Attitudes among healthcare professionals towards cardiopulmonary resuscitation during COVID-19

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ABSTRACT

Background: Out-of-hospital cardiac arrests (OHCAs) are a leading cause of mortality in the United States. The on-going COVID-19 pandemic has dramatically altered the landscape of response to OHCAs, particularly with regard to providing cardiopulmonary resuscitation (CPR). We aimed to describe, characterize, and address the attitudes and concerns of healthcare workers towards CPR of OHCA patients during the COVID-19 pandemic.

Methods: We performed a cross-sectional study of healthcare workers and trainees in the United States and Saudi Arabia via an online survey available between October 2020, and May 2021. The primary outcome of interest was willingness to perform CPR for OHCA, with confidence to handle CPR for OHCA as our secondary outcome.

Results: A total of 501 healthcare professionals, including 436 (87%) with background in emergency medicine, participated in our survey. 331 (66%) reported being willing to perform CPR for OHCA, while 170 (34%) were not willing. 311 (94%) willing participants stated that their medical oath and moral responsibility were the main motivators for willingness, while a fear of contracting COVID-19 was the primary demotivating factor for 126 (74%) unwilling participants. Time series analysis with simple exponential smoothing showed an increase in willingness to perform CPR from 30% to 50%, as well as an increase in mean confidence level to perform CPR from 60% to 70%, between October 2020 and May 2021.

Conclusions: The ongoing COVID-19 pandemic significantly affected healthcare workers' attitudes towards performing CPR for OHCA. Confidence levels and willingness to perform CPR increased over time during the study period. Efforts should be directed towards the creation of standardized and evidence-based guidelines for CPR during COVID-19, as well as increasing knowledge regarding risks of infection and effective use of PPE during resuscitation.

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1. Introduction

Out-of-hospital cardiac arrests (OHCAs) are a leading cause of mortality, accounting for over 350,000 deaths in the United States annually [1]. First responders and medical personnel play pivotal roles in early efforts to resuscitate these patients and optimize outcomes. The ongoing COVID-19 pandemic has dramatically altered the landscape of pre-hospital and hospital response to OHCAs, and emerging data regarding transmissibility as well as the widespread use of vaccines has resulted in a rapidly evolving situation. Research exploring the incidence of OHCA events during the pandemic

has been mixed. Early studies out of New York, Italy, and France initially indicated an increasing number of out-of-hospital cardiac arrests associated with an escalating COVID-19 case burden [2,3,4,5]. Other research from Washington State, Italy, and Germany demonstrated no appreciable change in OHCA incidence during the early pandemic period [6,7,8]. However, a meta- analysis of 35,379 OHCA events published in December of 2020 reported a 120% increase in incidence since the start of the pandemic, as well as higher mortality rates [9]. Researchers have proposed that OHCA mortality during the pandemic has trended upward due to difficulty accessing medical care, increased stress, and fewer health maintenance visits [5]. Though ongoing research will help elucidate and clarify the association between increased OHCA incidence and COVID caseload, the pandemic has undoubtedly impacted emergency response to these events.

The COVID-19 pandemic has posed major challenges to pre-hospital and hospital care of OHCA patients, particularly with regard to providing high-quality cardiopulmonary resuscitation (CPR). Early in the pandemic,

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guidance on the appropriate use of personal protective equipment (PPE) prior to initiation of resuscitation was inconsistent, sometimes contradictory, and frequently changing [10,11]. National agencies have since attempted to standardize resuscitation guidelines, but little research has been done to explore how first responders and healthcare workers would have modified their clinical practices in response. Variability in practice and willingness to perform CPR on a patient who is COVID-19 positive or whose COVID status is unknown can be attributed to a number of factors, including fear, individual values, and bias. The goal of this study is to describe, characterize, and address the attitudes and concerns of healthcare workers towards cardiopulmonary resuscitation of OHCA patients during the COVID-19 pandemic.

2. Methods

2.1. Survey design and distribution

This IRB-approved project was a cross-sectional study of healthcare workers in the United States and Saudi Arabia and was distributed in the form of an online survey, available from October 2020, to May 2021. Survey data was collected and managed using REDCap electronic data capture tools hosted at The George Washington University [12,13]. The questionnaire consisted of a series of single and multiple response items that examined study participant demographics and job titles, knowledge about COVID-19 transmission, attitudes and barriers to performing CPR on OHCA patients, and ways to improve healthcare workers' comfort with CPR during COVID-19. Other topics addressed in the questionnaire included Basic Life Support (BLS), Advance Cardiovascular Life Support (ACLS), and American Heart Association (AHA) competency regarding COVID-19 CPR, attitudes towards the use of PPE during CPR, and the role of COVID-19 testing in protecting healthcare workers who are involved in resuscitations. Question styles included simple "yes" or "no" responses, single or multiple selection categorical variables, and numerically scaled scores. Where applicable, survey participants were also able to free-text explanations and rationales for their answers, often in conjunction with selecting "other" in response to a question.

2.2. Study participants and consent

This study was a collaboration between The George Washington University, University of Maryland, and King Abdulaziz University in Saudi Arabia. Target participants were healthcare professionals and trainees in these two countries, including attending and resident physicians, physician assistants and nurse practitioners (PA/NP), medical students, emergency medical technicians (EMTs), registered nurses (RNs), and auxiliary medical staff. All healthcare workers who received the link to the survey via work or professional email were eligible to participate. Each participant was directed to a voluntary electronic consent form prior to answering the questionnaire.

