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Clinical paper

Technology activated community first responders in Singapore: Real-world care delivery & outcome trends

Fahad Javaid Siddiqui [a], *Stephanie Fook-Chong* [b], *Nur Shahidah* [b,c], *Colin K Tan* [d], *Jinn Yang Poh* [e], *Wei Ming Ng* [f], *Dennis Quah* [g], *Yih Yng Ng* [h,i], *Benjamin SH Leong* [j], *Marcus EH Ong* [a,c,*]

Abstract

Background: Community first responders (CFRs) strengthen the Chain of Survival for out-of-hospital cardiac arrest (OHCA) care. Considerable efforts have been invested in Singapore's CFR program, during the years 2016–2020, by developing an app-based activation system called myResponder. This paper reports on national CFR response indicators to evaluate the real-world impact of these efforts. Methods: We matched data from the Singapore Civil Defence Force's CFR registry with the Pan Asian Resuscitation Outcomes Study (PAROS) registry data to calculate performance indicators. These included the number of CFRs receiving and accepting an issued alert per OHCA event. Also calculated were the fraction of OHCA events where CFRs received an issued alert, or accepted the alert, and arrived at the scene either before or after EMS. We also present trends of these indicators and compare the prevalence of these fractions between the CFR-attended and CFR-unattended OHCA events. Results: Of 6577 alerted OHCA events, 42.7% accepted an alert, 50% of these arrived at the scene and 71% of them arrived before EMS. Almost all CFR response indicators improved over time even for the pandemic year (2020). The fraction of OHCA events where >2 CFRs received an alert increased from 62% to 96%; the same figure for accepting an alert did not change much but >2 CFRs arriving at the scene increased from 0% to 7.5%. The fraction of OHCA events with an automated external defibrillator applied and defibrillation performed by CFR increased from 4.2% to 10.3% and 1.6% to 3%, respectively. Statistically significant differences were observed in these indicators when CFR-attended and CFR-unattended OHCA events were compared. Conclusion: This real-world study shows that activating CFRs using mobile technology can improve community response to OHCA and are bearing fruit in Singapore at a national level. Some targets for improvement and future research are highlighted in this report.

Keywords: Out-of-hospital cardiac arrest, OHCA, Community First Responder, myResponder, Pre-hospital Emergency Care, CPR, AED, Defibrillation, Trends

Introduction

Community First Responders (CFRs) are the volunteers who respond when they are alerted to emergencies, like an out-of-hospital cardiac arrest (OHCA) event, near them. They can help improve the timeliness and quality of on-site OHCA care. CFRs can help reduce response times, deliver life-saving interventions, and improve OHCA outcomes especially when linked to the dispatch centre and the emergency medical services (EMS) system.

Many countries capitalize on the CFRs by connecting them to EMS system through a mobile phone application.[1–3] Experience from systems across the globe suggests that a CFR program increases the chances to initiate at-scene OHCA care such as cardiopulmonary resuscitation (CPR) and defibrillation before the ambulance arrives and decreases the time to initiate it.[4–7]

The evidence from Singapore suggests that the odds of receiving bystander CPR increased from 6.16 to 7·66 times when a CFR program was added to dispatcher-assisted CPR and CPR training programs as compared to no intervention; similarly, the odds of survival

* Corresponding author at: Pre-hospital & Emergency Research Centre, Duke-NUS Medical School, Postal address: 8 College Road, Singapore 169857, Singapore.

E-mail address: marcus.ong@duke-nus.edu.sg (M.EH Ong).

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to discharge increased to 3·10 [95% CI 1·53–6·26] times when the CFR program was added to the other interventions as compared to no intervention.[8] A Cochrane systematic review concluded, based on collated evidence, that a CFR program does seem to increase the likelihood of receiving CPR and defibrillation, although the authors couldn't conduct a meta-analysis due to the paucity of methodologically similar studies.[3] The ultimate objective, however, is to improve the clinical outcomes of OHCA patients through early CPR delivery and AED application by the CFRs.

In Singapore, a national app-driven CFR program was initiated in April 2015 by the Singapore Civil Defence Force (SCDF) and Unit for Prehospital Emergency Care (UPEC), Ministry of Health. SCDF is a uniformed organization that provides emergency services including the national ambulance service and maintains a large cohort of on-foot and vehicle-based CFR volunteers. The latter includes taxi drivers, private hire drivers, postal workers and delivery vans carrying Automated External Defibrillators (AEDs),and trained in CPR+AED skills under the 'AED-on-Wheels' program[9]. Currently, over 136,000 CFRs are registered with SCDF, and this number is expected to increase. All CFRs are linked to the SCDF through the 'myResponder' mobile phone application, which keeps a record of the number of OHCA events attended by the CFRs. As of now, 61,430 suspected OHCA cases have been attended by CFRs since its inception (Fig. 1). myResponder app is also linked to the national AED registry hence displays public access defibrillator locations.

