not participate in the survey

collecting all outcome variable types, albeit only in some areas of the country (see Table 5). Information in registries about the patients' neurological status at discharge was available in 13 registries, but follow-up after discharge and the patients reported quality of life was limited to data collection in some areas of seven countries.

Discussion

To the best of our knowledge this survey, covering 28 countries, provides the most comprehensive overview of EMS systems in Europe to date, particularly with regard to out-of-hospital cardiac arrest. The survey uncovers variations in service characteristics that are not fully explained in relation to total population, population density or geography. Our findings of substantial variation follow the pattern observed when EMS systems have been compared elsewhere [11–14].

There are some baseline characteristics shared by European countries in that the majority have publicly funded EMS systems and hospital bypass protocols for OHCA. However, our results suggest that while total population explained some proportion of variation, there remains large differences in fundamental measures of EMS activity such as EMS missions per 1000 inhabitants, and the capacity to respond to patients in a median of 10 min. Similarly, most countries were reported to have hospitals capable of providing post-resuscitation care as recommended in the ERC resuscitation guidelines 2015 [20], but there were vast differences in the number of hospitals with 24/7 emergency departments per 1 million inhabitants.

Our survey has shown differences in the types of personnel employed as part of the EMS and in the levels and types of interventions that EMS personnel are allowed to carry out independent of physician supervision. Previous studies have demonstrated how differences in EMS organisation may contribute to variation in OHCA survival. A prospective study showed that higher qualification and greater training experience of ambulance personnel contributed to higher OHCA survival across the four participating EMS agencies [21]. Across the ten ROC sites, differences in EMS practice with regard to initiation of resuscitation and transport was found to contribute to variation in OHCA

Table 3 Dispatch characteristics

Country	Dispatch centres per million inhabit-ants	Are the dispatch centres part of EMS?	Standar-dised dispatch protocol used in dispatch centres?	Dispatch-assisted CPR offered?	Type of dispatch-assisted CPR offered	Standard protocol for dispatch-assisted CPR used?	Dynamic deploy-ment used?	Registries of publicly available AED?	AED registries available in dispatch centres?
Albania	0.3		All	Yes	Compressions only	Yes	Yes	No	
Austria	1	Some	Some	Yes	Situation dependent	Some areas	Yes	All areas	All
Belgium	0.9	None	All	Yes	Full CPR	Yes	Yes	No	
Cyprus	1.1	All	All	Yes	Compressions only	Yes	Yes	No	
Czech Republic	1.3	All	Some	Yes	Situation dependent	Yes	Yes	All areas	All
Denmark	0.9	All	All	Yes	Situation dependent	Yes	Yes	All areas	All
Finland	1.1	None	All	Yes	Situation dependent	Yes	Yes	All areas	No
France	1.5	Some	All	Yes	Situation dependent	Yes	Yes	Some areas	Some
Germany	3.3	All	Some	Some areas	Situation dependent	Some areas	Some areas	Some areas	Some
Greece	1	All		No		No	Yes	No	
Hungary	0.7	All	All	Yes	Compressions only	Yes	Yes	All areas	All
Iceland	2.8	None	All	Yes	Full CPR	Yes	Yes	No	
Ireland	0.4	All	All	Yes	Compressions only	Yes	Yes	Some areas	Some
Italy	1.2	Some	All	Yes	Situation dependent	Yes	Yes	Some areas	Some
Lithuania	1.8	All	Some	Some areas	Situation dependent	Some areas	Yes	No	
Luxembourg	1.6	All	All	Yes	Compressions only	Yes	Yes	All areas	No
Netherlands	1	All	All	Yes	Situation dependent	Yes	Yes	All areas	Some
Norway	3	All	All	Yes	Situation dependent	Yes	Yes	All areas	All
Poland	0.4	None	All	Some areas	Situation dependent	No	Yes	Some areas	Some
Portugal	0.6	Some	Some	Yes	Compressions only	Yes	Yes	Some areas	Some

