

Use of public AEDs by untrained first responders with emergency-dispatcher assistance

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<p>The goals of this study were to explore whether the use of an automatic-external-defibrillator (AED) by an untrained layperson would adversely affect the quality of compression-only cardiopulmonary-resuscitation (CPR) provided at the same time and decrease the defibrillation delay in a simulated out-of-hospital-cardiac-arrest (OHCA) -situation.</p> <p>The study was a training mannequin simulation of an OHCA-scenario comparing participants performing dispatcher-assisted compression-only CPR with subjects who in addition retrieved and used an AED with dispatcher assistance.</p> <p>In this study, laypersons who had basic CPR (without AED) training could all perform dispatcher assisted CPR relatively well. In the AED group, laypersons were able to safely use an AED in a simulated OHCA-situation.</p> <p>This study suggests that adding an AED to the dispatcher assisted CPR protocol does not markedly decrease the hands-on-time nor the quality of CPR with layperson provided help in an OHCA-scenario and that it would decrease the out-of-hospital defibrillation delays and thus improve survival.</p> <p>(152 words)</p>			
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1 Introduction.....	1
2 Material & Methods.....	4
2.1 Subjects.....	4
2.2 Simulation scenario.....	5
2.3 Experimental protocols.....	6
2.4 Measurements.....	8
3 Results.....	9
4 Discussion.....	12
5 Limitations.....	14
6 Conclusions.....	15
7 Acknowledgements.....	16
8 References	17
Attachment 1..	20
Attachment 2.	21

1 Introduction

Defibrillation at an early stage is the single most important treatment for adult out-of-hospital cardiac arrest (OHCA) with ventricular fibrillation (VF) as the initial cardiac rhythm (1). Although the prognosis for an OHCA resulting from “nonshockable rhythms” (asystole and pulseless electrical activity) is often poor despite resuscitation attempts, in cases with a “shockable rhythm” such as VF, early defibrillation can result in better recovery. (2) While defibrillation is considered the major predictor of survival in VF OHCA-scenarios, its efficiency is highly time-dependent. Studies performed in monitored settings reveal survival rates of up to 80% with immediate defibrillation and down to only 2% with 12 minutes defibrillation delay from collapse. (3) Given the very narrow time frame, OHCA-situations form a major challenge for emergency medical services especially from the early defibrillation point-of-view.

The concept of the “chain of survival” has been created to describe effective treatment in OHCA-situations. This chain is formed by immediate recognition of cardiac arrest, alerting the emergency medical service (EMS), early initiation of cardiopulmonary-resuscitation (CPR), fast defibrillation, effective cardiac life support and thorough postresuscitation care. (4) It has been shown that when started early, the most basic treatments such as CPR are the most effective concerning the patient’s survival. (5)

Although it is often reported that bystander CPR quality is poor (6), CPR is known to improve survival and reduce treatment delays. (7) Despite the proven effectiveness of bystander CPR, the problem lies within the fact that the number of patients who receive bystander CPR is still low in many parts of the world. (8) To address this, several actions have been tested around the world. Implementation of the compression-only CPR concept into the latest resuscitation guidelines (9) has been shown to increase bystander CPR rates by making the CPR easier to learn. (10)

Studies conducted in Europe confirm that bystander CPR and public access defibrillator (PAD) -programs are effective and improve OHCA outcomes compared to EMS-systems without such programs. In Sweden, the overall OHCA survival-rate increased

from 4,8% in 1992 to 7,3% in 2005 due to increased bystander CPR. (11) By integrating the use of fire engines into the dispatch protocol, placing over a hundred automatic external defibrillators (AEDs) in public locations, including CPR into the primary school curriculum and adding telephone-CPR instructions to the EMS dispatch protocol, Sweden has tripled the OHCA survival in less than 10 years. (12)