A CFR program has the potential to alert nearby individuals, have them arrive at the scene before the ambulance arrives, ideally picking an AED on their way, deliver CPR and defibrillate to resuscitate the patient. Some of these steps also prepare the patient for immediate initiation of advanced care by EMS.

We previously reported on Singapore's CFR program, providing myResponder mobile application details and selected performance indicators.[9] A comprehensive exploration of CFRs' performance has yet to be conducted. In this paper, we, therefore, explored Singapore's CFR program response dynamics over the past 5 years and present the characteristics of OHCA patients where either CFR arrived before EMS, after EMS or did not arrive at all. We also assess the association of CFRs' arrival status with clinical outcomes for the cases where CFRs responded.

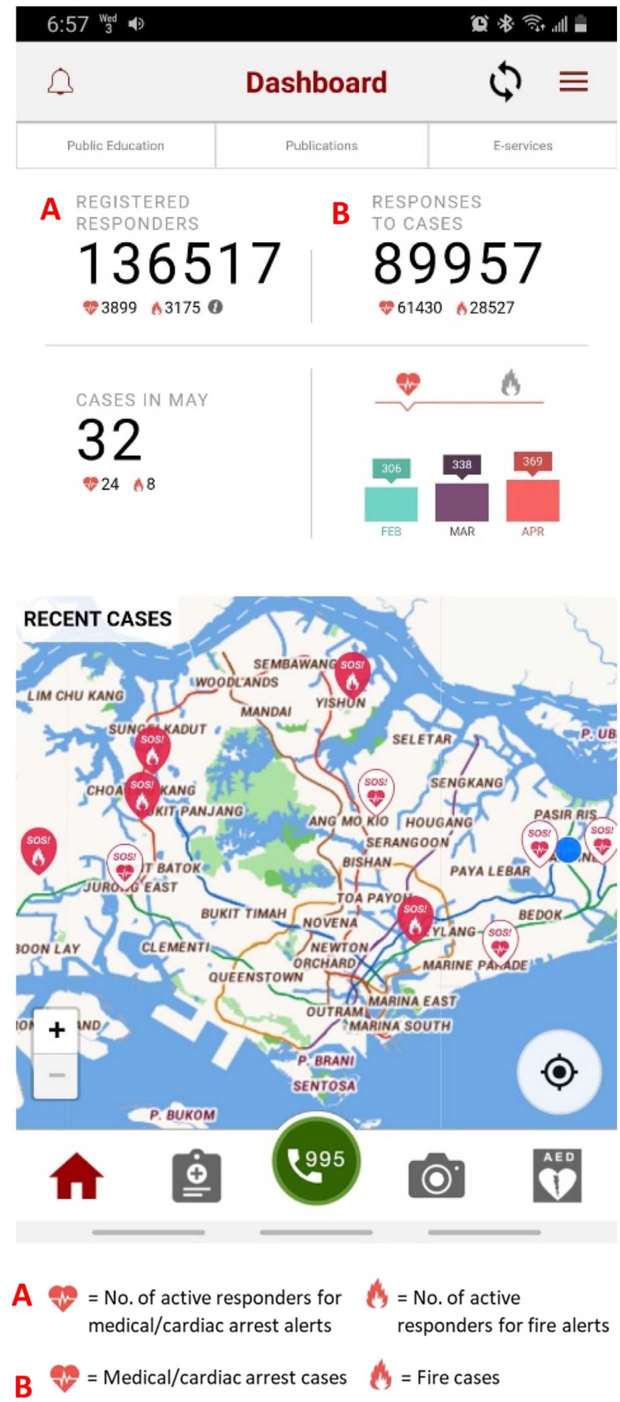

Fig. 1 – Screenshot of myResponder dashboard with information on cumulative registered and active CFRs, and number of cumulative cardiac arrest and fire cases responded to as of May 3, 2023. Active CFRs are defined as responders who turned on notifications for medical and/or fire alerts at any given point.

Methods

Settings

Densely populated equatorial island of Singapore has a national ambulance service managed by the Singapore Civil Defence Force (SCDF), working under the Ministry of Home Affairs.[10] The system includes a dispatch centre, a fleet of ambulances and fire-fighter responders and a network of volunteers connected through the 'myResponder' mobile application. The ambulance service can be activated free of charge by calling 9–9-5. The dispatch centre receives calls, assesses the cases, initiates telephone-CPR and dispatches ambulances. Simultaneously, it sends an alert to the myResponder app users in case of a suspected OHCA.

Study design and data source

We designed a retrospective analysis of data available through two prospectively maintained registries. We identified the OHCA cases from the Singapore Pan Asian Resuscitation Outcomes Study (PAROS) registry, maintained by UPEC, under the Ministry of Health. We obtained the matching CFR data from SCDF's Volunteer and Community Partnership Department which maintains the myResponder app.

