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ORIGINAL RESEARCH

Activation of Citizen Responders to Out-of-Hospital Cardiac Arrest During the COVID-19 Outbreak in Denmark 2020

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BACKGROUND: Little is known about how COVID-19 influenced engagement of citizen responders dispatched to out-of-hospital cardiac arrest (OHCA) by a smartphone application. The objective was to describe and analyze the Danish Citizen Responder Program and bystander interventions (both citizen responders and nondispatched bystanders) during the first COVID-19 lockdown in 2020.

METHODS AND RESULTS: All OHCAs from January 1, 2020, to June 30, 2020, with citizen responder activation in 2 regions of Denmark were included. We compared citizen responder engagement for OHCA in the nonlockdown period (January 1, 2020, to March 10, 2020, and April 21, 2020, to June 30, 2020) with the lockdown period (March 11, 2020, to April 20, 2020). Data are displayed in the order lockdown versus nonlockdown period. Bystander cardiopulmonary resuscitation rates did not differ in the 2 periods (99% versus 92%; P=0.07). Bystander defibrillation (9% versus 14%; P=0.4) or return-of-spontaneous circulation (23% versus 23%; P=1.0) also did not differ. A similar amount of citizen responders accepted alarms during the lockdown (6 per alarm; interquartile range, 6) compared with the nonlockdown period (5 per alarm; interquartile range, 5) (P=0.05). More citizen responders reported performing chest-compression-only cardiopulmonary resuscitation during lockdown compared with nonlockdown (79% versus 59%; P=0.0029), whereas fewer performed standardized cardiopulmonary resuscitation, including ventilations (19% versus 38%; P=0.0061). Finally, during lockdown, more citizen responders reported being not psychologically affected by attending an OHCA compared with nonlockdown period (68% versus 56%; P<0.0001). Likewise, fewer reported being mildly affected during lockdown (26%) compared with nonlockdown (35%) (P=0.003).

CONCLUSIONS: The COVID-19 lockdown in Denmark was not associated with decreased bystander-initiated resuscitation in OHCAs attended by citizen responders.

Key Words: Citizen Responder Program ■ COVID-19 ■ out-of-hospital cardiac arrest

Cardiopulmonary resuscitation (CPR) and early defibrillation are 2 of the most important factors for survival after out-of-hospital cardiac arrest (OHCA).[1,2] To increase bystander CPR and early defibrillation, Citizen Responder Programs are being implemented in several countries worldwide.[3] From December 2019, COVID-19 spread throughout the world and was classified as a pandemic by the World Health Organization on March 11, 2020.[4] Because of the severity of the COVID-19 pandemic, many countries implemented restricted regulations, such as temporary closure of public places, closing of country borders, and encouragement of social distancing and avoidance of close physical contact as an attempt to stop the spread of the virus.

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CLINICAL PERSPECTIVE

What Is New?

- The Danish Citizen Responder Program continued to operate with success during the first COVID-19 lockdown in Denmark as citizen responders continued to accept alarms and continued to provide high proportions of bystander interventions.
- Despite attending out-of-hospital cardiac arrest during a pandemic, fewer Danish citizen responders reported being psychologically affected by attending these incidents compared with before the pandemic.
- During the national COVID-19 lockdown, citizen responders were more likely to perform chest-compression-only cardiopulmonary resuscitation as they were instructed to by the operator of the Citizen Responder Program.

What Are the Clinical Implications?

- This study demonstrates that it is feasible to operate Citizen Responder Programs during severe health crises in a society (eg, the COVID-19 pandemic) to deliver continued high standard of care to patients with out-of-hospital cardiac arrest.
- Further studies are needed to determine whether these findings translate into other settings with Citizen Responder Programs worldwide.

Nonstandard Abbreviations and Acronyms

OHCA	out-of-hospital cardiac arrest

In Denmark, the first confirmed case of COVID-19 infection was reported on February 27, 2020; and by March 11, 2020, Denmark declared a nationwide lockdown.[5] First by April 21, 2020, the society began to reopen after the first COVID-19 surge, but some strictions remained for a longer period (eg, ban on gatherings for indoor arrangements).[5] The COVID-19 outbreak also affected citizen engagement in OHCA resuscitation across Europe, where Citizen Responder Programs either paused activation completely or continued activation with restrictions (omitting rescue breaths and recommending chest-compression-only CPR as the most common restriction).[6] In Denmark, the Citizen Responder Program remained active during the outbreak, but responders were advised to perform chest-compression-only CPR with no ventilations (if no facemask or similar device was present), in accordance with newly updated both European Resuscitation Council and American Heart Association COVID-19 Cardiopulmonary Resuscitation Guidelines.[7,8] Furthermore, citizen responders in risk of severe COVID-19 defined as most vulnerable by the Danish Health Authorities were advised not to accept alarms. Despite a worldwide implementation of Citizen Responder Programs, little is known about how the COVID-19 pandemic affected citizen responder activation and engagement, as well as the psychological impact for citizen responders dispatched to a resuscitation attempt during the pandemic.

In this observational study, we aimed to describe changes in citizen responders' availability and interactions with alarms during the COVID-19 outbreak in Denmark. Second, we examined whether lockdown of most businesses and public venues led to an increase in distances to nearest accessible automated external defibrillator (AED) for the citizen responders. We hypothesized that the increasing severity of the COVID-19 outbreak, followed by public information and restrictions in Denmark, led to fewer citizen responders being available and accepting alarms, fewer bystander interventions (CPR and defibrillation), and longer distances to nearest accessible AED. We also hypothesized a higher proportion of citizen responders reported increased psychological distress when alerted to a resuscitation attempt during the COVID-19 lockdown and that fewer responders performed rescue breaths during CPR.

