FirstAED emergency dispatch, global positioning of community first responders with distinct roles – a solution to reduce the response times and ensuring an AED to early defibrillation in the rural area Langeland

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Abstract: FirstAED is a supplement to the existing emergency response systems. The aim is to shorten the community first responder response times at emergency calls to below five minutes in a bridge connected island area. FirstAED defines a way to dispatch the nearby three first responders and organise their roles in a team structure to reduce response times, ensure citizens' safety and offer equal possibility of early defibrillation. First aid is provided by community first responders who use their smartphone. FirstAED global positioning system (GPS)-tracks the nine nearby first responders and enables the emergency dispatcher to send an organised team of three first

responders with distinct roles to the scene automatically. During the first 24 months the FirstAED system was used 718 times. Three first responders arrived in ~89% of the cases, and they arrived before the ambulance in ~94% of the cases. FirstAED entailed a significant reduction in median first responder response time to four minutes nine seconds and in median time to AED on site to five minutes and 47 seconds.

Keywords: cardiopulmonary resuscitation; CPR; response time; community first responder; CFR; dispatching; public access defibrillation; PAD; global positioning system; GPS; debriefing; automatic external defibrillator; AED; emergency medical services; EMS; emergency medical dispatch centre; EMD; basic life support; BLS; team structure; Denmark.

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1 Introduction

Sudden out-of-hospital cardiac arrest (OHCA) is the leading cause of death in developed countries. In Denmark, approximately 3,500 people suffer an OHCA every year. The overall survival rate for OHCA is increasing but still low, approximately 11% (Wissenberg et al., 2013). Throughout the period, 2001–2010, there was a significant increase in the proportion of patients receiving bystander cardiopulmonary resuscitation (CPR), 21.1% in 2001 to 44.9% in 2010. Only a small proportion was defibrillated with an automatic external defibrillator (AED) by bystander, 1.1% in 2001 to 2.2% in 2010 (Wissenberg et al., 2013). Public access defibrillation (PAD) and first responder AED programmes may increase the number of patients who receive bystander CPR and early defibrillation (The Public Access Defibrillation Trial Investigators, 2004). International guidelines recommend CPR within five to six minutes (Deakin et al., 2010; Weisfeldt et al., 2002) and early defibrillation with an automated external defibrillator with the purpose of increasing the survival rate from OHCA (Koster et al., 2010; Iwami et al., 2007). The full potential of PAD programmes and AEDs has not yet been achieved, because they are mostly used in public settings, yet 60%–80% of cardiac arrests occur at home (Weisfeldt et al., 2010; Kitamura et al., 2010). Shortening the ambulance/paramedic response times to less than five minutes in the rural areas of Denmark including the island of Langeland, is however extremely expensive and unrealistic. Therefore the dispatch of a team of volunteer trained community first responders (CFRs) may be a good, cheap, alternative solution.

Rapid emergency response teams are established at many hospitals to prevent in-hospital cardiac arrest (Peberdy et al., 2007; Devita et al., 2006) and to perform emergency resuscitation care in relation to evidence-based protocols. These treatments rely on teams whose personnel composition changes frequently, and these teams are usually composed of varying combinations of physicians, nurses, paramedics with different, dedicated skills and duties.

Dispatching of volunteer first responders is established in the Netherlands (Zijlstra et al., 2014) and in the RUMBA study in Stockholm, Sweden (Ringh et al., 2011). In both studies many volunteer laypersons can be alerted at the same time by the system. The Dutch system uses CPR-AED-Alert text messages to the local (living and/or working in the area) first responders to pick up the AED or to go to the victims of suspected OHCA and provide early CPR and defibrillation.

The Dutch model of emergency pre-hospital cardiac care began around five years ago, when it was clear that standard ambulance response times around 15 minutes were too long to provide an effective CPR service. Some rural Dutch regions have reduced the time from first emergency call to defibrillation to seven to eight minutes and increased the overall survival rate to 23% (Zijlstra et al., 2014).

In the RUMBA study, when an alarm call of a suspected OHCA is received by the EMS dispatch operator, a mobile positioning system (MPS) is activated. The MPS uses the mobile phone network to geographically locate all lay volunteers connected to a tailored mobile phone service called mobile life saver (MLS). The MPS then locates all lay volunteers within a pre-defined radius from the suspected OHCA and alerts them with a computer generated voice call and an SMS containing data about where the suspected OHCA is located. A map is also sent in order to make route finding easy.

The island of Langeland is a part of rural Denmark. Langeland is just around 60 kilometres (km) long and around 10 km at its widest. The island is bridge-connected and characterised by long ambulance response times and long distances to the local Svendborg Hospital, approximately 20–50 km.

The island has a population of 13,000 inhabitants, but in the summertime the population grows, when approximately 260,000 tourists visit the holiday island.