2.3. Data analysis

Once survey responses were collected in REDCap, data was initially presented via simple bar graphs within REDCap for categorical data and via scatterplot for quantitative or scaled data points. We used descriptive analysis to present the participants' demographics and survey choices. We expressed our continuous variables, when appropriate, as mean [Standard Deviation (SD)] and categorical variables as percentages. We used Student's t-test and chi-square test to compare continuous and categorical variables between groups, respectively.

We chose willingness of participants to perform CPR for OHCA as the primary outcome and confidence to handle CPR for OHCA as our secondary outcome. Willingness to perform CPR was dichotomized as "Yes" or "No", the latter including participants who answered "No" or "Not Sure". Confidence level was measured on a scale from 0 to 100

(with 0 being the least confident and 100 being the most) and expressed as an integer along the scale.

Table 1
Demographic information of 501 participants

Variables	All participants (N, %)	Willing to perform CPR (N)	(%)	Not Willing to Perform CPR* (N)	(%)	P
Total number	501	331	66	170	34	
Job titles, N (%)						
Attending physicians/consultants	263 (53)	186	(56)	77	(45)	0.02
EMT/Paramedics	27 (5)	18	(5)	9	(5)	0.99
Medical Students	20 (4)	5	(2)	15	(9)	0.001
Registered nurses	18 (4)	8	(2)	10	(6)	0.049
Resident - PGY-1	43 (9)	33	(10)	10	(6)	0.12
Resident - PGY-2	48 (10)	29	(9)	19	(11)	0.38
Resident - PGY-3	46 (9)	30	(9)	16	(9)	0.88
Resident - PGY-4	30 (6)	19	(6)	11	(6)	0.74
Other	5 (1)	3	(1)	2	(1)	0.99
Training background, N (%)						
Emergency Medicine	436 (87)	299	(90)	137	(81)	0.001
Family medicine	9 (2)	1	(0)	8	(5)	0.001
Intensive care	21 (4)	14	(4)	7	(4)	0.99
Internal medicine	7 (1)	1	(0)	6	(4)	0.01
Surgery	7 (1)	2	(1)	5	(3)	0.048
Other	20 (4)	14	(4)	6	(4)	0.71
Country, N (%)						
Saudi Arabia	238 (48)	146	(44)	92	(54)	0.03
United States	251 (50)	177	(53)	74	(44)	0.04
Other	11 (2)	8	(2)	3	(2)	0.76
Gender, N (%)						
Male	255 (51)	181	(55)	74	(44)	0.02
Female	240 (48)	145	(44)	95	(56)	0.01
Age (years), N (%)						
<30	130 (26)	87	(26)	43	(25)	0.81
30–39	225 (45)	132	(40)	93	(55)	0.001
40–50	105 (21)	82	(25)	23	(14)	0.41
>50	40 (8)	30	(9)	10	(6)	0.21
Years of practice, N (%)						
<5	207 (41)	129	(39)	78	(46)	0.14
5 to 10	138 (28)	92	(28)	46	(27)	0.86
>10	155 (31)	110	(33)	45	(26)	0.12
Types of Life Support Certification, N (%)						
None	35 (6)	25	(8)	10	6	0.49
BLS	62 (13)	29	(9)	33	(19)	0.001
BLS & ACLS	400 (81)	277	(84)	123	(72)	0.003
Knowledge about COVID-19 Transmission mode, N (%)**						
Droplets	481 (96)	316	(95)	165	(97)	0.39
Close contact	325 (65)	209	(63)	116	(68)	0.26
Touching contaminated surfaces	243 (49)	154	(47)	89	(52)	0.22
Airborne	218 (44)	154	(47)	64	(38)	0.06
Do not Know	5 (1)	1	(0)	4	(2)	0.047
Other	3 (1%)	3	(1)	0	(0)	NA
Personal opinion about the minimum acceptable PPE to perform CPR, N (%)**						
Surgical facemask	103 (21)	70	(21)	33	(19)	0.65
Face shield/goggles	302 (60)	199	(60)	103	(61)	0.92
N95 facemask	445 (89)	295	(89)	150	(88)	0.76
Disposable gloves	420 (84)	281	(85)	139	(82)	0.37
Disposable gowns	219 (44)	151	(46)	0	(0)	NA
Shoe cover	48 (10)	29	(60)	0	(0)	NA
Confidence Level to handle CPR for OHCA during the pandemic, mean (SD)	70 (23)	78	(19)	55	(23)	0.001

ACLS; Advanced Cardiovascular Life Support; BLS, Basic Life Support; COVID-19, Coronavirus disease 2019; EMT, Emergency medical technician; NA, statistical analyses were not performed; PGY-, post-graduate year; PPE, personal protection equipment.

* The group of Not Willing to perform CPR for OHCA included 58 participants who were NOT willing to perform CPR and 111 participants who were NOT Sure about performing CPR.

** Answer is not graded, one participant can select more than one answers.

We performed a time series analysis to investigate the trend of outcomes (willingness to perform CPR for OHCA and the mean confidence level to handle CPR for OHCA). We subsequently used a simple exponential smoothing algorithm to remove any seasonal or potential variations during the study period.

