



Citizen Response To Cardiac Arrest



When a person suffers a cardiac arrest, citizen first responders can play a crucial role. This document explores how volunteer responders can be engaged to save lives.

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1 | INTRODUCTION

In case of a sudden cardiac arrest, the time to treatment is of foremost importance. Without treatment, the survival rate drops 10% for every minute in cardiac arrest.¹

Since the 1970s, efforts have been made to educate the public in early recognition and cardiopulmonary resuscitation (CPR), which has increased overall survival. Still, the survival rates remain low worldwide, where only 1 in 10 survive.² In the early years of 2000, safe and easy-to-use automated external defibrillators (AED) emerged on the market. When used early in the process, such as in casinos or airports, were proven to have the potential to increase survival by as much as 70 %.^{3 4}

Today AEDs are placed and made publicly available in society, often in public areas, and their locations are made publicly known through web-based AED registries. Unfortunately, studies find AEDs to be seldom used by bystanders. A study from Sweden found that AED referral by dispatch centers through the national AED register was ineffective since dispatchers failed to remember accessing the AED register.⁵

A volunteer responder system is an effort to overcome these problems. The basic idea is that the emergency medical call centers (EMCC) can dispatch registered volunteers via their mobile phones to take part in immediate resuscitation in their vicinity.

¹ Larsen M.P. et al. Predicting survival from out-of-hospital cardiac arrest: a graphic model. *Ann Emerg Med* 1993

² Gräsner J-T. et al. European Resuscitation Council Guidelines 2021: Epidemiology of cardiac arrest in Europe *Resuscitation* 2021

³ Valenzuela TD. et al. Outcomes of rapid defibrillation by security officers after cardiac arrests in casinos. *N Engl J Med* 2000

⁴ Ringh, M. et al. Survival after Public Access Defibrillation in Stockholm, Sweden - A striking success *Resuscitation* 2015

⁵ Fredman, D. et al. Expanding the first link in the chain of survival - Experiences from dispatcher referral of callers to AED locations. *Resuscitation* 107 (2016) 129-134

2 | WHY ARE SOLUTIONS NEEDED?

Sudden cardiac arrest is the third leading cause of death in Europe. Most of the sudden cardiac arrests appear out-of-hospitals and clinics and are defined as Out-of-hospital cardiac arrests - OHCA. The European incidence of OHCA ranges between 67 - 170/100,000 inhabitants and the survival rate on average is 8 - 10%.⁶

A cardiac arrest is defined as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation.⁷ The heart cannot pump effectively or at all, often due to an electrical chaos from the heart's impulse-conducting system. The victim loses consciousness and death is imminent if not cardiopulmonary resuscitation (CPR) is prompted.

CPR by means of chest compressions and rescue breaths oxygenates the brain and heart. CPR also primes the myocardium to be susceptible to defibrillation. If the patient is found with a shockable rhythm (ventricular fibrillation (VF) and ventricular tachycardia (VT)), the rhythm can be restored to normal circulation by applying an electrical shock, i.e. defibrillation, to the chest.

The resuscitation of a cardiac arrest is strongly time-dependent, the chance for successful defibrillation decreases for every minute without CPR or use of an AED.⁸ If the victim is reached very early during the arrest, there is a higher probability of survival.^{9 10}

Resuscitation is attempted or continued by emergency medical service (EMS) personnel in about 50-60% of cases. Response times for EMS are often long, and resuscitation should be attempted within the first few minutes in order to save lives.¹¹ Hence basic resuscitation by bystanders becomes prominent.

The rate of bystander CPR in Europe varies between and within countries (between 13% to 83%). Even with increasing numbers, the use of AEDs remains low in Europe.¹² 75% of European countries have an AED register. The use of AEDs before EMS arrival reduces the time from alert to defibrillation of patients, thereby increasing the survival rate.

In order to reduce the time to perform CPR and rapid defibrillation using an AED, systems that dispatch volunteer responders have been developed and implemented over Europe.