The island has only one ambulance and one paramedic vehicle. That can cause very long response times in the case that the ambulance is reserved for another duty and another ambulance need to arrive from Svendborg 20–50 kilometres away. The official average ambulance response time is 12 minutes, but more than 30% of the ambulances arrive after more than 15 minutes and 15% after more than 20 minutes (The Region of Southern Denmark, http://www.regionsyddanmark.dk/wm337767).

In addition, there are plans for closing the emergency unit at the local Svendborg Hospital and building a new common emergency unit at the Odense University Hospital, located approximately 85 kilometres away from the distant parts of the island.

The information about the long ambulance response times and the imminent closure of the local emergency unit were essential to the inhabitants six years ago, when the idea about founding the Langeland AED Association was born. The inhabitants understood that they could not expect the public emergency services to save their lives in a case of an acute emergency or cardiac arrest. They needed to take part in the first aid/BLS, the CPR and to establish PAD.

The Langeland AED Association was established in March 2008 and the members collected money and raised funds for buying AEDs, AED cabinets, and resuscitation kits. They also established small local AED associations and provided first aid training to the volunteer first responders. Today there are 32 local AED associations in the Langeland AED Association. The population purchased 96 AEDs which are all accessible around the clock. All AEDs are placed with a travel distance to nearest AED of less than two kilometres to enable defibrillation of any patient in cardiac arrest within a few minutes. All the equipment across the island is standardised AEDs, physiocontrol CR+ or physiocontrol LP1000 + rescue kit, to minimise delays and confusion (Abella et al., 2007). Some of the AEDs are placed in temperature-regulated, GPS-controlled AED cabinets that are localised and activated (emergency light and siren) by the new FirstAED alert system. The total fundraising amounted to approximately €340,000.

Adverts in the local newspaper, posters in the town, and streamers on the cars were the media used to encourage the citizens to become CFRs. Two hundred and fifteen volunteer first responders in the age 18–72 years were recruited in 2011, and they all received a 12-hour evidence-based basic first aid training course (airway, breath, circulation, disability protocol) including CPR and how to use an AED. The training included how to recognise a patient whose condition is deteriorating, call for help, start CPR, direct others to get the nearest AED, and use the AED. Every year all the first responders receive a three-hour evidence-based back up training course including a new theme like basic paediatric life support, basic trauma life support (assess injuries, stabilisation of cervical spine, seal wounds, etc.), and anaphylactic reactions.

In the beginning of the project, various models for calling the first responders were tried. At first, a model with information cards/posters with the AED owner's contact details in combination with local telephone calls was tried, but very soon, this model proved to be inefficient. Next an emergency telephone call to the first responder registered in the Danish AED registry (http://www.hjertestarter.dk) was tried, again without major improvement in response times. Finally a model with emergency text messages sent to the local first responders was tested. But it became obvious that none of the models were effective enough to shorten the response time for CFRs to less than five minutes.

Often the first volunteer CFR was too far away to help, and the next CFR on the list had to be called losing valuable seconds or even minutes in the chain of survival. Generally the CFR arrived to the emergency scene after eight to ten minutes. They were often alone helping the patient, providing comfort to the relatives and sometimes giving CPR or basic trauma support, which could be a very dramatic and stressful experience – especially since the outcome was often dubious.

The Langeland AED Association understood that they needed to develop a more optimal dispatch system to the volunteers on the island. The smartphone application FirstAED was developed. The FirstAED solution GPS-tracks the CFRs' smartphones. FirstAED is an auxiliary to the public services and it enables the emergency dispatcher to send an organised team of first responders with distinct roles to the scene. All the first responders were asked to buy their own rescuer smartphone. Some of the first responders were too old to use smartphones or to poor to buy the smartphone at the price ~€530, but many younger people were attracted by the smartphone solution. At the beginning, 215 first responders were committed to the project.

The default FirstAED setup includes first responder case reporting and the possibility for routine debriefing. Debriefing sessions that review clinical and AED-recorded information may improve performance (Edelson et al., 2008). Debriefing of OHCA bystanders stimulates reflection, positively influencing the ability to cope with the emotional reactions and the cognitive perception of own performance, and it motivates the improvement of CPR skills. Importantly, it increases confidence to provide CPR in the future (Møller et al., 2014).

2 Aim and hypotheses

2.1 Reduction in CFR response time and AED on site time

The smartphone application FirstAED was developed with the aim of reducing the CFR response time during emergency calls to less than five minutes and to secure the arrival of an AED within six minutes in a rural part of Denmark.

2.2 Organisation of CFRs in a rescue team structure with the intention to co-work

The project defines a new way to dispatch the nearby CFRs and organise their specific roles (CPR, pick up the AED, on-site coordinator) in a rescue team structure in the hope of reducing response times, securing early defibrillation and in the long term improving survival rates.

First responders establish a rescue team of at least two participants in more than 90% of all the dispatches.