To identify factors associated with either outcome, we used the classification and regression tree (CART) model. The CART model is a machine learning algorithm which is particularly robust for data sets with outliers or missing variables. This model performs repetitive partitioning to identify a series of dichotomous splits (i.e., willing to perform CPR vs. not willing to perform CPR) according to the independent variables. At each step, the algorithm examines the interactions between each independent variable and all other independent variables or different values of the independent variables to perform the best classifications. This process is repeated until the algorithm achieves the best separation of independent variables. The CART model starts with a "node" and ends with "terminal nodes" when no further split is possible. The most significant independent variable that is responsible for a split is assigned a "relative variable importance" value of 100%. Subsequent significant independent variables are assigned a percentage of the most significant independent variable. The CART model offers advantages over the traditional multivariable regression models, because the CART's tree diagram is visually intuitive. Furthermore, the CART can provide exact values of any specific continuous independent variable that is responsible for the split, in contrast to a multivariable regression which only shows an association of a particular independent variable.

For our CART analysis, we used 10-fold cross-validation in which the CART will identify the significant independent variables in 90% of the population and then validate the results in a unique 10% of population up to 10 times. We did not limit the depth of our tree diagram, although we did specify three cases of each classification (i.e. willing to perform CPR vs. NOT willing to perform CPR) as the minimum number of "terminal nodes." We only considered independent variables with a "relative variable importance" of ≥10% as statistically significant.

We performed our descriptive analyses, CART using Minitab version 19 (Minitab LLC, State.

College, PA).

3. Results

3.1. Participants and demographics

A total of 501 healthcare professionals participated in our survey study. 331 (66%) participants were willing to perform CPR for OHCA during the pandemic, while 170 (34%) participants were *not* willing (Table 1). Among this group, there were 58 (12%) who were *not* willing

to perform CPR and 111 (22%) participants who were not sure about willingness to perform CPR for OHCA. 263 (53%) of participants listed attending physician/consultant as their job title, and 436 (87%) reported a training background in emergency medicine. Among participants, 255 (51%) were male, 251 (50%) were from the United States, and 238 (48%) were from Saudi Arabia (Table 1). The most common age group was 30–39 years old (225, 45%), and most participants reported <5 years of practice (207, 41%). 400 (81%) of participants reported having received both BLS and ACLS training and certification. A summary of demographic findings is listed in Table 1.

3.2. Knowledge about COVID-19 transmission

Participants were asked to select one or multiple transmission pathways for COVID-19 based on their baseline medical knowledge. 481 (96%) participants selected "droplet", while 325 (65%) chose "close contact with an infected person", 243 (49%) listed "touching contaminated surfaces", and 218 (44%) indicated "airborne transmission" (Table 1). An additional 5 (1%) and 3 (1%) of participants selected "do not know" and "other". Among the 331 participants willing to perform CPR, 316 (95%) indicated that droplet was a mode of transmission, while 209 (63%) listed close contact, 154 (47%) specified contaminated surfaces, and 154 (47%) selected airborne transmission (Table 1). Of the 170 participants who were not willing to perform CPR, 165 (97%) selected droplet as a mode of transmission for COVID-19, while 116 (68%) chose close contact, 89 (52%) listed contaminated surfaces, and 64 (38%) indicated airborne transmission. Additionally, 4 (2%) of participants who were not willing to perform CPR reported not knowing how COVID-19 was transmitted, which was statistically significant ($p = 0.047$) (Table 1).

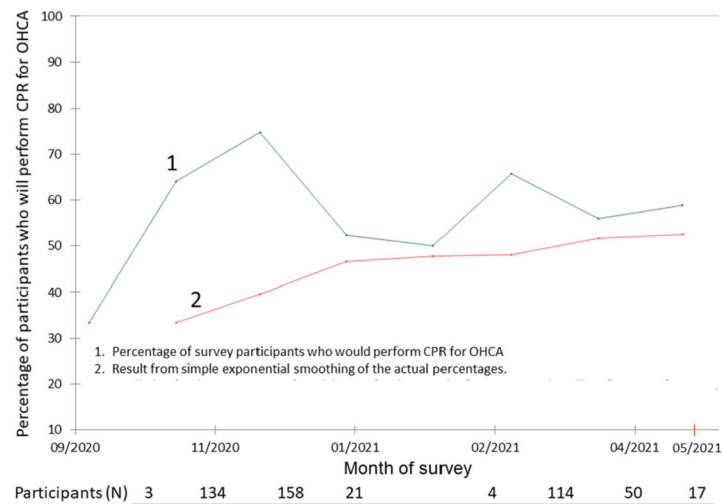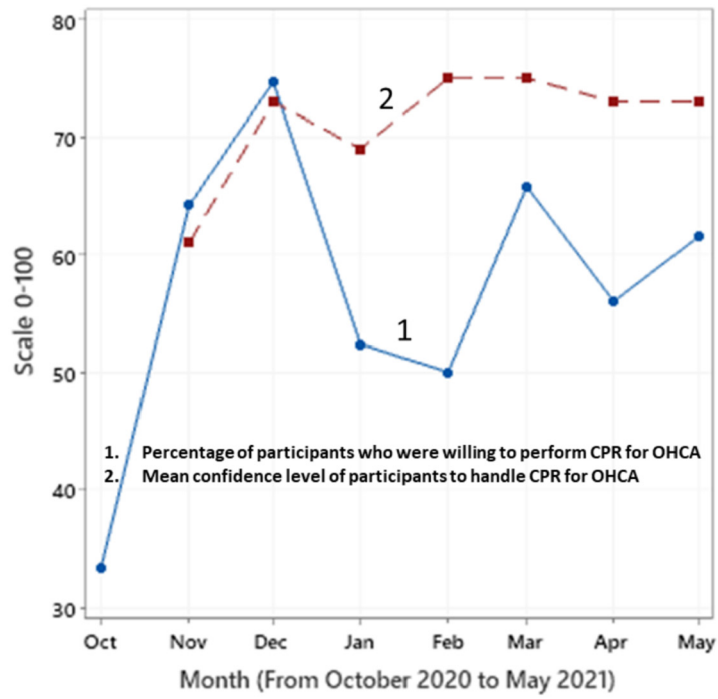### 3.3. Attitudes and barriers towards performing CPR on OHCA patients

