Early CPR and defibrillation by laypersons in out-of-hospital cardiac arrest: process evaluation of an early intervention program in the Netherlands

Authors Annemieke C. Scholten [1]

Jeannette G. van Manen
Carine J.M. Doggen

[1] **Affiliations**
Bachelor of Science
University of Twente
Enschede, the Netherlands

[1] **Address**
Sloetstraat 132
6821 CZ ARNHEM
The Netherlands

Department Health Technology & Services Research

School of Management and Governance
University of Twente
P.O. Box 217
7500 AE ENSCHEDE
The Netherlands

Corresponding author Dr. Jeannette G. van Manen

Department of Health Technology & Services Research
School of Management and Governance
University of Twente
P.O. Box 217
7500 AE ENSCHEDE
The Netherlands
j.g.vanmanen@utwente.nl

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ABSTRACT *392 words*

Aim

The purpose of this study was to evaluate and identify problems and potential improvements of an early intervention program of an Emergency Medical Service in the Netherlands, with which volunteer laypersons can be alerted by the system AED-Alert to go to victims of a suspected out-of-hospital cardiac arrest and provide early CPR and defibrillation.

Methods

Between February 1, 2010 and April 30, 2010 all laypersons who were sent an alert by AED-Alert, and had an active email address, were requested to fill in a web-based questionnaire. Laypersons characteristics, process after alerts, and experiences and satisfaction of laypersons with the alerts and intervention program were analyzed.

Results

AED-Alert was activated for 52 victims, sending 3,227 alerts to 2,287 laypersons. Laypersons filled in 2,098 questionnaires after alerts. Action was taken for 579 (28%) of the 2,047 received alerts, since most laypersons were not in the victim's neighbourhood (41%), noticed the alert to late (35%), or other reasons (24%). Laypersons faced problems during action after 298 (52%) of the 579 alerts, with taking AEDs (51%), traffic (5%), finding addresses (29%), or other problems (15%). Aid was then provided in 75 (13%) of the 579 alerts, by starting early CPR and defibrillation (53%), assisting EMS personnel (53%), or taking care of family members and bystanders (39%). The 504 laypersons who could not provide aid, often arrived after professionals (61%) or at the time enough laypersons were already present (58%). In 21 (40%) of the 52 alerts, laypersons were present before arrival of the EMS. In total, laypersons started early CPR and defibrillation to 18 (34.6%) victims, and assisted EMS personnel in 9 (17.3%) victims. Overall, 4 (8%) victims received help from EMS personnel alone. The information given in the questionnaires did not give insight in the remaining 21 (40%) victims.

Conclusions

Although the AED-Alert process was not optimal for several laypersons, laypersons provided aid or assisted EMS personnel to over 50 percent of the victims. The majority of problems laypersons had to encounter can be overcome. The AED-Alert process could be improved on laypersons' registration, mobile phone settings and carrying of mobile phones by laypersons, alerts of AED-Alert, distribution, accessibility and number of AEDs in the program, and training of laypersons. These improvements could lead to an increase of the number of laypersons who could provide aid, and thereby could increase survival of victims with an out-of-hospital cardiac arrest.

Keywords: Cardiopulmonary resuscitation (CPR); Automated External Defibrillator (AED); Defibrillation; Emergency medical services (EMS); Out-of-hospital cardiac arrest (OOH-CA)

1. INTRODUCTION

366 words

Sudden out-of-hospital cardiac arrest is a leading cause of death in developed countries. In the Netherlands, approximately 16,000 cases of sudden cardiac arrest occur out-of-hospital each year [1]. The overall survival rate for out-of-hospital cardiac arrest is low, between 5 and 10 percent [2]. The survival rate depends on a sequence of events including early recognition and call for help, early cardiopulmonary resuscitation (CPR), early defibrillation with an automated external defibrillator (AED), and advanced care [3].

Over 40 percent of cardiac arrests occur due to ventricular fibrillation [4-7], an abnormal heart rhythm that causes the heart to quiver rather then beat so that it is unable to pump blood effectively. Survival rates for victims of ventricular fibrillation cardiac arrest can reach up to 50 to 75 percent if the victim receives early CPR and defibrillation within 3 to 5 minutes after cardiac arrest [8]. However, victim's chance of survival decreases approximately 7 to 10 percent with every minute delay in defibrillation [9-10].

Studies reported that in most communities, time from collapse to arrival of emergency medical service (EMS) personnel is 7 to 8 minutes or longer [11-12]. This means that victims depend on others to provide CPR and defibrillation during the first minutes after cardiac arrest. Therefore, Ambulance Oost – EMS of Twente, a rural region in the eastern part of the Netherlands – started an intervention program. In 2008, the EMS implemented the system AED-Alert. This system enables the EMS to alert laypersons immediately after dispatching two ambulances, by sending laypersons a text message on their mobile phone to go to victims of an out-of-hospital cardiac arrest and provide early CPR and defibrillation.

The objective of this study was to evaluate the AED-Alert process of alerting laypersons to go to victims of an out-of-hospital cardiac arrest and provide early CPR and defibrillation. The evaluation identifies problems and potential improvements which may be used to improve the AED-Alert process. The evaluation included process factors such as training and enrolment of laypersons, and extent of taking action and providing aid after an alert of AED-Alert. Improvement of the AED-Alert process is important since improvement of care for victims of an out-of-hospital cardiac arrest is assumed to increase survival [11].

2. METHODS

1,126 words

2.1. Setting

This study evaluated all initial calls to EMS Ambulance Oost from February 1, 2010 to April 30, 2010 in which an out-of-hospital cardiac arrest was suspected and laypersons had been alerted by AED-Alert. The AED-Alert process that has been evaluated is part of an early intervention program of the EMS. This program was started in order to build a system that could alert citizens in rural areas to go to victims of an out-of-hospital cardiac arrest and provide early CPR and early defibrillation. As part of the intervention program, the EMS offers training in basic life support and in the use of an AED to citizens. By March 2008 the EMS implemented the system AED-Alert and thereby was one of the first EMSs that could alert citizens. On April 30, 2010 almost 6,000 volunteer citizens and about 475 AEDs were registered in the intervention program.

2.2. Emergency medical system and AED-Alert

EMS Ambulance Oost serves a specific region, Twente, in the Netherlands. This region encompasses 1,504 km^2, with some urban and suburban areas but mainly rural areas and a population of about 620,000 inhabitants. In this population 16% were over the age of 65 years and 50% were male [13].

