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Cardiac surgeons' concerns, perceptions, and responses during the COVID-19 pandemic

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Abstract

Background: The coronavirus disease 2019 (COVID-19) pandemic has had an unprecedented impact on health care and cardiac surgery. We report cardiac surgeons' concerns, perceptions, and responses during the COVID-19 pandemic.

Methods: A detailed survey was sent to recruit participating adult cardiac surgery centers in North America. Data regarding cardiac surgeons' perceptions and changes in practice were analyzed.

Results: Our study comprises 67 institutions with diverse geographic distribution across North America. Nurses were most likely to be redeployed (88%), followed by advanced care practitioners (69%), trainees (28%), and surgeons (25%). Examining surgeon concerns in regard to COVID-19, they were most worried with exposing their family to COVID-19 (81%), followed by contracting COVID-19 (68%), running out of personal protective equipment (PPE) (28%), and hospital resources (28%). In terms of PPE conservation strategies among users of N95 respirators, nearly half were recycling via decontamination with ultraviolet light (49%), followed by sterilization with heat (13%) and at home or with other modalities (13%). Reuse of N95 respirators for 1 day (22%), 1 week (21%) or 1 month (6%) was reported. There were differences in adoption of methods to conserve N95 respirators based on institutional pandemic phase and COVID-19 burden, with higher COVID-19 burden institutions more likely to resort to PPE conservation strategies.

Conclusions: The present study demonstrates the impact of COVID-19 on North American cardiac surgeons. Our study should stimulate further discussions to identify optimal solutions to improve workforce preparedness for subsequent surges, as well as facilitate the navigation of future healthcare crises.

KEYWORD
cardiovascular research

1 | INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic has had an unprecedented impact on health care, leading to marked global morbidity and mortality.[1–8] In the efforts to preserve and redirect limited resources and personnel for the treatment of patients with COVID-19, cardiac surgery programs were requested to adapt to the new challenge by deferring nonurgent cases to divert resources and personnel to help cope with this new challenge.[9] National and regional policies, as well as recommendations from the American College of Surgeons, Society of Thoracic Surgeons (STS), and Canadian Cardiovascular Society COVID-19 Taskforce have been published to guide the delivery of cardiac surgical care.[1,4,10,11]

Health-care providers are at an increased risk of contracting COVID-19 due to occupational exposure and require appropriate personal protective equipment (PPE), including N95 respirators. The worldwide spread of COVID-19 and the increased demand for PPE has led to critical shortages.[12,13] The Center for Diseases and Control (CDC) recommends that during crisis situations, N95 respirator masks to be used only during aerosol-generating procedures. Additional newly emerged guidelines from the CDC during the peak of the pandemic recommended reuse or recycling of PPE through specific approved resterilization processes.[11] The evidence supporting these recommendations is still evolving.[11] The information regarding the adoption rate of PPE conservation strategies, as well as the effect of COVID-19 on physician perceptions and well-being remains scarce.

Within the context of a rapidly evolving pandemic and subsequent surges,[14] timely amalgamation of regional and national pragmatic procedures and experiences are needed to develop evidence-based practice to prepare for future surges. This study aims to report the impact of COVID-19 on North American cardiac surgeons' concerns, perceptions, and responses.

2 | METHODS

2.1 | Study design

A survey using the Qualtrics Survey Software (Provo) was sent to a representative cardiac surgeon from each major North American adult cardiac surgical center to recruit participating centers. The survey was face validated by two independent surgeons and sent on April 17, 2020, with discontinuation of survey link access on May 2, 2020. The response rate was 40% (67/167 polled), representing cardiac surgery annualized case volumes of 60,452 in 2019. The survey tool consisted of multiple-choice and text entry items and was developed by the principal investigators (N. A., J. L., and T. N.) with several iterations of internal review and revision, and finally, external feedback solicited from several board-certified actively practicing cardiac surgeons. The survey evaluated methods institutions used to optimize COVID-19 surge capacity including cardiac surgical team redeployment to the care of patients with COVID-19, cardiac surgeon concerns regarding COVID-19, PPE usage, and conservation strategies as well as utilization and satisfaction with telemedicine. The study was approved by the Adventist Healthcare Institutional review board (protocol No. 2020-09).

2.2 | Definitions

COVID-19-confirmed patients were defined as those that tested positive (nasopharyngeal polymerase chain reaction swab, endotracheal tube aspirate); whereas, those who were classified as COVID-19 suspected were those who were symptomatic or had known COVID-19 exposure and awaiting confirmatory testing. Institutions with high burden of COVID-19 were defined as those with ≥ 100 hospitalized patients with confirmed or suspected COVID-19 at the time of the survey. Institutions with a low burden of COVID-19 were defined as those with < 100 hospitalized patients with confirmed or suspected COVID-19 at the time of the survey. The period of the COVID-19 pandemic was defined as March 1, 2020 onwards. Phases of the pandemic were defined as per prior consensus documents.[15,16]