METHODS

Study Design and Setting

This retrospective observational study included patients with OHCA from the Central Denmark Region and the Northern Denmark Region. The study area comprised almost 1.9 million inhabitants (≈33% of the total Danish population) and covered 20 986 km^2 (≈49% of the size of Denmark), including both urban and rural areas.[9] The 2 regions are served by individual emergency dispatch centers and by 2-tiered Emergency Medical Services (EMS) systems, dispatching an ambulance and a physician-staffed unit in the event of a cardiac arrest. The emergency dispatch centers have protocols for dispatcher-assisted CPR (telephone CPR) and, when feasible, referral of additional bystanders to nearest publicly accessible AED or instructions to contact the person responsible of the nearest AED and encourage him/her to deliver the AED to the location of OHCA. Furthermore, both regions can dispatch volunteer citizen responders to the cardiac arrest to assist with CPR and fetch a nearby AED via the Danish Citizen Responder Program.

The Danish Citizen Responder Program

Details about the Danish Citizen Responder Program (HeartRunner app) are described elsewhere.[10] Briefly

described, the HeartRunner app was implemented in the Central Denmark Region on October 1, 2018, and in the North Denmark Region on February 14, 2020. From May 1, 2020, the HeartRunner app was nationwide (in all 5 regions). At the beginning of the study on January 1, 2020, 25 408 citizen responders were registered in the 2 regions (21 100 in the Central Denmark Region, equaling 1583 responders/100 000 inhabitants; and 4308 in the North Denmark Region, equaling 730 responders/100 000 inhabitants). In every suspected cardiac arrest, the EMS dispatcher can activate volunteer citizens (aged ≥18 years) registered with the HeartRunner app to a nearby OHCA. Up to 20 citizen responders within 1800 m of the OHCA site will receive an alarm. Citizen responders can either accept or reject the alarm. If accepted, the citizen responder will be guided either directly to the OHCA incident site to perform CPR or via an accessible AED to ensure early defibrillation before EMS arrival. The HeartRunner app is directly linked to the national AED Network Registry.[11,12] Ninety minutes after a mission, all responding citizen responders receive a questionnaire for debriefing purposes. Nonresponders of the questionnaire are subsequently contacted by text message and encouraged to complete the questionnaire. The questionnaire consists of several items in Danish in relation to both the OHCA alarm (eg, if they arrived on scene before EMS, performed CPR, and applied an AED and defibrillated) and the citizen responders' well-being (both mentally and physically).[10] Citizen responders who answered that they performed CPR were subsequently asked: *"What kind of cardiopulmonary resuscitation did you perform?"*, with the following options: (1) *"only chest compression,"* (2) "*only ventilations,"* or (3) "*both chest compression and ventilations."* Furthermore, to evaluate psychological impact, a scale of self-perceived psychological impact, ranging from 1 to 5, was used. Citizen responders were asked: "*One could experience psychological impact when helping with cardiac arrest resuscitation. What psychological impact did the experience have on you?,"* with the following possible answers: (1) "*I was not affected,"* (2) "*mildly affected,"* (3) "*moderately affected,"* (4) "*severely affected, but no need for follow-up by health care personnel,"* and (5) "*severely affected, with need for follow-up by health care personnel."* All citizen responders requesting follow-up were contacted by professional health care personnel by telephone. Answers from citizen responders who reported to be severely affected with or without the need for follow-up (answers 4 and 5) were combined, thus making a variable with 1 to 4 categories to analyze (not affected, mildly affected, moderately affected, and severely affected). This evaluation tool has been used since the implementation of the Citizen Responder Program, and we have previously published data on citizen responders' psychological impact using this tool.[13]

The Danish Citizen Responder Program and COVID-19

Following the COVID-19 outbreak and lockdown in Denmark, all registered citizen responders received an e-mail (March 17, 2020) recommending all citizen responders to perform chest-compression-only CPR. This announcement was made before updated recommendations from the Danish Resuscitation Council, the European Resuscitation Council, and the American Heart Association.

The Danish AED Network Registry

The Danish AED Network is nationwide and covers both regions included in this study. Owners of AEDs can voluntarily register their AED with precise location and accessibility information. The network is linked directly to all emergency dispatch centers in Denmark and included ≈21 600 AEDs (375 AEDs/100 000 inhabitants) at the beginning of the study period, with ≈60% of the AEDs accessible 24 hours a day, 7 days a week.[11,14]

Data Sources

All variables (age, sex, first recorded rhythm, witnessed status, EMS response time, location of arrest, bystander interventions, and return of spontaneous circulation) in relation to patients experiencing OHCA were provided by the Danish Cardiac Arrest Registry, according to the Utstein Criteria.[15] The Danish Cardiac Arrest Registry does not differentiate between bystander interventions (bystander CPR and defibrillation) performed by the dispatched citizen responders and other, nondispatched bystanders on scene. Shockable rhythm was defined as pulseless ventricular tachycardia or ventricular fibrillation recorded by EMS or if the patient received bystander defibrillation by an AED before EMS arrival. The EMS response time included the period from dispatch to vehicle stop at scene and not by patient side. Citizen responder characteristic, dispatch information, including timestamps and global positioning system (GPS) locations, and data from questionnaires sent to citizen responders were available from the HeartRunner app server. Distances from citizen responder to AED and OHCA location were calculated as straight-line distances using the last updated coordinates to the app server at the time of selection for alarm. The data that support the findings of this study are available from the corresponding author on reasonable request.

