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A survey of the global impact of COVID-19 on the practice of pediatric anesthesia: A study from the pediatric anesthesia COVID-19 Collaborative Group

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Abstract

Background: Pediatric anesthesiology has been greatly impacted by COVID-19 in the delivery of care to patients and to the individual providers. With this study, we sought to survey pediatric centers and highlight the variations in care related to perioperative medicine during the COVID-19 pandemic, including the availability of protective equipment, the practice of pediatric anesthesia, and economic impact.

Aim: The aim of the survey was to determine how COVID-19 directly impacted pediatric anesthesia practices during the study period.

Methods: A survey concerning four major domains (testing, safety, clinical management/policy, economics) was developed. It was pilot tested for clarity and content by members of the Pediatric Anesthesia COVID-19 Collaborative. The survey was administered by email to all Pediatric Anesthesia COVID-19 Collaborative members on September 1, 2020. Respondents had six weeks to complete the survey and were instructed to answer the questions based on their institution's practice during September 1 - October 13, 2020.

Results: Sixty-three institutions (100% response rate) participated in the COVID-19 Pediatric Anesthesia Survey. Forty-one hospitals (65%) were from the United States, and 35% included other countries. N95 masks were available to anesthesia teams at 91% of institutions (n = 57) (95% CI: 80%–96%). COVID-19 testing criteria of anesthesia staff and guidelines to return to work varied by institution. Structured simulation training aimed at improving COVID-19 safety and patient care occurred at 62% of institutions (n = 39). Pediatric anesthesiologists were economically affected by a reduction in their employer benefits and restriction of travel due to employer imposed quarantine regulations.

Conclusion: Our data indicate that the COVID-19 pandemic has impacted the testing, safety, clinical management, and economics of pediatric anesthesia practice. Further investigation into the long-term consequences for the specialty is indicated.

The first three authors are co-first authors. Drs Soneru, Fernandez, Bradford contributed equally to this study.

1List of Pediatric Anesthesia COVID-19 Collaborative to be included in PubMed collaborator and institutions listing is provided in two supplementary files.

Collaborators names and Institutions listed in Accompanying Files 1 and 2.

KEYWORDS

COVID-19, hospital economics, pediatric anesthesia, personal protective equipment, preoperative testing, simulation

Clinical Implications**What is already known?**

The COVID-19 global pandemic has upended traditional hospital policies regarding preoperative testing, personal protective equipment, staffing, and visitation. No data exist on how operative care has changed as a result of the pandemic or its impact on perioperative patients and providers.

What this article adds

Responses showed COVID-19 had variable effects based on geographic location and institution. It has strained healthcare resources, and drastically changed the environment in which pediatric anesthesiologists practice.

1 | INTRODUCTION

In December 2019 a novel coronavirus, SARS-CoV-2 and its resulting disease COVID-19, were first reported in China.¹ By March 2020, COVID-19 was declared a worldwide public health crisis. As of December 2020, the number of global cases is 76 704 426 and the number of global deaths is 1 691 198 and climbing.² Currently, the overall rate of child COVID-19 cases in the United States is 3336 cases per 100 000 children in the population.³ In addition, the disease affects children and those who take care of children in different ways. Initial studies from China indicate that generally children experience less severe disease, and only 5.3% become severely ill and 0.6% critically ill.⁴ Perhaps because of the more serious disease pattern among adults, information published on children is limited and still evolving.^{5,6}

This novel coronavirus has disrupted the access, delivery, and economics of healthcare. The American Hospital Association estimates an average loss of \$50.7 billion per month for hospitals and health care systems from March 1 to June 30, 2020.⁷ Anesthesiology, including pediatric anesthesiology, has been greatly impacted by COVID-19, not just in the delivery of care to patients but for the individual anesthesiology providers as well. Much of the current pediatric anesthesia COVID-19 literature is focused on how to care for children in the perioperative setting, including methods for the resumption of elective outpatient surgery through preoperative testing.⁸⁻¹⁰