2.3 | Statistical analyses

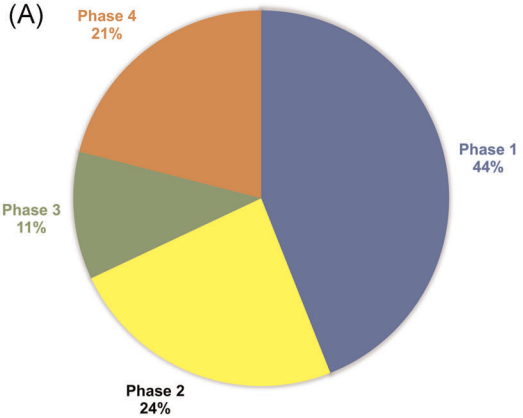
Parametric continuous variables are expressed as mean ± standard deviation (*SD*). Nonparametric continuous variables are expressed as medians with the interquartile range (IQR). Categorical data were expressed as counts and percentages. Descriptive statistical analyses were performed using Stata (Stata Corp).

3 | RESULTS

3.1 | Demographics

Our study comprises 67 adult cardiac surgery institutions representing centers from across North America. Institutional distribution in burden of hospitalized patients with confirmed or suspected COVID-19 are shown in Figure 1A and Table 1. Of all institutions, the majority (44%) were in Phase 1 of the pandemic, followed by Phase 2 (24%) and Phase 4 (21%), with a minority in Phase 3 (11%) (Figure 1B). Twenty-two (33%) institutions were categorized as high burden and 45 (67%) as low burden in terms of hospitalizations related to COVID-19. Institutional characteristics

(A)



(B)

Definition of the Phases of the Pandemic

Pandemic Phase	Patients with COVID-19	Hospital Resources	Trajectory
Phase 1	Few	Intact	Not in rapid escalation phase
Phase 2	Many	Limited	Rapid escalating phase
Phase 3	Overwhelming proportion	Critically limited	Peak
Phase 4	Declining proportion	Recovery	Recovery

FIGURE 1 (A) Distribution of institution pandemic phase and (B) definitions of pandemic phase

TABLE 1 Institution characteristics, COVID-19 burden, and change in practice due to COVID-19

	Phase 1 (*n* = 30)	Phase 2 (*n* = 15)	Phase 3 (*n* = 8)	Phase 4 (*n* = 14)	High burden (*n* = 22)	Low burden (*n* = 45)	Overall (*n* = 67)
Annual pump volume	751.5 ± 518.3	772.1 ± 336.4	1073.5 ± 465.8	1267.1 ± 752.0	984.4 ± 414.6	823.7 ± 650.1	902.3 ± 567.8
Number of the following							
Hospital beds	555.5 ± 315.1	578.7 ± 228.5	730.8 ± 122.9	1016.2 ± 977.1	916.4 ± 746.6	561.2 ± 329.6	677.9 ± 527.3
ICU beds	77.5 ± 61.6	76.1 ± 58.8	99.9 ± 45.8	173.3 ± 243.6	163.0 ± 196.6	69.0 ± 48.0	99.9 ± 125.7
Operating rooms	37.0 ± 53.5	28.1 ± 18.3	41.6 ± 14.4	57.1 ± 50.3	55.3 ± 36.7	32.2 ± 45.7	39.8 ± 44.1
COVID-19-confirmed patients	44.5 ± 82.1	82.4 ± 110.5	134.8 ± 136.7	440.7 ± 985.8	400.0 ± 774.4	22.7 ± 20.5	146.6 ± 472.2
COVID-19-suspected patients	33.1 ± 78.0	21.2 ± 24.2	46.5 ± 35.3	224.0 ± 665.4	192.0 ± 529.1	13.2 ± 15.3	71.9 ± 310.5
Convert the following locations to COVID-19 treating areas, *n* (%)							
None	10 (33)	0 (0)	1 (13)	3 (21)	0 (0)	14 (31)	14 (21)
CSICU	4 (13)	6 (40)	3 (38)	6 (43)	10 (45)	9 (20)	19 (28)
Operating rooms	4 (13)	0 (0)	2 (25)	4 (29)	6 (27)	3 (7)	10 (15)
Surgical wards	2 (7)	8 (53)	5 (63)	8 (57)	15 (68)	8 (18)	23 (34)
Medical wards	17 (23)	14 (93)	7 (88)	9 (64)	21 (95)	26 (58)	47 (70)
Convention centers/public facilities	4 (13)	6 (40)	2 (25)	2 (14)	6 (27)	8 (18)	14 (21)
Ground construction of tents/ buildings	3 (10)	3 (20)	2 (25)	1 (7)	6 (27)	3 (7)	9 (13)
CCU	0 (0)	2 (13)	2 (25)	2 (14)	4 (18)	3 (7)	6 (9)
Type of institution, *n* (%)							
Academic	22 (73)	12 (80)	8 (100)	11 (79)	20 (91)	22 (48)	53 (79)
Nonacademic	8 (27)	3 (20)	0 (0)	3 (21)	2 (9)	23 (52)	14 (21)
Redeployed, n (%)							
Cardiac Surgeon							
ICU	1 (3)	2 (13)	3 (38)	5 (36)	9 (41)	2 (4)	11 (16)
PACU	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Emergency	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Other medical/surgical service	1 (3)	1 (7)	1 (13)	1 (7)	3 (14)	1 (2)	4 (6)
Other	2 (7)	0 (0)	0 (0)	0 (0)	1 (5)	1 (2)	2 (3)
Overall	4 (13)	3 (20)	4 (50)	6 (43)	13 (59)	4 (9)	17 (25)
Trainee							
ICU	2 (7)	1 (7)	3 (38)	6 (43)	10 (45)	2 (4)	12 (18)
PACU	0 (0)	1 (7)	0 (0)	1 (7)	2 (9)	0 (0)	2 (3)
Emergency	0 (0)	1 (7)	0 (0)	0 (0)	1 (5)	0 (0)	1 (1)
Other medical/surgical service	0 (0)	1 (7)	1 (13)	1 (7)	3 (14)	0 (0)	3 (4)
Other	1 (3)	0 (0)	0 (0)	0 (0)	1 (5)	0 (0)	1 (1)
Overall	3 (10)	4 (27)	4 (50)	8 (57)	15 68)	4 (9)	19 (28)
Advanced care practitioners							
ICU	4 (13)	5 (33)	6 (75)	10 (71)	13 (59)	12 (27)	25 (37)
PACU	2 (7)	1 (7)	1 (13)	2 (14)	3 (14)	3 (7)	6 (9)