Table 3 Dispatch characteristics *(Continued)*

Country	Dispatch centres per million inhabit-ants	Are the dispatch centres part of EMS?	Standar-dised dispatch protocol used in dispatch centres?	Dispatch-assisted CPR offered?	Type of dispatch-assisted CPR offered	Standard protocol for dispatch-assisted CPR used?	Dynamic deploy-ment used?	Registries of publicly available AED?	AED registries available in dispatch centres?
Romania	2.1	All	All	Yes	Compressions only	Some areas	Some areas	Some areas	Some
Serbia	0.6	All	No	Some areas	Situation dependent	No	Some areas	No	
Slovakia	1.5	None	All	Yes	Compressions only	Yes	Yes	Some areas	Some
Slovenia	1	All	All	Yes	Situation dependent	Yes	Some areas	Some areas	All
Spain	0.7	All	Some	Yes	Compressions only	Yes	Some areas	Some areas	Some
Sweden	1.4	All	All	Yes	Situation dependent	Yes	Yes	All areas	All
Switzerland	1.8	All	All	Yes	Compressions only	Yes	Some areas	Some areas	Some
United Kingdom[a]	0.4	All	All	Yes	Situation dependent	Yes	Some areas	Some areas	Some

The answers are for the entire country which means that the answers "Some" and "Some areas" indicate this is not implemented in all dispatch centres in the entire country. Empty field means no information was given for that specific question

Abbreviations: *EMS* Emergency Medical Services, *AED* Automated External Defibrillator

[a]United Kingdom excluding Wales

Table 4 On scene management of out-of-hospital cardiac arrest by emergency medical personnel in the participating countries

Country	Is there team training in CPR involving all EMS personnel?	Mechanical CPR used?	Real-time CPR performance data collected for feedback?	Transport with ongoing CPR performed?	Defibrillators available in EMS vehicles dispatched for cardiac arrest?	Thrombolysis used in OHCA?
Albania	Some areas	No		Yes	Sometimes	No
Austria	Some areas	Some areas		Yes	Always	Some areas
Belgium	Some areas	Some areas	Some areas	Yes	Always	Some areas
Cyprus	Yes	All areas	Yes	Yes	Always	No
Czech Republic	Some areas	Some areas	Some areas	Yes	Always	Some areas
Denmark	Some areas	Some areas	Some areas	Yes	Always	Yes
Finland	Some areas	Some areas	Some areas	Yes	Always	Some areas
France	Yes	All areas		Yes	Always	Some areas
Germany	Yes	Some areas	Some areas	Yes	Always	Yes
Greece	Yes	No	Some areas	Yes	Always	No
Hungary	Some areas	Some areas	No	Yes	Always	No
Iceland	Yes	Some areas	Some areas	Yes	Always	No
Ireland	Yes	All areas	No	Yes	Always	No
Italy	Some areas	Some areas	Some areas	Yes	Always	Some areas
Lithuania	Some areas	Some areas	No	Yes	Always	No
Netherlands	Yes	Some areas	Some areas	Yes	Always	Yes
Norway	Some areas	Some areas	No	Yes	Always	Some areas
Poland	Some areas	Some areas	Some areas	Yes	Always	No
Portugal	Yes	No	No	Yes	Always	Yes
Romania	Yes	Some areas	Some areas	Yes	Always	Some areas
Serbia	Yes	Some areas	No	Yes	Always	Yes
Luxembourg	No	No	No	No	Always	Some areas
Slovakia	Some areas	Some areas	Some areas	Yes	Always	Some areas
Slovenia	Yes	Some areas	Some areas	Yes	Always	Yes
Spain	Some areas	Some areas	Some areas	Yes	Always	Some areas
Sweden	Yes	Some areas	No	Yes	Always	No
Switzerland	Some areas	Some areas	Some areas	Yes	Always	
United Kingdom[a]	Some areas	Some areas	Some areas	Yes	Always	Some areas

On scene management of out-of-hospital cardiac arrest by emergency medical personnel, including information on team training for all involved in the treatment of cardiac arrest paitents

Abbreviations: *EMS* Emergency Medical Services, *OHCA* Out-of-Hospital Cardiac Arrest

[a]United Kingdom excluding Wales

survival [22], and EMS agencies with the highest survival rates more often had: treatment from more than six EMS personnel; a shorter EMS call-response interval; more advanced airway attempts; and treatment from an advanced-basic life support tiered system [23].

