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Clinical paper

A text message alert system for trained volunteers improves out-of-hospital cardiac arrest survival[☆]

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ABSTRACT

Aims: The survival rate of sudden out-of-hospital cardiac arrests (OHCAs) increases by early notification of Emergency Medical Systems (EMS) and early application of basic life support (BLS) techniques and defibrillation. A Text Message (TM) alert system for trained volunteers in the community was implemented in the Netherlands to reduce response times. The aim of this study was to assess if this system improves survival after OHCA.

Methods and Results: From April 2012 to April 2014 data on all 1546 emergency calls for OHCA in the Dutch province of Limburg were collected according to the Utstein template. On site resuscitation attempts for presumed cardiac arrest were made in 833 cases, of which the TM-alert system was activated in 422 cases. Two cardiopulmonary resuscitation (CPR) scenarios were compared: 1. TM-alert system was activated but no responders attended ($n = 131$), and 2. TM-alert system was activated with attendance of $\geq$1 responder(s) ($n = 291$). Survival to hospital discharge was 16.0% in scenario 1 and 27.1% in scenario 2 corresponding with OR = 1.95 (95% CI 1.15–3.33; $P = .014$). After adjustment for potential confounders the odds ratio increased (OR = 2.82; 95% CI 1.52–5.24; $P = .001$). Of the 100 survivors, 92% were discharged from the hospital to their home with no or limited neurological sequelae.

Conclusion: The TM-alert system is effective in increasing survival to hospital discharge in OHCA victims and the degree of disability or dependence after survival is low.

Introduction

Sudden out-of-hospital circulatory arrest (OHCA) is an important public health problem,[1,2] largely caused by cardiac disease.[3] Survival rates are low[4–6] (<10%) and increase by early notification of Emergency Medical Systems (EMS) and early application of basic life support and defibrillation.[6]

In 50–70% of victims, their cardiac arrest occurs at home[1] and improving outcomes after OHCA requires new strategies. To counteract delayed ambulance arrival times, first responder systems were implemented in several countries.[7,8] In a number of regions in the Netherlands, a novel system was introduced where citizen volunteers trained in resuscitation and the use of an Automatic External Defibrillator (AED) are notified by the EMS dispatch centre, using a text message (TM) notification, to go to an OHCA victim in their zip code based vicinity.

The aim of this study, executed in the Dutch province of Limburg, has been to assess the ability of this TM-alert system to improve outcomes after OHCA.

Methods

Setting

A prospective registry included all OHCAs in the Dutch province of Limburg for which EMS were called between April 2012 and April 2014. Variables were gathered according to the Utstein recommendations and definitions[9–11] for assessing the contribution to survival of the TM-alert system. The study region consists of 1.12 million inhabitants living in an area of approximately 2153 km^2

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($831 mi^2$). Approval for the study was obtained from the medical ethics committee of the Maastricht University Medical Centre (project number 114029).

Resuscitation volunteer network in the study region

If EMS are called for (suspected) OHCA, the professional procedure throughout the Netherlands consists of dispatching two ambulances to the scene. Each vehicle is manned by 1 paramedic and a driver with CPR skills and equipped for providing advanced life support. First responders (policemen) are notified only if they are already in close range of the circulatory arrest case. To reduce the delay in response time to start BLS, a network of BLS/AED trained volunteers was developed. This network consists of TM-volunteers and AEDs placed in residential areas. TM-volunteers are notified by the dispatch centre, using the zip code derived location of the victim and the TM-volunteers. In a suspected OHCA, the dispatch centralist activates the system simultaneously with the two ambulances. Zip code identified TM-volunteers within a radius of 1 km (0.62 mi) of the victim receive a TM, directing them to the scene to either start BLS (1/3 of notifications) or to get a nearest network AED first (2/3). During the study period the network comprised 17 of the 24 Dutch dispatch centres and 61.000 TM-volunteers, including two dispatch centres and >9000 volunteers (8.3/1000 inhabitants) in Limburg.

Notification of TM-volunteers does not result in a predictable response, because this depends on the number of TM-volunteers in the specific zip code area and their availability. The dispatcher is not aware of actual attendance of volunteers.