TABLE 1 (Continued)

	Phase 1 (*n* = 30)	Phase 2 (*n* = 15)	Phase 3 (*n* = 8)	Phase 4 (*n* = 14)	High burden (*n* = 22)	Low burden (*n* = 45)	Overall (*n* = 67)
Emergency	1 (3)	2 (13)	0 (0)	1 (7)	3 (14)	1 (2)	4 (6)
Other medical/surgical service	4 (13)	3 (20)	0 (0)	0 (0)	3 (14)	3 (7)	7 (10)
Other	3 (10)	1 (7)	0 (0)	0 (0)	0 (0)	4 (9)	4 (6)
Overall	14 (47)	12 (80)	7 (88)	13 (93)	22 (100)	23 (51)	46 (69)
Nurses							
ICU	7 (23)	8 (53)	4 (50)	9 (64)	10 (45)	18 (40)	28 (42)
PACU	3 (10)	3 (20)	2 (25)	4 (29)	2 (9)	10 (22)	12 (18)
Emergency	3 (10)	2 (13)	1 (13)	0 (0)	6 (27)	0 (0)	6 (9)
Other medical/surgical service	13 (43)	0 (0)	0 (0)	0 (0)	4 (18)	9 (20	13 (19)
Other	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Overall	26 (87)	13 (87)	7 (88)	13 (93)	22 (100)	37 (82)	59 (88)
Exceptions to redeployment possible (yes), *n* (%)	28 (93)	13 (87)	7 (88)	13 (93)	16 (73)	45 (100)	61 (91)

Abbreviations: CCU, cardiovascular care unit; COVID-19, coronavirus disease 2019; CSICU, cardiac surgical intensive care unit; ICU, intensive care unit; PACU, postoperative anesthesia care unit.

stratified by pandemic phase and high versus low burden of patients hospitalized with COVID-19 are shown in Table 1.

3.2 | Hospital resources and strain of COVID-19 on healthcare system

The majority of centers had converted medical wards to COVID-19 treating areas (70%), followed by surgical wards (34%), cardiac surgical intensive care units (CSICU) (28%), convention centers or public facilities (21%), operating rooms (15%), ground-up construction with tents or buildings (13%) and cardiovascular care units (9%) (Table 1). In terms of cardiac surgical teams redeployment for the care of patients with COVID-19, there was increased redeployment in Phases 3 and 4 of the pandemic and in institutions with a high burden of patients with COVID-19 (Figure 2A). Of those redeployed, they were most likely to be allocated to provide care in the intensive care setting (Table 1). Exceptions to redeployment were more often considered in settings with a low burden as compared with those with a high burden of patients with COVID-19 (high burden 73% vs. low burden 100%) (Table 1).