COVID-19 directly impacted anesthesiologists because their own health is at risk when caring for infected patients. In addition, the pandemic increased emotional stress and created the possibility of adverse financial impact. Pediatric anesthesiologists, especially in the United States, were economically affected by a reduction in their employer benefits and restriction of important personal or family related travel due to employer imposed quarantine regulations. Anesthesiologists, like many other healthcare providers, struggled

to obtain adequate personal protective equipment and adequate COVID-19 testing for patients and themselves. Adult hospitals and intensive care units have been at times overwhelmed with patients, and some pediatric anesthesiologists were deployed to assist. The pandemic's impact is far reaching on pediatric anesthesia education and training programs as well. In a recent report, pediatric anesthesiology fellows reported increased stress about contracting COVID-19 at work, finding a job after graduation, and frustration with modified didactics.¹¹ Disease exposure and infections are also having adverse effects on perioperative workforce.¹²

Internationally, pediatric anesthesiologists have seen a decrease of 10%–15% or more in elective case volumes during the height of the pandemic due to the fact that many hospitals suspended elective cases early in March and April 2020.¹³ Since COVID-19 emerged, national and local public health policies have changed several times resulting in mixed messages on appropriate personal protective equipment, testing strategies, and quarantine requirements. The pandemic resulted in halting elective surgical procedures in many locations for a period of time, and in many cases employers changed compensation packages resulting in economic uncertainty for many healthcare providers.

The aim of this survey was to determine how the COVID-19 pandemic has impacted pediatric anesthesia departments and practice. The survey questions were structured around 4 domains including healthcare delivery, personal protective equipment access and policies, policies for COVID-19 testing of patients and personnel, and economics. We sought to determine how COVID-19 has affected the field of pediatric anesthesia over a large geographical range, and how pediatric anesthesiologists are transforming their practices. This information can help guide institutions to understand the details of the pandemic's impact and develop policies and procedures to keep their patients and anesthesia providers safe. Lessons learned from the operational challenges posed by COVID-19 should be used to inform preparation for similar challenges in the future.

2 | METHODS

Institutional Review Board (IRB) exemption was obtained from Boston Children's Hospital. A prospective survey questionnaire was developed by the study authors (supplemental material 1 & 2) and pilot tested for clarity and content by members of the Pediatric Anesthesia COVID-19 Collaborative (PEACOC). Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were followed. All 63 member institutions were included. There were no exclusion criteria. The authors sent out an email link to all members of the Pediatric Anesthesia COVID-19 Collaborative on September 1, 2020. Survey data were collected and managed with Research Electronic Data Capture (RedCap) software. If an institution had several anesthesiologists as members of the Pediatric Anesthesia COVID-19 Collaborative, they were instructed to select a representative with knowledge of their institution's COVID-19 policies to respond. Respondents had 6 weeks to complete the survey, and reminder emails were sent at the end of the time period. The survey closed on October 13, 2020. Respondents were instructed to answer the questions based on the current situation at their institutions during the study period September 1-October 13, 2020. Individual institution data were fully de-identified, so study authors knew only that a member from the corresponding institution had completed the survey.

2.1 | Statistical analysis

Descriptive analyses were performed for all data collected on all respondents. Categorical variables are presented as frequencies and percentages in the respondent cohort. For survey questions within conditional branching logic, denominators are presented to indicate

the sizes of respondent subgroups. Binomial exact 95% confidence intervals (CI) are calculated and presented for proportions for key measurements to provide precision around the observed data. All statistical analyses were performed using Stata (version 16.0, StataCorp LLC.).