To analyse the effect of attending TM-volunteers, two different resuscitation scenarios were compared. In scenario 1 the TM-alert system was activated but no TM-volunteers responded to the notification. This unwanted situation will improve with further implementation of the system, but for the purpose of our study these cases were considered as the reference group because survival of the OHCA victims depended on standard care. In scenario 2 the TM-alert system was activated and at least one TM-volunteer responded to the notification.

The primary outcome measure was the proportion of OHCA victims who survived to hospital discharge. Secondary outcome measures were proportion with return of spontaneous circulation (ROSC) at departure from site of the OHCA and at hospital arrival, proportion with discharge to rehabilitation centre and nursing/caring home and Modified Rankin score[12] (mRS) at discharge.

Data collection

Data were retrieved from the following sources: 1. the dispatch centres from Limburg North and South, 2. their respective emergency medical services, 3. notified volunteers, 4. TM-alert database (HartslagNu®), 5. the six hospitals in Limburg, and 6. AED providers.

On a daily basis, all emergency calls in the dispatch centre system were screened for suspected OHCAs. Data collected consisted of notification time, ambulance departure time and arrival time at the location, departure time to and arrival time at the hospital, patient's condition and treatment. Information was also obtained from the paramedics notes on the resuscitation scenario. The TM-alert system organisation provided information about the activation of the TM-alert system, such as the time the TM was sent, the number of notified TM-volunteers and AEDs, and type of notification (start BLS or first get an AED).

All notified TM-volunteers received a questionnaire gathering information about their attendance and if applicable about details of the CPR scenario. Information included the presence of a witness and the start of CPR by the witness or by a bystander. Importantly, a witness was defined as the one who saw, heard or monitored the arrest whereas the term bystander was reserved for those who did not witness the event but arrived the scene as well (e.g. a neighbour alarmed by the witness). Also recorded was if and how many TM-volunteers reached the scene. From the six hospitals receiving the victims, information was gathered about the post resuscitation treatment, outcome and discharge date, and if applicable, the medical history before OHCA. To acquire information about the quality of survival, discharge to the patients home, to a rehabilitation centre or to a nursing/caring facility was used as an indicator for cerebral outcome. Additionally, in one hospital (Maastricht) the Modified Rankin Scale[12] was used to determine the degree of disability at hospital discharge. The scores were derived from chart review. AED recordings were retrieved from the TM-alert system organisation or from private AED providers.

Statistical analysis

Patients with OHCA were categorised into two groups according to the corresponding CPR scenario. The distribution of age, gender, witnessed OHCA and other potential determinants of survival at hospital discharge were compared between the two CPR scenarios. Categorical variables were described as absolute numbers and percentages, and continuous variables as means with standard deviation or medians with interquartile range. The Chi square test was used to test for statistically significant differences between proportions. The *t*-test for independent samples or the Mann Whitney *U*-test was used for continuous variables.

To assess whether mobilisation of TM-volunteers improved probability of survival, odds ratios as a measure of relative risk with 95% confidence interval (95% CI) were calculated using scenario 1 as reference category. Multivariable logistic regression analyses were performed to assess the contribution to survival of scenario 2 with adjustment for between group differences in potential determinants of probability of survival. A *P*-value of ≤ 0.05 was considered as statistically significant. The statistical software package of SPSS (SPSS for Windows, version 22.0, SPSS Inc, Chicago, IL) was used to analyse the data.

Results

Fig. 1 depicts the flow chart of the study population. Out of a total of 1546 OHCA EMS notifications during the 24 months study period, 1040 resuscitation attempts were recorded. The group of 506 cases without a resuscitation attempt consisted of 461 cases being pronounced dead on arrival of the EMS and 45 with a "do not resuscitate" statement. Arrests within the ambulance were excluded and occurred in 31 instances. Another 5 cases were excluded, because they were, after sufficient recovery, discharged to a hospital outside the Netherlands and no information on outcome could be acquired. Because the purpose of this study was to evaluate the effect of the TM-system on arrests with a cardiac origin, 171 arrests with a non-cardiac origin were excluded. In 411 (49.3%) cases the dispatch centre decided not to activate the system mostly because the ambulance was already nearby or present at the scene, or the OHCA occurred in a (closed) public place with an on-site AED (such as shopping malls, sport venues etc.) These cases were excluded from the analysis. Hence, the total study population consisted of 422 (presumed) cardiac arrests in which the TM-alert system was activated. In 291 cases (69%) ≥1 TM-volunteers attended (scenario 2), and in 131 cases (31%) no responder attended (scenario 1, reference group).