2.3 Assessment of the time gap between CFRs and the professional staff

The project assesses the extent to which volunteer first responders arrive before the paramedics and the ambulance staff in the rescue missions. The project has the potential to calculate the time gap between the arrival of first responders and paramedics/ambulance staff.

The CFR arrives before the professional emergency staff in more than 95% of all the dispatches.

2.4 FirstAED GPS tracking will increase cooperation

Evaluation of the dispatching process, the activation of a few first responders, first responder endurance, the team spirit, the cooperation within the team, and the cooperation between the first responder team and the professionals.

3 Methods

3.1 Setting

In Denmark, there is a single phone number (112) to an emergency call centre that identifies the need for police, fire or medical assistance. In case of a medical problem, the caller is re-directed to an emergency medical dispatch (EMD) centre that answers, processes and responds to the call by activating the appropriate emergency medical services (EMS).

This study evaluates all initial calls to EMS ambulance Funen from April 1, 2012 to March 31, 2014 in which an emergency situation or OHCA was suspected and first responders had been alerted by the FirstAED Alert on the island of Langeland.

The project was designed in collaboration between the department of Cardiology at the Odense University Hospital, the Region of Southern Denmark and the Langeland AED Association.

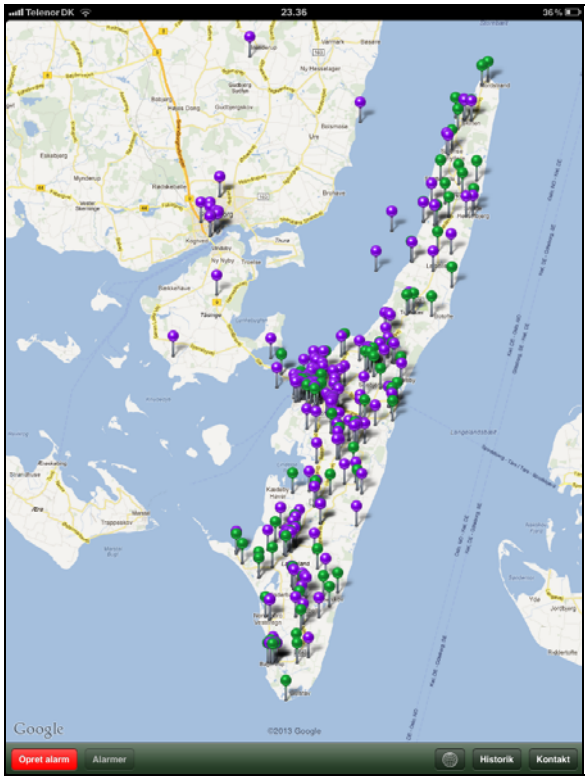
3.2 EMS and FirstAED

Emergency medical system (EMS) ambulance Rudkoebing serves the island of Langeland in Denmark. Like all EMSs in Denmark, the national emergency telephone number 112 is connected to the regional dispatch centre of the EMS. Specially trained nurses or paramedics who instruct different ambulance services with ambulance

posts spread over the Region of Southern Denmark man the dispatch centre. The decision-making process is supported by a criteria-based, nationwide EMD system (Danish Index for Emergency Care, http://www.rm.dk/files/Sundhed/Præhospitalog Beredskab/SundhedsberedskabogPræhospitaludvalg/DanskIndeksversion15Landsudgaven.pdf). When the nurse/paramedic at the dispatch centre suspects an emergency situation or a cardiac arrest in the initial call, an ambulance is dispatched. Immediately after dispatching the ambulance, the health care assistant manager at the dispatch centre activates the FirstAED GPS Alert system to dispatch three GPS tracked CFRs. When the health care assistant manager activates the FirstAED GPS alert system, the system GPS tracks all available first responders, and the EMS FirstAED iPad shows the position of all the first responders and the available AEDs (Figure 1).

The nurses use the following FirstAED dispatching categories: disease, accident, cardiac arrest, traffic accident, others (hanging, birth, drowning, diver with decompression sickness).

Figure 1 Photo from EMS FirstAED GPS Alert system iPad showing the position of anonymous first responders (purple pushpins) and the 96 AEDs (green pushpins) on a random day at the island of Langeland (see online version for colours)

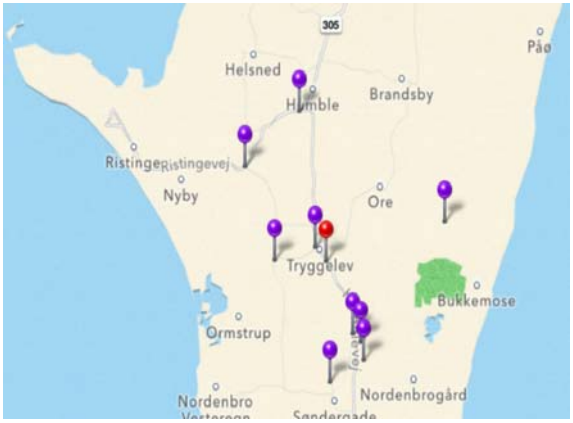


3.3 FirstAED-GPS-alert process

The FirstAED technology deployed on Langeland uses the global positioning system (GPS) to track the geographically nearest first responders when an emergency requires a