Singapore's Community first responder program

Alerting a CFR is a multi-step process. Once a suspected OHCA event call is made through 9–9-5, the SCDF dispatch centre sends an alert through myResponder which can be responded to until an ambulance arrives at the scene. To receive this alert, an on-foot CFR should be within the radius of 400 meters whereas a vehicle-based CFR should be within the radius of 1.5 kilometres of an event carrying a mobile phone with active myResponder app, else the alert remains unreceived.[11] Both on–foot CFR and vehicle-based CFR are alerted via the same process. If one or more CFRs receive an alert, any or all may choose to respond by tapping on the 'Accept' button on the app screen alerting SCDF of their decision after which the app displays the precise OHCA event location as well as the location of nearby AEDs, there is no restriction on the number of CFR that can accept the same mission. Currently for on-foot CFR, fetching an AED is based on CFR's initiative by using the information on nearby AED location shown on the app. The CFR will not be able to know if someone else e.g., a vehicle-based CFR is bringing an AED to the scene. Once at the patient's side, they need to tap on the 'Arrive' button informing the SCDF of their arrival and registering arrival time. If a CFR arrives before the ambulance, they provide the required care as per their training. If more than one CFR arrives before EMS, one takes the lead, and others help. If they arrive after the ambulance, they may help EMS crew.

We included all adult (≥18 years) OHCA patients managed through the SCDF-managed EMS system between 1 January 2016, and 31 December 2020 where CFR accepted to respond excluding EMS-witnessed events. CFR are alerted to all cases including those under 18 years. However, OHCA cases of age <= 17 years old were excluded from this analysis.

This study was exempted by SingHealth Centralised Institutional Review Board (CIRB ref: 2018/2937) as it analyzed de-identified data from the national cardiac arrest registry.

We enumerated the numbers OHCA events at each CFR response step calculating two proportions of the OHCA events: a) out of total OHCA events; and b) out of the previous step; these proportions provided different information about the CFR program: a) overall coverage of OHCA events; b) the point of greatest attrition. From this point onward, we focused on those OHCA events where a CFR accepted an alert because including the events where an alert was either not issued or not received will unduly reduce the effect of CFR response. We reported the distribution of OHCA event characteristics. We reported the yearly distribution of OHCA events for each CFR response step and for the selected characteristics. We graphically presented the trends of clinical outcomes in the background of changing pattern of CFR's arrival at patient side and arrival at patient side before EMS. Finally, we compared the clinical outcomes of the OHCA events where CFR arrived at patient side versus not, to evaluate the effect of CFR presence at the scene using chi square test at type I error of 5%. We used Microsoft® Excel® 2019 and IBM® SPSS® Statistics Software v23 for the analysis.

Results

Out of 6577 OHCA cases alerts issued, 57,879 non-unique CFRs received an alert with a median of 8 CFRs activated per alert (25th percentile [Q1], 75th percentile [Q3]: 4, 12). Of those receiving an alert, 8% (4653/57,879) accepted an alert and 3% (1787/57,879) arrived at the scene. From 4653 accepting an alert 38% (n = 1787) arrived at the scene. From 57,879 CFRs receiving an alert, 95.9% (n = 55,550) were on-foot CFRs whereas the rest were vehicle-based CFRs. More details are available in Fig. 2.

Out of the 55,500 on-foot CFRs receiving an alert 3.1% (n = 1740) arrived at the scene, whereas out of the 2364 vehicle-based CFRs receiving an alert 2% (n = 47) arrived at the scene even though acceptance rate in both the groups was similar (8% [n = 4449] vs 8.5% [n = 203], respectively).

The number of CFRs alerted over the years changed from 4139 in 2016 to 11,946 in 2020, the pandemic year. The peak was observed in 2019 where 19,026 CFRs were alerted. The 2020 dip was because 57% fewer alerts were issued as compared to 2019. The median number of the CFRs receiving an alert increased over the years from 3 to 12 CFRs per event. Similarly, Q1 values increased from 2 to 8, and Q3 values increased from 5 to 17 per event. The rising median trend remained unaffected by the pandemic. These values primarily reflect the trend of on-foot CFRs as