Many public locations such as airports and shopping malls are already equipped with AEDs and both the number of AEDs as well as the number of laypersons trained to use them is rising (13). It has also been previously shown that an untrained layperson, or even a child, can safely deliver a defibrillatory shock with an AED even without previous instructions (14,15). The new AEDs are shown to be both extremely accurate in rhythm recognition and easy to use, which combined with the new simpler compression-only CPR guidelines offers laypersons the possibility to provide lifesaving treatment. (16)

As the number of AEDs is increasing, a voluntary register for the devices was founded in Finland in 2011 by the Finnish Resuscitation council, Finnish Red Cross and Finnish Heart Association. (17) AED owners can register their devices with location information into the service where anyone can search and view all registered devices. The project's goal is to increase AED-awareness and provide information about available devices for both laypersons and professionals, and in the future also emergency dispatch centers.

In Finland, emergency calls are processed and dispatched by the National Emergency Response Center Authority. Currently, the calls for emergency medical services are prioritized by educated non-medical dispatchers into four categories – from A (highest risk) to D (lowest) – according to a national criteria-based dispatch protocol. By asking questions defined in the written protocol, the dispatcher identifies the nature of the emergency and dispatches the required units. Combined, the six regional emergency response centers (ERC) of the Emergency Response Center Authority processed 3 674 000 emergency calls during 2016, of which 655 000 were emergency medical calls. Of the calls related to OHCA-scenarios, 68 % were processed and the ambulance alerted in less than 90 seconds. (18)

The ERC operator and the dispatch protocol are significant parts of the emergency medical services, and together with the bystander the first link in the patient's chain of survival. (19) In Finland, the average call-to-arrival time of the EMS is approximately 8 minutes in the capital area. In an OHCA-situation, the emergency dispatcher will alert any unit closest to the victim, including fire brigade and volunteer-fire brigade units equipped with AEDs. Trials are also being run for AED-equipped volunteers, who could be dispatched with a phone message to a nearby OHCA-situation. (20) As response times can be much longer than 8 minutes, especially in sparsely populated areas, layperson-provided first aid and possible defibrillation may have a significant impact on the patient's survival, which is why we seek to evaluate the effectiveness of a layperson providing CPR and using an AED with dispatcher assistance in OHCA situations.

Current emergency-dispatcher protocols in Finland instruct the layperson to provide compression-only CPR in an OHCA-situation. The protocol does not currently include instructions how to acquire and use an AED. (21) An automatic external defibrillator (AED) used as a public access defibrillator (PAD), combined with dispatcher instructions, could provide a solution for decreasing defibrillation delays in OHCA-situations. These devices are within the reach of many who could provide early-stage-defibrillation if given the proper guidance. However, before implementing the use of an AED into the national emergency-dispatcher protocols in OHCA-scenarios, more information is needed about the effect of the use of an AED on the effectiveness of compression-only CPR.

The primary goal of this study was to explore whether the use of an AED by an untrained layperson in an OHCA-situation would adversely affect the quality of compression-only CPR provided at the same time.

As a secondary goal, we wanted to find out whether the layperson use of an AED with dispatcher assistance would decrease the defibrillation delay in a simulated OHCA-situation.

2 Material & Methods

The study was a training mannequin simulation of an out-of-hospital cardiac arrest (OHCA) scenario comparing participants performing dispatcher-assisted compression-only CPR with subjects who in addition retrieved and used an AED with dispatcher assistance.

2.1 Subjects

The subjects were a class of freshman students of the Arcada University of Applied Sciences in Helsinki. All students receive a course in basic CPR not including the use of an AED in the beginning of their studies as part of their curriculum irrespective of their educational program or background. Students attending the CPR course were asked to participate in the study after the course, excluding students of health care programs and subjects with previous training to use an AED. Thus, the CPR skill-level of all participants was similar to that of citizens with previous basic CPR training.

Of the total 28 participants most were female (22 females, 6 males). The age of the participants varied from 19 to 45, most of the subjects being under 30 years of age. Greater part of the participants had graduated from Finnish Matriculation Examination (14 persons), a few from Vocational School (6 persons) and some had other previous education (8 persons) such as university studies or courses.

