Resuscitation xxx (2017) xxx-xxx

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com

Clinical paper

Lay persons alerted by mobile application system initiate earlier cardio-pulmonary resuscitation: A comparison with SMS-based system notification☆

Caputo Maria Luce[a,*], Muschietti Sandro[b], Burkart Roman[c], Benvenuti Claudio[c], Conte Giulio[a], Regoli François[a], Mauri Romano[c], Klersy Catherine[d], Moccetti Tiziano[a], Auricchio Angelo[a]

[a] Division of Cardiology, Fondazione Cardiocentro Ticino, Lugano, Switzerland
[b] Federazione Cantonale Ticinese Servizi Autoambulanze, Lugano, Switzerland
[c] Fondazione Ticino Cuore, Breganzona, Switzerland
[d] Service of Biometry and Clinical Epidemiology, Fondazione IRCCS Policlinico San Matteo, Pavia, Italy

ARTICLE INFO

Article history:
Received 22 November 2016
Received in revised form 1 February 2017
Accepted 2 March 2017
Available online xxx

Keywords:
Out of hospital cardiac arrest
First responder
Recruitment system
Survival

ABSTRACT

Aim

We compared the time to initiation of cardiopulmonary resuscitation (CPR) by lay responders and/or first responders alerted either via Short Message Service (SMS) or by using a mobile application-based alert system (APP).

Methods

The Ticino Registry of Cardiac Arrest collects all data about out-of-hospital cardiac arrests (OHCAs) occurring in the Canton of Ticino. At the time of a bystander's call, the EMS dispatcher sends one ambulance and alerts the first-responders network made up of police officers or fire brigade equipped with an automatic external defibrillator, the so called "traditional" first responders, and – if the scene was considered safe – lay responders as well. We evaluated the time from call to arrival of traditional first responders and/or lay responders when alerted either via SMS or the new developed mobile APP.

Results

Over the study period 593 OHCAs have occurred. Notification to the first responders network was sent via SMS in 198 cases and via mobile APP in 134 cases. Median time to first responder/lay responder arrival on scene was significantly reduced by the APP-based system (3.5 [2.8–5.2]) compared to the SMS-based system (5.6 [4.2–8.5] min, p 0.0001). The proportion of lay responders arriving first on the scene significantly increased (70% vs. 15%, $p < 0.01$) with the APP. Earlier arrival of a first responder or of a lay responder determined a higher survival rate.

Conclusions

The mobile APP system is highly efficient in the recruitment of first responders, significantly reducing the time to the initiation of CPR thus increasing survival rates.

Introduction

Successful resuscitation for victims of out-of-hospital cardiac arrest is very time sensitive. Early initiated cardiopulmonary resuscitation (CPR) before the arrival of emergency-medical-services (EMS) personnel plays a key role in increasing the chance of survival.[1] However, the initiatives to increase the number of early initiated CPR are costly and the effectiveness of training unselected lay responders in CPR is quite uncertain.[2,3] Moreover, several communities have adopted a dual-dispatching EMS system which recruits lay responders who are trained in CPR to assist out-of-hospital cardiac arrest victims as well as "traditional" first responder groups (i.e. fire and police vehicles).[4–5]

First responders network may be alerted by short message service (SMS) or by using more advanced telecommunication technologies such as a mobile application (APP).[5,6]

There are no data on the efficiency of an SMS-based or APP-based system in effectively recruiting first responders or lay responders, and whether the time of first responder/lay responder—initiated CPR is influenced by the technology used to notify these volunteers. In the Swiss Canton of Ticino, we have a three-tier response system: EMS, police/fire first responders, lay responders. The first and lay responders have been traditionally alerted via SMS. Starting from 2014, a mobile APP-based alert system has been introduced to notify an OHCA occurrence. This mobile APP is available for both first and lay responders. Our goal was to evaluate the time between a bystander phone call to EMS provider and the arrival of first responders and/or lay responders when alerted either via SMS or the new APP-based alert system.

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2017.03.003.