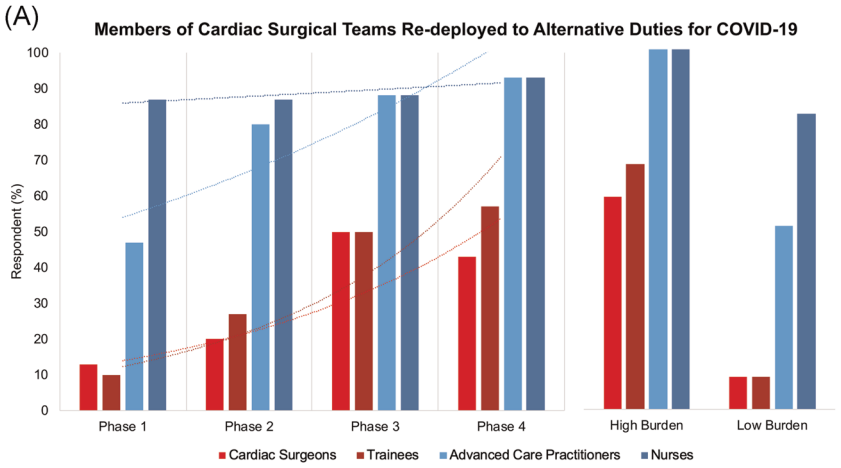
3.3 | Concerns regarding COVID-19

Examining cardiac surgeon concerns regarding COVID-19 revealed interesting trends. Cardiac surgeons appeared to be most worried about exposing their families to COVID-19, which was highest for centers in Phase 2 of the pandemic, and steadily declined with Phase 3 and 4 (Phase 1 80% vs. Phase 2 100% vs. Phase 3 88% vs. Phase 4 79%). Similarly, cardiac surgeons were least concerned regarding contracting COVID-19 during Phase 3 of the pandemic, with an increase in concern in Phase 4 (Phase 1 67% vs. Phase 2 53% vs. Phase 3 51% vs. Phase 4 78%). The same pattern of concern according to pandemic phase was seen in regard to PPE shortage (Phase 1 56% vs. Phase 2 47% vs. Phase 3 38% vs. Phase 4 50%) and limited hospital resources (Phase 1 50% vs. Phase 2 40% vs. Phase 3 26% vs. Phase 4 35%) (Figure 2B).

3.4 | Trends in PPE usage

Trends in PPE usage in terms of surgical masks and N95 respirators when in low-risk COVID-19 environments, which was defined as not near known COVID-19 exposure, were examined. Overall, there was a rise in use of the surgical mask at Phase 3 of the pandemic at home (Phase 1 0% vs. Phase 2 7% vs. Phase 3 13% vs. Phase 4 0%), in the public (Phase 1 47% vs. Phase 2 60% vs. Phase 3 63% vs. Phase 4 57%), and inside the hospital setting (Phase 1 73% vs. Phase 2 73% vs. Phase 3 88% vs. Phase 4 86%). Similarly, institutions with a high burden of patients hospitalized with COVID-19 had higher usage of the surgical mask (Figure 3A).

In terms of usage of N95 respirators when not near known COVID-19 exposure, there was a trend toward rise in usage of N95 respirators in the operating room (Phase 1 33% vs. Phase 2 53% vs. Phase 3 50% vs. Phase 4 14%) and intensive care unit (Phase 1 17% vs. Phase 2 7% vs. Phase 3 25% vs. Phase 4 21%) in Phase 3 of the pandemic (Figure 3B). These were similarly corroborated with a trend toward higher usage of N95 respirators in institutions with a high burden of patients hospitalized with COVID-19 as compared with those that were not (Figure 3B).



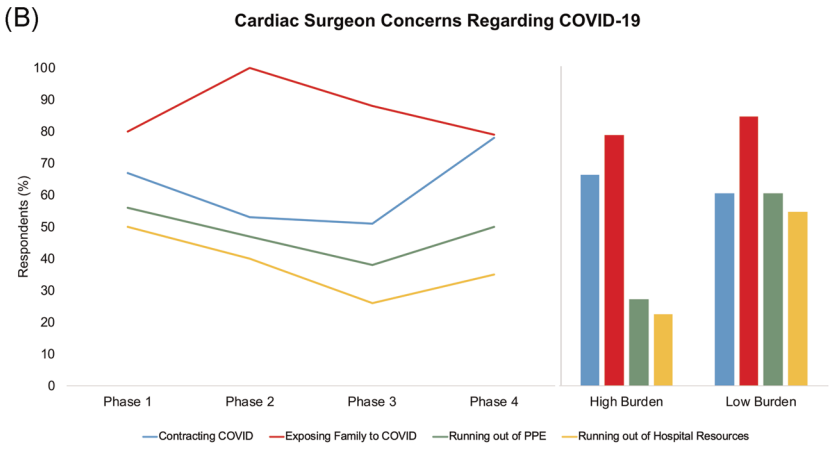
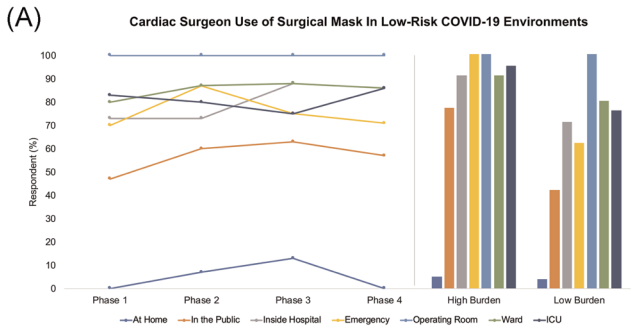
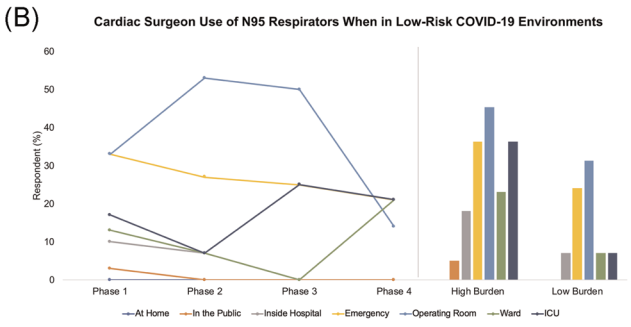