Cardiac arrest is highly time-sensitive and after 10 min with no CPR or defibrillation, the chances of survival are slim. Median response times for urban areas in Europe of under 10 min were achieved in only 32% of the countries. It is therefore encouraging that our survey has reported that at least 18 European countries have established first responder systems. However, another recent European survey described that many different kinds of first responder systems are used, and also highlighted that regions within countries had different approaches [24]. The introduction of first responder systems is positive, but further layers of difference now need to be considered when explaining variation in outcomes. Of the countries included in our survey, 67% had all dispatch centres as part of the EMS while 15% had some dispatch centres as part of the EMS. The size of the country or the total population did not seem to be

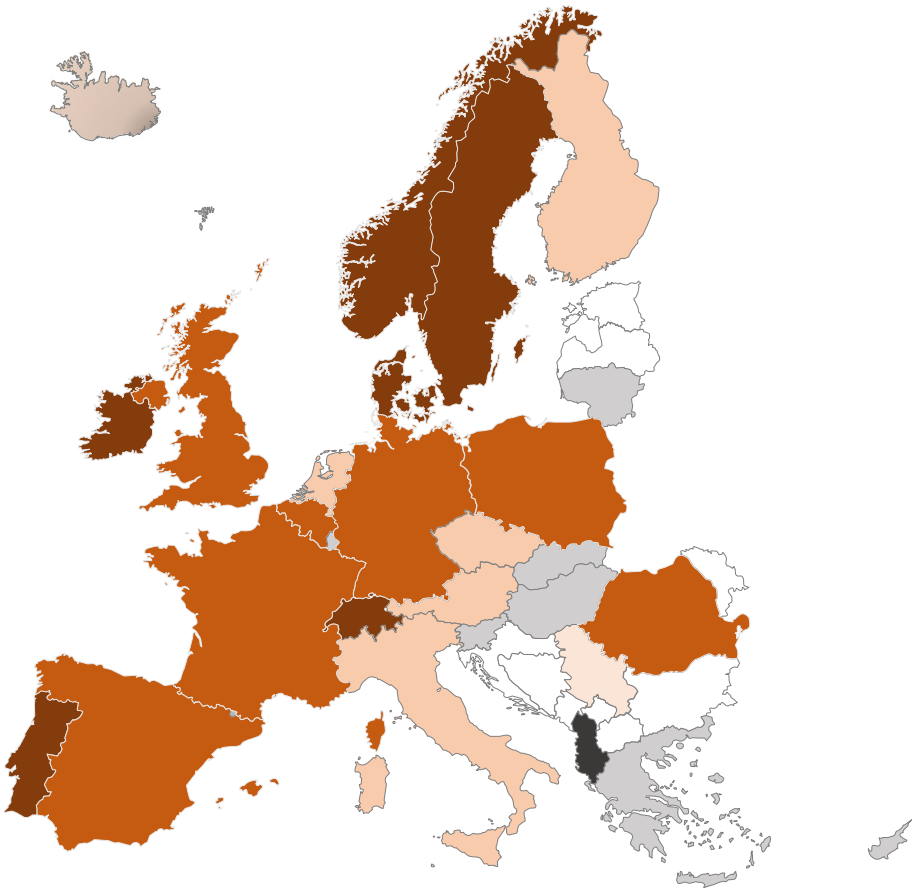

Fig. 4 Out-of-hospital cardiac arrest registries. Legend: The darkest colour indicates a national registry covering all of the country, the second darkest colour indicates a national registry covering parts of the country, medium orange indicates several local registries, light with grey indicates one local registry, grey indicates no local registries and black is unknown. White colour indicates the country did not participate in the survey

the determining factor in the number of dispatch centres. For example, despite differences in population density, Germany and Norway have approximately three dispatch centres per million inhabitants. Similarly, Poland, UK, Ireland and Albania are vastly different in terms of population and land mass, but all have less than 0.5 dispatch centres per million inhabitants. It is important to note that the vast majority of countries reported the use of standardised dispatch protocols and dispatch-assisted CPR instructions. While there was variation in the type of instructions offered, evidence on the type of dispatch-assisted CPR instructions that should be offered is still building [25, 26]. There is increasing evidence of the value of publicly accessible AEDs [27, 28], therefore it was encouraging that responses indicated availability of AED registries in 21 countries. Most importantly, the majority of these registries were available in dispatch centres.