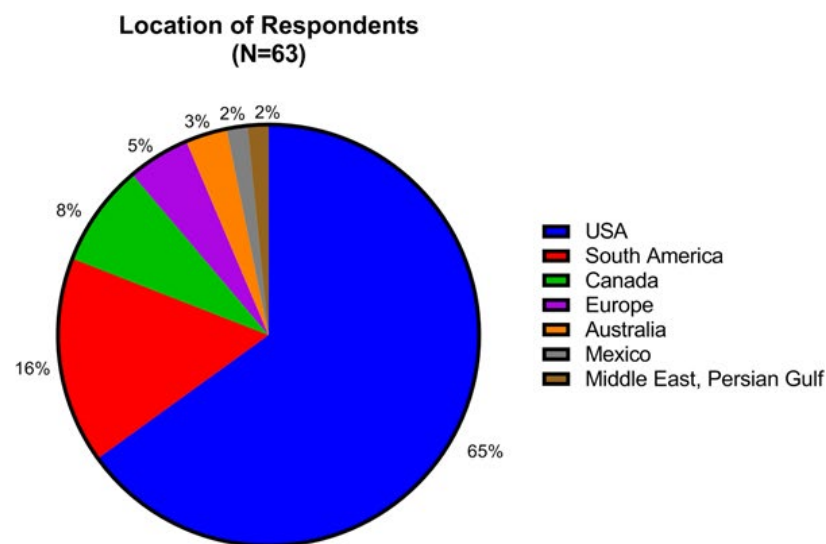
3 | RESULTS

3.1 | Demographics and characteristics of respondents

A total of 63 responses were collected for the COVID-19 Pediatric Anesthesia Survey. Demographics of respondents are presented in Figure 1. Forty-one respondents (65%) were from academic hospitals, 15 (24%) were from private institutions, and 16 (27%) were from public (government supported) institutions. Forty-six percent of institutions ($n = 29$) had 250 or more hospital beds dedicated to the pediatric population, and 54% had less than 250 beds. Forty-one hospitals (65%) were located in the United States and 35% respondents ($n = 22$) came from other countries across the globe.

3.2 | COVID-19 testing

Select COVID-19 testing data are summarized in Figure 2. Patient polymerase chain reaction testing for COVID-19 was required for elective surgery in 65% of hospitals ($n = 41$) and for urgent surgery in 56% of hospitals ($n = 35$). Thirteen percent of respondents ($n = 8$) reported that PCR testing was not used at their institution. Perioperative screening questionnaires were used at 92%