* Corresponding author. Fax: +41 918053173.
Email address: marialuce.caputo@cardiocentro.org (C.M. Luce)

http://dx.doi.org/10.1016/j.resuscitation.2017.03.003
0300-9572/

Methods

Emergency medical system and first responders alert

A single EMS system serves the Canton of Ticino. This region has a population of 350.363 inhabitants (2014) and encompasses a territory of more than 2.800 km^2 in the Southern part of Switzerland. This region presents significant geographic challenges as the territory consists of mountains, valleys, and lakes. About 49% of the population consists of men, and overall 21% is over the age of 65.[7] By December 31st 2015, 65,327 people (16.4% of the resident population) had completed a Basic Life Support-Defibrillation (BLS-D) course.

A national emergency telephone number, 144, is connected to the regional dispatching centre of the EMS. In the Swiss Canton of Ticino, the EMS dispatch centre is managed by three operators during the daytime (7.00 A.M.–8.00 P.M.) and by two operators during night time (9.00 P.M.–6.00 A.M.). The EMS dispatcher manages all emergencies based upon the medical priority dispatch system. When a cardiac arrest is suspected, assisted triage and life support are dispatched and medical assistance is initiated until an ambulance arrives. The EMS dispatcher send the ambulance and, in parallel, notifies the alert to the traditional first-responders. They are police officers and fire brigade, trained in BLS-D and equipped with an AED. If conditions are regarded as safe by the EMS Dispatcher (according to information on the circumstances and the position of the victim obtained by the caller), the lay responders are notified as well. The latter are mostly lay persons but can include off-duty healthcare providers (i.e. physicians, nurses, CPR course graduates). Their training includes the standard Swiss Resuscitation Council Basic Life Support (ERC BLS)/ AED course for lay rescuers that complies with the recommendations of the European Resuscitation Council.[8]

Text message responders and APP-users

To be part of the Ticino first responder network, an adult has to be trained and certified in the standard ERC BLS/AED course. Registration takes place via an online database in which they can enter their contact information including mobile phone number and specifications of their BLS certificate. Biannual retraining is required.

After the successful launch of the APP-based alert system in May 2014, the rescuers may select whether to receive SMS or APP alerts. The APP can be downloaded free-of-charge at http://www.ticinocuore.ch/it/first-responder onto a mobile device from the Apple App Store or Google Play. On December 31st 2015, 1825 people have downloaded the APP and registered themselves as lay responders.

*Text message alert (SMS) system (*Fig. 1*)*

Between January 2006 and May 2014, the first responder network was alerted only via SMS. At the time of an emergency call, the EMS dispatcher activated the first responder network by sending an SMS to a list of registered traditional first responders and lay responders. The SMS was sent only to those rescuers registered in the city or community where the out-of-hospital cardiac arrest occurred. According to Swiss privacy law, the SMS can only contain information about the street and the municipality without any further detail. The rescuers must return the EMS dispatcher's call to indicate their availability to reach the victim. By doing so, they obtain more detailed information, such as a text message which may include the exact location and name of the person. This system is active 24 h/365 days.

*Mobile application-based alert system (*Fig. 1*)*

On June 1st 2014, an APP-based alert system was introduced. By using the global positioning system and mapping functionality of mobile devices along with cardiac arrest location data provided by a local EMS dispatcher, the system directly sends the user a cardiac arrest notification. The first responders/lay responders who are available must press the "I am available" button in order to give their consent to the APP system which geo-localizes each one. Then the system gives the exact location of out-of-hospital cardiac arrest, estimates the time needed for each rescuer to be on scene, and provides the time the estimated ambulance arrival time. The system automatically excludes those first responders/lay responders who are further away than the ambulance. The shortest itinerary is shown on the screen of the mobile device and the nearby registered AEDs are also flagged on the map in order to facilitate their access to lay responders involved in the mission. Because some police officers and the fire brigade have continued to use the SMS-alert system, both the SMS and APP-based systems are running in parallel.

Study design

This is a prospective observational study that included out-of-hospital cardiac arrest, which occurred between January 1st 2012 and December 31st, 2015 in the Canton of Ticino, in which the first responder network was alerted via a SMS or an APP-based message.

We evaluated the time between the phone call by the bystander and the time to arrival of traditional first responders, and/or lay responders, when alerted either via SMS or via the new APP.