Time-to-shock is a critical determinant of survival [29], therefore the availability of defibrillators in EMS vehicles dispatched for cardiac arrest was a positive finding. Evidence on the value of mechanical CPR remains equivocal [30, 31], which may explain why mechanical CPR was reported to be available in all areas in only three countries. Availability of more advanced prehospital resuscitation interventions was limited, which may also be explained by the current limited evidence to support widespread adoption of these practices. It is of note that most countries permitted transport with ongoing CPR. However, most respondents described very specific circumstances for this practice.

In 2012 the European Parliament published a declaration recommending that all member states adopt common programs for implementing AEDs in public places and training of lay people, adjusting of legislation in order to facilitate CPR and defibrillation by non-medical persons, and organisation of systematic data collection on cardiac arrest for feedback and quality management [32]. Registry data collection in itself is not a guarantee for improved survival, but if core data variables are not available, routine monitoring and surveillance of OHCA outcomes may be difficult. In our survey only six countries reported having a registry with full population coverage and 14 countries reported having partial population coverage. In

Table 5 Cardiac arrest registry coverage and outcome variables collected

Country	Out-of-hospital cardiac arrest registry?	Any ROSC?	Sustained ROSC?	Status on arrival at hospital arrival?	Survival to hospital discharge?	Survival to 30 days?	Survival to one year?	CPC at discharge?	CPC at 3 to 6 months?	CPC at 1 year?	QoL?	Self-defined QoL?
Albania												
Austria	Several local registries	Some areas	Some areas	Some areas	Some areas	Some areas		Some areas				
Belgium	National registry, partial coverage	All areas	All areas	All areas	All areas	All areas		All areas				All areas
Cyprus	No											
Czech Republic	Several local registries	Some areas		Some areas	Some areas	Some areas		Some areas				
Denmark	Full national coverage	All areas		All areas		All areas	All areas					
Finland	Several local registries	Some areas	Some areas	Some areas	Some areas		Some areas	Some areas				
France	National registry, partial coverage	All areas		All areas	All areas	All areas		All areas	All areas			
Germany	National registry, partial coverage	All areas	All areas	All areas	Some areas	Some areas	Some areas	Some areas		Some areas		Some areas
Greece	No											
Hungary	No											
Iceland	Single local registry	Some areas	Some areas	Some areas								
Ireland	Full national coverage	All areas	All areas	All areas	All areas			All areas				
Italy	Several local registries	Some areas	Some areas	Some areas	Some areas	Some areas	Some areas	Some areas	Some areas	Some areas	Some areas	Some areas
Lithuania	No											
Luxembourg	No											
Netherlands	Several local registries	Some areas	All areas	All areas	All areas	All areas	All areas	All areas				
Norway	Full national coverage	All areas	All areas	All areas	All areas	All areas		All areas				
Poland	National registry, partial coverage	Some areas	Some areas	Some areas	Some areas	Some areas	Some areas					
Portugal	Full national coverage	All areas	All areas	All areas								
Romania	National registry, partial coverage	Some areas	Some areas	Some areas	Some areas							
Serbia	Several local registries	All	All areas	All areas	All areas	All areas						

Table 5 Cardiac arrest registry coverage and outcome variables collected *(Continued)*

Country	Out-of-hospital cardiac arrest registry?	Any ROSC?	Sustained ROSC?	Status on arrival at hospital arrival?	Survival to hospital discharge?	Survival to 30 days?	Survival to one year?	CPC at discharge?	CPC at 3 to 6 months?	CPC at 1 year?	QoL?	Self-defined QoL?
		areas										
Slovakia	No											
Slovenia	No											
Spain	National registry, partial coverage	All areas	All areas	All areas	Some areas	Some areas	Some areas	Some areas	Some areas	Some areas		
Sweden	Full national coverage	All areas	All areas	All areas	Some areas	All areas		Some areas	Some areas		Some areas	Some areas
Switzerland	Full national coverage	All areas	All areas	All areas	Some areas	Some areas	Some areas	Some areas		Some areas		
United Kingdom[a]	National registry, partial coverage	All areas	All areas	All areas	All areas	All areas						

Abbreviations: *ROSC* Return of Spontanious Circulation, *CPC* Cerebral Performance Category, *QoL* Quality of Life
[a]United Kingdom excluding Wales

these registries, availability of core outcome variables including ROSC was limited. The establishment of cardiac arrest registries in 20 out of 28 countries is promising, but renewed focus is needed to encourage countries to ensure that outcome data is a core component of data collection, as outcome data is essential to compare results and benchmark against the countries that have achieved high survival rates.