Among the 331 participants who reported being willing to perform CPR on OHCA patients during the COVID-19 pandemic, 311 (94%) stated that their medical oath and moral responsibility were the reasons for their willingness (Table 2). Additionally, 3 (1%) and 10 (3%) participants listed a legal liability and a belief that CPR carries minimal-to-low risk of COVID-19 transmission, respectively, as reasons for being willing to perform CPR. The 170 participants who were not willing to perform CPR were able to select more than one reason for their response, the most common being a fear of contracting COVID-19, which was selected by 126 (74%) of participants (Table 2). Among this same group, 78 (46%) participants indicated a fear of transmitting COVID-19 to others, 43 (25%) chose unavailability of PPE, and 36 (21%) believed OHCA from COVID-19 had a low survival rate. Other reasons for not being willing to perform CPR included an absence of effective treatment or vaccines and a fear of isolation and not being able to work for 14 days, which

Table 2
Reasons for willingness to perform CPR or NOT willing to perform CPR

Variables	Results
Reasons for performing CPR, N (%)	331 (100)
Medical oath and moral responsibility	311 (94)
Legal liability	3 (1)
CPR in OHCA carries minimal to low risk of COVID-19 transmission	10 (3)
Other reasons	7 (2)
Reasons for not performing CPR, N (%)*	170 (100)
Fear of contracting COVID-19	126 (74)
Fear of isolation and not able to work for 14 days	20 (12)
Fear of transmitting COVID-19 to others	78 (46)
Absence of effective treatment or vaccines	27 (16)
OHCA from COVID-19 has low survival rate	36 (21)
PPE is not available	43 (25)
Other reasons	3 (2)

COVID-19, Coronavirus disease 2019; CPR, cardiopulmonary resuscitation; OHCA, Out-of-hospital cardiac arrest; PPE, personal protection equipment.
 * One participant can select more than one answers.

Table 3
Participants' suggestions to improve healthcare workers' confidence in performing cardiopulmonary resuscitation (CPR)
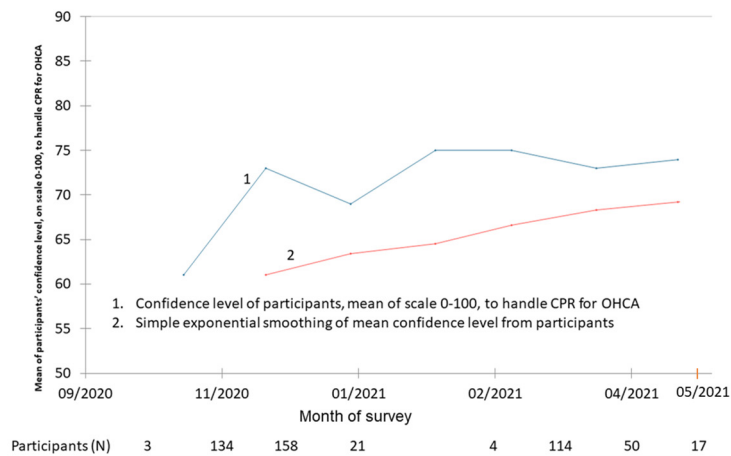
Variables*	Results
N = 501	N (%)
Including PPE with AEDs in all public places	442 (88)
Mandatory COVID-19 testing for bystanders who perform CPR for OHCA	204 (41)
Mandatory isolation for bystanders who perform CPR for OHCA if COVID-19 test is unavailable (paid for by Ministry/Department of health)	107 (21)
Other reasons	36 (7)

AED, Automated External Defibrillator; COVID-19, Coronavirus disease 2019; CPR, cardiopulmonary resuscitation; OHCA, Out-of-hospital cardiac arrest; PPE, personal protection equipment.
 * One participant can select more than one answers.

1. Percentage of participants who were willing to perform CPR for OHCA
2. Mean confidence level of participants to handle CPR for OHCA

1. Percentage of survey participants who would perform CPR for OHCA
2. Result from simple exponential smoothing of the actual percentages.

1. Confidence level of participants, mean of scale 0-100, to handle CPR for OHCA
2. Simple exponential smoothing of mean confidence level from participants

were chosen by 27 (16%) and 20 (12%) of participants, respectively (Table 2).

3.4. Improving healthcare workers' confidence in performing OHCA-associated CPR during COVID-19

Participants were able to provide multiple responses as to what measures they believed would improve confidence in performing CPR for OHCA. 442 (88%) participants stated that including PPE with Automatic External Defibrillators (AEDs) in public places would increase healthcare workers' confidence during COVID-19 (Table 3). Additionally, 204 (41%) believed a mandatory COVID-19 test for bystanders who perform CPR would increase confidence levels, with 107 (21%) reporting that, if COVID-19 testing is unavailable, requiring mandatory isolation for bystanders involved in these events would improve healthcare workers' confidence (Table 3).