Data collection

Since 2002, the Ticino Registry of Cardiac Arrest (TIRECA) has been collecting information about each out-of-hospital cardiac arrest occurring in the Canton of Ticino. The TIRECA is linked to the EMS administrative database that collects all recorded conversations between the EMS dispatcher and each traditional first responder or lay responder. These calls are systematically analysed for quality control. After retrieving and analysing all recorded conversations, the time to traditional first responder/lay responder recruitment and arrival on scene, the initiation of dispatched chest compressions and the ambulance arrival time could be determined.

Statistical analysis

Data are described as median (25th–75th percentile) for continuous variables, and counts and percent if categorical variables. Results of the SMS and APP systems were compared using the Mann–Whitney *U* test and the Fisher exact test, respectively. Hospital survival was computed separately for each group. The prognostic role of the system used on hospital mortality was assessed by means of logistic regression. The odds ratio (OR) of dying was reported together with its 95% confidence interval. Stata 14.2 (StataCorp, College Station, TX, USA) was used for computation.

Results

Between January 1st, 2012 and December 31st, 2015, 1013 out-of-hospital cardiac arrests occurred in the Canton of Ticino, 593 (58%) of them of presumed cardiac origin (Fig. 2). All EMS-witnessed cardiac arrests, aborted resuscitation efforts in individuals

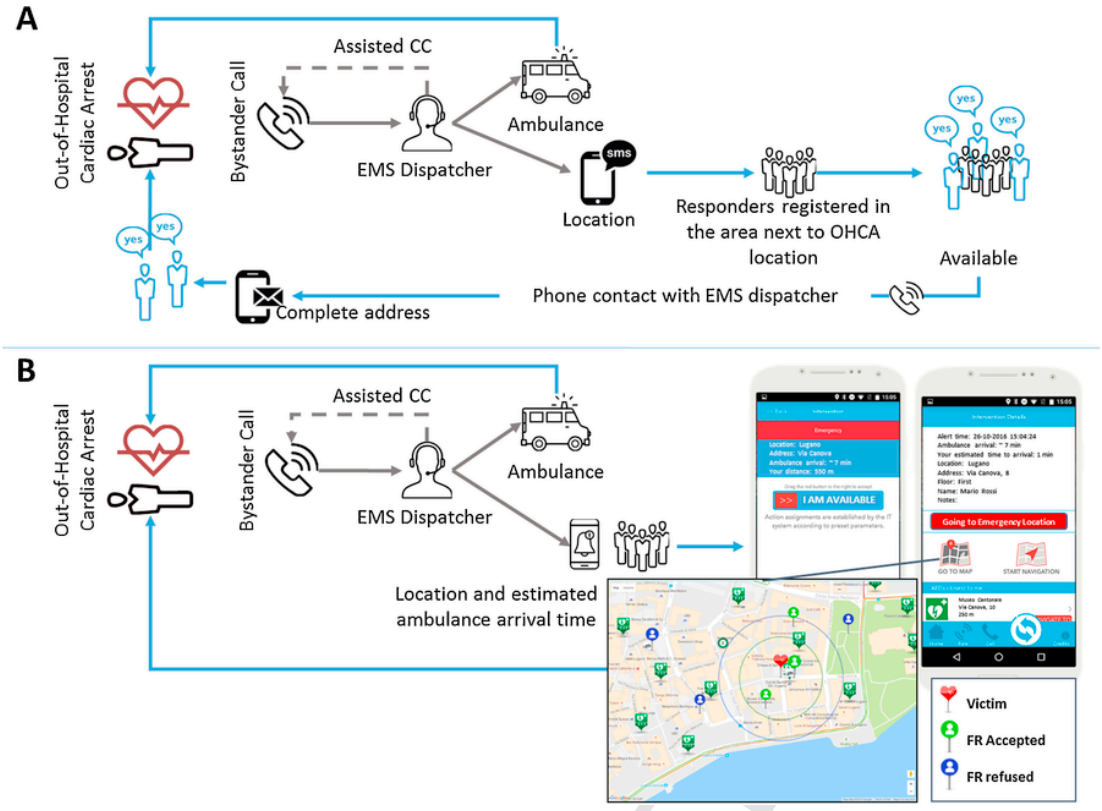

Fig. 1. First responder network alert systems in Swiss Canton Ticino. Panel A: SMS system; panel B: APP system. CC: chest compressions, EMS: emergency medical service, OHCA: out-of-hospital cardiac arrest, FR: first responder.