⁶ Gräsner J-T. et al. European Resuscitation Council Guidelines 2021: Epidemiology of cardiac arrest in Europe *Resuscitation* 2021

⁷ Jacobs, I. et al. Cardiac arrest and cardiopulmonary resuscitation reports: update and simplification of the Utstein templates for resuscitation registries. *Resuscitation* 2004;63:233-49

⁸ Larsen, MP. et al. Predicting survival from out-of-hospital cardiac arrest: A graphic novel. *Ann Emerg Med* 1993;22(11):1652-58

⁹ Herlitz, J. et al. Factors associated with an increased chance of survival among patients suffering from an out-of-hospital cardiac arrest in a national perspective in Sweden. *Am Heart J.* 2005 Jan;149(1):61-6.

¹⁰ Hasselquist-Ax, I. et al. *N Engl J Med.* Early cardiopulmonary resuscitation in out-of-hospital cardiac arrest. 2015;372(24):2307-15.

¹¹ Gräsner J-T. et al. European Resuscitation Council Guidelines 2021: Epidemiology of cardiac arrest in Europe *Resuscitation* 2021 161:61-79

¹² Gräsner J-T. et al. European Resuscitation Council Guidelines 2021: Epidemiology of cardiac arrest in Europe *Resuscitation* 2021 161:61-79

In the recent international resuscitation guidelines, installation of such systems is advocated strongly, although with very-low certainty evidence.¹³

Notwithstanding, among stakeholders and researchers, there is a high consensus that volunteer responder systems save lives.¹⁴ In a recently presented but not yet published study from 5 European areas with well-established volunteer responder systems including over 9000 OHCA's showed that the system was associated with 28 % higher 30-day survival.¹⁵

The overall goal with any volunteer responder system is to increase survival in OHCA using CPR trained volunteers or semi-professionals and publicly available AEDs.

3 | SUMMARY OF SOLUTIONS AVAILABILITY IN EU

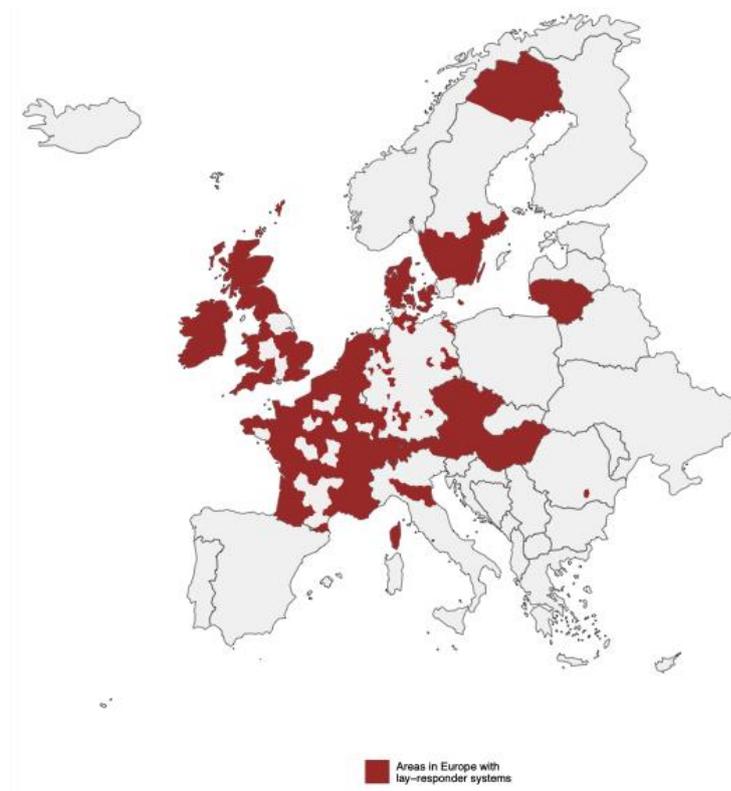


Fig 1. Map displaying European areas with volunteer responders active on a national or regional level.