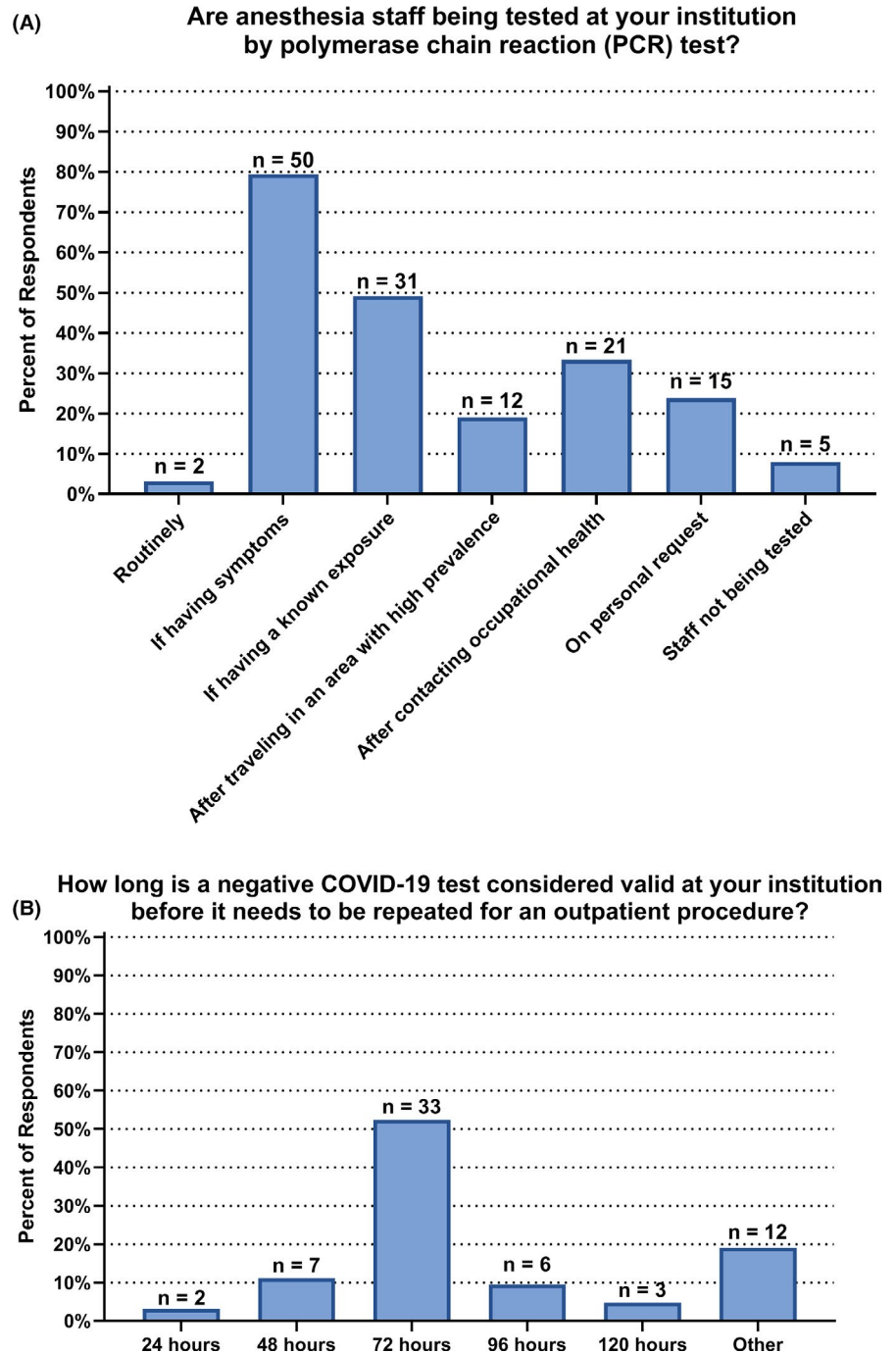


Demographics and Respondent Characteristics

Variable	n (%)
Primary Practice Setting	
Public (government supported)	16 (27%)
Private (non-government supported)	15 (24%)
Academic	41 (65%)
Other	0 (0%)
Number of Hospital Beds Dedicated to Pediatric Population	
0 – 50	4 (6%)
50 – 100	9 (14%)
100 – 250	21 (33%)
250 – 500	22 (35%)
> 500	7 (11%)
Primary Site of Practice	
Free standing pediatric hospital	36 (57%)
Pediatric hospital within an adult hospital	20 (32%)
Adult hospital	7 (11%)

FIGURE 1 Description of respondent characteristics. The majority of respondents were at US hospitals, but many international locations were represented. Most respondents came from academic practice settings (65%) and free standing pediatric hospitals (57%). A range of hospital volumes were represented [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

FIGURE 2 COVID-19 Testing of pediatric anesthesia staff. A, At most institutions, pediatric anesthesia staff are receiving polymerase chain reaction (PCR) testing if having COVID-19 symptoms, although there is variability across hospitals. B, Most often, a negative COVID-19 test is considered valid for 72 h or less [Colour figure can be viewed at wileyonlinelibrary.com]



of institutions ($n = 58$). Testing of anesthesia staff was performed routinely in 3% of institutions ($n = 2$), if having symptoms in 79% of institutions ($n = 50$), and if having known exposure in 49% of institutions ($n = 31$). In 67% of hospitals ($n = 41$), a negative COVID-19 test was considered valid for 72 h or less.

3.3 | Personal protective equipment

N95 masks were available to the anesthesia team at 91% of institutions ($n = 57$) (95% CI: 80%–96%). The most common personal

protective equipment worn by anesthesiologists while caring for an untested, patient under investigation for COVID-19, or COVID-19 positive patient were N95 masks (89%; $n = 56$), face shields or goggles (86%; $n = 54$), hat/bonnet (79%; $n = 50$), and gloves (71%; $n = 45$). In the event of a shortage of personal protective equipment, 51% of institutions ($n = 32$) allowed anesthesiologists to use their own protective equipment (Figure 3). Among institutions that did not allow anesthesiologists to use their own personal protective equipment, cases were cancelled when personal protective equipment was not available in 82% (9/11), whereas 18% of hospitals (2/11) proceeded without appropriate personal protective equipment.