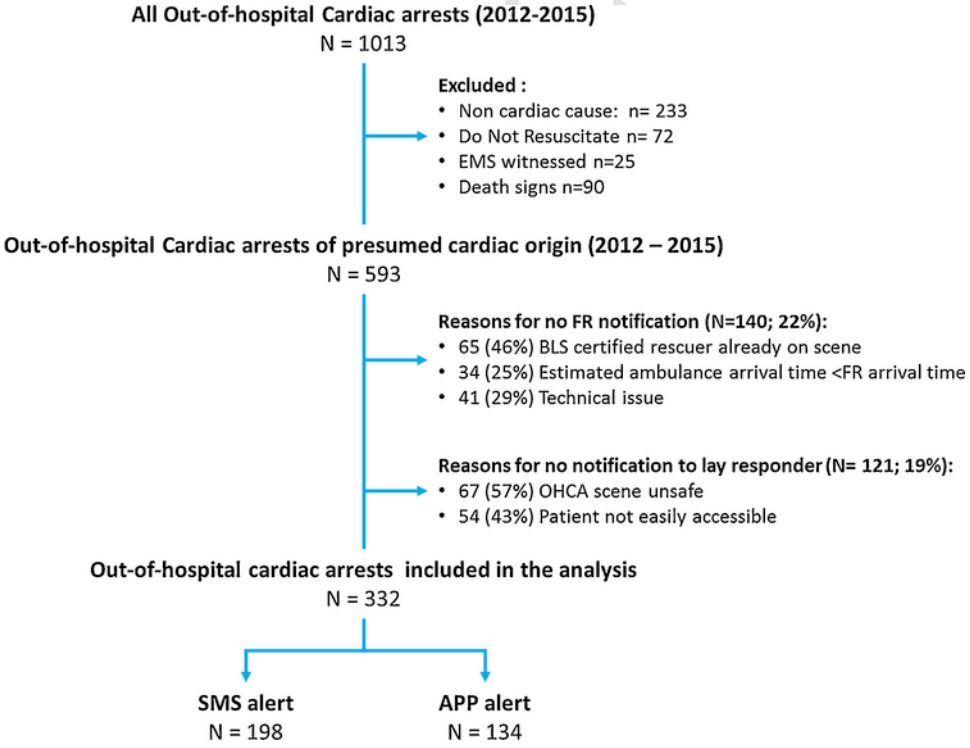

Fig. 2. Population of the study. FR: first responder.

with a "do not resuscitate" status or with signs of prolonged death were excluded from any further analysis (Fig. 2). In 332 cases, the first responders network was activated either by SMS and/or using the mobile APP. The most common reason for not activating the whole first responder network was either because CPR was already initiated by a bystander certified in BLS or/and ambulance arrival time was estimated to be shorter than first responders. Furthermore, the lay responders were not activated when the conditions of the intervention could be dangerous (Fig. 2).

Demographic characteristics of patients with out of-hospital cardiac arrest by type of alerting system are reported in Table 1. No differences in age, gender and location of out-of-hospital cardiac arrest were observed. The vast majority of events occurred during the daytime, without differences between the two groups.

Table 1
Demographic characteristics and timing of intervention of out-of-hospital cardiac arrest in which first responder and/or lay responder resuscitation was attempted.

	SMS (N = 198)	APP (N = 134)	P value
Male gender, n (%)	136 (69)	98 (73)	0.32
Age, median (IQR)	73 (61–81)	74 (61–82)	0.66
Location, n (%)			0.87
Private home	146 (74)	96 (72)	
Public	52 (26)	38 (28)	
Witnessed, n (%)	126 (64)	87 (65)	0.61
Shockable rhythm, n (%)	84 (42)	49 (37)	0.74
Time of the day, n (%)			0.36
07:00 A.M.–08:00 P.M.	128 (65)	99 (74)	
09:00 P.M.–06:00 A.M.	70 (35)	35 (26)	
Bystander-dispatched CC, n (%)	152 (77)	96 (72)	0.16
Time to put on the ground the victim, min [IQR]	2.6 [2.0–3.2]	2.4 [1.5–3.7]	0.90
Time to dispatched CC, min [IQR]	3.8 [3.2–5.1]	3.2 [3.0–5.3]	0.28

CC: chest compressions.