Study Population

We included all patients with EMS-treated OHCA in the 2 regions where citizen responders were activated and minimum one citizen responder was within activation radius (1800 m). Patients with OHCAs in the period

of January 1, 2020, to June 30, 2020, were included. Patients with EMS witnessed OHCA were excluded as citizen responders are unable to perform interventions (CPR and defibrillation) before EMS in these cases. For calculation of the daily OHCA incidence, all OHCAs were used (with or without citizen responder activation).

Study Groups

All included citizen responders were divided into 2 groups. The lockdown group constitutes citizen responders activated to patients with OHCA in the period from March 11, 2020, to April 20, 2020, whereas the nonlockdown group constitutes citizen responders activated to patients with OHCA in the period January 1, 2020, to March 10, 2020, and April 21, 2020, to June 30, 2020. The start of the lockdown period was defined from the day of the national television broadcast with the Danish Government announcing the closure of public places, schools, dentists, and hairdressers. The end of the lockdown period was defined as the day when the Danish Government allowed liberal professions (hairdressers, dentists, and similar) to reopen. Public schools reopened on April 15, 2020, approximately a week before the termination of the lockdown defined in this study.

Statistical Analysis

Because of the COVID-19 pandemic, Denmark was completely or partly locked down from March 11, 2020, to April 20, 2020. To investigate associations of the COVID-19 lockdown on citizen responder engagement, we examined the proportion of citizen responders who accepted an alarm in the lockdown and nonlockdown periods. Furthermore, we examined the proportion of OHCAs receiving bystander CPR and bystander defibrillation in the lockdown period compared with the nonlockdown period. Last, we examined the proportion of citizen responders who reported performing chest-compression-only CPR, ventilations only, or standard CPR in the lockdown period compared with the nonlockdown period. In relation, the degree of citizen responders' psychological impact in the 2 periods was also examined. The Fisher exact test was used to analyze categorical data (presented as proportions and percentages). Continuous variables were presented as medians and interquartile ranges (IQRs), and differences were analyzed using Kruskal-Wallis test. A 2-sided $P<0.05$ was defined as statistically significant. Statistical analyses were made in SAS Enterprise guide version 7.15 and SAS version 9.4 (SAS Institute Inc, Cary, NC) and R version 3.6.0 (2019-04-26).[16]

Ethical and Data Approvals

Patient data collection was approved by the Data Protection Agency (Journal No.: 2012-58-0004; VD-2018-28; I-Suite No.: 6222). The Danish Patient Safety Authority approved the project under case number 31-1521-342. Furthermore, use of data from the Danish Cardiac Arrest Registry was approved under journal number GLO-2002-07 and I-Suite 00146. Data with regard to the Citizen Responder Program were obtained from the Danish Citizen Responder Program (the HeartRunner project). At registration, citizen responders agree to share personal information and GPS location when logged on to the app. Furthermore, they consent to be contacted by the research team. Citizen responders can withdraw consent and delete the app at any time.

RESULTS

A total of 6120 citizen responders were alarmed in 443 cases with suspected OHCA in the 2 regions. In 58% (n=256) of all suspected OHCAs, 3531 citizen responders were dispatched to a true cardiac arrest, with 29% (n=74) of the OHCAs occurring during the national lockdown period. The inclusion of patients is illustrated in the flowchart in Figure 1. Furthermore, an overview of the Danish restrictions and key dates during the COVID-19 pandemic can be found in Figure 2.

Cardiac Arrest Characteristics, Bystander Interventions, and Outcomes

Throughout the study period, the incidence of all types of OHCA (with and without citizen responder activation) remained stationary. Furthermore, patient age and sex did not substantially differ during the COVID-19 pandemic (Table 1). In both periods (lockdown versus nonlockdown), OHCA occurred most frequently in residential areas (84% versus 82%; P=1.0). During the lockdown period, 99% (73 of 74 OHCAs) received bystander CPR compared with 92% (168 of 182 OHCAs) in the nonlockdown period (P=0.07). The proportion of patients receiving bystander defibrillation was 9% (7 of 74 cases) during the lockdown period compared with 14% (25 of 182 cases) during the nonlockdown period (P=0.4). Furthermore, the proportion of patients with return of spontaneous circulation at hospital arrival was the same in the lockdown and nonlockdown periods, 23% (17 of 74 cases) versus 23% (41 of 182 cases) (P=1.0). All characteristics of the 256 included OHCAs can be found in Table 1.