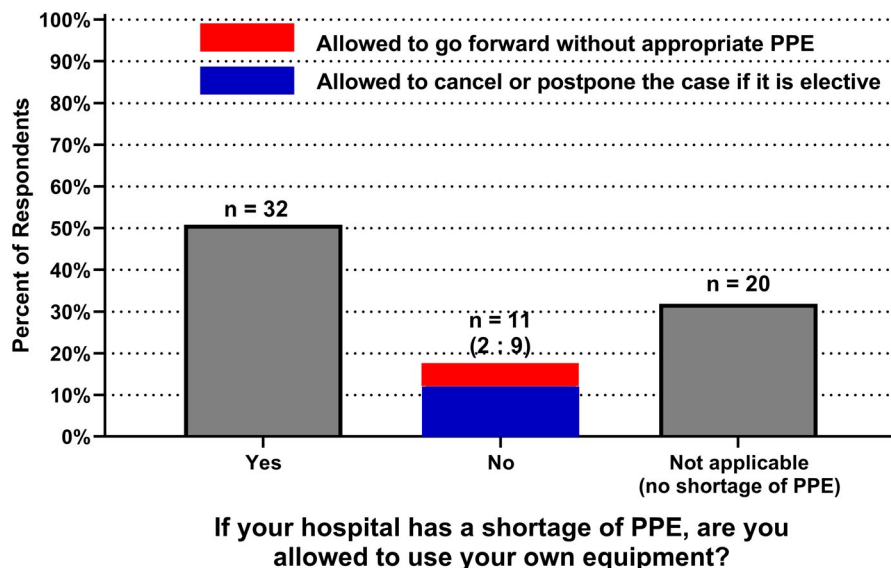


FIGURE 3 Personal protective equipment (PPE) during a shortage. Among the 43 respondents who had experienced PPE shortages at their institutions, 32 reported that the anesthesia staff was allowed to use their own PPE equipment during a shortage. In the 11 institutions where utilization of own PPE is not allowed, 2 allow going forward without appropriate PPE and 9 allow to cancel or postpone the case if it is elective [Colour figure can be viewed at wileyonlinelibrary.com]

3.4 | Clinical management

Seventy-one percent of hospitals ($n = 45$) had airway barrier methods utilized when intubating a patient under investigation for COVID-19 or COVID-19 positive patient. In 38 institutions of these 45 (84%), it was at the discretion of the anesthesiologist in which age group airway barriers were utilized. Parents were allowed to be present during induction of general anesthesia in 16% of hospitals ($n = 10$). Parental presence was determined on a case-by-case basis in 25% of hospitals ($n = 16$). Only 6 hospitals (10%) were testing parents of patients. The patient's COVID-19 status impacted the parental visitation policy in 73% of centers ($n = 46$), among which 78% ($n = 36/46$) allowed only one parent/legal guardian per patient to visit.

3.5 | Impact on pediatric anesthesia staff

Figure 4 provides a summary of the impact of COVID-19 on pediatric anesthesia staff. Disproportional fatigue due to COVID-19 was reported in 65% of institutions ($n = 41$), and 10% of respondents ($n = 6$ out of 63) believed that medical errors increased in their institution during the pandemic. The guidelines for returning to work after testing positive for COVID-19 varied by hospital 37% ($n = 23$) dependent on symptom resolution, 41% ($n = 26$) dependent on fixed number of days after symptoms started, 19% ($n = 12$) depended on repeat negative COVID-19 test, 33% ($n = 21$) were decided by occupational health on a case-by-case basis. Concerning pay and benefits, incentive pay was negatively impacted at 46% of institutions ($n = 29$) (95% CI: 33%–59%) during the pandemic, vacation time was reduced at 27% of hospitals ($n = 17$) (95% CI: 17%–40%), and personal travel restrictions were implemented at 62% of hospitals ($n = 39$) (95% CI: 49%–74%). Sixty-eight percent ($n = 43$) (95% CI: 55%–79%) of respondents indicated that staff were not given the choice regarding working with COVID-19 positive patients (Figure 4A), whereas 32% of staff ($n = 20$) were excluded for reasons listed in Figure 4B.

3.6 | Infrastructure

Utilization of negative pressure operating rooms was found in 44% of hospitals ($n = 28$). For a COVID-19 positive patient, staff without personal protective equipment was allowed to enter the operating room following intubation without a waiting period in 16% of hospitals ($n = 10$), and at the discretion of the team leader in 13% of hospitals ($n = 8$).