Table 2
Timing of traditional first responders/lay responders and of EMS intervention.

	SMS (N = 198)	APP (N = 134)	P value
Time to FR recruitment, s [IQR]	52 [35–90]	18 [8–49]	0.15
Time to FR arrival, min [IQR]			0.0001
Overall	5.6 [4.2–8.5]	3.5 [2.8–5.2]	
Day time	5.4 [3.9–7.5]	3.5 [2.5–4.6]	
Night time	6.5 [4.6–9.5]	3.9 [2.9–5.6]	
Time to defibrillation, min [IQR]	8.5 [5.3–11.8]	8.3 [6.2–9.4]	0.81
Time to ROSC, min [IQR]	24.2 [18.8–31.2]	24.3 [18.3–28.5]	0.62
Time to ambulance arrival, min [IQR]	9.7 [7.1–13.8]	9.9 [7.3–11.8]	0.67

FR: first responder; ROSC: return of spontaneous circulation.

Influence of alerting system on time to arrival of a first responder or lay responder

Overall, the first responder network performance was satisfactory. The mean time for recruitment, defined as the time from the initial bystander phone call to acceptance by a traditional first responder/lay responder was 35 s. A first responder or a lay responder was on scene within 4.5 min after the initial call, and on average 5.0 min before arrival of an EMS team.

As shown in Table 2 and in Fig. 3, compared to SMS system, the APP-based system showed shorter delays for each time component related to management of first responder network. Median time to arrival was significantly shorter for those using the APP-based alert (3.5 [2.8–5.2] versus SMS-based alert 5.6 [4.2–8.5] min, p 0.0001), and this difference was maintained even for those cardiac arrests occurring during night-time (3.9 [2.9–5.6] versus 6.5 [4.6–9.5] min, respectively, p 0.0001). Notably, there was a difference in the type of rescuers arriving on scene. Because traditional first responders are still relying on SMS-based technology compared to lay responders who are nearly all alerted via the APP-based system, there was a sig-

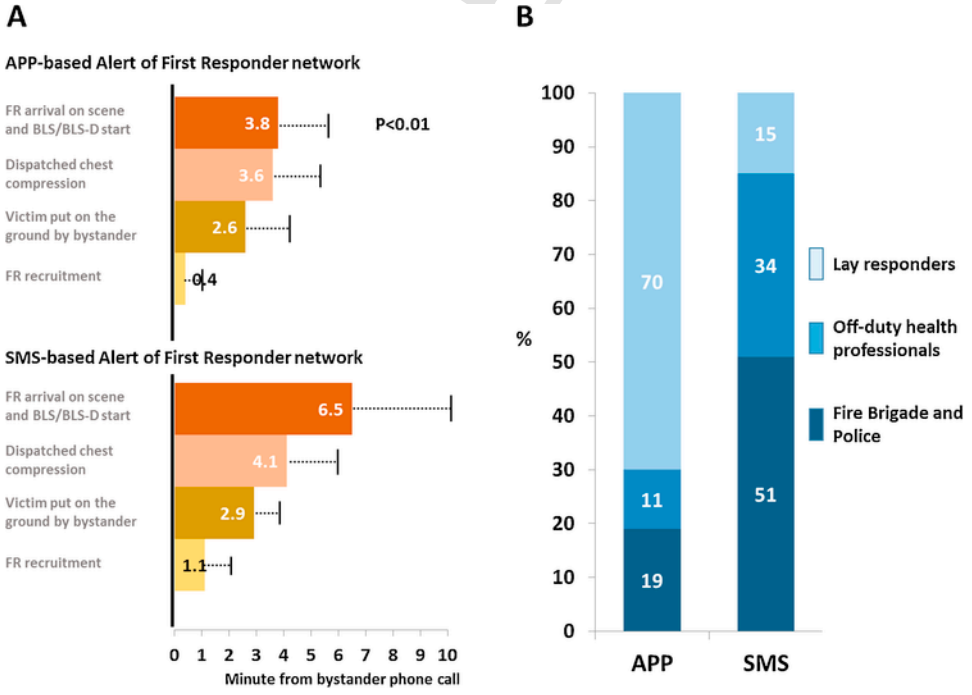

Fig. 3. Left panel (A): first responders recruitment and arrival time (mean and standard deviation). CC: chest compressions, BLS: basic life support, FR: first responders; right panel (B): First responder categories distribution according to alert system.