FIGURE 2 (A) Members of cardiac surgical teams redeployed to assist in the institutions' COVID-19 response and (B) cardiac surgeons' worries in regard to COVID-19. COVID-19, coronavirus disease 2019





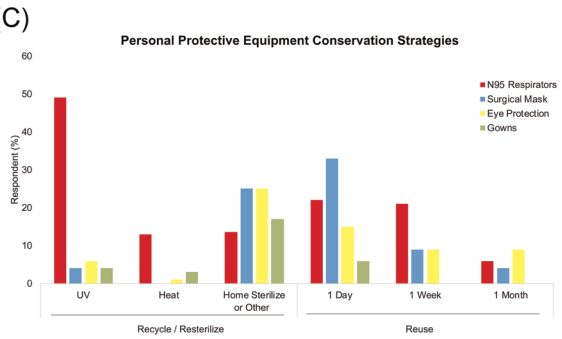


FIGURE 3 Cardiac surgeon personal protective equipment (PPE) usage of (A) surgical masks and (B) N95 respirators as well as (C) institution PPE conservation strategies, as stratified by phase of the pandemic. ICU, intensive care unit; UV, ultraviolet light

3.5 | PPE conservation strategies

PPE conservation strategies were examined amongst the 67 institutions. Among users of N95 respirators, nearly half (49%) were recycling them using ultraviolet light to decontaminate their used N95 respirators, followed by 13% that were using heat to decontaminate N95 respirators, and 12% that are sterilizing them using some other method (Figure 3C). Furthermore, institutions were requesting physicians to reuse their N95 respirators for 1 day (22%) or 1 week (21%), with a minority requesting physicians to reuse their N95 respirators for 1 month (6%). There were differences in adoption of methods to conserve N95 respirators based on institution pandemic phase and COVID-19 burden, with institutions with higher COVID-19 burden more commonly resorting to PPE conservation strategies (Table 2). Conservation strategies of other PPE include sterilization at home or other for surgical masks (25%), eye protection (25%), and gowns (17%) (Figure 3C). Stratification of various other PPE use and conservation strategies by institution pandemic phase and COVID-19 burden are shown in Table 2.

3.6 | Trends in utilization and satisfaction with telemedicine

The majority of institutions have adopted telemedicine strategies to connect with patients during the COVID-19 pandemic for their preoperative (91%), postoperative (78%), and follow-up care (91%) (Figure 4A). Furthermore, compared with pre-COVID-19, more respondents plan to continue to utilize telemedicine post-COVID-19 in their preoperative (40% vs. 9%), postoperative (42% vs. 9%), and follow-up (60% vs. 12%) care. In terms of telemedicine modality, the majority are utilizing the Zoom platform, with most satisfied with its performance (works well 52% vs. does not work well 4% vs. not using 19%). This is closely followed by the WebEx platform (61%), Microsoft Teams (58%), hospital proprietary software (58%), Skype (56%), and others (Figure 4B). Amongst all platforms, respondents were least satisfied with hospital proprietary software (9%).

4 | COMMENT

The COVID-19 pandemic presents a public health crisis that challenges the availability of health-care personnel and resources with over 66 million cases worldwide at the time of this manuscript with potentially millions more undetected.[17] The impact of COVID-19 on cardiac surgeon concerns, perceptions, and changes in practice remains unknown. Within the context of a rapidly evolving pandemic and second wave,[14] timely amalgamation of regional and national pragmatic procedures and experiences are needed to develop evidence-based practice to prepare for future surges.

In this survey with diverse geographic and pandemic phase representation, we identified several key trends. First, redeployment to a different hospital service was common and most prevalent among nurses, followed by advanced practice providers, trainees, and attending cardiac surgeons. Second, cardiac surgeons, like other health-care providers were most concerned about exposing their family to COVID-19, followed by contracting COVID-19, running out of PPE, and hospital resources. Third, in regard to PPE conservation strategies among users of N95 respirators, nearly half were recycling via decontamination with ultraviolet light (49%), followed by sterilizing with heat (13%), and home or other modality (13%). Furthermore, the reuse of N95 respirators for 1 day (22%), 1 week (21%) or 1 month (6%) has been shown. There were differences in adoption of methods to conserve N95 respirators based on institution pandemic phase and COVID-19 burden, with institutions with higher COVID-19 burden more likely to resort to PPE conservation strategies. Lastly, the majority of institutions have adopted telemedicine strategies to connect with patients during the COVID-19 pandemic for their preoperative, postoperative, and follow-up care, with these changes anticipated to continue for some in the post COVID-19 era.