The study protocol was approved by the Ethics Board of the Arcada university of applied sciences, and the study subjects were asked for their written consent to participate in this study. All participants received a letter of information in advance describing the goals and details of the simulation as well as a separate in-class presentation introducing the study.

After recruiting, all volunteer participants were able to make their simulation appointment via an electronic enrolment software without seeing who they were pairing up with.

The background information of the participants is presented in Table 1.

Participant background information	
Gender	
Male	6
Female	22
Age	
19-24	17
25-29	7
30-34	1
35-39	1
40-44	1
45-49	1
Education	
Finnish Matriculation Examination	14
Vocational School	6
Other	8

Table 1. Background information of the participants (gender, age and education)

2.2 Simulation scenario

The subjects were randomly formed in teams of two subjects and tested in a scenario of a sudden collapse of a person in a familiar office environment equipped with a fixed-line phone. The “patient” was their colleague, a Laerdal training mannequin, who

suffered an unexpected collapse. The study protocol included ventricular fibrillation (VF) as the initial cardiac rhythm, which continued throughout the simulation despite defibrillation attempts.

The subjects were instructed to perform as if the situation was real. They could place an emergency call to the national emergency response center 112. The phone was equipped with a speed-dial button labelled “112” which connected the call to a dispatcher, who randomly instructed the caller to follow either of two test protocols by blindly drawing a scenario from a basket. The emergency call could be spoken in Finnish, Swedish or English.

Short, written instructions were given to the participants before the simulation in addition to the observer’s directions.

2.3 Experimental protocols

There were two different test protocols. In the other, the dispatcher instructed the caller to give telephone-guided CPR (group 1) according to current Finnish guidelines (6). In the second protocol, the dispatcher gave similar basic CPR instructions as in group 1, and in addition told the caller that there was a defibrillator in the ground floor reception of the building and instructed the caller to fetch it and get back to the phone while CPR was in progress (group 2). The AED dispatcher protocol used for group 2 is shown in figure 1.

The test took place two floors above the ground floor. The participants could choose whether to take the stairs or to use the elevator when fetching the AED. Once the pair had the device on scene, the dispatcher instructed over the phone how to use it and how to place the electrodes correctly.

In both groups the teams were allowed to continue the simulation until 10 minutes had passed, while the patient remained in VF through the whole simulation. At that time, they were told that an ambulance had arrived at the scene and the test was ended.

Hätäkeskus / Nödcentral / Emergency center

Which city?

Address / location? Which floor?

(In case the caller says that the patient is lifeless or resuscitation has been started → continue to **red**)

Go to the patient and turn him on his back. Try to wake him up by shaking, does he wake up?

Wait without hanging up the phone, I will alarm help. (Ensihoito Helsinki 1431, Jan-Magnus Janossonin aukio, tehtävä B790)

Does the patient breathe normally? Can you feel the air flow against your palm?

(If yes: Turn the patient to the recovery position, wait until the ambulance arrives)

If no: Do not hang up the phone, I will alarm more help. (Ensihoito Helsinki 10 ja Pelastus Helsinki 41, Jan-Magnus Janssonin aukio, tehtävä A700)

Will you help, I will instruct?

Do you have anyone with you?

At the schools info-desk at the bottom floor you can find a device, a defibrillator. There is a white-green sign with a picture of a bolt on it. Send someone to fetch the device. Do not hang up the phone, ask someone to get the device.

Tell me when the device arrives. While we wait I will tell you what you should do. Can you resuscitate?

In case yes: Start performing compressions as you have been instructed, I will help if needed. When the defibrillator arrives, continue the compressions the whole time and ask for the person who fetched the device to come to the phone. Do not stop the compressions until told so. Continue to **violet**.

Settle on your knees on the floor to the side of the patients chest.

Open the patients shirt and expose his torso.

Put your hand in the middle of the patients sternum, between the breasts.

Put your other hand on the first one.