nificant increase in lay responders who first arrived on scene and started CPR (Fig. 3).

Outcome

The survival at discharge from hospital was significantly reduced for out-of-hospital cardiac arrests in which a notification was sent via mobile APP (28% versus 17%, Odds Ratio 0.53, 95% CI 0.34–0.82, p 0.004, Table 3). This result was confirmed in the subgroup of patients with no shockable rhythm (17% versus 6%, OR 0.32, 95% CI 0.16–0.66, p < 0.002, Table 3).

Discussion

The implementation of automatic or semi-automatic alert systems for first responder network recruitment has the obvious advantage to target people able to perform CPR and to dispatch them to the location of an out-of-hospital cardiac arrest, thus reducing the time from collapse to initiation of resuscitation manoeuvres which should increase survival.[9,10] Our findings confirm the importance of innovation technologies in the optimization of pre-hospital care of OHCAs. In line with the recent ILCOR recommendations,[11] our mobile APP represents an interactive delivery of information and an automatic system for notification and activation of the bystander.

As in previous experiences,[4–6] our study confirms this important notion but significantly expands current knowledge by comparing two different telecommunication systems – SMS-based versus APP-based – to alert first responders in the setting of out-of-hospital cardiac arrest of presumed cardiac origin. Our study showed a significant reduction (as high as 30%) in time to arrival on scene when first responders used an APP-based system compared to SMS system. Early arrival of first responders resulted in an anticipated start of chest compression that determined a higher survival rate in patients presenting either a shockable or non-shockable rhythm, although the latter group got the greatest benefit. Moreover and surprisingly, we noticed a significant increase in the proportion of lay responders to be on scene earlier than traditional first responders.

In the Swiss Canton of Ticino, the SMS system for first responder recruitment was launched in 2006.[12] Although this system worked well, it immediately showed multiple weaknesses and limitations including the underlying difficulty to periodically upgrade the list of volunteers (address, mobile number), and to verify their re-certification in BLS/BLS-D. Moreover, SMS is a costly technology and lacks selectivity so that even those first responders who are remotely located from an out-of-hospital cardiac arrest are notified. Scholten et al.[5] have recently indicated in their analysis on notification of suspected out-of-hospital cardiac arrest by SMS to a list of registered volunteers, that the 2% of alerts were not received by first responders and 25% were received but not noticed in time or ignored. Furthermore, due to Swiss federal and cantonal privacy law, the exact location or address of the victim cannot be transmitted as text message. Therefore, contact between first responder and EMS dispatcher is needed. As clearly shown by our data, it obviously delays the alerting process and potentially distracts the EMS dispatcher from giving further assistance to the bystander. The APP-based system automatically manages the information flow, and significantly reduces the workload of the EMS dispatcher.

Table 3
Survival at discharge.

Survival at discharge n (%)	SMS	APP	OR[a] (95% CI)	P value
Overall	37 (17)	43 (28)	0.53 (0.34–0.82)	0.004
Shockable rhythm	31 (37)	29 (49)	0.61 (0.32–1.14)	0.126
Non-shockable rhythm	6 (6)	14 (17)	0.32 (0.16–0.66)	0.002

[a] OR of dying for APP with respect to SMS.

A recent randomized, controlled trial conducted in the Stockholm area[6] tested the efficiency of a mobile-phone positioning system that was activated to dispatch ambulance, fire, and police services to an out-of-hospital cardiac arrest victim. The rate of first responder-initiated CPR was 62% in the APP-based intervention group and 48% in the control group. This increase in the rate of first responder-initiated CPR, however, did not have a measurable effect on the proportion of patients with return of spontaneous circulation nor on the survival rate. In contrast, our study showed a significant increase in the survival rate related to an earlier arrival of a first responder, especially in patients with non-shockable rhythm, by reducing the arrival time of a first responder by about 2 min.