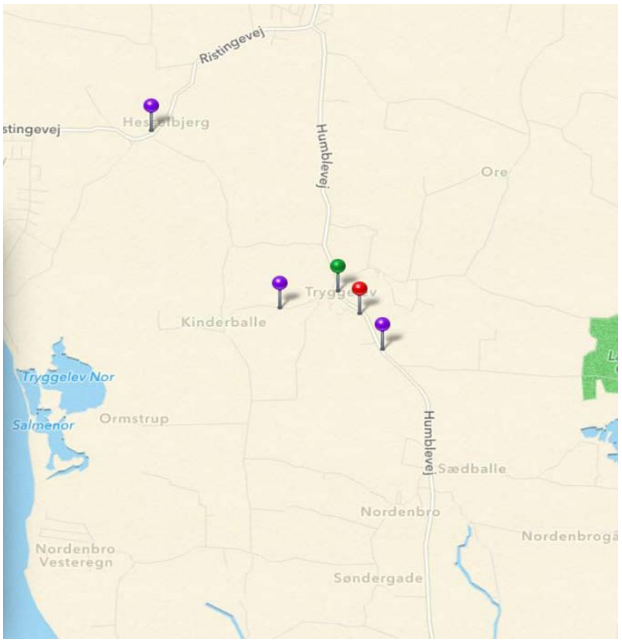
dispatch of first responders. GPS is a space-based satellite navigation system that provides location and time information anywhere on Earth.

Figure 2 Dispatch category cardiac arrest – 20 seconds after activation of the system (see online version for colours)



Notes: Photo from the EMS iPad showing the location of the geographically nearest nine first responders (purple pushpins) who were alerted on their iPhone. The place of the cardiac arrest is marked with the red pushpin.

Figure 3 Dispatch category cardiac arrest – 35 seconds after activation of the system (see online version for colours)

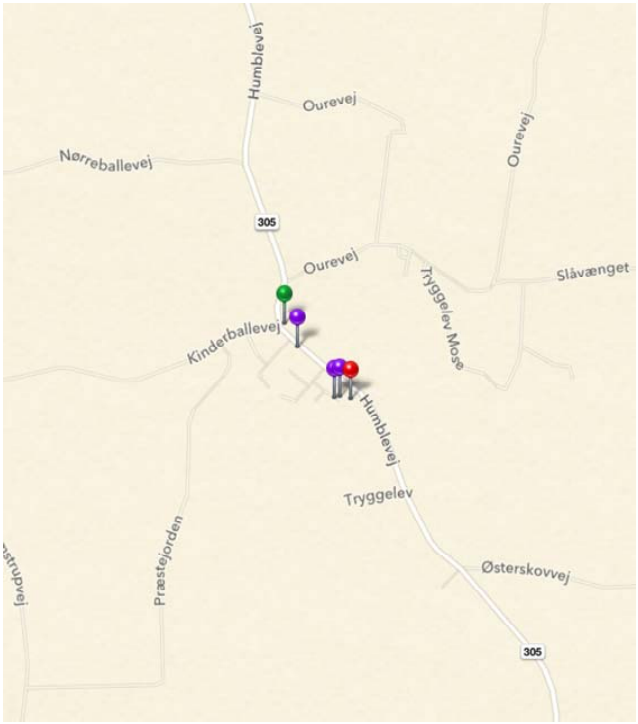


Notes: Photo from the EMS iPad showing the location of the three first responders (purple pushpins) who received distinct resuscitation tasks on their iPhone. The place of the cardiac arrest is marked with red pushpin and the place of the nearest AED is marked with the green pushpin.

FirstAED is activated by the nurses at the central dispatch centre either on an iPad or by automatic signal from the computer aided dispatch system. FirstAED alert starts an automated communication sequence, GPS-track and sends a push-message to the nine nearest first responders who can choose to accept or reject the alarm (Figure 2).

From the pool of the first responders who have accepted the alarm, FirstAED automatically chooses the three most optimally located first responders. FirstAED organises the three first responders in a team with distinct roles based on their current position: no. 1 reaches the patient to give first aid/CPR; no. 2 brings the AED; and no. 3 is the onsite coordinator (Figures 3 and 4).

Figure 4 Dispatch category cardiac arrest – 275 seconds after activation of the system (see online version for colours)



Notes: Photo from the EMS iPad showing the location of the three first responders (purple pushpins). Two first responders including the AED have arrived at the cardiac arrest site.