¹³ Semeraro, S. et al. European Resuscitation Council Guidelines 2021: Systems saving lives. *Resuscitation*: 161:80-97.

¹⁴ Metelmann, C. et al. Smartphone-based dispatch of Community First Responders to Out-of-Hospital Cardiac Arrest - Statements from an International Consensus Conference. *Scand J Trauma Resusc Emerg Med* 29, 29. 2021

¹⁵ <https://www.escardio.org/The-ESC/Press-Office/Press-releases/If-you-witness-a-cardiac-arrest-your-actions-could-save-a-life>

There is a wide variety of volunteer responders' systems, introduced between and even within European countries. Volunteer responder systems in some forms are available in nearly 50% of all European countries. (Fig 1.)

Introduced in the late 2000s, volunteer responder systems were first based on GSM localization and short text message system (SMS) alerts. Later, with the introduction of smartphone technology, they became more commonly app-based using GPS or assisted GPS for locating volunteers and providing map aided assist during the alert.

Volunteer responders are often recruited in their community when taking a basic CPR course but can also in some systems be professional or semi-professional health workers or security personnel such as firefighters or police officers when off-duty. In some systems, a specific course in first aid and basic CPR is required, and certain equipment and certificates are provided.

The system of dispatch can be either:

- Semi-automatic, manually triggered from EMCC dispatcher with little or no communication between the dispatcher and the volunteer responder.
- Open for communication and overt, where the dispatcher can see the path of the volunteer responder on a map and provide information either orally or via message.

A system enabling communication between volunteer responder and dispatcher can involve a group of specially trained volunteers or semi-professionals (Langeland in Denmark, GoodSam in Great Britain) off-duty firefighters, or home care nurses with other duties (Sweden). These systems are often dispatched at many types of high priority calls (not only OHCA), because of an expected long response time for EMS and require a specific course for the participant, who can be either a volunteer or a professional and include other urgent medical treatments other than CPR and defibrillation.

A semi-automatic system engages many volunteer responders who are positioned via the smartphone's location services and GPS on a regular basis. In case the volunteer responder is located nearby an OHCA victim at the time of the dispatch, the volunteer responder is alerted, and can either accept or decline the mission. The system is triggered by the dispatcher at the local EMCC and automatically alerts a given number (approx. 20-40) of volunteer responders within a certain radius around the victim ranging from approximately 500 to 10 000 meters.

An automatic system engages a predefined number of volunteer responders who are located within a present radius/distance via the smartphone's location service and GPS at alert time. Those systems use an algorithm in order to optimize the dispatch of volunteers according to their position and sometimes skill. The system is automatically triggered by the CAD software in case of OHCA, which makes it possible to systematize the triggering of volunteers and to minimize the alert delay. Volunteers search radius is automatically linked to the population density in the OHCA area.

Some older technical systems are still in use in the EU and use location by GSM or by Zip code and text message for alert. In Amsterdam, text message responders living in a specific area or under a zip code are alerted in this particular area in case of an OHCA regardless of where they are at the moment.

Other resources can also be present in an area, such as firefighters and/or police officers acting as professional first responders. Some of these systems (i.e. Ticino, Switzerland & France) recruits both on-duty first responders as well as volunteer responders within the same application system.

Description of a typical system, what's needed?