Baseline characteristics

The mean age of these 422 OHCA victims was 68.1 years and 71.6% were male. Table 1 shows the distribution of the baseline

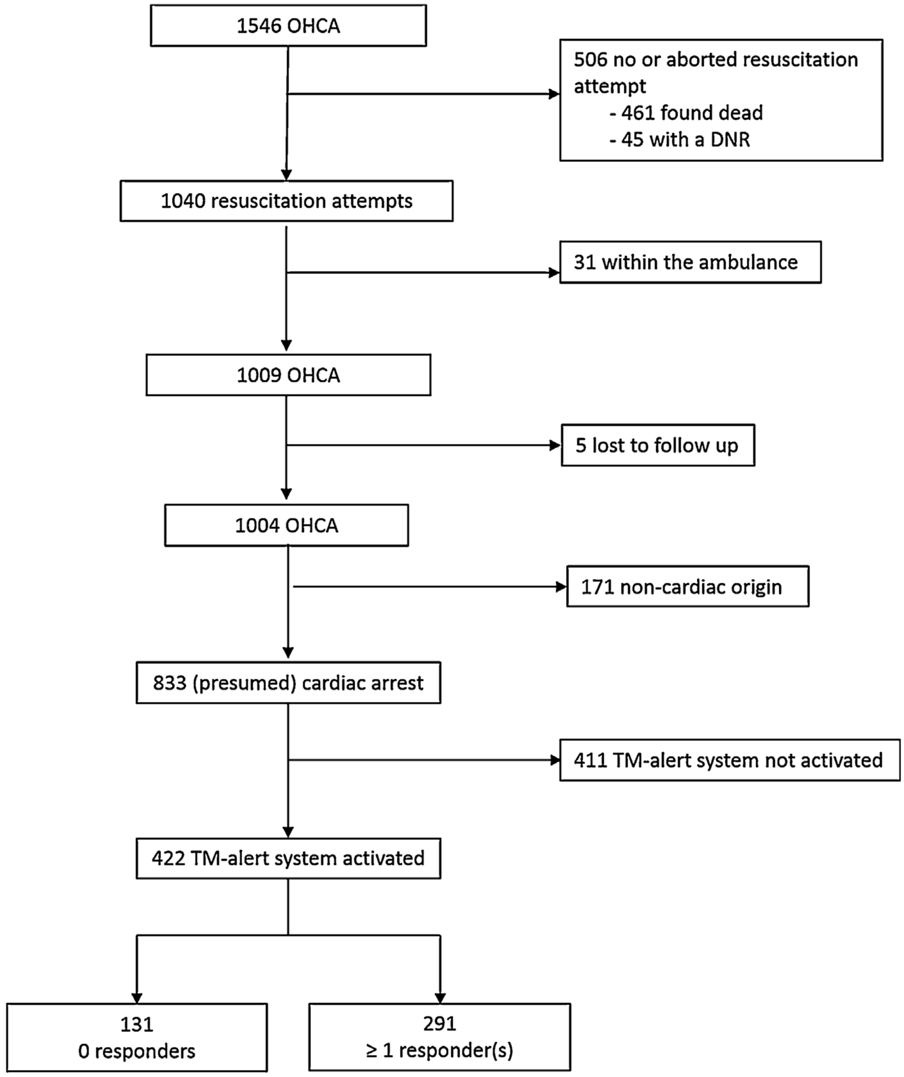

Fig. 1. Flowchart of patient inclusion. OHCA indicates out-of-hospital circulatory arrest; DNR, do not resuscitate policy; system activated 0 TM-responders, scenario 1; system activated ≥ 1 TM-responder, scenario 2.

variables among the two scenarios. Study groups were comparable regarding most variables, but significant differences were observed with respect to initial rhythm and the person who started BLS. In scenario 2, BLS was less often started by a witness (35.8% vs 41.5%) and more often by other parties. In scenario 2, a TM-volunteer started BLS in 24.7%. Patients in scenario 2 were more likely to have a shockable initial rhythm compared to the patients in scenario 1 (59.9% vs. 46.5%; $P = .011$). Although differences were not statistically significant, patients in scenario 2 were slightly older than patients in scenario 1 and the ambulance arrived more often after 8 min (50.9% vs 43.3%). The lack of difference in departure times between the first and second ambulance suggests equal accurateness in both scenarios in identifying OHCAs by the dispatch centralist.