Press straight downwards with straight hands so that you press the sternum inwards for 5-6cm. Press hard in a pumping motion in and out, I will count the pace. Do not stop the compressions. When the defibrillator arrives, continue the compressions and ask the person who fetched the device to come to the phone. Do not stop the compression until told so.

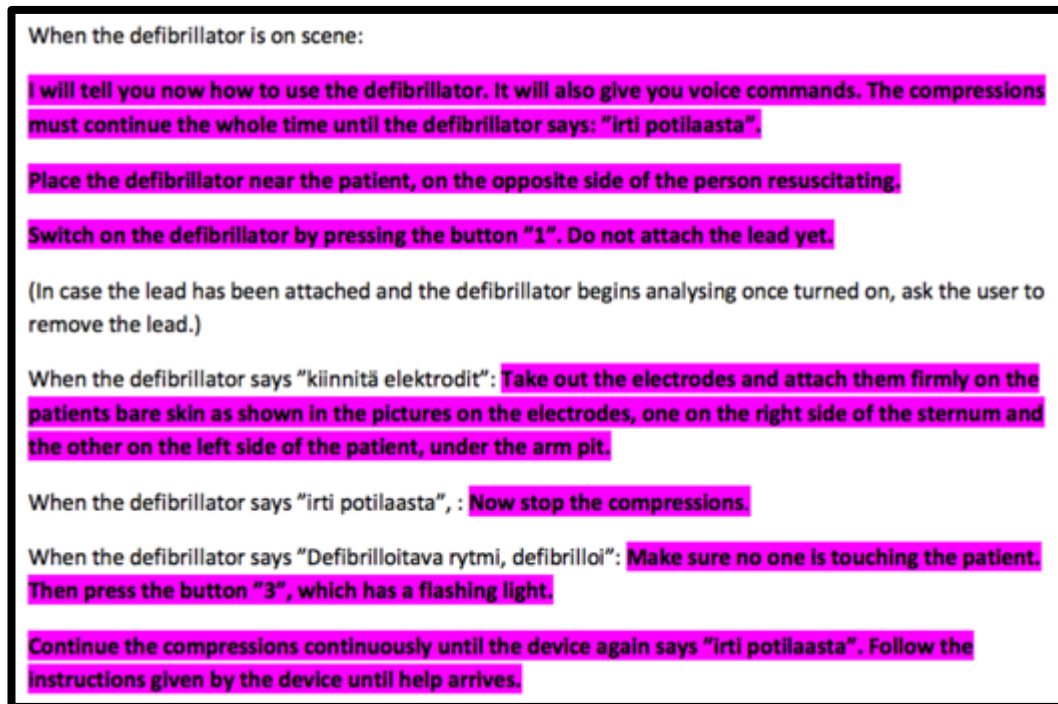


Figure 1. The dispatch protocol used with group 2 including the use of an AED

2.4 Measurements

The data measured included the time period from collapse to first compression (point of first compression), the quality of CPR and whether the team was able to give any defibrillatory shocks within the given time window, and if so, how fast the first shock occurred (point of first shock). Quality indicators were defined as compression rate and depth and the time when the victim received compressions in relation to the total duration of CPR from first compression (hands-on-time). The mannequin recorded the number of shocks and compression parameters. The placing of the electrodes (1=correct, 0=incorrect) and the site of compression were also evaluated by the observer positioned in a control room behind a mirror-glass. The whole simulation was videotaped. The performance of the subjects in the two different scenarios was compared based on the data recorded by the mannequin and observer.

Statistical analyses were performed based on the data recorded by the mannequin through a Laerdal SimPad –device. The data recorded was collected and analysed using

the Laerdal Session Viewer –software (version 5.2.5821.26904) and IBM SPSS Statistics version 24.0.0.0.

3 Results

In group 1 (non-AED scenario) there were six performing pairs. Hands on time varied from 64% to 97% with an average of 79%. All pairs managed to maintain a mean compression rate of approximately 100 bpm as well as a mean compression depth of approximately 50 mm.