When the call-out is completed, the first responders have the opportunity to fill in a case report on their smartphones, and in the case they wish to discuss the life-saving activities with a supervisor they have the possibility to request debriefing.

3.4 Study population and data collection

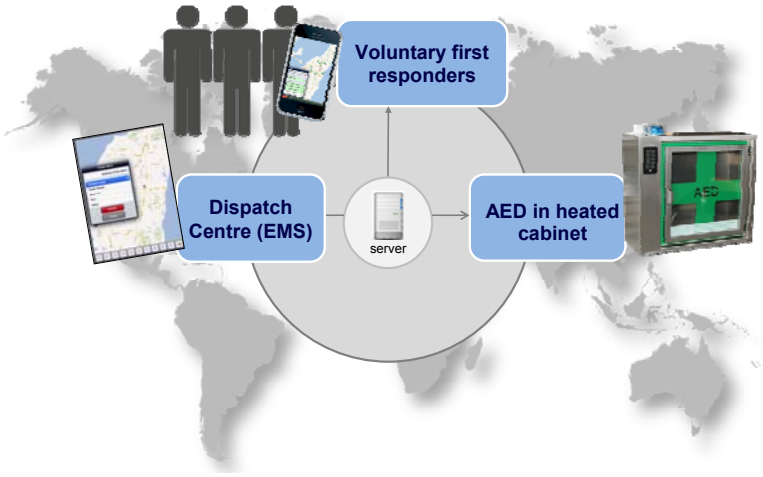
This study uses information from dispatching 215 trained volunteer first responders, including 15 nurses and three doctors.

FirstAED exchanges data between different units and ties it all together, in a unified infrastructure-based communication (Figure 5).

The FirstAED IT-system collect dispatching data about the dispatching category, the emergency place location, the nine first responders involved in the alarm, the three first responders in the rescue team and their tasks, the GPS tracked first responder arrival time, and the first responder case report.

The response time is the time measured from the dispatch to the arrival of the first responder or the AED at the location; the arrival is automatically logged when the first responder arrives at the GPS position of the emergency.

Figure 5 FirstAED modern IT technology connects the healthcare assistant manager at the EMS dispatch centre, first responders and AEDs located in GPS controlled AED cabinets (see online version for colours)



Another part of the study compares the dispatching data with the Regional and University Hospital database, Cosmic. This part of the study will in the future evaluate dispatching diagnoses, patient diagnoses, and 30-day and 12-month survival rates.

3.5 Data collection

Response times of the first responders as well as the professional rescuer (ambulance or paramedic) were recorded. Median response times were calculated for the first arriving first responder, the AED, and the first arriving professional rescuer.

First responder activity level and contribution to the rescue process was also calculated.

3.6 Statistical analysis

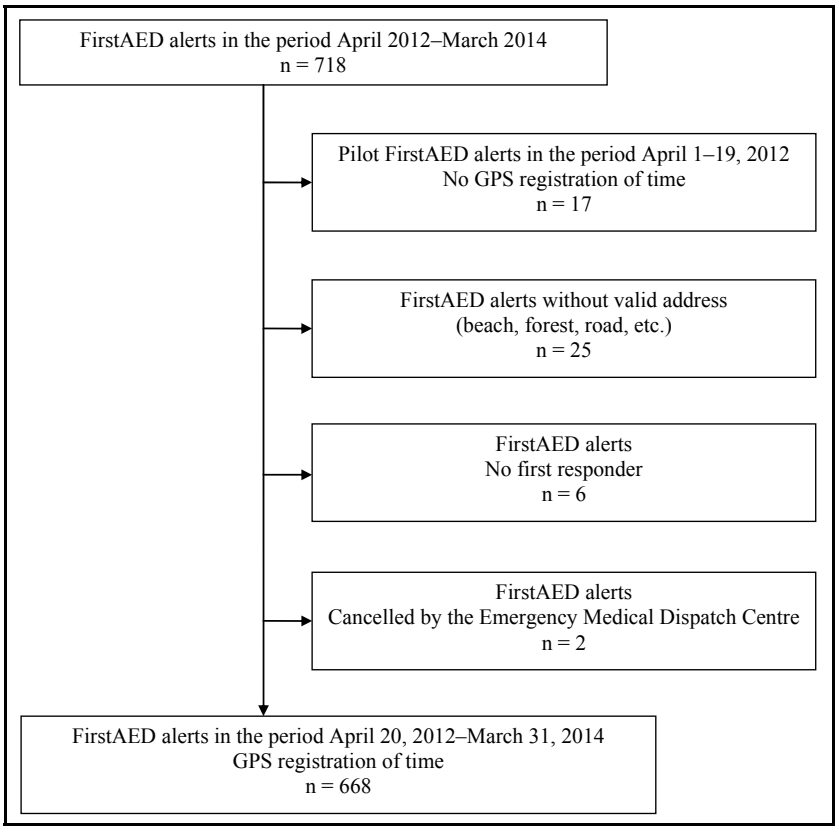
Summary statistics (percentages, median value, and range). All statistical analyses were performed with the use of the Excel statistical package.