<p>Dispatch</p>	<p>Any system alerting volunteer responders needs to be initiated from a public safety answering point (PSAP) or emergency medical communication center (EMCC). After a 112 call and the initial interview to determine the nature of the call the dispatcher (or the CAD software) can trigger the system in case of a suspected cardiac arrest. It is possible to add exclusion criterias for alerts that can differ from site to site: e.g. unsafe location, traumatic OHCA cases, obvious signs of death, OHCA in private homes, EMS already on scene etc.</p>
<p>A volunteer responder system</p>	<p>Most systems are triggered from the dispatcher at 112, nowadays based on map guided smartphone applications, but can also be based on text messages with links to coordinates and with address information in the text message.</p>
<p>Prerequisites and training for volunteer responders</p>	<p>Most systems require the volunteer responder to state that they have undergone a CPR course. Many systems do not provide specific training or CPR courses. Repetition courses are always recommended in line with European or national CPR guidelines.</p> <p>Some systems are targeted towards semi-professionals rather than volunteer responders and require specific training and certificates before registration.</p> <p>Some systems use untrained volunteers, to specifically fetch an AED.</p>
<p>AED-register</p>	<p>It is preferred that the region has an online AED-register with information on location and availability of publicly available AEDs. With AED data available the volunteer responders can be asked to go via a nearby public AED on the way to the patient and this increases the effect of the system.</p>
<p>Registered Volunteers</p>	<p>The volunteer responders must register into the system, and if app based allow for daily or live location tracking through the app. In case of being located near a victim, the volunteer responder can accept or decline the mission. The volunteer responder can either be directed to perform CPR or to fetch an AED.</p>

Location system

App Based solutions use location services in the smartphone (3g/4g/GPS) but older tracking systems may be GSM-based or in some cases based on Zip code.