The greatest differences between the pairs could be identified in the point of first compression. On average, the pairs managed to perform the first compression in 02:00 minutes, the point of first compression varying from 00:25 to 04:33.

Group 1 (without AED)			
Case ID	002	004	005
Hands on time	97 %	91 %	64 %
Mean compression rate	97/min	122/min	100/min
Mean compression depth	50mm	46mm	62mm
Point of first compression	02:43	02:48	00:38
Case ID	006	013	014
Hands on time	77 %	73 %	72 %
Mean compression rate	111/min	113/min	112/min
Mean compression depth	48mm	53mm	60mm
Point of first compression	04:33	00:50	00:25

Table 2. Group 1 CPR quality factors, presenting the data recorded by the mannequin and observer.

Group 1 (without AED)	AVERAGE
Hands on time	79 %
Mean compression rate	109/min
Mean compression depth	53mm
Point of first compression	02:00

Table 3. Group 1 CPR quality factor averages, presenting the data recorded by the mannequin and observer.

In group 2 (with-AED-scenario) there were eight performing pairs. Hands on time varied from 62% to 77% with an average of 70%. With the exception of one pair, all managed to maintain a mean compression rate of approximately 100bpm. Mean compression depth varied more than in group 1, from 41mm to 60mm. As in group 1, also in group 2 the point of first compression had the largest differences with an average of 01:26 and the time varying from 00:29 to 03:39.

Group 2 (with AED)				
Case ID	001	003	007	008
Hands on time	71 %	66 %	85 %	65 %
Mean compression rate	112/min	101/min	95/min	120/min
Mean compression depth	41mm	60mm	52mm	59mm
Point of first compression	00:43	00:43	03:39	02:04
Case ID	009	010	011	012
Hands on time	70 %	62 %	77 %	62 %
Mean compression rate	75/min	100/min	109/min	116/min
Mean compression depth	58mm	50mm	38mm	41mm
Point of first compression	00:29	00:43	02:26	00:43

Table 4. Group 2 CPR quality factors, presenting the data recorded by the mannequin and observer.

Group 2 (with AED)	AVERAGE
Hands on time	70 %
Mean compression rate	103,5/min
Mean compression	49,9mm
Point of first	01:26

Table 5. Group 2 CPR quality factor averages, presenting the data recorded by the mannequin and observer.

Group 2 fetched and used the AED in addition to the basic CPR. The placing of the electrodes was evaluated by the observer during the simulation. If evaluated incorrect, the placing of the electrodes would not have made an effective defibrillatory shock possible. Four out of eight pairs managed to place the electrodes correctly and all but one pair managed to give at least two defibrillatory shocks before an ambulance arrived at the scene. Also the pairs that placed the electrodes incorrectly, managed to give at least two defibrillatory shocks during the simulation. In the incorrect cases, the left electrode was always placed too medially.

Group 2 (with AED)				
Case ID	001	003	007	008
Number of shocks	2	2	2	2
Point of first shock	06:33	07:17	08:18	05:51
Electrodes	incorrect	correct	correct	incorrect
Case ID	009	010	011	012
Number of shocks	2	2	1	3
Point of first shock	09:22	05:54	09:35	05:05
Electrodes	incorrect	correct	correct	incorrect

Table 6. Group 2 defibrillation performance factors.

The fastest pair managed to give the first defibrillatory shock within 6 minutes of the collapse and on average all pairs gave the first shock within 7 minutes. In all cases the telephone-guided basic CPR continued throughout the AED-fetching process and the placing of the electrodes had little or no effect on the CPR in progress.

Group 2 (with AED)	AVERAGE
Number of shocks	2
Point of first shock	07:11
Electrodes	-

Table 7. Group 2 defibrillation performance factor averages.

In both groups all subjects were able to identify the correct site of compression.

Due to the small sample size, the simulation statistics are presented in detail for each tested pair in Tables 2 through 7.