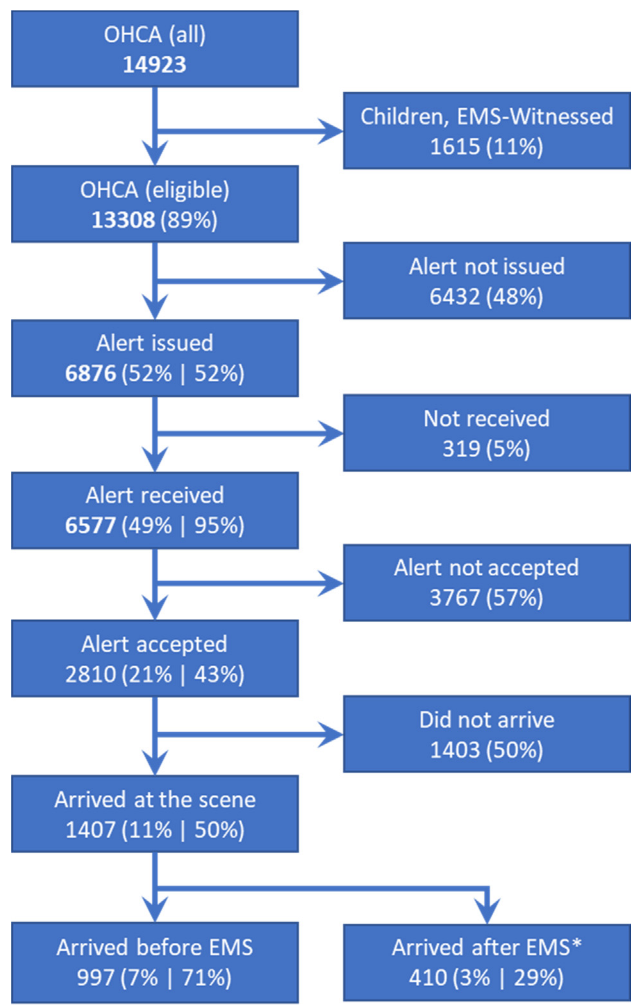

Fig. 2 – Community first responder program for confirmed Out-of-hospital cardiac arrest (OHCA) events in Singapore: Event selection and system function. (Percentages presented before the '|' sign reflect the fraction of all the eligible cases, whereas the ones presented after are the proportion from the subset above). *Some of these CFRs might have arrived before EMS but forgot to log the time through app.

Table 1 – Characteristics of OHCA events by CFR response where the alert was received by CFRs in Singapore (2016–2020).

Characteristics		Alert received	Alert Accepted		CFR arrived at the scene		
			No	Yes[a]	Before EMS[b]	After EMS[c]	Not Arrived[d]
		n = 6577	*n* = 3767 (57.2) §	*n* = 2810 (42.8) §	*n* = 997 (15.2) §	*n* = 410 (6.2) §	*n* = 5170 (78.6) §
Alert received by	On-foot CFR	4663	2698 (57.9)	1965 (42.1)	715 (15.3)	291 (6.2)	3657 (78.4)
	Vehicle-based CFR	63	56 (88.9)	7 (11.1)	1 (1.6)	1 (1.6)	61 (96.8)
	Both	1851	1013 (54.7)	838 (45.3)	281 (15.2)	118 (6.4)	1452 (78.4)
Location of arrest	Public	836	499 (59.7)	337 (40.3)	104 (12.4)	58 (6.9)	674 (80.6)
	Residence/ home	5741	3268 (56.9)	2473 (43.1)	893 (15.6)	352 (6.1)	4496 (78.3)
Time call received at dispatch centre	00:00–05:59	909	639 (70.3)	270 (29.7)	80 (8.8)	34 (3.7)	795 (87.5)
	06:00–18:59	4348	2517 (57.9)	1831 (42.1)	649 (14.9)	258 (5.9)	3441 (79.1)
	19:00–23:59	1320	611 (46.3)	709 (53.7)	268 (20.3)	118 (8.9)	934 (70.8)
First rhythm*	Non-shockable	5500	3171 (57.7)	2329 (42.3)	831 (15.1)	336 (6.1)	4333 (78.8)
	Shockable	1027	568 (55.3)	459 (44.7)	156 (15.2)	70 (6.8)	801 (78.0)
Arrest witnessed	No	3508	2006 (57.2)	1502 (42.8)	534 (15.2)	222 (6.3)	2752 (78.4)
	Yes	3069	1761 (57.4)	1308 (42.6)	463 (15.1)	188 (6.1)	2418 (78.8)

CFR: Community first responder; Column of alert received is the total cohort of analysis; *: Unknown rhythms excluded; §: percent of 6577; Values in the cells are: n

the vehicle-based CFRs were only a very small proportion of total number of CFRs who received an alert.

Table 1 displays the distribution of the selected characteristics of OHCA events across different steps of the CFR response system. It shows that the system primarily capitalizes on the on-foot CFRs who received alert in almost all (99%; including 'both') of the OHCA events. OHCAs happening between, 19:00–23:59 compared to the 2 other time categories (00:00–05:59, 06:00–18:59) had higher proportion of alert acceptance (53.7% vs 29.7% vs 42.1%) and CFR arriving at the scene before EMS (20.3% vs 8.8% vs 14.9%). All other OHCA event characteristics such as location, first rhythm and witnessed status did not show any notable difference in proportion of OHCAs with at least 1 CFR accepting alert and at least 1 CFR arriving before EMS. In a subgroup analysis where CFR arrived before EMS (N = 997), the median (Q1, Q3) time difference from call-to-arrival at patient's side between EMS and CFR was 3.3 (1.7, 5.7) minutes.