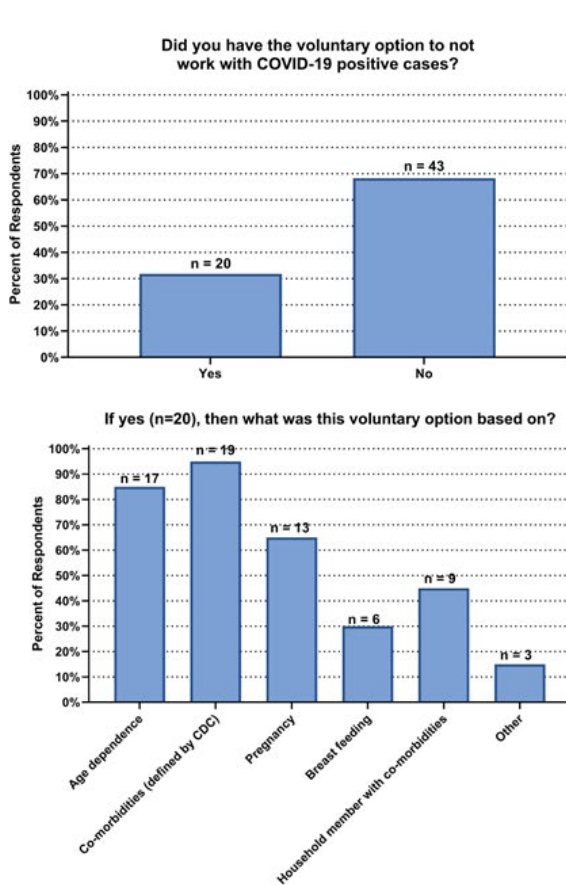
3.7 | Training of Staff

Among the 62% ($n = 39$) of hospitals offering structured simulation training, 100% ($n = 63$) reported that simulation training led to staff to feel better-prepared managing COVID-19 patients (95% CI: 91%–100%, Figure 5). During the care of a COVID-19 positive patient or patient under investigation for COVID-19 64% of institutions ($n = 40$) had a designated spotter available for donning and doffing of personal protective equipment, however, during the off-hours this safety feature was only available in 35% of institutions ($n = 14/40$).

3.8 | Policy and management

Respondents to the survey indicated that COVID-19 had an impact on policy and management practices at their institutions. For example, 81% of respondents ($n = 51$) indicated that their hospitals followed recommendations regarding COVID-19 set forth by their national anesthesia society for personal protective equipment use, and 67% of respondents ($n = 42$) indicated the same for patient COVID-19 testing.

Eighteen percent of institutions ($n = 11$) mandated that paid days off were taken due to decreased case volume. These mandated days off were either randomly distributed (46%; $n = 5/11$), followed a planned distribution (46%; $n = 5/11$), or were evenly distributed (9%;



Impact of COVID-19 on Pediatric Anesthesia Staff

Variable	n (%)
Do you attest to a COVID-19 screening questionnaire orally or written prior to work every day?	
Yes	40 (64%)
No	23 (36%)
Does your employer check your temperature daily prior to entering the workplace?	
Yes	29 (46%)
No	34 (54%)
Did any attending anesthesiologist have a reduction in their base salary as a result of the COVID-19 pandemic?	
Yes	27 (43%)
No	35 (56%)
Prefer not to answer	1 (2%)
Did any attending anesthesiologists lose their incentive pay?	
Yes	29 (46%)
No	30 (48%)
Prefer not to answer	4 (6%)
Did your employer compensate you for decreased income with additional time off?	
Yes	12 (19%)
No	45 (71%)
Prefer not to answer	6 (10%)
Did any anesthesiologist lose vacation time as a result of the COVID-19 pandemic?	
Yes	17 (27%)
No	44 (70%)
Prefer not to answer	2 (3%)
Did any anesthesiologist lose academic time as a result of the COVID-19 pandemic?	
Yes	25 (40%)
No	35 (56%)
Prefer not to answer	3 (5%)
Did your employer stop matching or reduce matching your retirement plan?	
Yes	10 (16%)
No	47 (75%)
Prefer not to answer	6 (10%)