4 Discussion

In this study, laypersons who had basic CPR training excluding the use of an AED could all perform dispatcher assisted CPR relatively well. In the AED group, laypersons were able to safely use an AED in a simulated OHCA-situation. Only half of the AED group could place the electrodes properly and give a defibrillatory shock that would have been beneficial to the victim.

It has previously been shown that the quality of dispatcher-assisted CPR is often poor (6). Difficulties in OHCA-recognition, CPR uncertainty, fear of causing harm to the victim, mouth-to-mouth ventilation reluctance and cultural barriers are among the

factors discouraging bystanders from beginning CPR at all. (22-24) Since better quality of CPR is linked to improved survival and lesser neurological deficits (6,25), the training of laypersons in CPR skills is important for both decreasing CPR delay and improving the victim's prognosis. Although our subjects could change tasks during the simulation and thus the quality of the CPR could vary during the simulation, on average the quality of CPR in both groups matched current guidelines in terms of compression rate and depth (9).

The odds that a cardiac arrest victim has a shockable rhythm and thus has a better prognosis increases dramatically if the patient has received layperson CPR. It has been proven that layperson provided CPR can both slow down VF deterioration into asystole and provide brain perfusion to prevent neurological deficits. (26, 27) It is therefore obvious that especially in sparsely populated areas, layperson CPR is important. In our simulation scenario, an ambulance arrived at the scene after 10 minutes had passed. In the Helsinki capital area in Finland, the ambulance response time is 8 minutes on average and much longer in sparsely populated areas (28). All groups performed the first compression in less than 5 minutes and most in less than 2 minutes. The point of first compression varied as some subjects first placed an emergency call and waited for instructions, while others began to resuscitate at once when the victim collapsed, and the phone call was in progress. The fetching and use of an AED did not affect the point of first compression. Thus, in all groups, layperson provided CPR reduced the time from collapse to first compression, regardless of the possible use of an AED compared to a scenario where no layperson help would have been available.

All AED pairs managed to use the device itself according to the instructions given by the dispatcher. 50% of the pairs would have failed to deliver an effective defibrillatory shock because they placed the left electrode too medially. Based on these observations, the correct placing of the electrodes seems to be an important issue in layperson provided defibrillation, which should be specifically addressed when dispatcher assisted AED protocols are developed in the future.

There are a number of small, subject related variables that can affect the CPR in progress both in the simulated scenario and obviously also in actual OHCA-situations.

We observed that only some participants discovered the use of the speakerphone function of their mobiles and thus were able to participate more efficiently in delivering CPR. The participants were also able to choose whether to use the stairs or the elevator while fetching the AED. This did not markedly affect the fetching time in our test environment, but it can be of significant importance in real life. The extent of how much the dispatcher should give guidance e.g. on such matters needs to be further assessed. For example, based on our observations the dispatcher should advise all callers to use speakerphone in order to improve efficiency.

We also noted that the instructions given by the AED itself can in some situations be in conflict with the dispatcher's. Given that there are numerous models of AEDs on the market which all offer slightly differently phrased instructions, the actual dispatcher protocol needs to be even more generic to avoid confusion of the layperson on scene. It would be interesting in the future to evaluate between AED-only or dispatcher-only instructions, compared to the combination of those two.

In order for a national AED dispatching protocol to work efficiently, the emergency dispatcher needs to have up-to-date and easy accessible information about available AEDs based on the caller's location in an OHCA situation. Although a voluntary register for AEDs already exists in Finland, more development is needed both to increase its coverage and to make it easily accessible for the emergency dispatcher. Ideally, there should be a national register for all AED devices in Finland, which could be integrated directly into the dispatching program used by the ERC-operator.

5 Limitations

The main limitation of this study is evidently the fact that from unexpected organisational reasons, the number of study subjects eventually recruited was too small to draw definite conclusions based on this study. Eventually, the sample size was limited to a total of 14 pairs attending the simulation. Initial statistical analyses revealed that no statistical significance could be discovered within this material.

Therefore, due to the small sample size and the nature of our measurements, no elaborate statistical analyses were made or presented in this study.