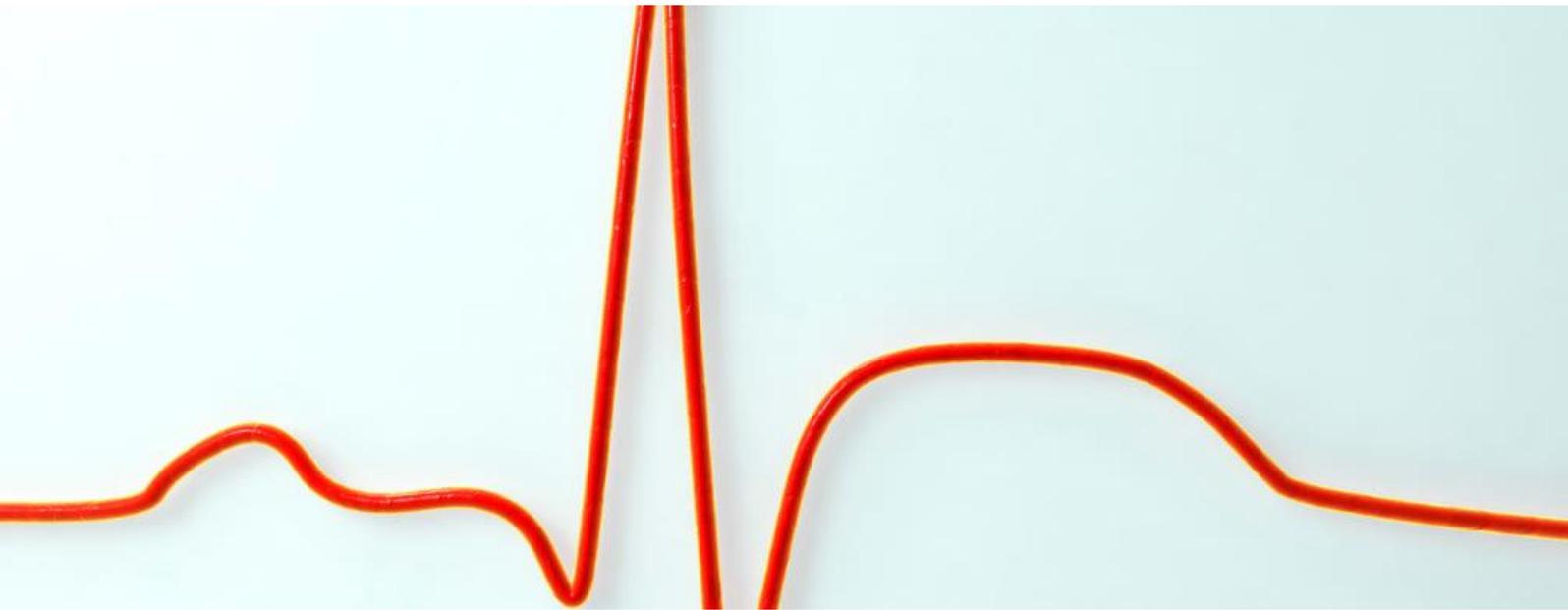
Pros and cons

In a publication by Caputo et al. the authors compared a text message-based system and an app-based system. With a similar number of alerts, the app system was deemed highly efficient by significantly increasing the number of volunteer responders arriving on scene before the ambulance from 15 % to 70%.¹⁶

The drawback of an app-based system is mainly that the system needs mobile data (4G/3G/GPRS) to function. A text message-based system will instead use the carrier network for SMS/texts, and thus be less reliant on data. But with an app there are the advantages of GPS location and tracking possibilities, and also information and other means of communication are available. Nevertheless, we need to address the fact that apps need to be updated regularly otherwise they may lose functionality. It may also be a struggle to keep many thousands of app users alert and updated. One of the main issues with apps is mobile phone renewal every 2 to 4 years. There is a risk that volunteers forget to reload a rarely used app or to register again.

Most volunteer responder apps also provide an AED location system enabling users to quickly and easily find the closest AED in case of emergency.

¹⁶ Caputo, ML. et al. Lay persons alerted by mobile application system initiate earlier cardio-pulmonary resuscitation: A comparison with SMS-based system notification. Resuscitation. 2017; 114:73-78



4 | KEY RECOMMENDATIONS FOR COUNTRIES

In the 2021 *European CPR guidelines*, it is stated that technologies to alert volunteer responders to cardiac arrests through smartphone apps / text messages should be implemented.¹⁷

The benefit of volunteer responder systems has been repeatedly shown in international research and the benefit may be significant when such systems are in systematic use in more regions/nations.^{18 19 20 21 22 23}

Today, we see many emerging systems in regions and countries around Europe. We acknowledge that it may seem easy to set up an app for alerting volunteer responders. But

¹⁷ Semeraro, S. et al. European Resuscitation Council Guidelines 2021: Systems saving lives. *Resuscitation*: 161:80-97.

¹⁸ Squizzato, T. 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.

¹⁹ Andelius, L. Et al. Smartphone Activation of Citizen Responders to Facilitate Defibrillation in Out-of-Hospital Cardiac Arrest *J Am Coll Cardiol*. 2020 Jul, 76 (1) 43-53

²⁰ Ringh, M. et al. Mobile-Phone Dispatch of Laypersons for CPR in Out-of-Hospital Cardiac Arrest and Others *N Engl J Med* 2015; 372:2316-2325

²¹ Zijlstra J.A. et al. Local lay rescuers with AEDs, alerted by text messages, contribute to early defibrillation in a Dutch out-of-hospital cardiac arrest dispatch system. *Resuscitation*. 2014;85(11):1444-9.

²² Weir A. Community first responders: improving access to defibrillation in cardiac arrest. *Journal of Paramedic Practice*. 2015;7(3):114-6.

²³ Derkenne, C. et al. Mobile Smartphone Technology Is Associated With Out-of-hospital Cardiac Arrest Survival Improvement: The First Year "Greater Paris Fire Brigade" *Academic Emergency Medicine* 2020; vol 27 issue 10; 951-962

a system like this needs to have a long lifespan, and that should be taken into account when choosing to develop a new or use an existing solution.

Another highly important factor is to maintain an active group of recruited volunteer responders. In Sweden, volunteer responders are actively recruited at CPR training courses. And in Denmark, Sweden and France there are active social media sites (such as Facebook, Twitter, Instagram) supporting the volunteer responder community (TrygFonden Hjerteløber, Sms-livräddare & le Bon Samaritain).