4 Results

4.1 Dispatching alarms

In April 2012 the FirstAED system was implemented. During the next two years the FirstAED alarm system was used 718 times (Figure 6). The first 19 days was a pilot phase in which the project group experienced that GPS registration of the first responders arrival times was crucial for the validity of the project. Few alerts were without a valid address, for example cardiac arrest at the beach or traffic accident on the road. The project is based on volunteers, and sometimes in the Easter days, areas in the North and the South of the island are depopulated and in selected cases it seems impossible to find volunteer first responders within a radius of five kilometres.

Figure 6 Overview over the FirstAED alarms in the period April 2012–March 2014

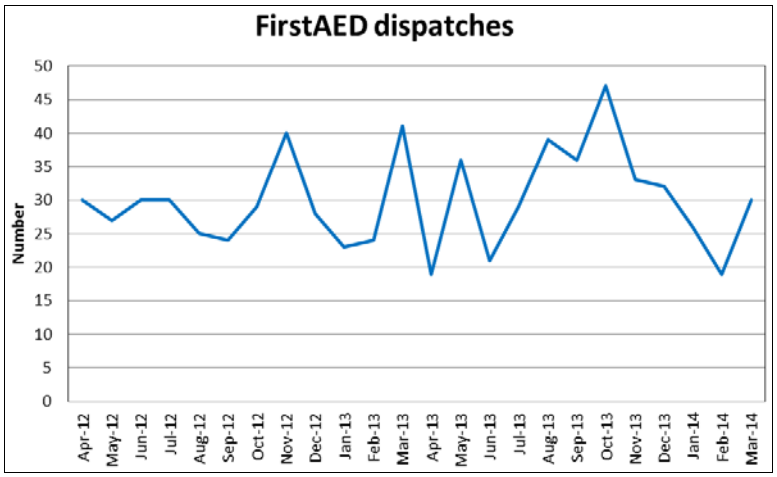


The frequent dispatching category was illness (Table 1). There were 32 dispatches in the category cardiac arrest, but the figure was not entirely correct. It turned out that not all the patients in this category had cardiac arrest, but on the other hand some of the patients in the illness category suffered from cardiac arrest. There was variation in the number of alarms from 19 dispatches in April 2013/February 2014 to 47 dispatches in October 2013. There was no clear seasonal variation in the number of dispatches per month (Figure 7).

Table 1 Distribution of dispatch categories during the project period April 2012–March 2014

Dispatch category	*Number*
Disease	591
Accident	55
Cardiac arrest	32
Traffic accident/fire	25
Others	15
Total	*718*

Figure 7 Number of FirstAED dispatches per month during the project period April 2012–March 2014 (see online version for colours)



4.2 Response time – fastest CFRs on site

The median response time for the CFR on site was 249.5 seconds (4 minutes and 9.5 seconds) (Table 2). Figure 8 illustrates that the median response times for both first, second and third arriving CFRs were decreasing as time passes. The CFR was on site in less than five minutes in more than 60% of the cases.

Table 2 CFR and AED on site (median response time + range)

	Median response time	*Range*
First responder on site	249.5 sec.	(1–1,297 sec.)
AED on site	347 sec.	(1–1,996 sec.)

Figure 8 Monthly median response time for first, second and third arriving CFR (CFR) on site during the project period April 2012–March 2014 (see online version for colours)