FIGURE 4 Impact of COVID-19 on pediatric anesthesia staff. Twenty respondents reported having the voluntary option to not work with COVID-19 positive cases, and this was most often based on age, comorbidities and pregnancy of the pediatric anesthesia staff. Many workplace procedures and economic factors in pediatric anesthesia staff were impacted due to the COVID-19 pandemic [Colour figure can be viewed at wileyonlinelibrary.com]

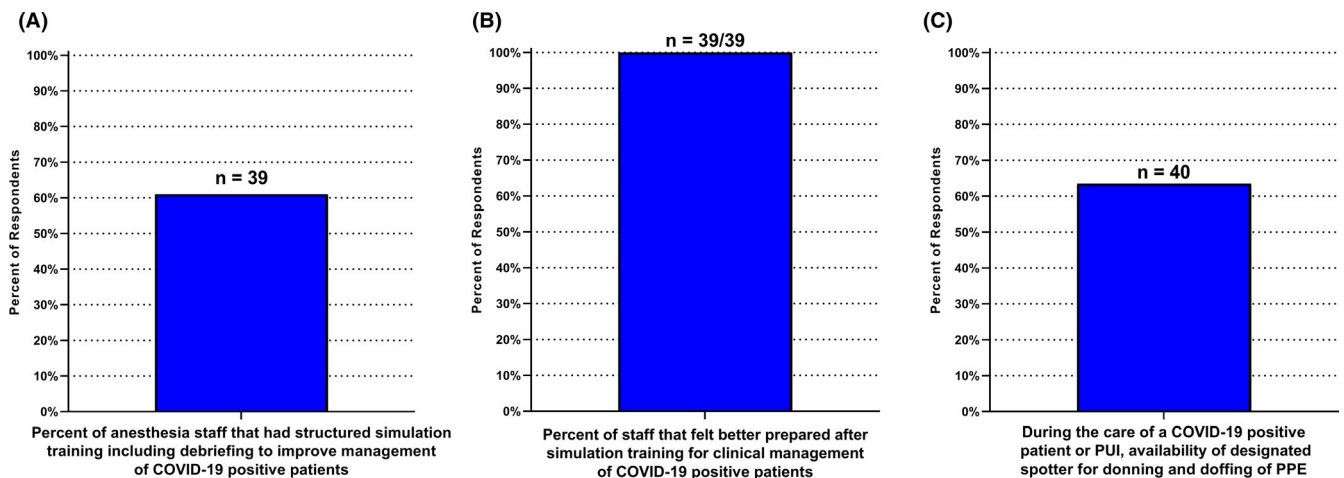


FIGURE 5 Training of pediatric anesthesia staff. A, At 39 among the 63 institutions, anesthesia staff had structured simulation training including debriefing to improve management of COVID-19 positive patients. B, At all 39 of these institutions (100%; 95% CI: 91%–100%), staff felt better prepared for clinical management of COVID-19 patients after simulation training. C, Availability of a designated spotter for donning and doffing of personal protective equipment (PPE) was available at 40/63 institutions. PUI = untested patient under investigation for COVID-19 [Colour figure can be viewed at wileyonlinelibrary.com]

n = 1/11). Since reopening, a returning volume of elective surgical cases has been observed at 36% of institutions (n = 4/11), however, not necessarily to prepandemic levels and these required extra shifts on weekends or extended work days at 25% of institutions (n = 1/4).

4 | DISCUSSION

Our international survey has confirmed that the COVID-19 pandemic brought forth widespread impact on pediatric anesthesiology.