3.5. Trend of willingness to perform CPR for OHCA and confidence level of handling CPR for OHCA

Our time series plot demonstrated the trend of participants who were willing to perform CPR for OHCA over time (Fig. 1A). This figure also showed changes to the participants' level of confidence during resuscitations over the course of the study period (Fig. 1A). The time series plot with single exponential smoothing demonstrated an upward trend for both the primary and secondary outcomes (Fig. 1B). Early survey data from the beginning of the study period showed that approximately 30% of participants were willing to perform CPR for OHCA. This percentage gradually increased over time (Fig. 1B).

Participants' confidence levels regarding CPR increased in a similar fashion. Survey data indicated that confidence level (measured between 0 and 100) was lowest at the beginning of the study at approximately 60% (Fig. 1C). This confidence level reached 68% by the end of our study (Fig. 1C).

3.6. Factors associated with willingness to perform CPR for OHCA

The classification and regression tree (CART) regression model identified nine factors that were associated with willingness or unwillingness to perform CPR for OHCA (Fig. 2A). From this list, fear of contracting COVID-19 was most significant and was assigned a relative variable importance of 100%. Additional factors were a fear of transmitting COVID-19 to others and the belief that COVID-19 related OHCA has a low survival rate, which were assigned a relative variable importance of 78% and 29%, respectively (Fig. 2A). Two factors were somewhat associated with willingness to perform CPR: seniority (attending physicians and upper level residents) and having "life support certification". These factors were assigned a small relative variable importance of 6% and 4%, respectively.

The following decision tree diagram illustrates how the three most significant factors identified in the survey data were associated with this outcome (Fig. 2B). In summary, there were 501 participants, 331 (66%) of whom would be willing to perform CPR for OHCA (Node 1, Fig. 2B). Among 376 participants who did *not* report "fear of contracting COVID-19 infection", 331 (88%) would be willing to perform CPR while 45 (12%) would *not* be willing to perform CPR (Node 2, Fig. 2B). For 125 participants who reported a "fear of contracting COVID-19 infection", all

125 (100%) would *not* perform CPR for OHCA (Terminal node 1, Fig. 2B). Among 357 participants who did *not* "fear transmitting COVID-19 to others", 331 (93%) would perform CPR while 26 (7%) would *not* perform CPR (Node 3, Fig. 2B). Similarly, for 19 participants who "feared transmitting COVID-19 to others", all 19 (100%) participants would *not* perform CPR for OHCA (Terminal node 2, Fig. 2B). There were 17 participants who stated that they thought "COVID-19 related OHCA has low survival rate", and all 17 (100%) would *not* perform CPR (Terminal Node 3, Fig. 2B). In contrast, with regard to the 340 participants did *not* think "COVID-19 related OHCA has low survival rates", only 9 (3%) would *not* perform CPR (Terminal Node 4, Fig. 2B).

3.7. Factors associated with level of confidence to handle CPR in OHCA

The CART model identified eight factors that were associated with the confidence level to handle CPR in OHCA (Fig. 3A). From this list, fear of contracting COVID-19 was most significant and was assigned a relative variable importance of 100%. The second important factor, which was assigned a relative variable importance of 63%, was the availability of personal protection equipment (Fig. 3A). The following decision tree diagram illustrates how these factors were associated with this outcome (Fig. 3B). In summary, of the available data on 482 participants, the population's mean confidence level to handle CPR for OHCA on a scale of 0–100 was 70 with a standard deviation of 23 (Node 1, Fig. 3B). Among the 120 participants who "feared contracting COVID-19 infection", the mean confidence level was 58 (SD of 23) (Node 2, Fig. 3B), compared to the confidence level of 76 (SD of 21) reported by 362 participants who did *not* "fear contracting COVID-19 infection" (Node 3, Fig. 3B). Among the participants who did *not* "fear contracting COVID-19 infection", 8 participants expressed concerns about the availability of PPE, and their mean confidence level was 40 (SD of 25) (Terminal Node 3, Fig. 3B). Among 354 participants who did *not* "fear contracting COVID-19 infection" AND did *not* express concerns regarding PPE availability (Node 4, Fig. 3B), the mean confidence level to handle CPR was 77 (SD of 20). Within this group, attending physicians, paramedics, and upper-level residents demonstrated a mean confidence level of 79 (SD of 18) (Terminal Node 5, Fig. 3B). In contrast, medical students, registered nurses, and first-year residents reported lower confidence levels with a mean of 64 (SD of 22) (Terminal Node 4, Fig. 3B). For the 120 participants who "feared contracting COVID-19 infection", the mean confidence level for 103 participants trained in either Emergency Medicine or Internal Medicine was 57 (SD of 20) (Terminal Node 2, Fig. 3B), while the mean confidence level to handle CPR in OHCA for 17 participants who were trained in different specialties was 26 (SD of 19) (Terminal Node 1, Fig. 3B).