Table 2 shows an increasing CFR density during the study period in Singapore. The pandemic year did slow down the registration, however. The table also provides the rising response trend of CFRs receiving (Median no. of CFR: 3 in 2016 to 12 in 2020), accepting (% of OHCAs: 35.1% in 2016 to 57.8% in 2020), and arriving at the scene (% of OHCAs: 11.8% in 2016 to 36.2% in 2020) per OHCA event occurring between 2016 and 2019. Out of 1914 OHCA cases with taxis alerted over the whole period 2016–2020, only 2.4% (46/1914) had at least 1 taxi CFR arriving at scene. However, there was a higher percentage of defibrillation by non-EMS in the group with at least 1 taxi CFR arriving at scene compared to the group with no taxi CFR arriving, though not statistically significant [4.3% (2/46) vs 2.1% (39/1868), $p = 0.259$, not shown but computed from data in Table 2].

Fig. 3 displays the process indicator and clinical outcome trends against the background of a rising number of OHCA attended by CFRs and CFRs arriving before EMS. Bystander AED application increased from 4.2% to 10.3% during this period as more OHCA events were attended by CFRs and arriving before EMS.

Table 3 shows that there was a statistically significant association between bystander CPR, bystander AED or defibrillation by non-EMS and CFRs' arrival at the scene. However, we did not find an association between clinical outcomes and CFRs arrival at the scene.

Discussion

Singapore's Community First Responder Program is one of the key components of the Save-A-Life initiative introduce in 2015.[12] It includes: a) country-wide deployment of publicly accessible AEDs with their locations made available; b) training community volunteers in saving lives in various emergencies, including OHCA events; and c) deployment of the myResponder mobile application that links volunteers to the AEDs and OHCA or fire events.[12]

This is the first detailed evaluation of the CFR response dynamics in Singapore since its inception in 2015. We analysed the data from 2016 onwards to eliminate the noise of teething issues in the first year. We do note there was a gap between eligible OHCA and issued alerts. This gap could be attributed to a few reasons such as: no CFR available within the stipulated radius, the incident may have not presented as cardiac arrest at time of call but subsequently arrested before EMS arrival, thus dispatcher did not issue the alert at time of call, and EMS may not have accurately recognised the incident as suspected OHCA or considered activating CFRs in the beginning stages of app implementation.

The report highlights the fact that once an alert is issued it is received by CFRs in 95% of the OHCA events (Fig. 2). This high rate of alert receipt is likely a combined effect of the small geographic area, dense population, numerous registered CFRs and universal mobile phone and internet access. This observation contrasts with

Table 2 – The yearly trend of CFR density, EMS & CFR response per OHCA event and OHCA event characteristics in Singapore (2016–2020).