Of the 28 subjects, only 6 were male and thus the study subjects did not perfectly resemble the general population. Most of the participants were young and perhaps more oriented in the use of electronic devices such as an AED. It would be interesting to explore how the use of an AED is managed by the elderly.

After consulting with a professional dispatcher, we developed our own test-protocol for the dispatcher when advising the layperson in the use of an AED, because there currently is none in use.

During the simulations, some participants experienced the simulated scenario somewhat confusing while others lacked motivation to fully act as though the situation was real, which resulted in the possibility that some individuals would have performed differently had the situation been real.

Also, the AED practise-device used in the simulation does not actually recognize the mannequin's rhythm but repeats a pre-recorded AED-programme. This sometime was found confusing by our participants, as the device could begin analysing the rhythm before the electrodes had even been properly attached. The problem was noted prior to the simulations and was taken into account by the dispatcher during the emergency phone-call.

6 Conclusions

The use of an AED by an untrained layperson in a simulated OHCA-situation did not noticeably affect the quality of compression-only CPR provided at the same time in this study.

Dispatcher assisted use of an AED by a layperson may be a promising way of decreasing the defibrillation delay in an OHCA-situation.

There is a need to develop and deploy a fully functional dispatcher protocol with AED instructions.

Based on these conclusions this study suggests that adding an AED to the dispatcher assisted CPR protocol does not markedly decrease the hands-on-time nor the quality of CPR with layperson provided help in an OHCA-scenario. While dispatcher assisted CPR is already an important link in the chain of survival, it would be reasonable that AEDs were carefully added to the out-of-hospital dispatcher instructions in the future, given that both the number of AEDs and the people trained to use them is increasing.

Also, it would be beneficial that at least all publicly located AEDs were nationally added to a register available to the emergency dispatchers, who could then point out the devices and instruct their use based on the caller's location. We suggest that this would decrease the out-of-hospital defibrillation delays and thus improve survival.

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Attachment 1. The information letter used in the recruiting.



Helsinki 21.09.2015

Information for students

Want to participate in a CPR simulation study?

Dear students,

The Helsinki university hospital is performing a study in collaboration with Arcada concerning layperson resuscitation. The goal of the study is to evaluate how laypersons with basic CPR training perform with dispatcher assistance in a simulated resuscitation situation.

Participants will take part in a short resuscitation scenario. The simulation lasts up to 15 minutes and is carried out in pairs. The participants are given further instructions before the situation.

Participation is on a fully voluntary basis, but we would be grateful for your contribution. The simulation is NOT an exam or a test, rather an opportunity to drill your skills in a controlled environment at the end of your CPR-course. After the simulation, those who want will be given feedback. The individual results of the simulation are kept confidential, and participants cannot later be identified.

We are grateful for your involvement, please get in touch

Sincerely,

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Attachment 2. The written instructions for the participants during the simulation.

SUOMEKSI

Olet kahden työkaverisi kanssa palaverissa, kun yllättäen toinen heistä lyhyhistyy äkillisesti, ilman ennakkovaroitusta.

Huoneessa on lankapuhelin, jolla saat tarvittaessa soitettua lisäapua soittamalla pikavalintaan, joka on merkitty "112"-tarralla.

Toimikaa tilanteessa kuten aidosti toimisitte.

Valvoja ilmoittaa, kun tilanne alkaa.

IN ENGLISH

You are at a meeting with your two colleagues when suddenly one of them collapses without any warning.

In the room you will find a phone that you can use to call for help, dialing the "112" tagged speed-dial.

Act as if the situation was real.

The supervisor will announce when the situation begins.

PÅ SVENSKA

Du är på ett möte tillsammans med två av dina kollegor. Utan förvarning kollapsar plötsligt ditt ena arbetspar.

I rummet finns en telefon som du vid behov kan ringa tilläggshjälp med genom att trycka på knappen som är märkt med numret "112".

Fungera som situationen skulle ske på riktigt.

Övervakaren meddelar då situationen börjar.