Like all EMSs in the Netherlands, a national emergency telephone number, 112, is connected to the regional dispatch centre of the EMS. The dispatch centre is manned by experienced nurses who instruct different ambulance services with ambulance posts spread over the region. When the nurse at the dispatch centre suspects a cardiac arrest in the initial call, two ambulances are dispatched simultaneously. Immediately after dispatching two ambulances, nurses of the dispatch centre activate the system AED-Alert. The system AED-Alert automatically selects all volunteer citizens that live or work on an address within 1,000 meters of the victim, and sends them a text message on their mobile phone to go to the victim and provide early CPR and defibrillation. This text message contains the location of the victim and if applicable the location of the nearest AED.

2.3. AED-Alert process

The process of alerting laypersons to go to victims of an out-of-hospital cardiac arrest and provide early CPR and defibrillation is a structured set of activities (Fig. 1). Only volunteer citizens who are qualified to perform basic life support, preferably supplemented by a valid certificate of AED training, are enrolled in the intervention program of the EMS. Volunteers are free to decide where and from which organisation they receive training in basic life support and use of an AED. Second, only volunteers who live or work on an address in the region are enrolled.

After enrolment, volunteer laypersons may receive alerts on their mobile phone in case of a suspected out-of-hospital cardiac arrest in the neighbourhood of their residential or work address. Laypersons who are trained in using an AED may receive a message to take an AED on their way to the victim. If there is no AED in the victim's neighbourhood, all laypersons are alerted to start CPR. Laypersons who receive an alert and are able to go to the victim take action. These laypersons start providing early CPR and defibrillation using the AED if possible. Others

assist laypersons or EMS personnel, or take care of family members and bystanders. After the alert, the EMS Ambulance Oost offers laypersons the opportunity to receive follow-up care. Laypersons are free to decide whether and when they discontinue their enrolment in the intervention program.

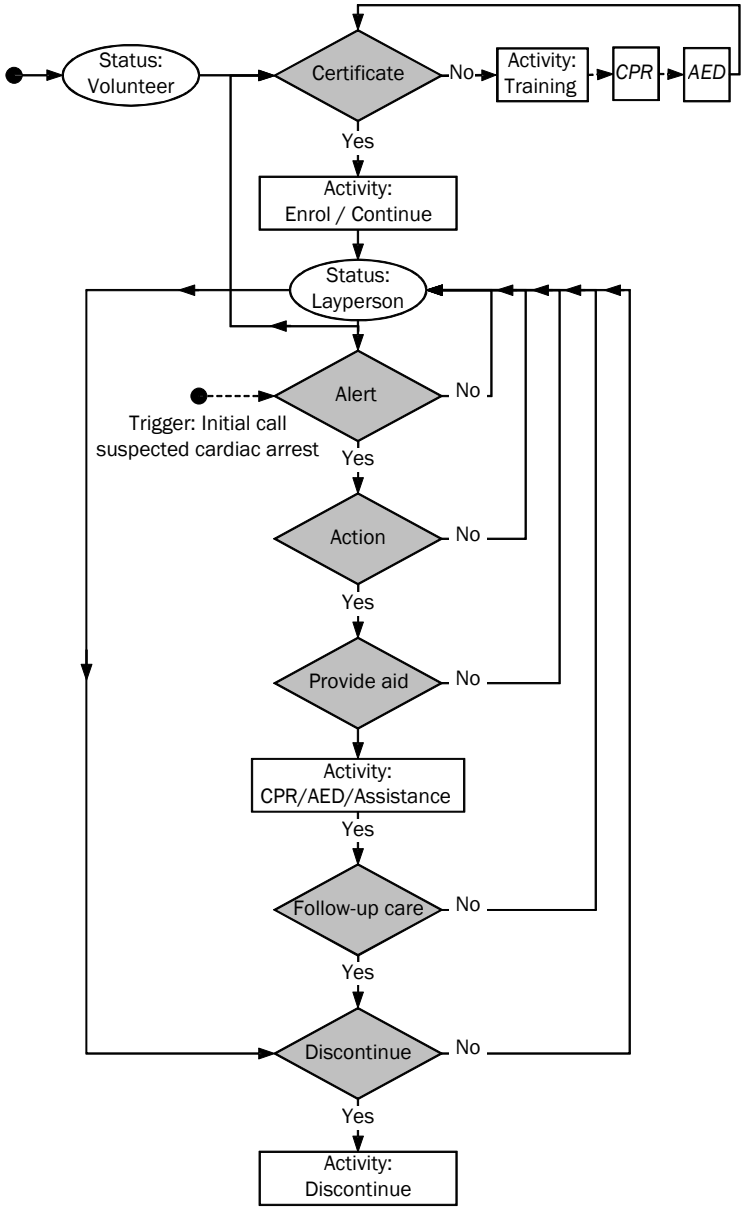

Fig. 1. Model of AED-Alert process

2.4. Study population

This study used information from two databases, RAVIS and PAMS. RAVIS is the database in which the EMS registers all information of the processes after initial calls to the EMS, like ambulances send, characteristics of victims, and aid provided. RAVIS was used to collect information about the time on which initial calls to the EMS for victims with an out-of-hospital cardiac arrest were received. The database PAMS (Public Access Meldkamer

Software) registers all details from alerts of AED-Alert, like date and time on which the alert was send by the EMS, or the number of laypersons alerted. PAMS was used to collect information about the time alerts were send, laypersons alerted, number of AEDs registered in the victim's area, and number of AEDs indicated in alerts. Also, based on information from PAMS, the study included: 1) all laypersons in Twente 2) with an active email address 3) to whom AED-Alert sent text messages between February 1, 2010 and April 30, 2010. These laypersons were requested to fill in a web-based questionnaire.

2.5. Data collection

The web-based questionnaire focused on the recent alert of AED-Alert and activities in the process that followed, and examined the experiences and satisfaction of laypersons with the intervention program of EMS Ambulance Oost in general. The questionnaire was drawn up on the basis of results from a pilot study in which experiences of laypersons with the intervention program were explored, using 11 interviews and 138 questionnaires. The web-based questionnaire was pre-tested by laypersons beforehand. Based on the results of the pre-test the questionnaire was revised to generate the final edition, which includes the topics that are listed in Table 1.