Health-care workers are at the forefront in the response to the COVID-19 pandemic and are at high risk of infection due to direct contact with patients with COVID-19 as well as ongoing shortages of diagnostic tests and PPE.[18] Given that previous studies on SARS and Ebola have revealed that 18%–57% of health-care workers experienced emotional distress during outbreaks,[19] the concerns of cardiac surgeons during COVID-19 identified trends and aspects for interventions to mitigate distress. It is interesting that the lowest level of concern amongst cardiac surgeons were those in Phase 3 of the pandemic, in terms of exposing family to COVID-19, contracting COVID-19, running out of PPE and hospital resources. This was further corroborated by the lower amount of concern amongst institutions with a high burden of patients hospitalized with COVID-19, as compared with those with low burden. Similar concerns of health-care workers regarding the health and wellness of family members is shared by previous work,[18,20] with additional perspective provided in the present study through stratification by pandemic phase.

The reasons for the lower levels of concern remains unknown, but can potentially be explained by health-care workers becoming overwhelmed with the surge of patients with COVID-19 to the point that one remains focused solely on the task at hand rather than being concerned about one's own family and mortality. It is also possible that concern decreases as respondents become infected themselves or require periods of self-quarantine. Reasons to explain this could be the rise in community and/or institutional support to aid health-care workers during the surge phase of the pandemic, including but not limited to, alternative accommodations or childcare support, altered work-schedules to maximize telemedicine and work-from-home modalities. Furthermore, it may reflect the community or institutional acquisition of sufficient PPE and essential equipment or increased adoption of PPE conservation practices such as recycling or reusing of single-use PPE, as demonstrated in our study. Other potential reasons for decreased concern include the possibility that with a higher COVID-19 burden, processes to treat patients with COVID-19 become more defined, and as testing increases with

TABLE 2 Personal protective equipment conservation strategies during the COVID-19 pandemic

	Phase 1, (n = 30)	Phase 2 (n = 15)	Phase 3 (n = 8)	Phase 4 (n = 14)	High burden (n = 22)	Low burden (n = 45)	Overall (n = 67)
Personal protective equipment conservation strategies, *n* (%)							
N95 respirators							
Recycle-UV	16 (53)	7 (47)	2 (25)	8 (57)	15 (68)	12 (27)	33 (49)
Recycle-heat	6 (20)	2 (13)	1 (13)	0 (0)	3 (14)	6 (13)	9 (13)
Recycle-other	4 (13)	1 (7)	2 (25)	1 (7)	0 (0)	8 (18)	8 (12)
Recycle-home sterilize	0 (0)	0 (0)	1 (13)	0 (0)	1 (5)	0 (0)	1 (1)
Reuse-1 day multiple patients	7 (23)	2 (13)	2 (25)	4 (29)	12 (55)	3 (7)	15 (22)
Reuse-1 week	5 (17)	2 (13)	2 (25)	5 (36)	9 (41)	5 (11)	14 (21)
Reuse-1 month	2 (7)	1 (7)	1 (13)	0 (0)	2 (9)	2 (4)	4 (6)
Surgical mask							
Recycle-UV	1 (3)	1 (7)	0 (0)	1 (7)	0 (0)	0 (0)	3 (4)
Recycle-heat	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Recycle-other	8 (27)	2 (13)	3 (38)	3 (21)	4 (18)	12 (27)	16 (24)
Recycle-home sterilize	0 (0)	0 (0)	1 (13)	0 (0)	1 (5)	0 (0)	1 (1)
Reuse-1 day multiple patients	9 (30)	4 (27)	4 (50)	5 (36)	13 (59)	9 (20)	22 (33)
Reuse-1 week	3 (10)	1 (7)	1 (13)	1 (7)	3 (14)	3 (7)	6 (9)
Reuse-1 month	2 (7)	1 (7)	0 (0)	0 (0)	1 (5)	2 (4)	3 (4)
Eye protection							
Recycle-UV	1 (3)	0 (0)	0 (0)	3 (21)	1 (5)	3 (7)	4 (6)
Recycle-heat	0 (0)	1 (7)	0 (0)	0 (0)	0 (0)	1 (2)	1 (1)
Recycle-none	6 (20)	3 (20)	1 (13)	3 (21)	3 (14)	10 (22)	13 (19)
Recycle-home sterilize	1 (3)	1 (7)	2 (25)	0 (0)	2 (9)	2 (4)	4 (6)
Reuse-1 day multiple patients	6 (20)	2 (13)	1 (13)	1 (7)	3 (14)	7 (16)	10 (15)
Reuse-1 week	2 (7)	0 (0)	1 (13)	3 (21)	3 (14)	3 (7)	6 (9)
Reuse-1 month	3 (10)	1 (7)	2 (25)	0 (0)	3 (14)	3 (7)	6 (9)
Gowns							
Recycle-UV	2 (7)	0 (0)	0 (0)	1 (7)	1 (5)	2 (4)	3 (4)
Recycle-heat	1 (3)	1 (7)	0 (0)	0 (0)	0 (0)	2 (4)	2 (3)
Recycle-none	7 (23)	3 (20)	1 (13)	0 (0)	3 (14)	8 (18)	11 (16)
Recycle-home sterilize	1 (3)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2)	1 (1)
Reuse-1 day multiple patients	1 (3)	1 (7)	1 (13)	1 (7)	3 (14)	1 (2)	4 (6)
Reuse-1 week	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Reuse-1 month	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gloves							
Recycle-UV	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Recycle-heat	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Recycle-none	9 (30)	4 (27)	1 (13)	4 (29)	4 (18)	14 (31)	18 (27)
Recycle-home sterilize	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