Contribution of TM-responders to survival

Survival to hospital discharge of 27.1% (79/291) in scenario 2 was significantly higher compared to 16.0% (21/131; $P = .013$) in scenario 1. In total, 100 of the 422 victims (23.7%) were discharged alive from the hospital. Percentages with specific clinical outcomes among the scenarios are depicted in Table 2. The percentages of victims with ROSC at departure from the site of the event and at hospital arrival was higher in scenario 2 (41.4% respectively 41.7%) than in scenario 1 (30.5% respectively 32.3%), although not reaching statistical significance ($P = .063$ and $P = .098$, respectively). Moreover, 79 (47.9%) in scenario 2 compared to 20 (30.8%) in scenario 1 arrived at the hospital with ROSC or "CPR continued".

Table 3 shows the results from univariable and multivariable logistic regression analyses with survival at discharge as dependent variable and comparing scenarios 1 and 2 in terms of odds ratios. The probability of survival decreases with increasing age, but male sex, presence of a witness, start of BLS by a witness and arrival of the first ambulance within 6 min are associated with significant increase of survival probability. Patients in scenario 2 had a higher probability of survival at hospital discharge than patients in scenario 1 with an odds ratio 1.95 (95% CI 1.15–3.33; $P = .014$). After correction for potential confounders (age, sex, location of the arrest, witnessed arrest, BLS started by witness or other parties, time until arrival of the first ambulance), the odds ratio increased to 2.82 (95% CI 1.52–5.24; $P = .001$) compared to scenario 1.

Quality of life of survivors

Of the 100 patients who were discharged alive from the hospitals, 92 (92.0%) were discharged home, 5 (5.0%) were referred to a

Table 1
Distribution of baseline variables among the two CPR scenarios.

	Scenario 1 N = 131	Scenario 2 N = 291	P-value
Demographic and clinical variables			
Age, mean (SD), years, n = 422	67.0 (±11.9)	68.7 (±14.3)	.241
Gender, No. (%), n = 422			.448
Male	97 (74.0)	205 (70.4)	
Female	34 (26.0)	86 (29.6)	
Cardiac history, No. (%), n = 403			.429
Yes	51 (41.5)	128 (45.7)	
No	72 (58.5)	152 (54.3)	
Resuscitation variables			
Location of the arrest, No. (%), n = 422			.402
Home	105 (80.2)	243 (83.5)	
Public location	26 (19.8)	48 (16.5)	
Witnessed, No. (%), n = 422			.885
Yes	99 (75.6)	218 (74.9)	
No	32 (24.4)	73 (25.1)	
BLS started by, No. (%), n = 418			<.001
Witness	54 (41.5)	103 (35.8)	
Bystanders	31 (23.8)	74 (25.7)	
EMS	31 (23.8)	27 (9.4)	
TM-responders	0 (0.0)	71 (24.7)	
First responders	14 (10.8)	13 (4.5)	
Initial rhythm recorded, No. (%), n = 416			.027
Asystole/PEA/EMD	68 (52.7)	111 (38.7)	
VT/VF	60 (46.5)	172 (59.9)	
Other[a]	1 (0.8)	4 (1.4)	
Shock delivered, No. (%), n = 422			.173
Yes	76 (58.0)	189 (64.9)	
No	55 (42.0)	102 (35.1)	
Ambulance times			
Time until arrival of first ambulance, No. (%), n = 412			.496
≤6 min	36 (28.3)	76 (26.7)	
7–8 min	36 (28.3)	64 (22.5)	
9–10 min	24 (18.9)	64 (22.5)	
≥11 min	31 (24.4)	81 (28.4)	
Difference between departure time of the first and second ambulance, n = 372			.624
Median (min)	1 (0.5–3)	1 (0–3)	

Scenario 1 indicates system activated 0 TM-responders; scenario 2, system activated ≥ 1 TM-responder; BLS, basic life support; EMS, emergency medical system; TM, text message; PEA, pulseless electrical activity; EMD, electromechanical dissociation; VT, ventricular tachycardia; VF, ventricular fibrillation.