Citizen Responder Characteristics

A total of 3531 citizen responders received an alarm to a true OHCA during the study period. Of those, 1335 (38%) accepted the alarm. The age and sex distribution among citizen responders remained stationary during the 2 periods. We saw an increase in the median

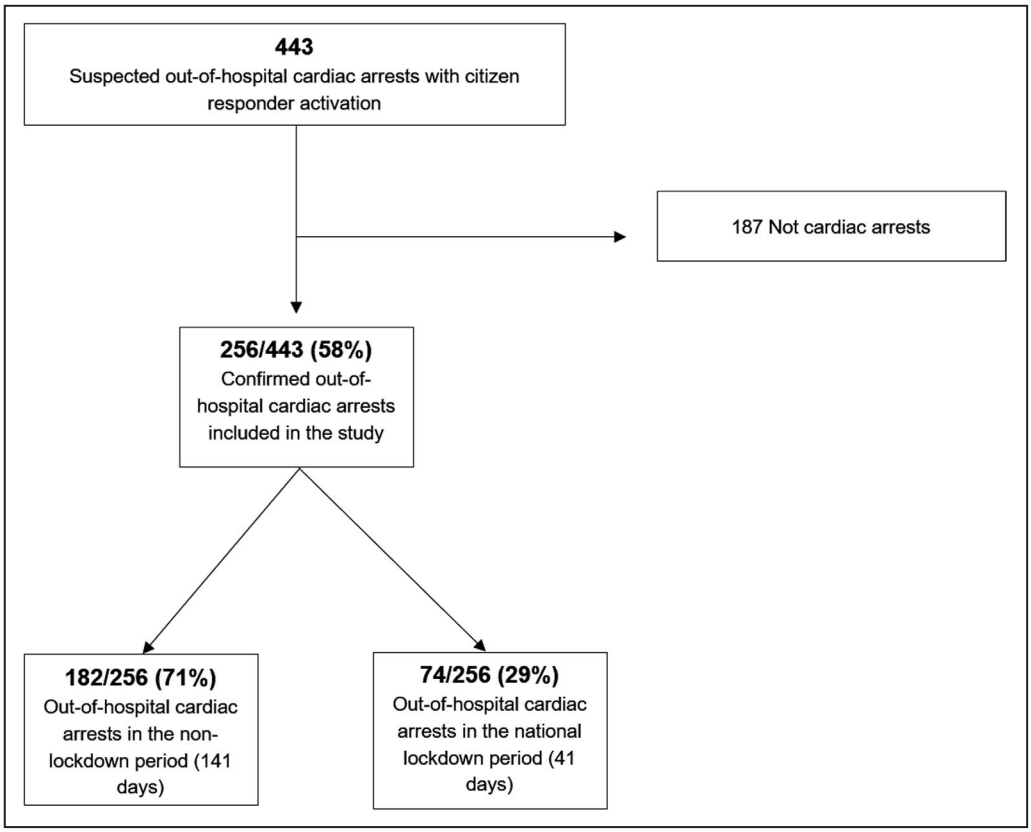

Figure 1. Flowchart showing patient selection.

number of citizen responders who accepted an OHCA alarm in the lockdown period (6; IQR, 6) compared with the nonlockdown period (5; IQR, 5) (*P*=0.05). The median distance from an available citizen responder to the OHCA location also remained unchanged throughout the study period, with a median of 640 m (IQR, 571 m) during lockdown versus 622 m (IQR, 561 m) in the nonlockdown period (*P*=0.3). Furthermore, straight-line distance between the available citizen responder and a public accessible AED was similar in the lockdown period (360 m; IQR, 400 m) compared with the nonlockdown period (354 m; IQR, 406 m) (*P*=0.1). Further characteristics of all included citizen responders can be found in Table 2.

Citizen Responder Interventions and Psychological Impact

A total of 1152 citizen responders (86% of those who accepted the alarm) answered the questionnaire following the alarm to a true OHCA in the study period. Among these, 375 (33%) citizen responders reported arriving before the EMS. A total of 249 citizen responders reported performing CPR. Of them, statistically more reported performing chest-compression-only CPR in the lockdown period (79%) compared with the nonlockdown period (59%) (*P*=0.0029; Figure 3A). Likewise, fewer reported performing standardized CPR (including ventilations) during the lockdown period (19%) compared with the nonlockdown period (38%) (*P*=0.0061). There was no difference between the proportions of those who reported to perform ventilations only in the lockdown period (2%) compared with the nonlockdown period (3%) (*P*=0.68). A total of 1133 (98%) answered the item about psychological impact (flowchart of questionnaire responders is presented in Figure S1). During lockdown period, we observed a statistically significant increase in the proportion of citizen responders who reported being not psychologically affected (68%) by attending an OHCA compared with the nonlockdown period (56%) (*P*<0.0001; Figure 3B). Furthermore, fewer citizen responders reported being mildly affected (26%) during lockdown period compared with the nonlockdown period (35%) (*P*=0.0033). No statistically significant difference was observed between those reported being moderately or severely affected.

DISCUSSION

This study demonstrated how the Danish Citizen Responder Program was able to continue with high rates of bystander interventions and low rates of