There are a number of limitations to this survey. Firstly, the questionnaire was distributed via an established network, primarily developed for conducting the EuReCa ONE and TWO studies. This network has a specific interest in and responsibility for OHCA management and data collection. While there is a risk of selection bias, it is assumed that respondents have a prior knowledge of the EMS systems in their countries. Additionally, respondents were required to validate their answers with another national expert. Secondly, respondents were required to provide answers about their entire country therefore differences in EMS systems within countries were not the focus of this survey. However, respondents were given the option to answer 'sometimes' or 'in some areas' where appropriate. Finally, the survey was conducted in English but this is not the primary spoken language for most countries that participated. It is therefore possible that there may have been differences in interpretation of questions by different respondents.

This survey has described some of the differences in the EMS systems in Europe and have raised a number of new research questions. In future, research surveys should be set up to look for correlations or associations between variables, and linking the results to outcome after out-of-hospital cardiac arrest and survival after trauma. In addition, future research on EMS systems in Europe should consider using the WHO emergency care system assessment tool.

Conclusion

Throughout Europe there are significant differences in EMS systems and the response to OHCA. Even for interventions that have been shown to have an effect on survival, implementation across Europe varies. While the impact of EMS system differences is not fully understood, having documented these differences provides the opportunity to adjust for the differences when looking at incidence and survival after OHCA.

Supplementary information

Supplementary information accompanies this paper at https://doi.org/10.1186/s13049-020-00798-7.

Additional file 1. EMS survey.

Abbreviations

OHCA: Out-of-hospital cardiac arrest; ROC: Resuscitation Outcomes Consortium; Aus-ROC: Australian and New Zealand Resuscitation Outcomes Consortium; PAROS: Pan Asian Resuscitation Outcomes Study; EuReCa: European Registry of Cardiac Arrests; ROSC: Return of spontaneous circulation; EMS: Emergency Medical Services; ERC : European Resuscitation Council; Writing Group: Guidelines 2020 Epidemiology Writing Group; PCI: Percutaneous Coronary Intervention; EMTs: Emergency medical technicians; ALS: Advanced life support; HEMS: Helicopter EMS; DA-CPR: Dispatch-assisted Cardio Pulmonary Resuscitation; AED: Automated External Defibrillators; ECMO: Extracorporeal membrane oxygenation; REBOA: Resuscitative endovascular balloon occlusion of the aorta

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Authors' contributions

Ingvild Tjelmeland: Conceptualization and design of the work, analysis and interpretation of data, written first drafted and revised the final article, project administration. Siobhan Masterson: Conceptualization and design of the work, analysis and interpretation of data, written first drafted and approved final version. Johan Herlitz: Conceptualization and design of the work, analysis and interpretation of data, written first drafted and approved final version. Jan Wnent: Conceptualization and design of the work, analysis and interpretation of data, written first drafted and approved final version. Leo Bossaert: Conceptualization and design of the work, analysis and interpretation of data, written first drafted and approved final version, supervision. Fernando Rossell Ortiz: Conceptualization and design of the work, analysis and interpretation of data, written first drafted and approved final version. Kristin Alm-Kruse: Analysis and interpretation of data, written first drafted and approved final version. Berthold Bein: Conceptualization and design of the work, analysis and interpretation of data, approved final version. Gisela Lilja: Conceptualization and design of the work, analysis and interpretation of data, written first drafted and approved final version. Jan-Thorsten Gräsner: Conceptualization and design of the work, analysis and interpretation of data, written first drafted and approved final version, supervision. The author(s) read and approved the final manuscript.

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Availability of data and materials

The individual responses to the survey are available from the corresponding author on reasonable request. Consent from all involved participants will be sought before sharing.

Ethics approval and consent to participate

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Consent for publication

Not applicable.

Competing interests

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