4. Discussion

This cross-sectional study of healthcare workers in the United States and Saudi Arabia aimed at examining resuscitative measures for patients with OHCA during COVID-19 and identifying the factors affecting healthcare providers' willingness to engage in CPR. Our study found that over half the participants were willing to perform CPR for OHCA during the pandemic, with time series analysis demonstrating that willingness increased throughout the study period over time. However, the number of healthcare professionals who reported that they were not sure or would not be willing to engage in life-saving cardiopulmonary resuscitation was considerable. Many factors affected these healthcare

Fig. 1. Time series plot for percentage of participants who were willing to perform Cardiopulmonary resuscitation (CPR) in Out-of-hospital cardiac arrest (OHCA) and the confidence level of participants to handle CPR in OHCA. B. Time series with single-exponential smoothing for percentage of participants who were willing to perform cardiopulmonary resuscitation (CPR) in out-of-hospital cardiac arrest (OHCA). The Y-axis is the percentage of participants who were willing to perform CPR for OHCA. The X-axis is the number of participants for each month. C. Time series with single-exponential smoothing for confidence level, from scale 0–100, of participants who were willing to perform cardiopulmonary resuscitation (CPR) in out-of-hospital cardiac arrest (OHCA). Confidence level was expressed as mean of the participants for each month. The Y-axis is the mean of the participants' confidence level to handle CPR in OHCA. The X-axis is the number of participants per month.
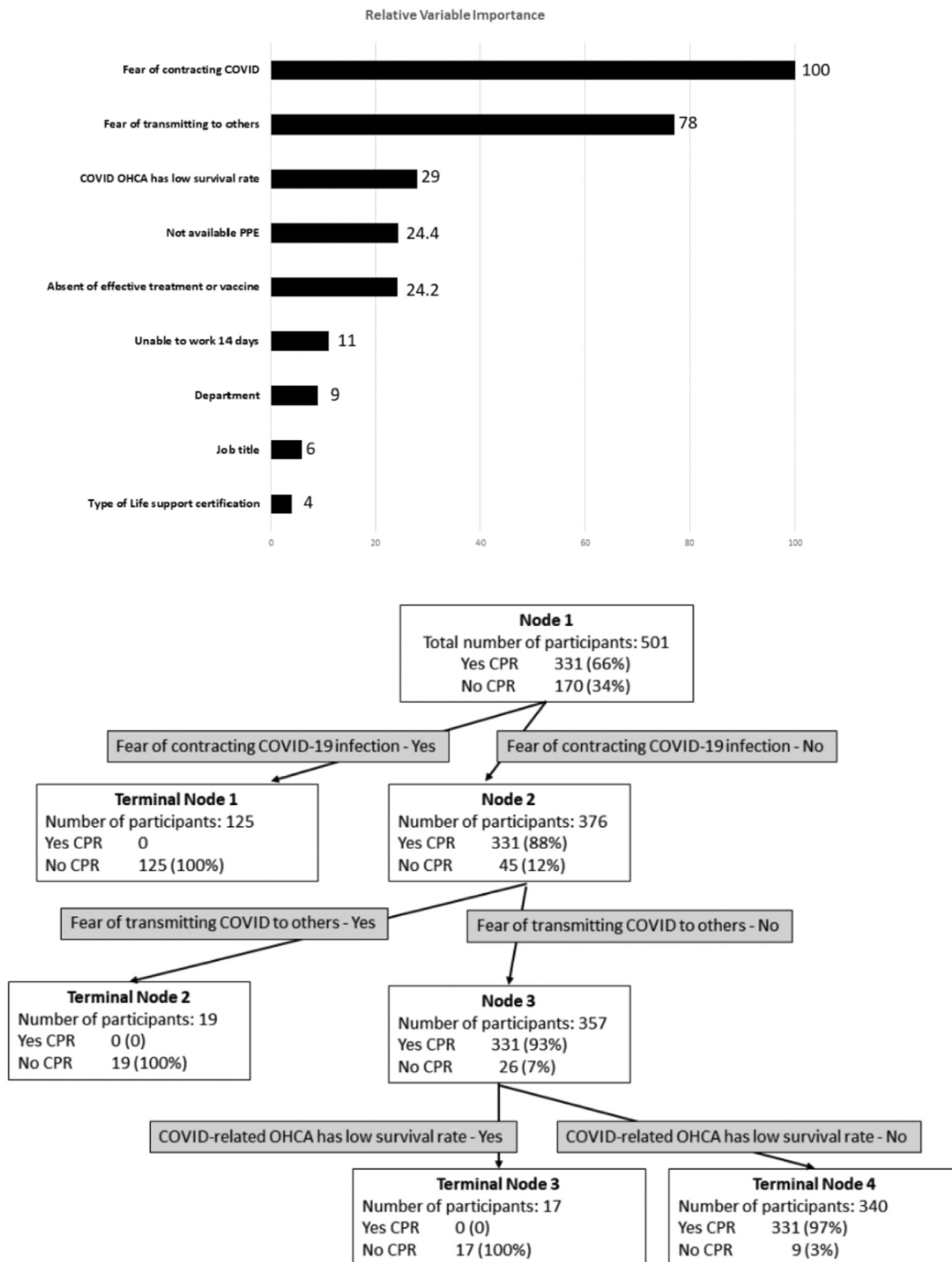
Relative Variable Importance

Fig. 2. A. Results from the Classification and Regression Tree (CART) showing the Relative Variable Importance of significant factors associated with participants' willingness to perform cardiopulmonary resuscitation (CPR) for out-of-hospital cardiac arrest (OHCA). Most important factor was assigned a value of 100%. Subsequent factors would be assigned a value as a percentage of the most important factor. Factors that were not considered important were not included by the CART model. B. Figure Classification and Regression Tree (CART) decision tree for participants' willingness to perform cardiopulmonary resuscitation (CPR) for out-of-hospital cardiac arrest (OHCA). COVID, coronavirus disease; CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; PPE, personal protective equipment.

providers' willingness, particularly fear of contracting COVID-19 infection, fear of transmitting COVID-19 to others, and the belief that COVID-19-related OHCA has a low survival rate.