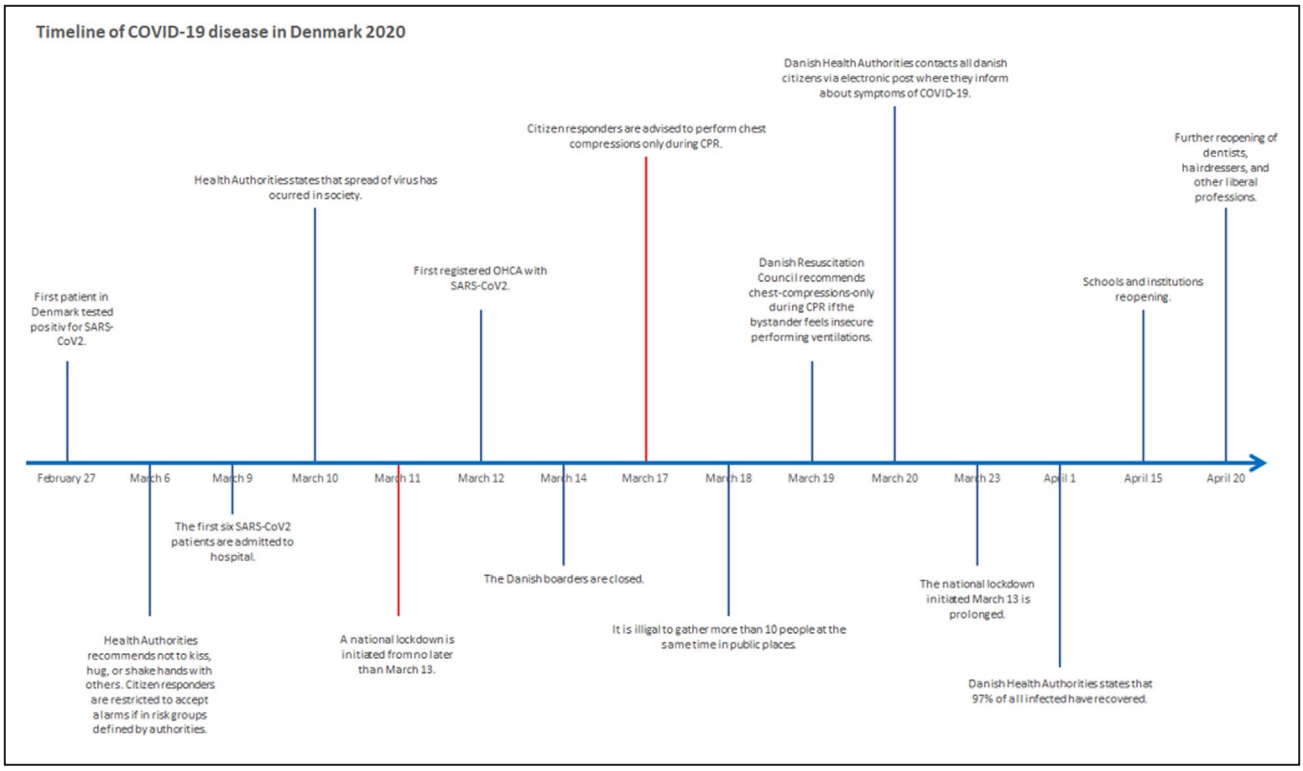

Figure 2. Timeline of the national restrictions and announcements during the COVID-19 pandemic in the first half year of 2020 in Denmark.
Red bars indicate important announcements. CPR indicates cardiopulmonary resuscitation; and OHCA, out-of-hospital cardiac arrest.

self-reported psychological impact on citizen responders attending OHCA during the first half year of the COVID-19 pandemic.

Despite nationwide restrictions introduced to prevent the spread of COVID-19 in Denmark, including closedown of public places, encouragement of social distancing, and avoidance of close physical contact, we found a high citizen responder engagement when alerted to an OHCA via a smartphone app during the lockdown period in Denmark. Bystander CPR, performed by either citizen responders or nondispatched bystanders on scene, remained high during the national lockdown. We did, however, see a shift toward citizen responders performing chest-compression-only CPR during lockdown and a decrease in the proportion of citizen responders performing standard CPR with ventilations, which was recommended by the Citizen Responder Program. The distance from citizen responder to nearest public available AED did not differ between the periods, but a nonsignificant decrease in bystander defibrillation was seen during the lockdown period. However, the number of OHCAs defibrillated by EMS experienced a nonsignificant increase in the lockdown period compared with the nonlockdown period, making the number of OHCAs who were defibrillated by either bystanders or EMS similar in both periods. Surprisingly, citizen responders reported less degree of psychological impact when attending OHCA in the lockdown period.

Citizen Responder Activation in a Pandemic

In Denmark, the Citizen Responder Program remained active during the COVID-19 pandemic. In Europe, most other similar Citizen Responder Programs were paused or continued with restrictions (recommendation of chest-compression-only CPR).[6] In the United States, the PulsePoint first responder application[17] also continued to operate during COVID-19.[18] The PulsePoint application is typically used to dispatch responders to OHCA in public places. In contrast, the Danish Citizen Responder Program is predominantly used to treat OHCAs in residential areas (≈80% of all OHCAs with dispatched citizen responders). We continued to experience a high degree of citizen responders accepting alarms during the lockdown and even observed a small trend toward an increase in acceptance rates. This may partially be explained by the amount of people commanded to work from home, as most OHCAs occurred in residential settings. In addition, it might be easier to postpone work tasks if working alone out of office and hence making acceptance of an OHCA alarm more likely. The

Table 1. Characteristics for Patients With OHCA in the Period From January to June 2020 in Denmark

Characteristic	Lockdown status 2020		*P* value	Missing
	Nonlockdown (141 d)	Lockdown (41 d)		
Cardiac arrest characteristics				
Total No. of OHCAs*	533	165	…	…
Cardiac arrest incidence/100 000 inhabitants per d	0.2	0.2	…	…
No. of patients included	182	74	…	…
Age, median (IQR), y	74 (18)	74 (16)	0.6	4
Male sex, n (%)	117 (65)	50 (68)	0.6	4
Residential location, n (%)	150 (82)	62 (84)	1.0	…
Bystander-witnessed arrest, n (%)	90 (50)	41 (55)	0.5	1
Bystander CPR, n (%)†	168 (92)	73 (99)	0.07	…
Shockable rhythm (VF/pVT), n (%)	43 (24)	17 (24)	1.0	3
Bystander defibrillation, n (%)†	25 (14)	7 (9)	0.4	…
EMS defibrillation, n (%)	50 (27)	24 (32)	0.4	…
Outcomes				
ROSC at hospital arrival, n (%)	41 (23)	17 (23)	1.0	…

CPR indicates cardiopulmonary resuscitation; EMS, Emergency Medical Services; IQR, interquartile range; OHCA, out-of-hospital cardiac arrest; pVT, pulseless ventricular tachycardia; ROSC, return of spontaneous circulation; and VF, ventricular fibrillation.