CFR response & event characteristics	Year				
	2016	2017	2018	2019	2020
OHCA events where an alert was received by a CFR [n (%)]; Total N = 6577					
Number of registered CFRs[^]	9299	18,956	26,259	49,797	51,164
Call to EMS arrival time (mins)[$]	10.8 (8.8, 13.1)	12.3 (10.2, 15.1)	11.3 (9.5, 13.9)	10.9 (9.1, 12.9)	11 (9.5, 13.0)
Alert received by CFRs (n)	1,064	1,396	1,495	1,667	955
Median (min, max)	3 (1, 19)	7 (1, 59)	7 (1, 62)	10 (1, 81)	12 (1, 34)
One CFR*	201 (18.90)	60 (4.30)	66 (4.40)	21 (1.30)	16 (1.70)
Two CFRs*	195 (18.30)	89 (6.40)	89 (6.00)	36 (2.20) 1610 (96.60)	17 (1.80)
>2 CFRs*	668 (62.80)	1247 (89.30)	1340 (89.60)		922 (96.50)
CFR accepting alerts*	373 (35.1)	648 (46.4)	378 (25.3)	859 (51.5)	552 (57.8)
Median (min, max)	0 (0, 8)	0 (0, 13)	0 (0, 4)	1 (0, 6)	1 (0, 6)
Zero CFR*	691 (64.9)	748 (53.6)	1117 (74.7)	808 (48.5)	403 (42.2)
One CFR*	202 (19)	388 (27.8)	291 (19.5)	498 (29.9)	300 (31.4)
Two CFRs*	87 (8.2)	159 (11.4)	61 (4.1)	222 (13.3)	152 (15.9)
>2 CFRs*	84 (7.9)	101 (7.2)	26 (1.7)	139 (8.3)	100 (10.5)
CFR arriving at the scene	126 (11.8)	282 (20.2)	176 (11.8)	477 (28.6)	346 (36.2)
Median (min, max)	0 (0, 2)	0 (0, 4)	0 (0, 3)	0 (0, 4)	0 (0, 6)
Zero CFR*	938 (88.2)	1114 (79.8)	1319 (88.2)	1190 (71.4)	609 (63.8)
One CFR*	116 (10.9)	243 (17.4)	148 (9.9)	343 (20.6)	257 (26.9)
Two CFRs*	10 (0.9)	33 (2.4)	25 (1.7)	106 (6.4)	63 (6.6)
>2 CFRs*	0 (0)	6 (0.4)	3 (0.2)	28 (1.7)	26 (2.7)
OHCA events where at least one CFR responded to an alert by CFR type; Total N = 6577					
On-foot CFR†					
Alerted	1011 (95.0)	1391 (99.6)	1492 (99.8)	1666 (99.9)	954 (99.9)
Accepted	342 (32.1)	612 (43.8)	372 (24.9)	847 (50.8)	548 (57.4)
Arrived	113 (10.6)	267 (19.1)	175 (11.7)	473 (28.4)	344 (36.0)
Vehicle-based CFR†					
Alerted	361 (33.9)	475 (34.0)	456 (30.5)	426 (25.6)	196 (20.5)
Accepted	79 (7.4)	76 (5.4)	10 (0.7)	25 (1.5)	9 (0.9)
Arrived	13 (1.2)	21 (1.5)	3 (0.2)	7 (0.4)	2 (0.2)
OHCA events with a CFR arriving at the patient's side [n (%)]; Total N = 1,407					
N	126	282	176	477	346
Time call received at dispatch centre					
00:00–05:59	13 (10.30)	20 (7.10)	13 (7.40)	41 (8.60)	27 (7.80)
06:00–18:59	77 (61.10)	185 (65.60)	115 (65.30)	317 (66.50)	213 (61.60)
19:00–23:59	36 (28.60)	77 (27.30)	48 (27.30)	119 (24.90)	106 (30.60)
CFR arrived before EMS	84 (66.7)	228 (80.9)	130 (73.9)	332 (69.6)	223 (64.5)
Location of arrest					
Public	17 (13.50)	27 (9.60)	31 (17.60)	50 (10.50)	37 (10.70)
Residence/home	109 (86.50)	255 (90.40)	145 (82.40)	427 (89.50)	309 (89.30)
Shockable rhythm					
No	103 (82.40)	223 (80.80)	152 (86.40)	408 (86.40)	281 (81.70)
Yes	22 (17.60)	53 (19.20)	24 (13.60)	64 (13.60)	63 (18.30)

^Cumulative; *n (%). [$]Median (Q1, Q3); Statistics in the table are count (%) for categorical data and median (minimum, maximum) for continuous data. CFR: community first responder who could be either an on-foot or a Vehicle-based. †Out of 'Alert Received by CFRs'.

other CFR systems where much smaller fraction of the alerts was received. In the UK, 6.7% and 22% of the alerts were received by CFRs.[13] The catchment area of the alert in Singapore's CFR system was also much smaller than most other systems i.e., within 400 meters of an OHCA event location.[2] Overall, the system's access to the CFRs was higher in Singapore.

Once an alert was received, it was accepted in 42% of OHCA events, an increase of 12 percentage points from the previously reported figure of 29.3%[9] and double than that of other systems, ranging between 23% to under 28%.[2] Although much higher than reported in other systems, the acceptance rate was still quite low given that most OHCA occurs in awake hours in Singapore,