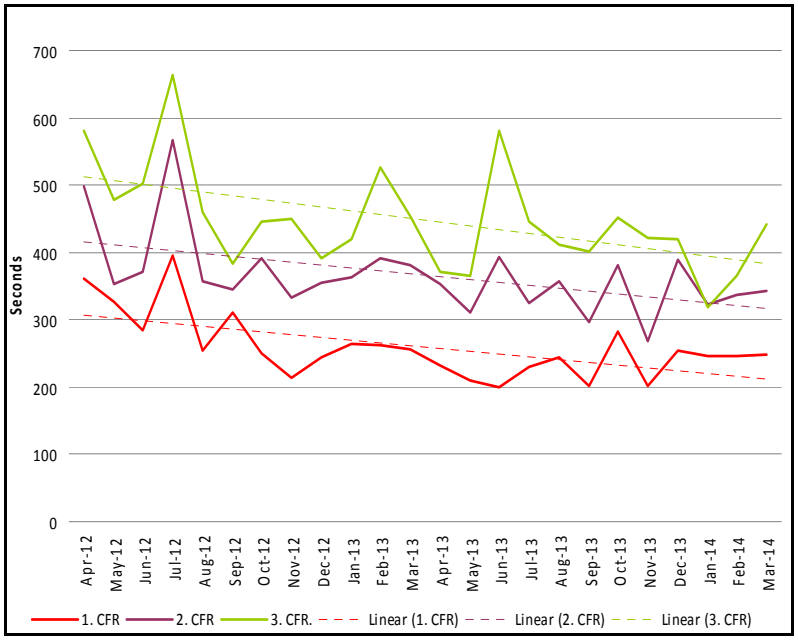
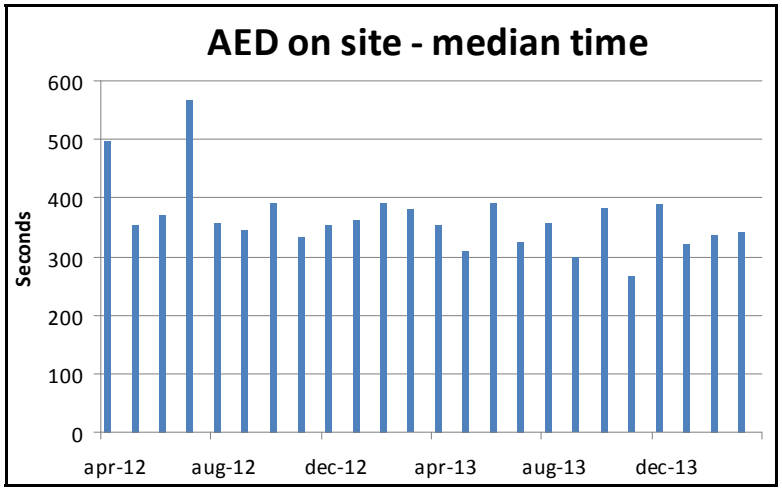


Figure 9 Monthly median time for the AED on site during the project period April 2012–March 2014 (see online version for colours)



4.3 Response time – AED on site

The AED was on site in more than 99% of the alerts. There was no AED on site in the six alerts where it was impossible to find a CFR. The AED arrived within a median time of 347 seconds (5 minutes and 47 seconds) (table 2) during the project period. There were only small fluctuations in the monthly median time (Figure 9), the longest response time was observed the first summer when many tourists visited the island, and many first responders left the island for vacation. The CFRs became aware of the AED cabinet locations as time passed.

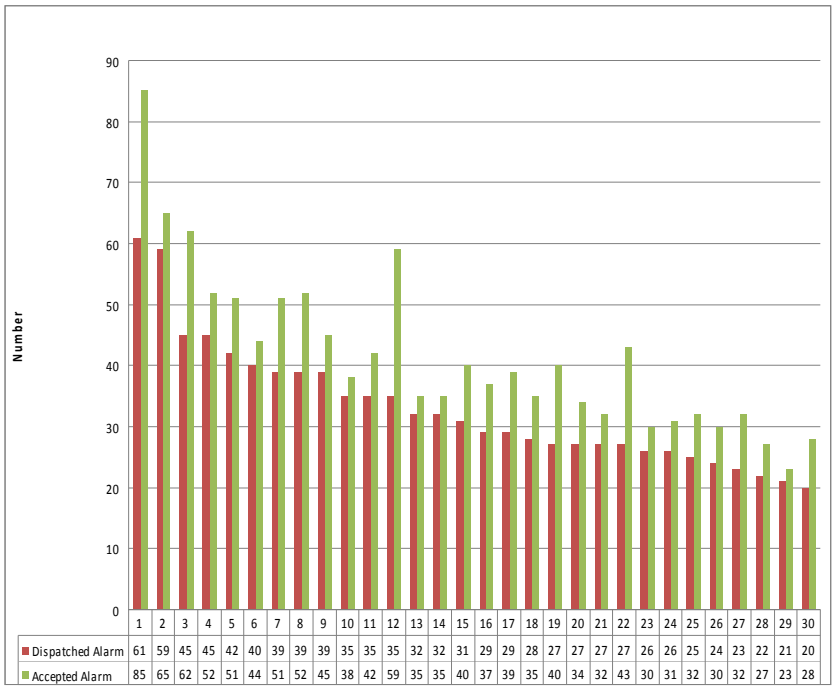
4.4 Rescue team structure

Three CFRs arrived in 89% and two first responders in 7% of the cases (Table 3).

Table 3 Number of dispatched CFRs

Number of first responders on site (n = 718)	*Percentage distribution*
3 first responders	89.1% (n = 640)
2 first responders	7.1% (n = 51)
1 first responder	3.1% (n = 21)
0 first responder	0.7% (n = 6)

Figure 10 Top 30 list of the most active CFRs (see online version for colours)



Note: Number of alarms accepted versus number of alarms where the first responder was dispatched.