TABLE 2 (Continued)

	Phase 1, (n = 30)	Phase 2 (*n* = 15)	Phase 3 (*n* = 8)	Phase 4 (*n* = 14)	High burden (*n* = 22)	Low burden (*n* = 45)	Overall (*n* = 67)
Reuse-1 day multiple patients	0 (0)	0 (0)	0 (0)	1 (7)	1 (5)	0 (0)	1 (1)
Reuse-1 week	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Reuse-1 month	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Home-made masks when facemasks not available, *n* (%)	5 (17)	2 (13)	0 (0)	2 (14)	5 (23)	4 (9)	9 (13)

Abbreviation: COVID-19, coronavirus disease 2019.

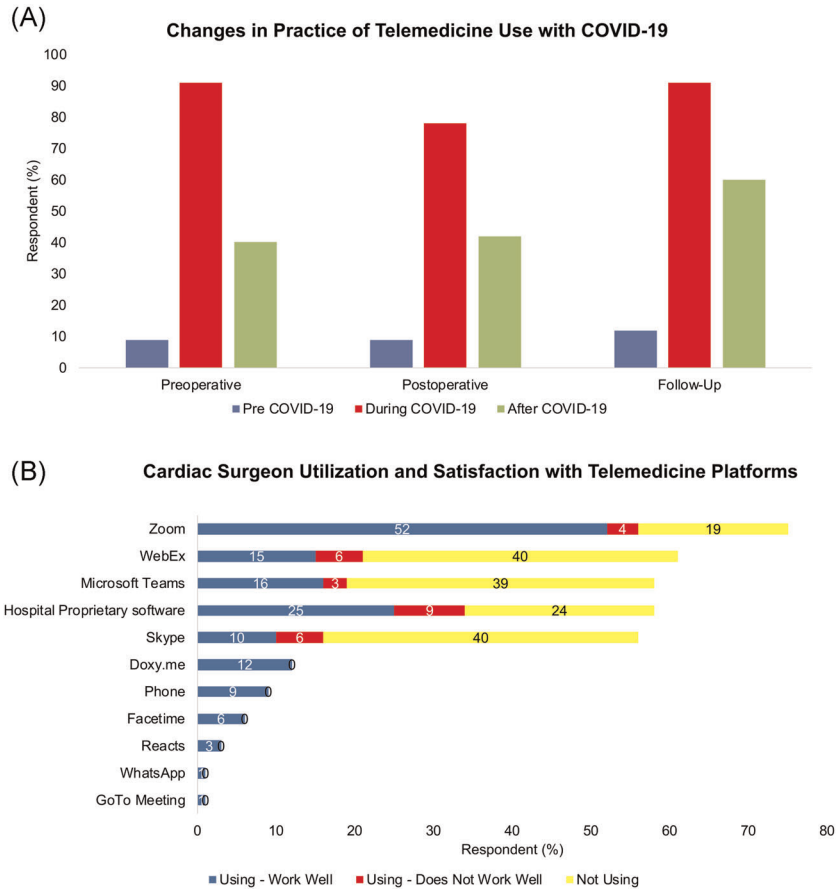


FIGURE 4 (A) Cardiac surgical changes in the practice of telemedicine with COVID-19 and (B) utilization and satisfaction of various telemedicine platforms

evolution in speed and availability of tests, this can lead to lower concern with increased experience when institutional protocols become better defined.

The primary means of protecting frontline health-care personnel from contracting COVID-19 is the proper use of PPE. Examining trends in PPE usage revealed interesting findings. Increased usage of N95 respirators in low-risk COVID-19 exposure environments may demonstrate surgeons' concern for asymptomatic transmission.[21] In addition, high usage of N95 respirators in the operating room may be a reflection of sufficient availability of PPE. The higher usage of N95s in institutions with higher COVID-19 burden is ultimately consistent with COVID-19 Taskforce guidelines that recommend presumption that all patients could be carriers of COVID-19 in areas of documented or suspected community spread.[1,4,10,11]