All survey participants, who acknowledged a "fear of contracting COVID-19 infection" while performing CPR and/or admitted to a "fear of transmitting COVID-19 to others", would *not* be willing to perform CPR during the pandemic. These findings highlight the need to better understand the risk of COVID-19 transmission during cardiopulmonary resuscitation. The World Health Organization (WHO) released a scientific brief in late March of 2020 listing chest compressions as an aerosol
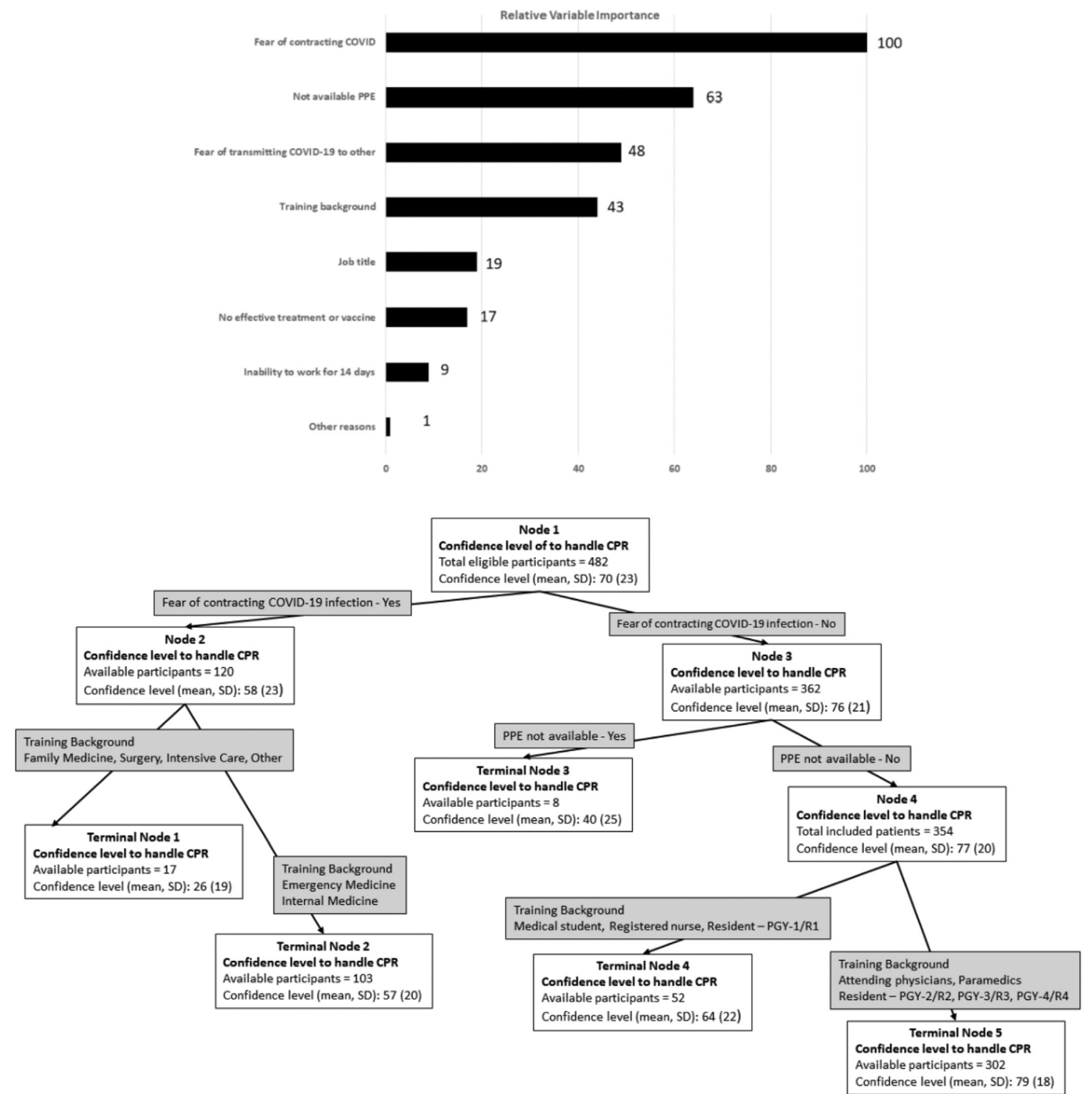
Fig. 3. A. Results from the Classification and Regression Tree (CART) showing the Relative Variable Importance of significant factors associated with participants' confidence level, on scale 0–100, to handle cardiopulmonary resuscitation (CPR) in out-of-hospital cardiac arrest (OHCA). Most important factor was assigned a value of 100%. Subsequent factors would be assigned a value as a percentage of the most important factor. Factors that were not considered important were not included by the CART model. B. Figure Classification and Regression Tree (CART) decision tree for participants' confidence level to handle CPR for OHCA. COVID-19, coronavirus disease 2019; CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; PGY−/R-, post-graduate year-/Resident year-; PPE, personal protective equipment; SD, standard deviation.

generating procedure (AGP) [14]. However, the International Liaison Committee on Resuscitation (ILCoR) has stated that direct evidence of transmission due to individual components of CPR remains uncertain [10]. Without a clear consensus, the degree of risk for COVID-19 transmission during CPR is still unclear for first responders participating in resuscitation for OHCA events.