Table 1
Topics in web-based questionnaire

General	*Recent alert*
Laypersons characteristics	**Alerts from AED-Alert**
Age	Receipt date and time
Education level	Content
Employment status	Problems with alert
Profession	
Additional activities	**Action**
	Action after alert
CPR and AED training	Reason of action
Training institute	Problems on way to victim
Refresher courses	
Payment	**Local situation**
Utility	Location of victim
Materials, examples and exercises	(Lay)persons and AEDs present
Attention to intervention program	Professionals present
Potential improvements	
	Aid
Enrolment intervention program	Aid provided
Moment of enrolment	Collaboration
Way of enrolment	Problems in providing aid
Reason of enrolment	
Expectations	**Follow-up care**
Registered adresses	Experiences with alert
Problems with enrolment	Need for follow-up care
	Need for feedback
Intervention program	
Communication	**Continuation of enrolment**
Prublic relations	Overall experiences
Potential improvements	Continuation of enrolment

All answers to the questions in the questionnaire could be chosen from a set of multiple choice answers. For almost all questions, laypersons had the opportunity to fill in their own alternative answer.

In January 2010 an announcement with information about the evaluation study and the use of questionnaires was sent to all laypersons in the intervention program. Simultaneously, an announcement was published on the website of the intervention program.

Between February 1, 2010 and April 30, 2010 all involved laypersons were requested by mail within a week after each alert to fill in the web-based questionnaire. Laypersons who received more than one alert in the study period and already filled in the questionnaire, were requested to answer questions about the recent alert only. Laypersons were sent reminders to fill in the questionnaire after 3 and 6 weeks after the first mail about each alert. The study included all questionnaires that were filled in until June 30, 2010.

2.5. Statistical analysis

Summary statistics (percentages, means and SD) were used to describe the results. If relationships between variables were studied, Student's t-tests were performed. P values of less than 0.05 were considered to indicate statistical significance. All statistical analyses were performed with the use of the SPSS statistical package, IBM SPSS Statistics 18 UK (SPSS, Inc., Chicago, IL, USA).

Finally, during analysis of the study results, information about the status of the victims was obtained by comparing the information given by all laypersons that were able to take action and who went to the victim. Cases in which laypersons had no information were defined as 'unknown'. Victim's status was also defined as 'unknown' when less than 2 laypersons gave the same information about the victim, or answers differed between laypersons and there was no clear majority.

3. RESULTS

2,159 words

Between February 1, 2010 and April 30, 2010 AED-Alert was activated for 52 victims with a suspected out-of-hospital cardiac arrest. Per victim on average respectively 43, 47, and 92 laypersons were alerted (range: 1 – 407) in February, March, and April. During these 3 months AED-Alert send 3,227 alerts to 2,287 laypersons (Table 2).

Table 2
Activation of AED-Alert between February 1, 2010 and April 30, 2010 in Twente, and study population and response

	February *n* (%)	March *n* (%)	April *n* (%)	Total *n* (%)
Use of AED-Alert				
No. of AED-Alert activations	17	16	19	52
No. of laypersons alerted	577	667	1,043	2,287
No. of alerts send [a]	729	751	1,747	3,227
Alerted area	**N=17**	**N=16**	**N=19**	**N=52**
Rural (less than 10,000 inhabitants)	5 (29.4)	2 (12.5)	10 (52.6)	17 (32.7)
Suburban (10,000 to 50,000 inhabitants)	7 (41.2)	3 (18.8)	3 (15.8)	13 (25.0)
Urban (more than 50,000 inhabitants)	5 (29.4)	11 (68.8)	6 (31.6)	22 (42.3)
Time of alert				
Morning (07:00 to 12:00)	2 (11.8)	4 (25.0)	6 (31.3)	12 (23.1)
Afternoon (12:00 to 18:00)	5 (29.4)	8 (50.0)	6 (31.3)	19 (36.5)
Evening (18:00 to 24:00)	7 (41.2)	2 (12.5)	6 (31.3)	15 (28.8)
Night (24:00 to 07:00)	3 (17.6)	2 (12.5)	1 (5.3)	6 (11.5)
Content alerts [b]	**N=729**	**N=751**	**N=1,747**	**N=3,227**
CPR for 'CPR laypersons'	40 (5.5)	45 (6.0)	71 (4.1)	156 (4.8)
AED	466 (63.9)	516 (68.7)	1,464 (83.8)	2,446 (75.8)
CPR for 'AED laypersons'	219 (30.0)	189 (25.2)	202 (11.6)	610 (18.9)
Other	4 (0.5)	1 (0.1)	10 (0.6)	15 (0.4)
Access to AEDs				
No. of AEDs registered in victim's area	49	40	88	177
No. of AEDs indicated in alerts	43	34	82	159
Study population and response				
No. of laypersons eligible for study [c]	542	630	996	2,168
No. of laypersons who filled in one or more questionnaires	476	457	746	1,679
No. of questionnaires send	683	701	1,648	3,032
No. of questionnaires filled in [d]	537	509	1,052	2,098

[a] Laypersons could be alerted several times in the study period for different victims with an out-of-hospital cardiac arrest
[b] *CPR for 'CPR laypersons'*: Alert to start CPR for laypersons qualified in performing basic life support; *AED*: Alert to take nearby AED for laypersons trained in using an AED, and qualified in performing basic life support; C*PR for 'AED laypersons'*: Alert to start CPR for laypersons trained in using an AED, and qualified in performing basic life support; *Other*: Errors and missing cases
[c] Laypersons with an active email address
[d] Per layperson multiple questionnaires could be filled in, one for each alert they received in the study period

In February most alerts went to laypersons in suburban areas with 10,000 to 50,000 inhabitants, while in March the majority of alerts went to urban and in April to rural areas. Overall, most of the 52 alerts were sent in the afternoon (36.5%) or evening (28.8%). The content of the majority of the 3,227 alerts of AED-Alert was to take a nearby AED (75.8%). In the study period, 177 AEDs were registered in the area of the 52 victims with an out-of-hospital cardiac arrest. In total, 159 (89.8%) of these 177 AEDs were in the area of the registered addresses of laypersons and therefore could be indicated in the alerts.