Must haves for effective implementation of volunteer responder system:

PSAP - EMCC - 112

In order to set up a successful volunteer responder system a centralised medical dispatch is required. It all starts with someone calling 112 and the dispatchers identifying the call as a suspected cardiac arrest as soon as possible. The Public Safety Answering Point (PSAP) or EMCC needs a systematic and structured interview function to be able to identify and classify incidents to be able to differentiate the 112 calls concerning OHCA incidents as soon as possible and alert volunteer responders.

Regardless app-based or text message based any volunteer responder system will only perform as well, and as fast as the EMCC allows since it will only respond to input from the EMCC.

A potential risk with volunteer responder systems is if the selection of cases and activation of a third-party system like this is not automated at EMCC but relies on the individual dispatcher's memory and workload. Without systematic and technological reminders for the dispatchers it may lead to underuse and seem like the volunteer responder system is malfunctioning due to missed activation from dispatchers.

A key point is to integrate the volunteer responder service with the EMCC system through APIs in order to trigger volunteer responders structured and automatically to avoid missed activation.

Technological infrastructure and carrier network

Every volunteer responder solution needs to be highly secure to comply with EMCC requirements. Data encryption and IP filtering for system activation are among the minimum precautions to be taken.

The volunteer responder front-end used in the EMCC can either be installed locally or in the cloud depending on the solution provider. While both solutions may work equally, a cloud-based solution avoids potential disruption through system updates in the EMCC.

Both app-based and text message-based volunteer responder systems rely on carrier network infrastructure. With a good national and regional signal and data traffic coverage functionality is ensured.

App based systems require available data traffic for the user/volunteer and the app must be updated regularly to comply with software updates for the smartphone platforms. The GPS/location service functionality gives an exact position for the user but has a trade off with battery life.

A text message-based system uses carrier network signal strength for triangulation and this brings issues with precision and speed for positioning.

CPR education / volunteer

Depending on the requirements for registration of volunteer responders sufficient training is necessary. At a minimum systematic and structured CPR education should be in effect in the country to be able to produce skilled volunteers.

AED registry

To make the most effective volunteer responder system, a digital AED registry is important since it makes it possible to include information on AED locations in the alerts. The AED registry could be national or regional but should be vendor agnostic and as up to date as possible.

OHCA outcome register to validate effect

In order to evaluate the outcome of any volunteer responder system, regardless of technology an Utstein style OHCA outcome register will prove valuable. This allows robust collection of key data elements (e.g. initial arrest rhythm, witnessed status, location and cause of collapse) and enables analysis of survival in OHCA patients.²⁴

²⁴ Gräsner J-T. et al. European Resuscitation Council Guidelines 2021: Epidemiology of cardiac arrest in Europe *Resuscitation* 2021 161:61-79

5 | LAWS AND LEGISLATIONS

Laws and regulations regarding volunteer responders vary a lot in Europe. In most countries, the Law protects volunteer responders from liability. A few examples follow.

In France, there is a Good Samaritan Law which protects anyone acting in an emergency situation:

"A person who, in the face of actual or imminent danger to himself, another person or property, performs an act necessary to safeguard the person or property is not criminally liable, unless the means employed are disproportionate to the gravity of the threat." (art. 122-7 Code Pénal).²⁵

Furthermore, anyone is allowed to use an AED since 2007 even without any training.

In 2020, a new Law (*n° 2020-840 3rd july 2020*)²⁶ was voted in the French Parliament which creates the "Citizen Responder" status and protects the person from any liability: *"A citizen responder is "any person providing voluntary assistance to a person in an apparent situation of serious and imminent danger". The actions that characterise the citizen responder are the practice of CPR, the use of a cardiac defibrillator or any other first aid action. As soon as they provide assistance, citizen responders contribute to civil security. They benefit from the status of occasional collaborator of the public service. The purpose of this status is to reduce the criminal liability of the citizen responder during their intervention. It exonerates the citizen responder from any civil liability for the damage resulting for the victim from their intervention (except for intentional or characterized fault).*

In Sweden, Chapter 24 Section 4 of the Swedish Penalty Code (*brottsbalken*) states that criminal actions or omissions which are committed out of necessity, do not constitute a crime as long as they are not indefensible.²⁷ In Sweden volunteer responders/Sms-livräddare are currently not covered by national or other insurances apart from their own.