[a] Other: Total AV-block, bradycardia in inferior wall acute coronary syndrome, sinus rhythm in collapse due to severe aortic stenosis, strong vagal reaction in atrial fibrillation, sinus rhythm after unidentified non-perfusing rhythm.

rehabilitation centre, and 3 (3.0%) to a nursing home. Scores on the Modified Rankin Scale were available for a subgroup of 34 survivors, who were discharged from the Maastricht University Medical Centre. Within this group, 28 patients (82.4%) had no significant to slight disability with a score of 0 to 2, whereas scores 3–5 were observed in 6 patients (17.6%).

Table 2
Percentage of patients with specific clinical outcome among the two CPR scenarios.

	Scenario 1 N = 131	Scenario 2 N = 291	P-value
ROSC status at departure on site, No. (%), n = 418			
ROSC	39 (30.5)	120 (41.4)	.063
CPR continued	26 (20.3)	46 (15.9)	.082
Deceased (reference)	63 (49.2)	124 (42.8)	–
ROSC status at hospital arrival, No. (%), n = 418			
ROSC	42 (32.3)	121 (41.7)	.098
CPR continued	25 (19.2)	44 (15.2)	.791
Deceased (reference)	63 (48.5)	125 (43.1)	–
Alive at discharge, No. (%), n = 422	21 (16.0)	79 (27.1)	.013

Scenario 1 indicates system activated 0 TM-responders; scenario 2, system activated ≥ 1 TM-responder; ROSC, return of spontaneous circulation; CPR, cardiopulmonary resuscitation.

Table 3
Unadjusted and adjusted odds ratios for survival at discharge from hospital derived from univariable and multivariable logistic regression analysis.

	Unadjusted OR (95% C.I.)	P-value	Adjusted OR (95% C.I.)	P-value
CPR scenario				
Scenario 1	1.00 (reference)	–	1.00 (reference)	–
Scenario 2	1.95 (1.15–3.33)	.014	2.82 (1.52–5.24)	.001
Sex				
Female	1.00 (reference)	–	1.00 (reference)	–
Male	1.95 (1.12–3.39)	.018	2.32 (1.21–4.47)	.011
Age	.98 (0.96–0.99)	.004	.97 (0.95–0.99)	.002
Location				
Home	1.00 (reference)	–	1.00 (reference)	–
Public location	1.59 (0.91–2.76)	.102	1.07 (0.55–2.09)	.837
Witnessed				
No	1.00 (reference)	–	1.00 (reference)	–
Yes	8.56 (3.38–21.69)	<.001	7.28 (2.40–22.14)	<.001
BLS started by				
EMS	1.00 (reference)	–	1.00 (reference)	–
Other[a]	1.08 (0.47–2.51)	.851	1.14 (0.45–2.92)	.782
Witness	4.08 (1.81–9.19)	.001	2.96 (1.17–7.51)	.022
Time until arrival of first ambulance				
≤6	1.00 (reference)	–	1.00 (reference)	–
7–8	.62 (0.34–1.13)	.121	.67 (0.34–1.31)	.243
9–10	.39 (0.20–0.76)	.006	.29 (0.13–0.63)	.002
≥11	.34 (0.18–0.64)	.001	.25 (0.12–0.52)	<.001

Scenario 1 indicates system activated 0 TM-responders; scenario 2, system activated ≥ 1 TM-responder; OR, odds ratio; CI, 95% confidence interval; CPR, cardiopulmonary resuscitation; BLS, basic life support; EMS, emergency medical services; VT, ventricular tachycardia; VF, ventricular fibrillation.

[a] Other: bystander, first responder.