3.1. Characteristics of laypersons

Of the 2,287 alerted laypersons, 2,168 (94.8%) were registered with an active email address in the intervention program, and were thus eligible for this study (Table 2). These eligible laypersons were requested by email to fill in 3,032 web-based questionnaires in total for alerts they received in the study period. To June 30, 2010, 1,679 (77.4%) of all 2,168 eligible laypersons filled in 2,098 (69.2%) of these 3,032 questionnaires send, one for each alert the laypersons received. Table 3 shows the characteristics of these 1,679 laypersons, of which 891 (53.1%) were men and 788 (46.9%) were women.

Table 3
Characteristics of volunteer laypersons alerted between February 1, 2010 and April 30, 2010 in Twente [a]

	Men, *n* (%) N = 891	Women, *n* (%) N = 788	Total, *n* (%) N = 1,679
Age (year)			
19 or younger	8 (0.9)	14 (1.8)	22 (1.3)
20-29	88 (9.9)	90 (11.4)	178 (10.6)
30-39	143 (16.0)	197 (25.0)	340 (20.3)
40-49	294 (33.0)	275 (34.9)	569 (33.9)
50-59	209 (23.5)	154 (19.5)	363 (21.6)
60-69	122 (13.7)	50 (6.3)	172 (10.3)
70 or older	20 (2.2)	7 (0.9)	27 (1.6)
Unknown	7 (0.8)	1 (0.1)	8 (0.5)
Education level			
Primary education	8 (0.9)	3 (0.4)	11 (0.7)
Secondary education	546 (61.3)	502 (63.7)	1,048 (62.4)
Higher professional education	235 (26.4)	226 (28.7)	461 (27.5)
Academic education	54 (6.1)	28 (3.6)	82 (4.9)
Unknown	48 (5.4)	29 (3.7)	77 (4.6)
Employment status			
Full-time employed	633 (71.0)	166 (21.1)	799 (47.6)
Part-time employed	45 (5.1)	472 (59.9)	517 (30.8)
Unemployed [b]	160 (18.0)	122 (15.5)	282 (16.8)
Unknown	53 (5.9)	28 (3.6)	81 (4.8)
Profession and additional activities			
Police / Fire department / Medical care	233 (26.2)	338 (42.9)	571 (34.0)
Other	623 (69.9)	427 (54.2)	1,050 (62.5)
Unknown	35 (3.9)	23 (2.9)	58 (3.5)

[a] Laypersons who filled in the questionnaire for an alert in the period between February 1, 2010 and April 30, 2010

[b] Includes laypersons who are not employed, retired, or not (fully) participating in labour market

The age of laypersons ranged from 16 to 76 (mean 45.5 ± 11.9). The mean age was significantly higher for men than for women (46.9 ± 12.3 years versus 43.2 ± 11.2 years; $P < 0.001$, Student's t-test). Both groups showed no differences in education level. Men and women differed at employment status, since most men worked full-time (71.0%), and most women worked part-time (59.9%). More than one third of these laypersons had a profession or additional activities at the police, fire department or in medical care. Of these laypersons who worked for the police, fire department or in medical care, men worked most of the time either at the fire department (47.2%) or in medical care (42.1%), while almost all women worked in medical care (91.7%).

Training

Most of the 1,679 laypersons described above were trained by EMS Ambulance Oost (49.2%) or specialised first aid training companies like the 'Dutch Red Cross', the Dutch foundation 'The Orange Cross' and local emergency response training institutes (27.4%), see Table 4. The majority of laypersons followed one refresher course per year (64.6%). Most of the 1,598 laypersons who followed refresher courses, were satisfied with their amount of training per year (86.9%). Only 8.1 percent of these 1,598 laypersons had a need for more training, of whom 84.6 percent followed 1 or less than 1 refresher course per year. Courses were paid by laypersons themselves (29.8%), most times paying less than 25 euro (54.9%), or payment was shared with employers (29.4%) or neighbourhoods and communities (28.0%).

Table 4
Training of laypersons

	Total, *n* (%) N = 1,679	
Training institute		
EMS Ambulance Oost	826	(49.2)
Specialised first aid training company	460	(27.4)
Other	272	(16.2)
Unknown	121	(7.3)
No. of refresher courses		
None	81	(4.8)
Less than 1 per year	47	(2.8)
1 per year	1,084	(64.6)
More than 1 per year	409	(24.4)
Unknown	58	(3.5)
Satisfaction no. of refresher courses	**N = 1,598**	
Satisfied	1389	(86.9)
Need for more training	130	(8.1)
Need for less training	11	(0.7)
Unknown	68	(4.2)
Payment courses		
Self	501	(29.8)
(Partly) Employer	494	(29.4)
(Partly) Neighbourhood and community	470	(28.0)
Other	74	(4.4)
Unknown	140	(8.4)

The 1,679 laypersons evaluated the courses as useful (88.7%) and judged them positively (88.0%), see Table 5. Course materials, and practical examples and exercises were used, according to respectively 91.4 and 89.6 percent of all 1,679 laypersons. These laypersons also indicated that often course books (32.4%), videos (37.9%) or anatomic models (7.9%) were used for the theoretical part, and a resuscitation dummy (90.1%) or AED (87.6%) for the practical part. The 1,679 laypersons evaluated the amount of practical examples and exercises as satisfactory (81.0%) and useful (83.2%). Overall, most courses met the needs of the 1,679 laypersons (87.6%).

Table 5 also shows that only a minority of all 1,679 laypersons indicated by answering multiple choice questions that their training could be improved by using more practical examples and exercises (8.4%), and paying more attention to the intervention program (6.5%) in courses.

In total, 211 laypersons came up with spontaneous suggestions for improvement of training. Of the 1,679 laypersons, 89 (5.3%) laypersons spontaneously indicated that there is a difference between practice and theory of providing aid. They suggested to better prepare laypersons for the process after alerts, by practicing cases, sharing examples and experiences, and discussing the process and possible problems after alerts. Here, the course should also pay attention to the practical part of getting and using an AED, and dealing with the AED after an alert. The laypersons also suggested that courses need to be repeated more often (2.6%), and should include more medical information (0.8%). Finally, they suggested that all information in the course should be provided to laypersons by means of a summary, text book or sources on the Internet for future reference (0.7%).