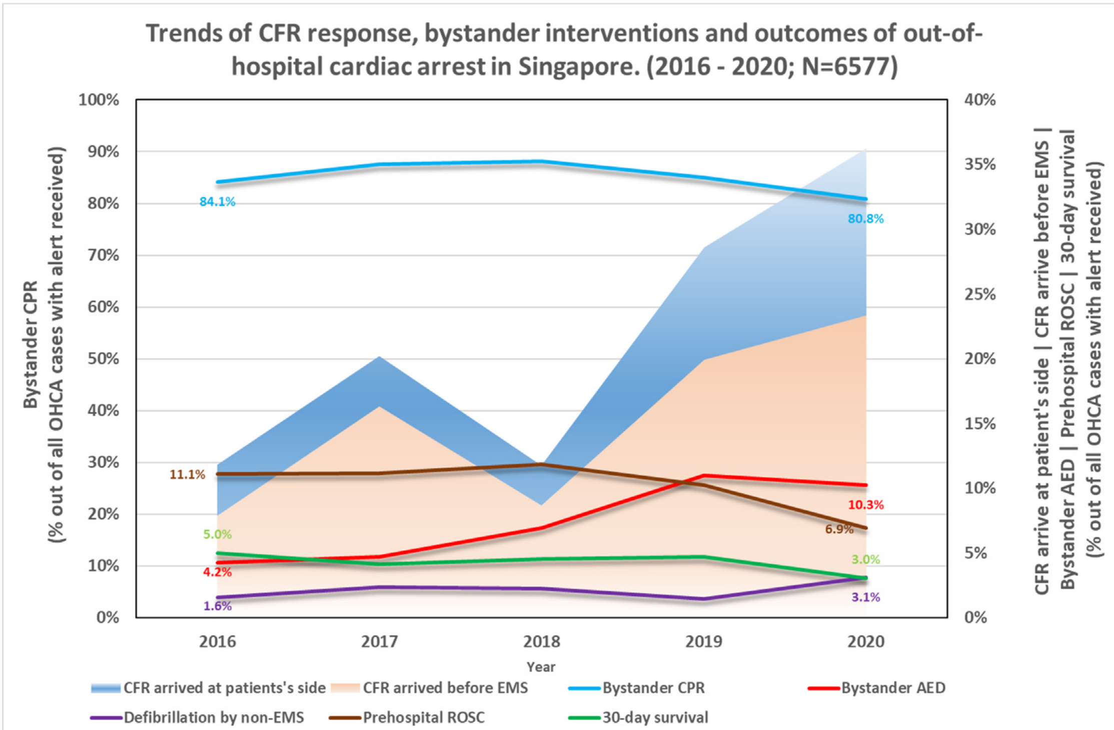

Fig. 3 – Trends of CFR response, bystander interventions and outcomes of OHCA cardiac arrest.

Table 3 – Association of outcomes of the Out-of-hospital cardiac arrest events with whether CFR arrived before EMS in Singapore (2016–2020; n = 6577).

Outcomes	Total	CFR Arrived at the scene			p-value
		Before EMS (N=997)	After EMS (N=410)	Not arrived (N=5170)	
Bystander CPR					
Yes	5624 (85.5)	889 (89.2)	342 (83.4)	4393 (85)	0.001
No		108 (10.8)	68 (16.4)	777 (15)	
Bystander AED					
Yes	496 (7.5)	151 (15.1)	47 (11.5)	298 (5.8)	<0.001
No		846 (84.9)	363 (88.5)	4872 (94.2)	
Defibrillation performed by non-EMS					
Yes	138 (2.1)	35 (3.5)	8 (2)	95 (1.8)	0.003
No		962 (96.5)	402 (98)	5075 (98.2)	
Prehospital ROSC					
Yes	688 (10.5)	100 (10)	41 (10)	547 (10.6)	0.831
No		897 (90)	369 (90)	4623 (89.4)	
30-day survival					
Yes	287 (4.4)	39 (3.9)	18 (4.4)	230 (4.4)	0.749
No		958 (96.1)	392 (95.6)	4940 (95.6)	

Statistics in table are count (%) for categorical data. Significance level = <0.05.

distances to walk are short and security was not an issue.[14,15] CFRs have anecdotally reported that the alerts received while onboard a train or bus moving snugly through densely packed high-rise residential and office buildings restricts any action. This can imaginably be the case where a CFR receives an alert as the train enters an active OHCA alert zone with CFR unable to take any action. Other possible reasons may include CFR fatigue due to frequent alerts or an assumption that EMS will arrive before them resulting in a low acceptance rate. There is little systematic evidence to further comment on these reports. Qualitative research aiming to know the barriers to accepting an OHCA alert will help understand the factors causing attrition at this step. This knowledge will help design tailored interventions to alleviate the lacuna.

Out of those CFRs who accepted the alert, half arrive at the scene. This fraction changed little since last reported in 2019.[9] Globally, this fraction ranges from 26% to 95%.[2] This wide variation can be a manifestation of a variety of reasons including the distances to be covered, physical barriers, weather, terrain, and the location details available to a CFR.[2] An inadvertent touch or lack of courage after pressing the accept button can be also contribute to this attrition.[16] Though unpublished, some of the CFRs in Singapore reported that they forgot to tap on the 'Arrive' button on the app as patient management became the focus of attention. Prioritizing the patient over an administrative step is understandable but has likely led to considerable under reporting at this stage. The incomplete arrival reporting of CFRs means our results are an underestimate and we can safely assume that the system is performing somewhat better than what the numbers are telling us. Going forward, implementing automatic arrival detection with a delayed manual confirmation in the app may reduce missing data.

Out of those CFRs who arrived at the scene, over 70% arrived before EMS. In a dense, urban, real-life setting, 14% pre-EMS arrival out of 13,308 alerted OHCA events over the study period is encouraging. Reported international figures range from 3% to 95% in a variety of settings.[2,3,17] Each setting is rather unique, and a fair comparison is not possible for this key success indicator of any CFR system. Arrival before EMS can possibly shorten the delay in CPR initiation and has potential to bring AEDs earlier to the scene. Even if a CFR doesn't arrive early enough to start CPR before EMS arrival, they can initiate optimizing the scene, positioning, and preparing the patient for CPR and AED application by EMS. This 'anticipatory' preparation can give EMS a potentially lifesaving head start.