²⁵ https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000006417220

²⁶ <https://www.legifrance.gouv.fr/loda/id/LEGIARTI000042081129/2021-10-31/>

²⁷ <https://lagen.nu/1962:700#K24>

6 | CASE STUDIES:

Sweden

In Sweden a system for alerting volunteer responders through text messages was introduced as early as in 2010. Initially using GSM triangulation, the introduction of Sms-livräddare was part of a scientific evaluation from the Karolinska Institutet. The scientists targeted CPR trained individuals over 18, initially only in down-town Stockholm. In the first steps alerts were only sent in cases of OHCA in public locations but after a short time this was changed to also include OHCA in private homes. The reason was two-folded, EMCC staff struggled to identify and verify the OHCA location and over 70% of the OHCA in Sweden occur in private homes. No adverse events related to arrest location (i.e. private homes vs public location) were reported during the course of the scientific evaluation. In 2015, in a publication in the New England Journal of Medicine, the result of a randomized controlled trial showed a significant increase in bystander-CPR.²⁸

During 2015 an app-based system was introduced and by 2016 the second largest region Västra götaland joined. Still closely tied to science the Karolinska Institutet carried out research and a PhD thesis was successfully defended in 2020.²⁹

Since 2018 the national PSAP/EMCC organisation SOS Alarm AB has distributed the system in Sweden. In november 2021 10 of the 21 Swedish regions were connected. Currently over 98 000 citizens have registered as volunteer responders and over 14 000 alerts have been issued since 2015. The Swedish AED register (www.hjartstartarregistret.se) is maintained by the Swedish Resuscitation council (www.HLR.nu) and the AED data is made available in alerts in the app as well as for app users when no alert is active.

Denmark

In 2017 the Danish TrygFonden decided to install a system for alerting volunteer responders. They use the swedish app based Heartunner system under their own brand TrygFonden Hjerteløber. The introduction was done in the capital region (Copenhagen) in close collaboration with scientists and several research projects are currently ongoing.³⁰

With the introduction of TrygFonden Hjerteløber in all five Danish regions in 2020 Denmark is possibly the first European country to use one uniform system for alerting volunteer responders. In november 2021 over 123 000 Danish citizens had enrolled as volunteer responders.³¹

²⁸ Ringh, M. et al. Mobile-Phone Dispatch of Laypersons for CPR in Out-of-Hospital Cardiac Arrest and Others N Engl J Med 2015; 372:2316-2325

²⁹ <https://openarchive.ki.se/xmlui/handle/10616/47448>

³⁰ <https://hjertestarter.dk/hjerteloerber/forskning/forskningsprojekter-om-hjerteloerberordningen>

³¹ <https://hjertestarter.dk/hjerteloerber/tal-og-fakta-om-hjerteloerber>

TrygFonden Citizen Responder Application – Development in Registered Citizen Responders 2017-2021

● TOTAL ● CAPITAL REGION OF DENMARK ● CENTRAL DENMARK REGION ● REGION OF SOUTHERN DENMARK ● REGION ZEALAND ● NORTH DENMARK REGION