FirstAED chooses the three most optimally located CFRs from the pool of those who have accepted the alarm. The first responders engaged the team, took account of the tasks with distinct roles, sometimes all first responders cooperated in CPR, at other times it was most advisable that the on-site coordinator stayed outside with flashing lights on the car making it easy for the professional staff to find the emergency place. Once in a night the first responders highlighted the corners of a field making it possible for the rescue helicopter to land. During the time some of the first responders developed a team spirit, they parked their cars with the front facing the road to reduce the response times. Some of the first responders were committed to the project; they had a high tolerance and endurance. Thirty first responders accepted the FirstAED alarm more than 25 times during the project period, although they were, of course, not dispatched every time (Figure 10).

4.5 Time gap between CFRs and the professional staff

The first first responder arrived before the paramedic/ambulance staff in more than 94% of the cases or at the same time as the paramedic/ambulance staff in 2.4% of the cases (Table 4).

Table 4 First first responder arrival before/simultaneously/after arrival of first professional rescuer (paramedic/ambulance)

Arrival-time registrated alarms (n = 668)	*Percentage distribution*
Before ambulance/paramedic	94.3% (n = 630)
Simultaneously with the ambulance/paramedic	2.4% (n = 16)
After the ambulance/paramedic	3.3% (n = 22)
Cancelled by EMD/no time registration	(n = 50)

Figure 11 Response times for the CFRs (red) and ambulance/paramedic (green) (see online version for colours)

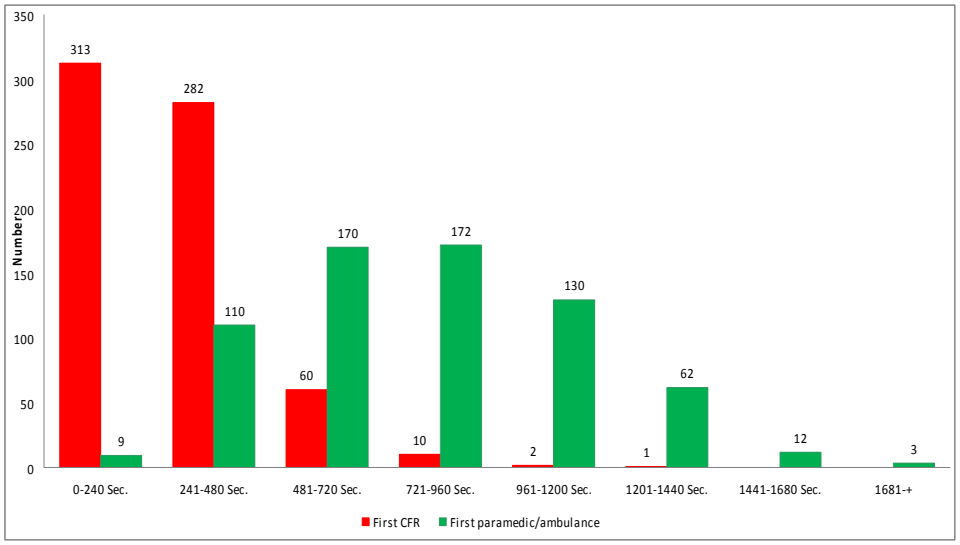


Figure 11 illustrates the distribution of the arrival times for both first arriving of the community first reponders and the ambulance/paramedic. There are significant ($p < 0.001$) time differences between the local GPS-tracked first responders and the professionals coming from the middle of the island. The general time gap between the median arrival time for the first responders and the professionals (ambulance/paramedic) is every month more than 400 seconds.

4.6 Clinical results

The CFRs were involved in patients with cardiac arrests (ventricular fibrillation, third degree AV block), hangings, serious respiratory insufficiency, acute myocardial infarction, subarachnoid haemorrhage (complete cured), and children with febrile seizures. They were also involved in divers with decompression sickness, sea rescue and more than ten traffic accidents.

5 Conclusions

The new FirstAED solution has reduced the time of first responder and AED on-site remarkably. The first responder was on site in less than five minutes in more than 60% of the cases. It is ensured that in 96% of the cases help from more than one person is quickly on-site. Peer support and feedback is provided to the CFRs.

The FirstAED technology implements strategic location of the AEDs, the development of a team with responsibility for monitoring and maintaining the devices, and training and retraining programmes for the volunteer first responders. FirstAED GPS-tracking reduces the first responder response times, and the quality of the effort improves as all the first responders who accept the FirstAED alarm have distinct roles. FirstAED localises and activates all the GPS activated AED cabinets, which makes it easy to collect the AED from the AED cabinet, also in adverse conditions like snow, heavy fog, and on dark nights. FirstAED is a logistic solution to reduce response times for first responder programmes, on the island of Langeland to less than five minutes. FirstAED defines a way to dispatch the nearby first responders and organise their roles in the hope of reducing response times, ensuring citizens safety and equal possibility to early defibrillation.

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