The APP-based system tested in Sweden or the PulsePoint Respond system[13] share similarities but also significant differences with our APP-based alert system. The APP presented by Ringh et al.[6] locates trained volunteers whereas the PulsePoint notifies citizens when a suspected out-of-hospital cardiac arrest occurs.[13] Our APP-based system is more similar to the Swedish model because it alerts only trained people who have up-to-date certification. Moreover, to avoid the activation of first responders/lay responders after the arrival of an ambulance, our APP automatically excludes those responders whose arrival time on the scene is estimated to be after that of an ambulance. Therefore, the APP dynamically adapts the distance of traditional first responders, lay responders and the ambulance rather than pre-defining a given radius of intervention (500 m in the Swedish application, and 400 m in the PulsePoint application) from the victim. In our opinion, this represents an important advantage in terms of resources, allocation, and management.

Our study showed two important and unexpected findings. First, we observed a nearly unchanged time of AED use but an increased survival, possibly suggesting that initiation of CPR manoeuver is of paramount importance especially in victims of out-of-hospital cardiac arrest presenting with a non-shockable rhythm. Our APP system privileged the start of chest compression by the lay responder, instead to address her/him to look for an AED and carry it. This could explain why the time to defibrillation remained almost unchanged between the two alert systems. Secondly, we noticed a shift in the proportion of traditional first responders or lay responders who first arrived on scene. With the introduction of the APP-based alert, the proportion of lay responders to be first on scene massively increased up to 70%; whether the improvement of the performance of our first responder network was due to technology or due to the possibility that many more people, by having downloaded our APP, are exposed to an alert is not definitively proven by our study. In any case, the APP-based alert system is able to engage more effectively lay responders and, to promote the culture of resuscitation. Lay responders, however, may have limited access to a public AED. In our study as in other experiences,[14–16] two-thirds of all out-of-hospital cardiac arrests occur at home where on-site AED is rarely available; usually these events are associated with lower rates of early initiated CPR and worse outcomes.[14] Zijlstra et al.[4] reported that, by notifying AED location via SMS to lay persons, an AED was connected to the victim before EMS arrival in 23% of all out-of-hospital cardiac arrest occurring in residential areas. The possibility to geo-localize not only the victim and the first responder but also the closest AED represents a driver for optimizing placement of public AEDs.[14]

In comparison with the Swedish system our alerting system was always active 24 h/365 days while theirs was available only between 6:00 A.M. and 11 P.M., An unexpected finding was the impressive

performance of the APP-based alerting system during both the day and night time. The delay between the call and intervention between SMS and APP-based alerting systems was even larger during the night hours. The prolonged recruitment time observed with the SMS system, together with the reduced number of EMS dispatchers during night, could cause an unavoidable delay in answering the call of first responders, and consequently in the departure of the lay person and reduced efficiency of the entire pre-hospital resuscitation system.

Limitations

This study has some limitations. It was a single-center study and involved only one dispatch centre. The analysis was conducted throughout a period of 4 years and the results could be influenced by several factors including awareness and training initiatives, improvement in the pre- and in-hospital management. To achieve meaningful results, a sufficient number of lay volunteers trained in CPR is probably the key factor to the current results, limiting their extension to other social and cultural contexts. Moreover, privacy laws and our country regulations may have indirectly favoured the APP-based alerting system. As in other similar studies, the time from cardiac arrest to the arrival of first responders could not be precisely and objectively measured; it was derived from a review of all recorded phone calls for a suspected out-of-hospital cardiac arrest which however represents the state-of-the art for this kind of analysis. Finally, the analysis was not conducted in cases of trauma, drowning, intoxication, or suicide or in persons younger than 1 years of age; thus, our results might not apply to out-of-hospital cardiac arrests occurring in such circumstances.