Discussion

Main findings

This is a population based survey, performed in a well-defined area in the Netherlands, including all consecutive resuscitations of OHCA cases during a 2 year period, studying the contribution of a novel citizen responder system (Table 1). Results showed improved outcomes in survival to hospital discharge when 1 or more TM-volunteers responded with 27.1% survival (79/291) compared to 16.0% (21/131) in case no volunteer responded (P = .001).

After correction for differences in the distribution of other determinants of survival, the adjusted relative risk estimate of survival at hospital discharge in scenario 2 was 2.82 (95% CI 1.52–5.24; P = .001) compared to scenario 1 (Table 3). Survivors had a low degree of disability or dependence, as suggested by the low referral rate to rehabilitation or nursing centres (8%) and accordingly low scores in the majority of survivors with an available Modified Rankin score.

Study population and the TM-alert system

Our study group consists of consecutive cases from the general population. The TM-alert system was activated in 50.7% of resuscitations for OHCA with a (presumed) cardiac cause. In about one third of these cases, no volunteer responded, either due to the absence or non-availability of volunteers in the zip code area of the victim. With further implementation of the system the number of citizen volunteers will increase, with expectedly higher attendance rates. Where we studied the system comprising 61.000 volunteers, at the moment of this writing the TM-alert system studied contains already more than 91.000 rescuers. The fact that during the study period no volunteer attended in a substantial number of cases provided us with the opportunity to handle these cases (scenario 1) as a reference group, because they were derived from the same population as the group where volunteers attended (scenario 2) but had to depend on standard care.

Our findings suggest that the lay rescuer system substantially attributed to different links in the chain of survival: 1. In 24.7% of the 291 cases where TM-responders did arrive on the scene, they were the first to start BLS and in 26.8% they were the first to connect an AED. The higher survival rate in scenario 2 compared to scenario 1 suggests that the TM-alert system is successful in decreasing response time. 2. The observation that the initially recorded rhythm was more often shockable in scenario 2 compared to scenario 1 (59.9% vs 46.5%, $P = .015$), is probably also related to the shorter arrival times and adequate BLS. 3. The probability to arrive at the hospital alive was higher in the study arm with ≥ 1 responders (47.9% vs 30.8%). Moreover this difference not only persisted but further increased as reflected by higher survival at hospital discharge, suggesting a better medical condition at hospital arrival.

Other factors contributing to survival

Like in comparable studies regarding survival of OHCA, multivariable logistic regression analysis suggested that higher age was associated with worse survival whereas male sex, particularly witnessed OHCA, BLS started by a witness and a short arrival time of the first ambulance were associated with better survival (Table 3).

Quality of survival

The low degree of disability of survivors in our study population is in agreement with recent studies by Moulaert et al. in the same geographical area. Here it was found that almost 80% of the patients experience high quality of life[13] and that 70% of employed patients returned to work within 12 months after discharge.[14]

Comparison with other community responder systems

In different countries different strategies exist to involve citizen volunteers for improving survival of OHCA.[15,16] To our knowledge, however, no data on their contribution to survival have been published thus far.

The Dutch TM-alert system was recently evaluated in two other regions, but this research was focused on the use of AEDs and no survival data were reported.[17]

Limitations

The design of the study was observational. More formal proof of the effect of the TM-alert system would require a (randomised) controlled study design. Such an approach is impossible, given the already widespread implementation of the system. Exact information on neurological outcome was not available due to practical limitations. However 92% of the surviving patients were discharged home and assessment of scores on the Modified Rankin Scale in one hospital provided good functional outcomes, in agreement with results from previous research in the same region[13,14] and elsewhere in the Netherlands.[18,19]

Five foreign patients were excluded, because they were, after sufficient recovery within the local hospital in Limburg, transferred to a hospital outside the Netherlands. They therefore likely survived, but their survival status could not be confirmed.

Although we tried to obtain accurate information from the notified TM-volunteers by use of a questionnaire, it was practically impossible, due to the rapidly changing nature of a resuscitation setting, to retrieve exact numbers of TM-responders and their arrival times at the location. Therefore, the reduction in response times could not be quantified.

Conclusion

The TM-alert system has shown to be effective in increasing survival to hospital discharge in OHCA victims. About 90% of survivors went home after hospital discharge. Further improvement in survival will likely be achieved by a higher density and availability of citizen rescuers.

Conflict of interest statement

None declared.

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