Table 5
Evaluation and potential improvements of training

	Total, *n* (%) **N = 1,679**
Evaluation courses	
Useful course	1,489 (88.7)
Positive judgement course	1,478 (88.0)
Satisfactory no. of practical examples and exercises	1,360 (81.0)
Useful no. of practical examples and exercises	1,397 (83.2)
Course met needs	1,471 (87.6)
Suggestions for improvement training	
Multiple choice	
Use of practical examples and exercises	141 (8.4)
Attention to intervention program	109 (6.5)
Content course	46 (2.7)
Use of course materials	33 (2.0)
Other	76 (4.5)
Spontaneous suggestion	
Difference practice and theory of providing aid	89 (5.3)
Repetition of courses	44 (2.6)
Medical information in courses	14 (0.8)
Information for future reference	12 (0.7)
Other	52 (3.1)

Enrolment

After training, laypersons were able to enrol in the intervention program. The majority of the 1,679 laypersons arranged their own enrolment (82.7%), and were registered in 2009 (53.2%), see Table 6. Most times because they were aware of the importance of providing early aid (42.6%).

Table 6 also shows that of all 1,679 laypersons, 1,029 (61.3%) laypersons only registered their residential address. These 1,029 laypersons were often not able to leave their workplace in case of an alert (28.8%), had no work address (26.1%), had different work addresses or working hours (24.3%), or did not know that their work address could be registered (5.1%). In total, 569 (33.9%) of all 1,679 laypersons were enrolled with their work address. These 569 laypersons often had permission from their employer to leave their workplace in case of an alert of AED-Alert (56.0%), or were entrepreneurs (11.8%). However, some laypersons did not know whether they had permission (26.1%) or even had no permission (6.0%), see Table 6.

Table 6
Enrolment of laypersons

	Total, *n* (%) N = 1,679
Moment of enrolment	
2008	320 (19.1)
2009	894 (53.2)
2010	250 (14.9)
Unknown	215 (12.9)
Way of enrolment	
Self	1,388 (82.7)
Someone of intervention program	170 (10.1)
Family, friends or neigbours	42 (2.5)
Other	8 (0.5)
Unknown	21 (4.3)
Reason of enrolment	
Importance of providing early aid	715 (42.6)
Training or experience in providing aid	381 (22.7)
Helping people	380 (22.6)
Other	138 (8.2)
Unknown	65 (3.9)
Registered addresses	
Residential address only	1,029 (61.3)
Work address only	14 (0.8)
Residential and work address	555 (33.1)
Other	23 (1.4)
Unknown	58 (3.5)
Reason no work address registered	**N = 1,029**
Not able to leave workplace in case of alert	296 (28.8)
No work address	269 (26.1)
Different work addresses or working hours	250 (24.3)
Option not known	52 (5.1)
Other	162 (15.7)
Permission to leave work address	**N = 569**
Permission of employer	319 (56.0)
Not applicable (Entrepreneur)	67 (11.8)
Permission employer unknown	148 (26.1)
No permission	34 (6.0)

The terms of use of AED-Alert were read by most of the 1,679 laypersons during (61.9%) or after (15.2%) their enrolment in the intervention program, see Table 7. Quite a few laypersons (19.0%) had never read these terms of use. The majority (92.1%) of all 1,679 laypersons had clear expectations before enrolment about their role as layperson in the intervention program. Of all 1,679 laypersons, only 7.9 percent had problems with their enrolment in the intervention program, see Table 7.

Table 7
Reading terms of use, expectations and problems with enrolment of laypersons

	Total, *n* (%) **N = 1,679**
Terms of use	
Read during enrolment	1,040 (61.9)
Read after enrolment	255 (15.2)
Never read	319 (19.0)
Unknown	65 (3.9)
Expectations	
Clear expectations before enrolment	1,547 (92.1)
No clear expectations before enrolment	74 (4.4)
Unknown	58 (3.5)
Problems with enrolment	
Confirmation of enrolment	28 (1.7)
Registering mobile number	27 (1.6)
Registering addresses	15 (0.9)
Other	63 (3.8)

3.2. AED-Alert process

Table 2 showed that 1,679 laypersons filled in 2,089 questionnaires after alerts of AED-Alert. Based on these 2,098 alerts, figure 2 provides an overview of the characteristics of the process after alerts in the study period.

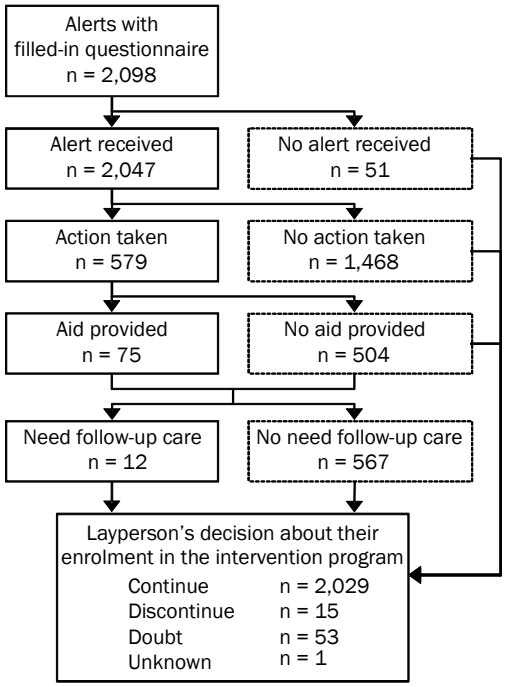

Fig. 2. Characteristics of process after alerts between February 1, 2010 and April 30, 2010 in Twente

Reception of alerts

Laypersons indicated that they received almost all of the 2,098 alerts of AED-Alert (97.6%). Laypersons did not receive 51 (2.4%) alerts, often because they were not registered with their correct mobile number (33.3%), or had technical problems with their mobile phone or provider (7.8%). For the majority of the non-received alerts, it remains unclear why laypersons did not receive the alert (58.8%), see Table 9.

According to the information on their mobile phone, laypersons received most of the 2,047 alerts on the same time as the registered time the alert was sent according to database PAMS (54.6%). A substantial number of alerts however, were received between the initial emergency call and this registered time in PAMS (11.3%).

The 2,047 alerts were frequently read within 1 minute after receiving the alert (55.2%). Corresponding to the registered content of alerts in Table 1, the majority of the 2,047 received alerts contained a message to take a nearby AED (72.6%). In only 43.8 percent of all received alerts laypersons recognized the address of the victim exactly. For respectively 36.2 and 18.9 percent of the 2,047 alerts it was roughly clear or even unclear for laypersons where the victim's address was.