*All OHCAs in the 2 regions with and without citizen responder activation.

†Bystanders include both citizen responders and nondispatched bystanders present on scene.

Danish Health Authorities defined that people aged <65 years had little risk of severe COVID-19 when no chronic illnesses were present.[19] The median age of citizen responders in both periods (35 years) was far from this cutoff, which also could contribute to the continued high acceptance rate. Our findings are in agreement with a recent German observational study based on 1000 cases from a similar Citizen Responder Program, which also found that at least one citizen responder accepted the alarm in ≈50% of all cases during the COVID-19 pandemic.[20] Finally, a change of citizen responders' attitude toward accepting alarms is probably a slow and multifactorial process. This attitude of acting as a citizen responder is not modified overnight by a governmental decision of initiation of a national lockdown as the current situation with few COVID-19 cases in Denmark, the concerns about what is happening in other countries worldwide, the growing volume of governmental information, and one's own beliefs and disbeliefs influence the attitude.

We also observed that both distance from citizen responder to OHCA and an available AED were unchanged during the study period. The lockdown resulted in closure of offices, bars and restaurants, and other public available places where AEDs typically are placed. However, this did not seem to impact the distance to nearest publicly available AED for the citizen responders. A partial explanation might be that ≈60% of all registered AEDs in Denmark already are publicly available 24 hours 7 days a week.[14] Therefore, the closure of shops and public buildings could have less impact on the number of available AEDs. In contrast, other countries experienced a major reduction in public available AEDs during the closure of nonessential businesses and buildings.[21]

Citizen responders who reported having performed CPR were more likely to perform chest-compression-only CPR during the lockdown period compared with the nonlockdown period. All citizen responders received an e-mail only 6 days after the national lockdown was initiated on March 11, 2020, to prevent spread of COVID-19 to attending citizen responders and bystanders. The recommendation about chest-compression-only CPR (and further to place a cloth or facemask over the patient's nose and mouth during resuscitation attempt) was later on April 6, 2020, supported by the Danish Resuscitation Council.[22] The Danish recommendations were supported by both the American Heart Association Cardiopulmonary Resuscitation Guidelines during COVID-19, published April 9, 2020, and the updated European Resuscitation Council Guidelines, published June 7, 2020.[7,8]

A lower degree of psychological impact on citizen responders attending OHCA during the lockdown compared with nonlockdown was an unexpected finding. Numerous other studies report a high degree of psychological distress among both health care workers and the general population during the COVID-19 pandemic.[23–27] The early information campaign with respect to chest-compression-only CPR might have

Table 2. Characteristics for Citizen Responders in the Period From January to June 2020 in Denmark

Characteristic	Lockdown status 2020		*P* value	Missing
	Nonlockdown (141 d)	Lockdown (41 d)		
Citizen responder characteristics Presumed OHCA				
No. of cases (presumed OHCA) with citizen responder activation	312	131	…	…
No. of alarmed citizen responders (presumed OHCA)	4176	1944	…	…
Citizen responders who responded to the alarm, n (%)	3017 (72)	1389 (71)	…	…
Citizen responders who accepted the alarm, n (%)	1525 (37)	728 (37)	…	…
No. of citizen responders accepting an alarm of all presumed OHCAs, median (IQR)	5 (5)	6 (6)	0.05	…
Male sex of alarmed citizen responders (presumed OHCA), n (%)	2140 (52)	1016 (53)	0.51	42
Age of alarmed citizen responders (presumed OHCA), median (IQR), y	35 (19)	35 (19)	0.55	42
Citizen responder characteristics True OHCA				
No. of true OHCAs with activation of citizen responders	182	74	…	…
No. of alarmed citizen responders to true OHCA	2456	1075	…	…
Citizen responders who responded to the alarm, n (%)	1776 (72)	779 (72)	…	…
Citizen responders who accepted the alarm, n (%)	928 (38)	407 (38)	…	…
Citizen responder distance				
Distance between citizen responder and OHCA, median (IQR), m	622 (561)	640 (571)	0.3	…
Distance between citizen responder and AED, median (IQR), m	354 (406)	360 (400)	0.1	…

AED indicates automated external defibrillator; IQR, interquartile range; and OHCA, out-of-hospital cardiac arrest.

had a calming effect on those who chose to remain active. The young median age of alarmed citizen responders (35 years) might also contribute to the continued high support to the Citizen Responder Program during COVID-19 as the median age of those with severe illness is higher.[28] Furthermore, the incidence of COVID-19 cases in Denmark on March 31, 2020 (36/100 000), never reached levels as high as found in southern European countries (Italy, 65/100 000; and France, 45/100 000) or the United States (53/100 000), which could also explain why more citizen responders accepted to attend in OHCA resuscitation.[29]