The rapid spread of COVID-19 around the globe has led to a critical supply shortage of PPE, which has been well documented.[12,22,23] The CDC recommends that during crisis situations, N95 respiratory masks to be used only during aerosol-generating procedures. Additional guidelines from the CDC when PPE shortage becomes critical, have recommended reuse or recycling of PPE that are intended for one-time use, and to resort to scarves or bandanas, if necessary. Respondents to this survey indicated that the reuse of N95 respirators were primarily accomplished through decontamination using ultraviolet germicidal irradiation, or moist heat by

Aspect	Recommendations
Communication	➢ Regular and frequent communication with colleagues ➢ Regular and proactive follow-up of outpatients ➢ Establish evidence-based guidelines and recommendations to guide patient care, triage, resource allocation, etc. ➢ Implement real-time database tracking of patient outcomes
Safety of Healthcare Workers	➢ Adequate supply of PPE ➢ Evidence-based guidelines in the use and / or conservation practices of PPE ➢ Ensure healthcare workers have access to testing and vaccine, when available ➢ Designate disease-free patient care areas ➢ Allow those who are ill to stay home ➢ Allow exceptions for redeployment in certain situations
Telemedicine	➢ Ensure adequacy of video and audio component as well as ease of use ➢ Ensure affordability, access, and availability of technological support ➢ Establish guidelines for confidentiality ➢ Contingency planning for privacy breach
Support	➢ Implementation of support services (e.g., childcare, alternative housing, counselling, contingency planning, crisis hotlines, financial support, etc) ➢ Listen to healthcare worker concerns and suggestions ➢ Establish shift rotations

FIGURE 5 Recommendations to prepare for subsequent surges of COVID-19 and future pandemics. PPE, personal protective equipment

autoclaving or home sterilization, as recommended by the CDC.[11] Evidence supporting the safety and effectiveness of these PPE conservation strategies are urgently needed. Linking physician concern and PPE supply through a survey of 2,500 physicians in Canada, 90% of physician respondents indicated that a greater availability of PPE would help reduce their anxiety around the pandemic.[24] Other interventions respondents indicated would help ease their concerns include greater availability of medications (54%), better virtual care options (53%), and increased peer support (49%).[24] There is a need for standardized guidelines that support evidence-based methods for PPE conservation practices to guide the current and future pandemics.

In recent years, the growth of telemedicine usage in health care has been incremental, with utilization of only 8% of North Americans in 2019.[25] Telemedicine provides opportunities to strengthen health systems and can be a vital resource in the current public health emergency. Telemedicine care can help reduce emergency room visits, conserve health-care resources, provide continuity and access to care for patients, patient education and empowerment, and avoid the spread of COVID-19 by treating patients remotely. It is encouraging that the majority of cardiac surgery institutions have adopted telemedicine, with the majority using consumer applications such as Zoom, and other video chat platforms to interact with medical providers remotely.

Ultimately, this is an unprecedented time that calls for the need to support our health-care workers, to ensure their safety and well-being, so that they can continue to care for patients. The World Health Organization has provided recommendations for the prevention and reduction of fatigue and psychosocial stress, which include the delegation of responsibilities, implementation of support services, contingency planning for incident mobilization, crisis support hotlines, specialized counseling, work hour limitations, and establishment of shift rotations.[26] In addition, there is a need to ensure that there is an adequate supply of PPE for health-care workers, as well as evidence-based recommendations to guide appropriate PPE conservation strategies. Additional studies are needed to determine the impact of COVID-19 on health-care worker wellness and to determine and evaluate the effectiveness of therapeutic interventions. Recommendations to prepare for subsequent surges of COVID-19 as well as future pandemics are shown in Figure 5.

5 | LIMITATIONS

Our study is subject to response bias and relies on center self-reported data. The response rate to this survey was 40%, however the included sites represent a diverse geographic sample. We demonstrated the concerns of cardiac surgeons, but these may not generalize across specialties and levels of training. We provided the current trends in utilization and conservation strategies of PPE but were unable to evaluate the effectiveness and durability of these conservation strategies as well as other methods that have emerged since the survey. Although we were able to demonstrate telemedicine utilization and satisfaction amongst surgeons, we were unable to correlate telemedicine use with patient satisfaction and outcomes. Our study is a snapshot in a rapidly evolving milieu affecting heterogenous populations and regions with variable testing, availability of PPE and responses due to the pandemic's impact. Participating institutions were predominantly from academic institutions and may not be reflective of community programs. Case volumes were provided as an answer to a question in the survey and was not subject to further validation. In addition, we do not have data on the potential delay in care due to the pandemic and impact on patient outcomes.

6 | CONCLUSIONS

The present study demonstrates the impact of COVID-19 on North American cardiac surgeons' perceptions, concerns, and responses from 67 institutions, with diverse geographic and pandemic phase representation. Our study should stimulate further discussions to

identify optimal solutions to improve workforce preparedness for the COVID-19 emergency response, as well as preparation for subsequent surges and future pandemics. In the best interest of public health during this rapidly evolving pandemic, timely amalgamation of national and regional pragmatic practice and experiences are needed to develop evidence-based practice.

CONFLICT OF INTERESTS

Dr. Ad discloses relationships with Atricure Inc., Medtronic and LivaNova.

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