Most of the 1,679 laypersons indicated that the system AED Alert could be improved. They suggested to send text messages that include a landmark in the victim's neighbourhood (42.5%), a map or plan of the local area (41.0%), and only AEDs in the vicinity (28.5%). Finally, laypersons indicated that the use of GPS would be an improvement of AED-Alert (42.1%), a method with which the system would only alert laypersons in the victim's neighbourhood, see Table 9.

Table 9
Characteristics of received alerts

	Total, *n* (%) **N = 2,047**
Time of alerts [a]	
Before initial emergency call to EMS	386 (24.1)
Equal to registered time of sending the alert	874 (54.6)
Between intial emergency call to EMS, and time of sending the alert	180 (11.3)
Within 5 minutes after time of sending the alert	98 (6.1)
Over 5 minutes after time of sending the alert	62 (3.9)
Unknown	447
Reading of alerts	
Within 1 minute after reception	1,129 (55.2)
Over 1 minute after reception	895 (43.7)
Unknown	23 (1.1)
Content of alerts	
Start CPR	543 (26.5)
Take nearby AED	1,486 (72.6)
Unknown	18 (0.9)
Recognition victim's address in alerts	
Exactly	896 (43.8)
Roughly clear	740 (36.2)
Unclear	387 (18.9)
Unknown	24 (1.2)
Suggestions for improvement AED-Alert [b]	**N = 1,679**
Landmark in alert	714 (42.5)
Use of GPS	707 (42.1)
Map/plan in alert	688 (41.0)
Only AEDs in vicinity in alert	479 (28.5)
Alerts on fixed telephone	249 (14.8)
Complete contents of alert	184 (11.0)
Other	131 (7.8)

[a] Information obtained from databases RAVIS and PAMS. RAVIS automatically registers the time of the 'intial call to EMS', a call by which the EMS is informed and alarmed for a victim. PAMS automatically registers the 'time of alert', the time on which AED-Alert sent the alerts to laypersons
[b] Per layperson multiple answers could be given

Action after alerts

Laypersons could take action for 579 of the 2,047 received alerts (28.3%). Per alert on average 11 laypersons came into action (range: 0 – 74), see Table 10. For 1,468 of all 2,047 received alerts, laypersons were often not in the victim's neighbourhood (40.9%), or noticed the alert too late (35.0%), see Table 10. For most of these 1,468 alerts, laypersons had neutral feelings for not being able to take action (80.3%). However, laypersons indicated for some of these 1,468 alerts, that it was a negative (15.3%) or even very negative (2.3%) experience not being able to take action.

In about 85.2 percent of the 579 alerts for which laypersons could take action, laypersons were in in the victim's neighbourhood, see Table 10. In 144 (24.9%) of these 579 alerts, laypersons were able to take a nearby AED. In the study period only 12 (8.3%) of the taken AEDs were actually used in providing aid to victims. For most of the 144 alerts in which laypersons were able to take a nearby AED, it was clear (18.1%) or even very clear (57.6%) what to do with the AED after the alert. However, for 12 (8.3%) of the 144 alerts, laypersons did not know what to do with the AED after the alert.

Table 10 also shows that laypersons faced problems during action after 298 (51.5%) of the 579 alerts. In these 298 alerts often the AED was already taken (50.7%), and sometimes the address of the victim was hard to find (23.8%), or even unknown because the alert contained the wrong address or not all necessary information (4.7%). Accordingly, 1,197 (71.4%) of all 1,679 laypersons who filled in a questionnaire stated that the distribution (25.3%), accessibility (22.3%), and number of AEDs in the program (23.8%) could be improved.

Table 10
Action after alerts

	Total, *n* (%)
No. of victims for whom AED-Alert was activated	**N = 52**
Number of laypersons who came into action	
0	5 (9.6)
1-9	26 (50.0)
10-19	13 (25.0)
20-29	6 (11.5)
30-74	2 (3.8)
No. of alerts not followed by any action	**N = 1,468**
Reason no action	
Not in victim's neighbourhood	601 (40.9)
Not noticed alert in time	513 (35.0)
Personal circumstances	146 (10.0)
Could not leave work place	65 (4.4)
Other	143 (9.7)
Experiences no action	
Neutral	1,179 (80.3)
Negative	224 (15.3)
Very negative	34 (2.3)
Other	18 (1.2)
Unknown	13 (0.9)
No. of alerts followed by action	**N = 579**
Location of layperson at time of alert	
Within 1,000 meters of victim	493 (85.2)
Over 1,000 meters of victim	50 (8.6)
Unknown	36 (6.2)
No. of alerts followed by action, and AED taken	**N = 144**
Use of AEDs in providing aid	
AEDs used	12 (8.3)
AEDs not used	132 (91.7)
Clarity of dealing with AEDs after alert	
Very clear	83 (57.6)
Clear	26 (18.1)
Not clear, not unclear	18 (12.5)
Unclear	12 (8.3)
Unknown	5 (3.5)
Problems during action [a]	**N = 298**
AED already taken	151 (50.7)
Address victim hard to find	71 (23.8)
Traffic	16 (5.4)
Wrong address in alert	14 (4.7)
Other	61 (20.5)
Suggestions for improvement action [a]	**N = 1,679**
Distribution of AEDs	424 (25.3)
Accessibility of AEDs	374 (22.3)
Number of AEDs in intervention program	399 (23.8)
Other	482 (28.7)

[a] Per layperson multiple answers could be given

For only 75 (13.0%) of the 579 alerts for which action could be taken, laypersons could provide aid. Per alert on average 1 to 2 laypersons provided aid (range: 0 – 6). For 504 (87.0%) of the 579 alerts no aid could be provided, often because professionals were already present (60.9%), see Table 11. For the 75 alerts, laypersons could often provide or assist in early CPR and defibrillation to the victim (53.3%), and assist the EMS personnel (53.3%). In 18 (24.0%) of these 75 alerts, laypersons indicated that there were problems with providing aid, of whom 6 (33.3%) spoke of a chaos at the scene.