Out-of-Hospital Cardiac Arrest During a Pandemic

Although the total daily OHCA incidence in 2 regions of Denmark during the COVID-19 pandemic in the first half year of 2020 did not increase, several other European countries experienced increased cases of OHCA during the COVID-19 pandemic in 2020.[30,31] A similar trend with increased OHCA incidence was seen in the United States, especially in areas with high COVID-19 mortality.[32,33] The first patient with COVID-19 in Denmark was diagnosed on February 27, 2020. In France, the first patient was diagnosed a month earlier on January 24, 2020.[34] The Danish government initiated a national lockdown on March 11, 2020, while lockdown in Paris began on March 17, 2020.[30] Both the late spread of COVID-19 and the early national lockdown in Denmark might have contributed to the lack of increase in the incidence of OHCA during the Danish COVID-19 pandemic in the first half year of 2020. This is supported by another study investigating all-cause mortality in Denmark, which did not increase in the study period compared with the same period during 2015 to 2019.[35] However, several European countries (including Denmark) and the United States saw a decline in cardiovascular hospital admissions and an increase in non–COVID-19 deaths during the beginning of the COVID-19 pandemic.[36–47]

Our study found that the COVID-19 pandemic in Denmark did not affect willingness to perform bystander CPR and defibrillation in patients with OHCA. A recent systematic review, including 10 studies, found lower OHCA survival, lower bystander defibrillation, and longer ambulance response time during the pandemic.[48]

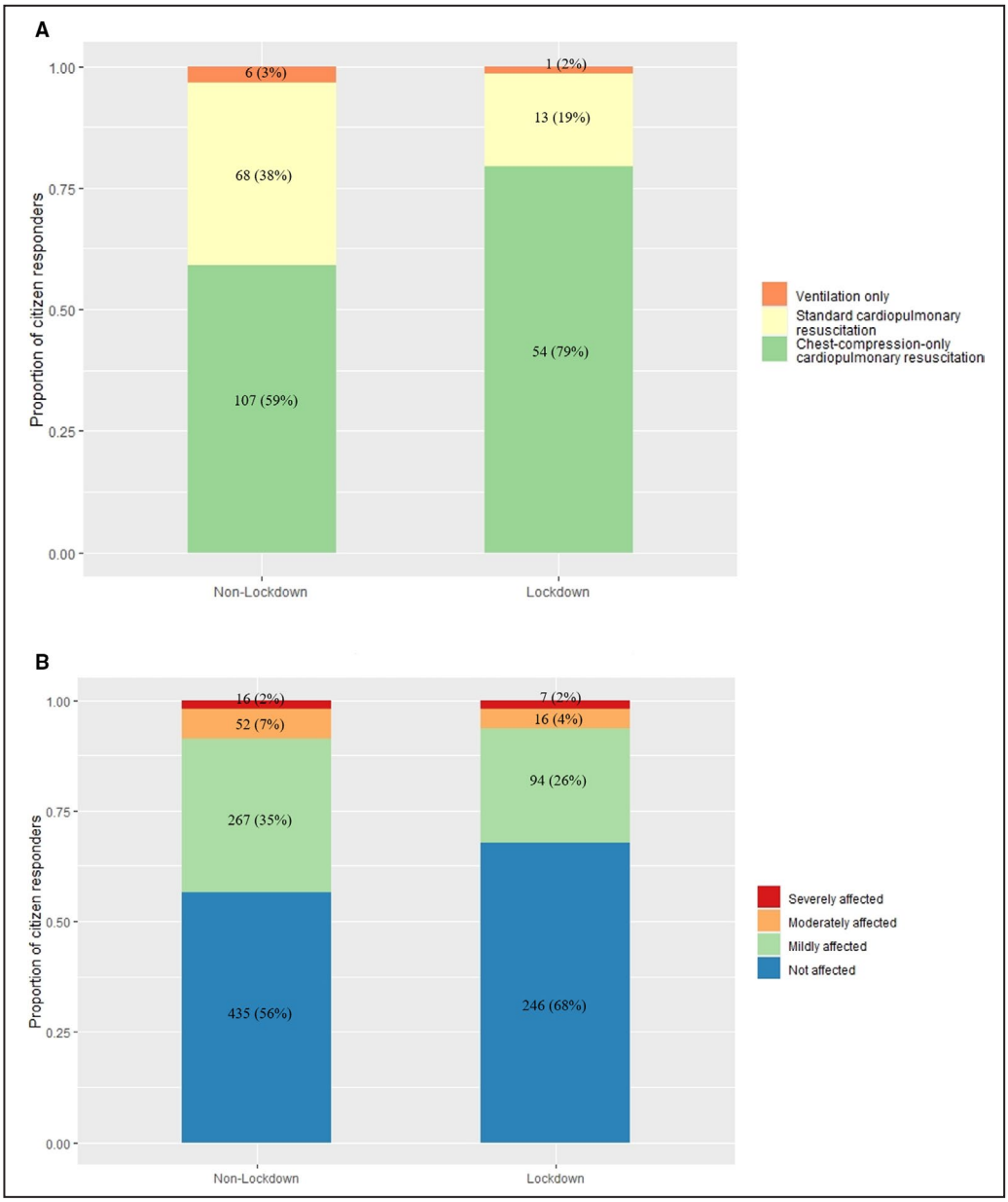

Figure 3. Citizen responder reports with respect to cardiopulmonary resuscitation and psychological impact.
A, Type of cardiopulmonary resuscitation performed by citizen responders during nonlockdown and lockdown. **B,** Citizen responder psychological impact following out-of-hospital cardiac arrest. Degree of psychological impact in percentages reported by citizen responders in nonlockdown and lockdown periods.