Conclusions

The mobile APP system is extremely efficient in the recruitment of first responders (especially if lay people) in the setting of out-of-hospital cardiac arrest. In respect to SMS-based system, the use of mobile APP can significantly reduce the arrival time of first responder and anticipate the initiation of CPR. Large prospective studies are however required to demonstrate and confirm the return to spontaneous circulation and the impressive increase of survival found in this study, especially in patients presenting with non-shockable rhythm.

Conflict of interest statement

Claudio Benvenuti and Roman Burkart have co-developed the mobile application commercialized by DOS-group. However, none of them or family members receives personal financial benefit. Fondazione Ticino Cuore receives royalties by DOS-Group. All other co-authors do not have conflict of interest to disclose.

References

1. R.A. Waalewijn, J.G. Tijssen, R.W. Koster, Bystander initiated actions in out-of-hospital cardiopulmonary resuscitation: results from the Amsterdam Resuscitation Study (ARRESUST), Resuscitation 50 (2001) 273–279.
2. M. Wissenberg, F.K. Lippert, F. Folke, et al., Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest, JAMA 310 (2013) 1377–1384.
3. P.W. Groeneveld, D.K. Owens, Cost-effectiveness of training unselected laypersons in cardiopulmonary resuscitation and defibrillation, Am J Med 118 (2005) 58–67.
4. J.A. Zijlstra, R. Stieglis, F. Riedijk, M. Smeekes, W.E. van der Worp, R.W. Koster, Local lay rescuers with AEDs, alerted by text messages, contribute to early defibrillation in a Dutch out-of-hospital cardiac arrest dispatch system, Resuscitation 85 (2014) 1444–1449.
5. A.C. Scholten, J.G. van Manen, W.E. van der Worp, M.J. Ijzerman, C.J. Doggen, Early cardiopulmonary resuscitation and use of Automated External Defibrillators by laypersons in out-of-hospital cardiac arrest using an SMS alert service, Resuscitation 82 (2011) 1273–1278.
6. M. Ringh, M. Rosenqvist, J. Hollenberg, et al., Mobile-phone dispatch of laypersons for CPR in out-of-hospital cardiac arrest, N Engl J Med 372 (2015) 2316–2325.
7. Summary Vital Statistics in Ticino. Swiss Federal Statistics Office website: www.statistics.admin.ch. [Accessed 29 October 2016].
8. J.P. Nolan, M.F. Hazinski, J.E. Billi, et al., Part 1: executive summary: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations, Resuscitation 81 (2010) e1–e25.
9. C. Sasson, M.A. Rogers, J. Dahl, A.L. Kellermann, Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis, Circ Cardiovasc Qual Outcomes 3 (2010) 63–81.
10. R.T. Fothergill, L.R. Watson, D. Chamberlain, G.K. Virdi, F.P. Moore, M. Whitbread, Increases in survival from out-of-hospital cardiac arrest: a five year study, Resuscitation 84 (2013) 1089–1092.
11. J. Finn, F. Bhanji, B. Bigham, et al., Part 8: education, implementation, and teams: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations, Resuscitation 95 (2015) e205–e227.
12. R. Mauri, R. Burkart, C. Benvenuti, et al., Better management of out-of-hospital cardiac arrest increases survival rate and improves neurological outcome in the Swiss Canton Ticino, Europace 18 (2016) 398–404.
13. S.C. Brooks, G. Simmons, H. Worthington, B.J. Bobrow, L.J. Morrison, The PulsePoint Respond mobile device application to crowdsource basic life support for patients with out-of-hospital cardiac arrest: challenges for optimal implementation, Resuscitation 98 (2016) 20–26.
14. F. Folke, G.H. Gislason, F.K. Lippert, et al., Differences between out-of-hospital cardiac arrest in residential and public locations and implications for public-access defibrillation, Circulation 122 (2010) 623–630.
15. T. Iwami, A. Hiraide, N. Nakanishi, et al., Outcome and characteristics of out-of hospital cardiac arrest according to location of arrest: a report from a large-scale, population-based study in Osaka, Japan, Resuscitation 69 (2006) 221–228.
16. R.M. Merchant, D.A. Asch, J.C. Hershey, et al., A crowdsourcing innovation challenge to locate and map automated external defibrillators, Circ Cardiovasc Qual Outcomes 6 (2013) 229–236.