Table 11
Aid after alerts

	Total, *n* (%)
No. of alerts followed by action, but no aid is provided	**N = 504**
Reason no aid provided [a]	
Professionals already present	307 (60.9)
Sufficient amount of laypersons present	291 (57.8)
Victim had other diseases	51 (10.1)
Victim was already conscious	7 (1.4)
Victim was already deceased	7 (1.4)
Other	14 (2.8)
No. of alerts followed by action, and aid is provided	**N = 75**
Provided aid [a]	
Providing / assisting in early CPR and defibrillation	37 (49.3)
Assisting EMS personnel in providing aid	24 (32.0)
Guiding EMS personnel to the victim	15 (20.0)
Taking care of family members and bystanders	29 (38.7)
Other	3 (4.0)
No. of alerts followed by action, with problems on scene	**N = 18**
Chaos due to too many persons present	6 (33.3)
AED not accessible, incomplete, or absent	6 (33.3)
Other	6 (33.3)

[a] Per layperson multiple answers could be given

For 12 (2.1%) of the 579 alerts in which action was taken, laypersons indicated to have a need for follow-up care, see Table 12. Only 105 (18.1%) of the 579 alerts, laypersons expressed to have a need for feedback on their actions and provided aid. For the marjority of the 579 alerts, laypersons had a need for information about the victim's status after the alert (52.2%), and indicated that they already searched for this information themselves (37.5%). Quite a few of all 1,679 laypersons who filled in a questionnaire, suggested that the intervention program could be improved by giving more information about the victim's status after an alert (12.7%). In the end, for the majority of the 579 alerts laypersons indicated to have little (15.9%) or no (69.4%) difficulty in handling their experiences with the alerts after taking action.

Table 12
Needs and experiences of laypersons

	Total, *n* (%) **N = 579**
Needs, of all alerts followed by action [a]	
Need for follow-up care	12 (2.1)
Need for feedback	105 (18.1)
Need for information on victim's status	302 (52.2)
Search for information on victim's status	217 (37.5)
Experiences	
Difficulties	9 (1.6)
Little difficulties	92 (15.9)
Neutral	62 (10.7)
No difficulties	402 (69.4)
Unknown	14 (2.4)

[a] Per layperson multiple answers could be given

Overall, laypersons indicated for only 15 (0.7%) of all 2,098 alerts for which a questionnaire was filled-in, to discontinue because of personal circumstances (33.3%), or costs of training (13.3%). For 53 (2.5%) of the 2,098 alerts laypersons indicated to doubt about their enrolment, because of unavailability (20.8%), anxiety (18.8%), or costs of training (3.8%).

3.3. Results for victims

In total, 37 (71.2%) of all 52 victims had an incident at home, and 4 (7.7%) in a public area like a restaurant, train or place on the street, see Table 13. In 21 (40%) of the 52 alerts, laypersons were present before arrival of the EMS. Based on the information from the questionnaires it is certain that laypersons could provide aid to at least 18 (34.6%) victims, by starting early CPR and defibrillation. Furthermore, it is known from the questionnaires that laypersons could assist the EMS in providing aid to at least 9 (17.3%) victims. Another 4 victims (7.7%) received aid from the EMS alone. For the other 21 (40.4%) of the 52 victims, it is not known from the questionnaires whether laypersons could provide aid, because laypersons had no information about the victim, or the information differed between laypersons without a clear majority.

Table 13 also shows that for the majority of the 52 victims, between 6 and 10 persons were present at the scene (65.4%). Furthermore, according to laypersons, 6 (11.5%) victims had other diseases than a cardiac arrest, and became unwell, had a febrile convulsion, problems with their insulin, were choking, or drunk. Laypersons indicated that, according to what they knew at the time of filling in the questionnaire, in total 16 (30.8%) victims survived.

Table 13
Results for victims for whom AED-Alert was activated between February 1, 2010 and April 30, 2010 in Twente [a]

	Total, *n* (%) **N = 52**
Location victim	
Home	37 (71.2)
Public area	4 (7.7)
Other	1 (1.9)
Unknown	10 (19.2)
Aid provided	
Laypersons	18 (34.6)
Laypersons and EMS personnel	9 (17.3)
EMS personnel	4 (7.7)
Unknown	21 (40.4)
No. of people in total present [b]	
1-5	7 (13.5)
6-10	34 (65.4)
Unknown	11 (21.2)
Arrest	
Cardiac arrest	46 (88.5)
No cardiac arrest	6 (11.5)
Status victim	
Survived	16 (30.8)
Deceased	12 (23.1)
Unknown [c]	24 (46.2)

[a] Information obtained from questionnaires filled in by laypersons
[b] Includes all laypersons, professionals and other people, like family members and bystanders, present on scene
[c] Includes all cases in which laypersons had no information or no clear understanding between each other about the victim's status

4. DISCUSSION

1,689 words

This study evaluated the AED-Alert process to identify problems and potential improvements, based on 2,098 questionnaires related to 69% of all alerts send in a 3 month period. Study results showed that in 21 of the 52 alerts laypersons were present before arrival of the EMS. Laypersons provided aid or assisted EMS personnel in 27 of all 52 victims with an out-of-hospital cardiac arrest. Nevertheless, laypersons provided aid in just 3.6 percent of all 2,098 alerts send by AED-Alert.

Most activities in the AED-Alert process, like enrolment, providing aid, and handling experiences after alerts, progressed well. At the same time, in 84 percent of all 2,098 filled in questionnaires, laypersons identified one or more problems and potential improvements. Study results made clear that the AED-Alert process could be improved on laypersons' registration, mobile phone settings and carrying of mobile phones by laypersons, alerts of AED-Alert, distribution, accessibility and number of AEDs in the program, and training of laypersons.

This study is the first to report on problems and potential improvements of the process of an early intervention program in which an EMS is able to alert trained and volunteer laypersons by sending them a text message on their mobile phone to go to victims of an out-of-hospital cardiac arrest and provide early CPR and defibrillation. The early intervention program is in some parts comparable to existing programs as public access defibrillation programs [11], or lay rescuer AED programs [14], regarding the use of public access of AEDs and early CPR and defibrillation before arrival of the EMS. International organizations have recommended critical elements for such programs: planned and practised response, training of anticipated rescuers in CPR and use of the AED, link with the local EMS system, and continuous audit and quality improvement [8,14-15]. In addition, this study provides information and recommendations for institutions that have plans to adopt such an early intervention program.