Bystanders, citizen responders, and emergency responders might hesitate to perform basic interventions on potentially COVID-19–infected patients with OHCA, especially as CPR is considered an aerosol-generating procedure.[49] Furthermore, health care professionals were advised not to perform CPR without full personal protective equipment, hence potentially delaying treatment to patients with OHCA.[50] Providing full personal protective equipment to citizen responders is not feasible. However, in Denmark, it was emphasized that bystander interventions remained a high priority.[22] This recommendation might have contributed to the continued high rate of bystander CPR, defibrillation, and return of spontaneous circulation at hospital arrival in Denmark. In addition, the Citizen Responder Program in Denmark continued with the above restrictions during the COVID-19 pandemic. A recent study showed that all of the included Citizen Responder Programs in Europe

either continued with some restrictions or temporarily stopped activation of volunteers to OHCA.[6] This approach is supported by a study from the United States, which found that the risk of dying of community-acquired severe COVID-19 for bystanders and citizen responders attending OHCA is markedly lower compared with the chance of successfully resuscitating patients experiencing OHCA with early bystander CPR and defibrillation.[51] The recommendation to continue bystander interventions was despite a COVID-19 incidence among patients with OHCA of 5% to 11% in homes and nursing home facilitites.[51] However, a recent systematic review was unable to estimate the risk of aerosol transmission of SARS-CoV-2 (the virus causing COVID-19) during CPR and defibrillation because of little existing evidence.[52] However, bystander interventions reflected interventions performed by both nondispatched bystanders (eg, the one who made the emergency call) and dispatched citizen responders. It is difficult to register which interventions that are performed strictly by nondispatched bystanders as both nondispatched bystanders and dispatched citizen responders may be present on EMS arrival. This comparison is identical to previously published data on citizen responder activation.[10] Last, we report the number of citizen responders who accepted the alarm, which is of greater interest in this current study.

Limitations

This study is limited by its observational nature, and associations should be interpreted as so and not as causalities. We compared a lockdown period with nonlockdown period, although the rate of community transmission of COVID-19 might not be causally linked to these periods. Subsequently, the first patient with COVID-19 was diagnosed ≈2 weeks before the first nonlockdown period ended, which could contribute to some degree of confounding. However, at this time, no restrictions were yet implemented, and the Danish citizens could do their daily businesses unhindered. Therefore, we believe that the degree of potential confounding is minimal. Screening of nonsymptomatic citizens without contact to a COVID-19–infected patient was not initiated during the study period, nor were patients with OHCA or citizen responders who attended an alarm routinely screened. Only OHCAs admitted to hospital were tested for COVID-19. Therefore, the lockdown period might not reflect the time with the highest COVID-19 incidence in Denmark. Second, the study included a limited number of OHCAs, and the results should be interpreted with caution. The primary outcomes of the study relate to few OHCAs with citizen responder activation (≈35% of all OHCAs in the period). Therefore, the findings do not necessarily describe the general trends with respect to bystander interventions in the full OHCA population. The study was performed in only 2 of 5 regions of Denmark. One of the included regions, North Denmark Region, implemented the citizen responder application on February 14, 2020. This was approximately a month after the study was initiated. This could underestimate the number of OHCAs with dispatched citizen responders in the nonlockdown period. Overall, the lack of complete national data from all 5 regions of Denmark could underestimate the number of OHCAs in both lockdown and nonlockdown periods. The implementation of the Citizen Responder Program in the North Denmark Region during the study period might contribute as a bias as the EMS dispatchers initially had limited experience with the program. Yet, other similar citizen responder text-message programs have been used in the North Denmark Region years before the implementation of the app-based program, making the dispatchers experienced in citizen responder activation in general. Furthermore, when the app was launched in the North Denmark Region, several thousand had already registered as users in this area. A high proportion of citizen responders who accepted an alarm (86%) answered the following questionnaire. However, the remaining ≈15% not answering the questionnaire could potentially be severely affected and, therefore, these results should be interpreted carefully. Finally, this is a simple pre-post analysis comparing *P* values as opposed to multivariable logistic regression models or interrupted time series analysis that can take into account multiple factors.[53]

CONCLUSIONS

This retrospective register study found continued high proportions of bystander interventions in OHCAs attended by citizen responders during the COVID-19 lockdown in 2 regions of Denmark in the first half year of 2020. The willingness to perform bystander CPR was unchanged, but a shift toward chest-compression-only CPR among citizen responders was observed during the lockdown period after repeated recommendations to this approach. We found no difference in the number of citizen responders accepting alarms in the lockdown period compared with the nonlockdown period. However, fewer citizen responders reported being psychologically impacted during the lockdown period. No difference in return of spontaneous circulation at hospital arrival was seen, and the total daily OHCA incidence (with and without citizen responder activation) remained unchanged.

ARTICLE INFORMATION

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Disclosures

None.

Supplemental Material

Figure S1

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SUPPLEMENTAL MATERIAL

Figure S1: Flowchart of the amount of citizen responders who answered the questionnaire.