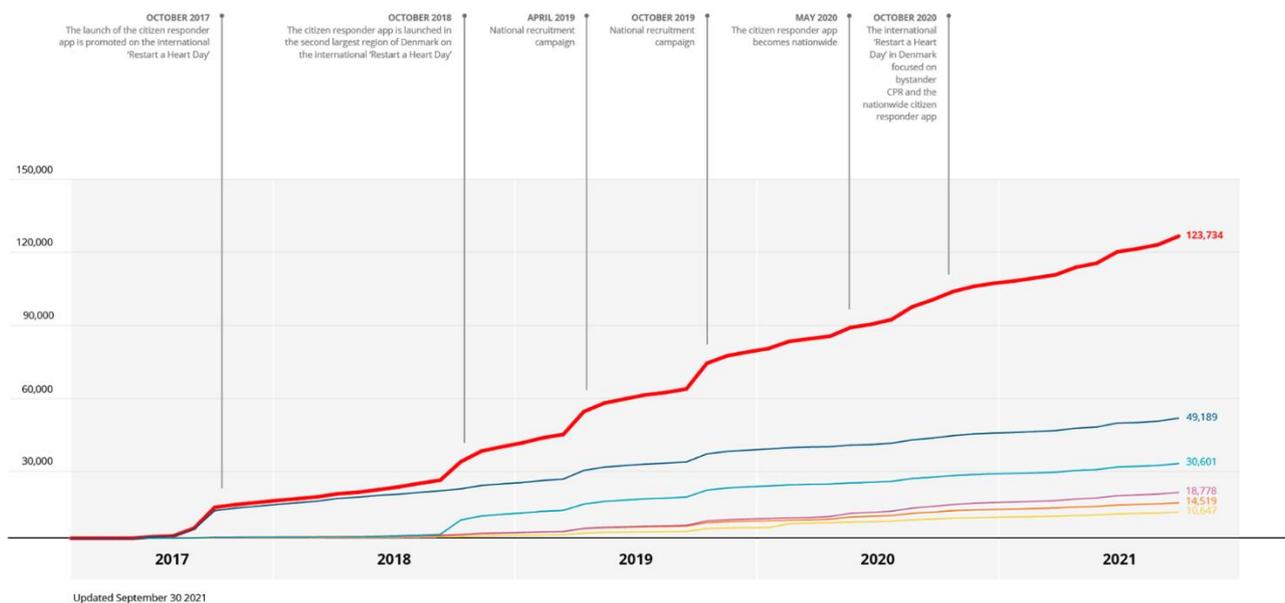


Fig 2. Development of registered volunteer responders in Denmark since the introduction of the TrygFonden Hjerteløber in 2018 until 2021

In Denmark the national AED register (<https://hjertestarter.dk/find-hjertestartere/find-hjertestartere>) is maintained by TrygFonden and the AED data is made available in alerts in the app as well as for app users when no alert is active.

France

In France there are 2 systems to alert volunteers in case of OHCA:

The first one, Le Bon Samaritain, was launched in 2016 in partnership with the Paris firefighters (112 PSAP). It now covers 70 French states that have almost 50 million citizens. It's mainly deployed among firefighter's dispatch (112) centers. It's fully automated and integrated in NexSIS, the new national emergency calls handling system deployed among Fire & Rescue Services. Le Bon Samaritain uses Staying Alive mobile app to enroll, locate live and alert responders. Staying Alive provides an international AED database. The system uses both trained and untrained responders. Untrained responders being only sent to fetch an AED.

More than 16.000 alerts have been triggered since launch. A study conducted by the Paris Fire department showed a x2 survival rate (from 16 to 35%) among OHCA when responders were sent on site.³²

The second one, Sauv Life, was launched in 2018 among the French EMCC (SAMU). It covers roughly 55 states so far. It uses a mobile app to enroll volunteers and SMS to alert them. The system uses both trained and untrained volunteers, both dispatched to the victim.

We are aware of other systems being available in different European countries including Stan in the Netherlands, Fondazione Ticino Cuore in Italy and GoodSam in the UK but we lack the competence to fully describe them.



³² Derkenne, C. et al. Mobile Smartphone Technology Is Associated With Out-of-hospital Cardiac Arrest Survival Improvement: The First Year "Greater Paris Fire Brigade" Academic Emergency Medicine 2020; vol 27 issue 10; 951-962

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