First of all, the study made clear that, based on the problems that were mentioned by most laypersons, some recommendations can be made to improve the AED-Alert process.

Study results showed that laypersons did not receive 2 percent of the 2,098 alerts, often because they were not registered with their correct mobile number (33%). Furthermore, 25 percent of all 2,047 received alerts were not noticed in time. This number of alerts received and noticed by laypersons could be increased. For this purpose, laypersons should check and update their registered information in the intervention program, like their mobile number, enrolled addresses, and working hours if applicable. Secondly, laypersons should adjust the settings of their mobile phone to be able to notice alerts, and carry their mobile phone with them whenever it suits them. In this context, it is important to repeatedly remind laypersons to verify their registered information in the intervention program.

Study results also showed that in 29 percent of all 2,047 received alerts laypersons were not in the victim's neighbourhood, and that in 9 percent of the 579 alerts in which action could be taken laypersons were over 1,000 meters of the victim. In another 15 percent of these 579 alerts the victim's address was hard to find or incorrect in the alert. Eventually, the number of laypersons that arrived at the victim's location without these problems could be increased. As suggested by the majority of the 1,679 laypersons who filled in a questionnaire,

for this purpose the system AED-Alert should be improved by sending messages with more additional information about the addresses in the alert (for example a landmark, map or plan), and using techniques (as GPS) with which only laypersons in the victim's neighbourhood are alerted and only nearby AEDs on the way to the victim are included in the alerts.

At fourth, 71 percent of the 1,679 laypersons who filled in a questionnaire suggested that the intervention program could be improved by paying more attention to the distribution and accessibility of AEDs, and by increasing the number of AEDs in the program. Further study must therefore investigate the distribution and availability of AEDs in the intervention program. Furthermore, study outcomes must be used to make a judgement whether or not to increase the number of AEDs in the program. As in other studies, it could be that laypersons need more training and practice, and that the mere presence of an AED does not ensure that it will be used when a victim with a sudden out-of-hospital cardiac arrest occurs [11].

Consistent with this latter point, laypersons should be better prepared for the process after alerts. In this study, 37 percent of the 1,679 laypersons suggested that the training could be improved in some way. As suggested by almost 12 percent of the 1,679 laypersons who filled in a questionnaire, for this purpose special training should be given to all laypersons in the intervention program, that focuses on narrowing the gap between theory and practice of providing aid in the AED-Alert process. Now, laypersons also receive training from general public training institutes that pay little or no attention to the AED-Alert process, and providing CPR or using an AED as a layperson. In this context, it is certainly useful to inspect the training of laypersons at the different training institutes.

This study also made clear that the time of sending and receiving alerts of AED-Alert is a potential problem which should be further investigated. Results showed that for 45.4 percent of all 2,047 received alerts, laypersons indicated that the time of receiving alerts by laypersons differed from the time of sending alerts by AED-Alert. Some laypersons spontaneously indicated in the questionnaire that the ambulance already drove by when they received the alert of AED-Alert. Others indicated that they saw a difference, of sometimes exactly 2 minutes, in the time that the alert was send according to the information in the text message of AED-Alert, and the time of reception of the alert according to the provider of their mobile number. The difference in time of sending and receiving alerts could depend on clock settings of the emergency call registration, the AED-Alert registration, and the provider of the mobile phone of laypersons. However, it must be examined whether or not the reception of alerts is affected for example by the area laypersons live in (rural or suburban), or the transmission of alerts by the provider of their mobile number. While victim's chance of survival decreases approximately 7 to 10 percent with every minute delay in defibrillation [9-10], it is crucial to investigate whether, and in what proportion, there is a delay in the reception of alerts by AED-Alert.

4.1. Limitations

The study has some limitations. First, the study results are based on an evaluation of the AED-Alert process over only a 3 month period, between February 1, 2010 and April 30, 2010. Evaluation over a longer or other period could have given different results. Yet, the chosen study period was a correct moment for an evaluation,

because of the development of the intervention program and an accompanying increase of use of AED-Alert. Since the start of the intervention program in 2008, more laypersons have been enrolled, and more areas in the region joined the intervention program. In 2010 therefore many more alerts were sent over the same 3 month period compared to 2009, 3,227 alerts (range: 1 – 407) instead of 1,030 (range: 3 – 80). These developments lead to a situation in which more problems and difficulties could occur in the AED-Alert process. Therefore, it probably was the right time to evaluate the AED-Alert process and to early identify problems and potential improvements.

Secondly, although 77% of all eligible laypersons participated in this study, a smaller percentage of all questionnaires (69%) were filled in. Another 1 percent of the questionnaire response was obtained from emails of laypersons in which they indicated that they would or could not fill in the questionnaire, because they already filled in a questionnaire, discontinued in the intervention program, were unable to fill in the questionnaire due to personal circumstances, did not receive the alert, or were abroad on the moment of alert. It may be assumed that most of the other 30 percent of the questionnaire response can be explained by the same reasons. It may also be assumed that these missing questionnaires do not drastically change the results found in this study, since per alert on average 75 percent (range: 50 – 100 percent) of the questionnaires were filled in.

Third, in this study web-based questionnaires were only sent to laypersons who received an alert of AED-Alert in the study period. The study thereby did not include laypersons who still have never received a message of AED-Alert, or have discontinued the program. Future study must provide evidence whether the results on opinions and experiences of these laypersons differ from the laypersons in this study.

Finally, information on the situation at the victim and victim's results after alerts was only obtained from web-based questionnaires filled in by laypersons. Thereby, for 21 of the 52 victims it is now unknown whether laypersons provided aid to them. Further study should therefore also include information from the involved EMS personnel, and database RAVIS in which the EMS registers all information of the processes after initial calls to the EMS. Based on the information of laypersons, EMS personnel, RAVIS, and possibly hospital records, a full oversight of the situation on scene and victim's results after alerts could be given.

Overall, this study showed that although the AED-Alert process was not optimal for several laypersons, the program achieved that laypersons provided aid or assisted EMS personnel to over 50 percent of the victims. Study results showed that the majority of problems laypersons had to encounter can be overcome. The recommended improvements of the AED-Alert process could lead to an increase of the number of laypersons who could provide aid, and thereby could increase survival of victims with an out-of-hospital cardiac arrest. Other types of study are needed to investigate to what extent this early intervention program is effective in increasing survival of victims with an out-of-hospital cardiac arrest.

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