In the remaining 30% of the OHCA events, where the CFRs arrived after the EMS, they can still provide additional helping hands. In a high-rise built-up environment, CFRs can help speed up shifting the patient from the scene to the ambulance through corridors, elevators, and stairs. An experienced or emotionally stable CFR can also help calm the patient's relatives allowing EMS staff to manage patients in a more congenial environment. We couldn't find any report on this aspect. If post-EMS arrival was also found helpful, appropriate message should be conveyed to the CFRs to increase participation.

In Singapore, the only notable OHCA event characteristic that seemed to influence the CFRs' response dynamics was time of arrest. CFRs were most responsive during evening time (19:00–23:59), followed by the working hours (06:00–18:59) and the night-time (00:00–05:59) (Table 1). Work-related commitments or inability to alight from transit while passing by an OHCA event contributed to the lack of responsiveness in daytime. Night-time tardiness is also reported by Lee et al, who excluded night OHCA events from their analysis.[5]

The trend of CFR attended OHCA events over time is encouraging. Year-on-year, per OHCA event, an increasing number of CFRs are receiving and accepting an alert and arriving at the scene. This upward trend even persisted during the pandemic year.

With increasing CFR responsiveness, it was encouraging to see a statistically significant difference in the process outcomes – Bystander CPR, AED and defibrillation – between the OHCA events where a CFR arrived or did not arrive at the scene. However there is still potential for our AED application fraction of 7.5% to improve, as other studies have reported a range of 9–26%.[2] (Fig. 3). We are planning a trial to equip CFRs with the portable AEDs.

However, improving process indicators have not translated into clinical outcome improvement yet. One study did reported a lack of association between arrival of CFR and pre-hospital ROSC.[5] Most other studies studied these association using pre- and post-intervention not arrival vs no arrival.[2] We believe that if CFR response trends persist, clinical outcomes will improve as well.

Strengths and limitations

The report is based on all OHCA cases occurring in Singapore that fulfil our eligibility criteria and therefore, is fully representative of the target population. The effect of time of arrest on CFRs' response is being reported for the first time with a potential to be an intervention target. We only included the CFRs who confirmed their arrival by interacting with the app. Many CFRs missed this step resulting in incomplete capture of the time of arrival at the patient's side. We also included the pandemic period in the analysis, during which the system was performing sub-optimally. Consequently, we are reporting conservative CFRs response estimates.

Conclusion

This real-world study shows that activating CFRs using mobile technology can improve community response for OHCA. CFR response is not affected by patient/OHCA event characteristics, except for time of day. The response rate was mostly maintained during the pandemic. Early arrival is helping more OHCA patients get defibrillated before EMS arrival. However, there is an unexplained attrition of response between receiving and accepting an alert. The attrition between accepting an alert and arriving at the scene also demand further research.

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CRediT authorship contribution statement

Fahad Javaid Siddiqui: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Stephanie Fook Chong:** Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Nur Shahidah:** Methodology, Investigation, Resources, Data curation, Writing – review & editing, Project administration. **Colin K Tan:** Resources, Writing – review & editing. **Jinn Yang Poh:** Resources, Writing – review & editing. **Wei Ming Ng:** Writing – review & editing. **Dennis Quah:** Writing – review & editing. **Yih Yng Ng:** Writing – review & editing. **Benjamin SH Leong:** Writing – review & editing. **Marcus EH Ong:** Conceptualization, Methodology, Resources, Writing – review & editing, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: MEH Ong reports grants from the Laerdal Foundation, Laerdal Medical, and Ramsey Social Justice Foundation for funding of the Pan-Asian Resuscitation Outcomes Study; an advisory relationship with Global Healthcare SG, a commercial entity that manufactures cooling devices. MEH Ong has a licensing agreement with ZOLL Medical Corporation and patent filed (Application no: 13/047,348) for a "Method of predicting acute cardiopulmonary events and survivability of a patient". He is also the co-founder and scientific advisor of TIIM Healthcare, a commercial entity which develops real-time prediction and risk stratification solutions for triage. All other authors have no conflict of interest to declare.

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Author details

[a]Health Services & Systems Research, Duke-NUS Medical School, Singapore [b]Pre-hospital & Emergency Research Centre, Duke-NUS Medical School, Singapore [c]Department of Emergency Medicine, Singapore General Hospital, Singapore [d]Emergency Medical Services Department, Singapore Civil Defence Force, Singapore [e]Volunteer & Community Partnership Department, Singapore Civil Defence Force, Singapore [f]Emergency Medicine Department, Ng Teng Fong General Hospital, Singapore [g]Operations Department, Singapore Civil Defence Force, Singapore [h]Digital and Smart Health Office, Ng Teng Fong Centre for Healthcare Innovation, Tan Tock Seng Hospital, Singapore [i]Department of Preventive and Population Medicine, Tan Tock Seng Hospital, Singapore [j]Emergency Medicine Department, National University Hospital, Singapore

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