Additionally, training background appeared to influence participants' attitudes towards performing CPR for OHCA during the

pandemic. Among attending physicians, the proportion of participants who were willing to perform CPR was significantly higher than those who were not willing, while the opposite was true for medical students and registered nurses who participated in the survey. This could be explained by the fact that attending physicians have a higher degree of medical knowledge and experience, which may translate to willingness to participate in life-saving measures. However, this assessment is limited by the fact that only 8% of study participants were medical students

or registered nurses, while over 50% were attending physicians. Further studies should be performed to evaluate if a true association exists between training background and willingness to perform CPR.

Our study identified an upward trend in participants' self-reported confidence levels to handle CPR for OHCA, progressively increasing until the end of our study in May 2021 and predicted to approach even higher levels by June 2021. This is likely due to a number of factors, particularly rapidly emerging data about the transmission of COVID-19, as well as availability of PPE and widespread vaccination of healthcare workers. Since the two most significant factors affecting healthcare providers' confidence in performing CPR in this study were "fear of contracting the virus" and "availability of PPE", it is possible that an increased ability to protect ourselves ameliorated some of the concerns that were highlighted in this study. This is further confirmed by most participants' opinions that the inclusion of PPE with automated external defibrillator in all public places would increase healthcare workers' confidence in performing CPR.

For participants who reported that they feared "contracting COVID-19 infection" during CPR, their average confidence level was significantly lower than those participants who were not afraid of infection. This highlights the importance of ensuring that medical personnel feel safe when caring for critically ill patients by establishing effective infection control guidelines to minimize transmission risk to providers. Our research also demonstrated that participants with a background in emergency medicine were both significantly more willing and more confident performing CPR than participants from other specialties. However, the statistical significance of this is limited by the fact that over 90% of study participants were emergency medicine trained. Further study should be performed that specifically examines this relationship in order to ascertain if a true association exists.

Personal protection equipment (PPE) availability was a significant factor for participants who felt less confident. Our analysis showed that, among those who did not report a fear of contracting COVID-19, confidence level was lowest when providers expressed concerns about PPE availability. Additionally, for the participants who did not report a "fear of contracting COVID-19" and were not concerned about their ability to obtain adequate PPE, the confidence level was significantly higher. The guidance for PPE during OHCA has been not always been consistent between advising agencies, and first responders have been forced to adapt to more localized emergency response guidelines. Organizations such as the American Heart Association (AHA), English National Health Service (NHS), and Belgian Resuscitation Council have recommended that first responders don gloves, gowns, and N95 respirators prior to initiation of CPR on a patient of unknown COVID-19 status [11]. Conversely, the International Liaison Committee on Resuscitation (ILCoR) was more liberal in their guidance, suggesting that chest compressions and the use of public access defibrillators prior to donning PPE could be performed on a case by case basis where potential benefits to the patient outweigh risks of transmission to the responder [10]. Other notable impacts on EMS response to OHCA events include increased door-to-door time for EMS calls, greater dispatcher workload, and reductions in bystander CPR [5,15]. Standardizing recommendations for the appropriate usage of PPE, clearly detailing the risk of transmission for specific procedures, and ensuring an adequate supply of equipment in order to keep providers safe would likely help increase confidence and ameliorate fears in these critical situations.

5. Limitations

Our study had several limitations. It was a survey study and thus was subject to participants' bias. The actual number of participants who were unwilling to perform CPR for OHCA was small (58, 12%) with an additional 111 (22%) who were "not sure" whether they would engage in resuscitation. Although their reasons for not performing CPR were similar, combining these two groups potentially skewed statistics, since it is not known whether the cohort who had doubts would elect

to perform CPR if confronted with the situation in a real-life clinical setting. Additionally, we did not consider the participants' vaccination status, though vaccines were widely available to healthcare providers during the latter part of the study period. This could have affected a provider's feelings of safety in a critical care scenario and changed their attitudes or willingness to perform CPR. Another limitation is the relative age of the participants. Though age was not a data point collected, most attending physician participants in our study had less than 5 years of experience, thus making this a relatively young cohort. Since it is well-documented that COVID-19 disproportionately affects older adults, it is unknown whether our participants' young average age skewed our statistics. Lastly, as discussed previously, the vast majority of participants had a background in emergency medicine, which limits the generalizability of the study results. Additional research should be conducted to evaluate the association between training background and willingness to perform CPR on a potentially infectious patient.

6. Conclusion

The ongoing COVID-19 pandemic significantly affected health care workers' attitudes towards performing cardiopulmonary resuscitation for OHCA due to a fear of COVID-19 transmission and concerns about the availability of personal protective equipment. Confidence levels and willingness to perform CPR increased over time during the study period. However, as out-of-hospital cardiac arrests remain a leading cause of mortality worldwide, and COVID-19 infection persists as a threat despite vaccination efforts, it is imperative that medical personnel continue to effectively (and safely) perform life-saving CPR. Efforts should be focused on the creation of standardized and evidence-based guidelines for CPR during COVID-19, as well as increasing knowledge in all healthcare workers and students regarding risks of infection and effective use of PPE during resuscitation.

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