Numerous institutions required preprocedure patient COVID testing within 72 h of the procedure as outlined by the American Society of Anesthesiologists and Anesthesia Patient Safety Foundation Statement on Perioperative Testing.¹⁴ However, very few anesthesiology staff were being tested routinely (Figure 2) despite potential asymptomatic transmission, as pointed out by Stock et al who recommend frequent testing regimens of healthcare workers on a regular, multi-modal basis to prevent spread within the workforce and to patients.¹⁵ Hospitals relied more on questionnaires and daily attestations rather than routine testing of employees. In addition, most (57/63 respondents) institutions allowed parents to enter facilities without testing them for COVID-19. A minority (25% of institutions) also allowed parents to enter the operating rooms for induction despite that they could be sources of asymptomatic spread. Variation of timing and testing could reflect local testing supplies, recommendations set forth by the American Society of Anesthesiologists and Anesthesia Patient Safety Foundation, government and the subsequent local hospital policies, and healthcare system capacity.^{13,16,17}

Early in the COVID-19 pandemic, there were reports of critical supply shortages of equipment and personal protective equipment in many facilities worldwide.¹⁸ Compounding this problem was an increased demand and cost for personal protective equipment.⁷ Our survey demonstrated that the vast majority (91%, 57 out of 63 responding institutions) of anesthesiologists had access to N95 masks. However, not all anesthesiologists had access to adequate personal protective equipment even though they participate in high-risk aerosolizing procedures. This troubling finding was not in line with the recommendations set forth by the American Society of Anesthesiologists, Anesthesia Patient Safety Foundation and the World Health Organization. Unfortunately, our survey did not ascertain why this was not universal. However, our survey indicated that 22% of anesthesia providers left their practice because they felt unsafe taking care of COVID-19 patients. Some institutions allowed employees to purchase and wear other approved personal protective equipment if it could not be supplied by the facility, as endorsed by the American Society of Anesthesiologists.¹⁶ Among the 11 institutions where using one's own personal protective equipment was not allowed, anesthesiologists at 2 of these institutions had to proceed with elective cases in patients under investigation for COVID-19 or COVID-19 positive patients without personal protective equipment (Figure 3).

As the COVID-19 pandemic surges, educational needs continue to require frequent reassessment to maintain safety and high clinical standards. Proper donning and doffing of personal protective equipment are important to prevent self-contamination and spread of COVID-19 to other staff and patients. Cook et al postulated that the lower than expected risk of occupational infection in our specialty might be due to the excellent attention to detail that most anesthesiologists have with respect to the use of personal protective equipment and robust airflow in the venues in which they work.¹⁹ In addition, staff education on these practices, simulation training, and having spotters to ensure compliance would mitigate these risks as reviewed by Zucco et al.¹⁷ Figure 5 highlights the results of

our survey indicating that only 62% of responding institutions had simulation training for donning and doffing of personal protective equipment. Our survey found a reduction in spotter availability for donning and doffing of personal protective equipment during off-hours. Furthermore, providers taking care of COVID-19 positive patients needed to be proficient in new intubation techniques such as using barrier devices to prevent contamination. In our survey, 71% of institutions were using airway barrier methods. However, reports about experience with these novel protective barrier enclosures were controversial due to limitations on the ability to perform airway interventions and in containing aerosols during aerosol-generating procedures.^{20,21} Staff involved in formalized simulation training felt more prepared to deal with the cognitive load that accompanies taking care of COVID-19 positive patients. As outlined by Gaba et al, simulation training has been found to advance patient safety and reduce the risk of medical errors.²² In our survey disproportional fatigue due to COVID-19 was reported in 65% of institutions, and 10% of respondents believed that medical errors increased in their institution during the pandemic. Our survey results emphasize how formal simulation training promotes a safety culture.

In March and April of 2020, many hospitals temporarily halted pediatric elective procedures, and the economic impact was tremendous.²³ Hospitals in the United States lost an average of \$50.7 billion from March 1-June 30 2020, according to the American Hospital Association.⁷ Many hospitals in the United States depend on elective surgeries to stay financially solvent, and the sharp decline in revenue is exacerbated by increased costs associated with taking care of COVID-19 positive patients.⁷ The cessation of surgical elective cases led to a backlog of surgical elective cases. For healthcare systems to recover, many institutions required pediatric anesthesia providers to work extra hours upon resumption of normal clinical activity. Our survey results indicated that 25% of the anesthesia providers were required to work extra hours. The economic situation deteriorated for many Americans who were unemployed due to COVID-19 including healthcare workers²⁴ and hospitals saw more uninsured patients as well.⁷

During the pandemic, there were also changes to staffing roles to accommodate the need to care for COVID-19 positive patients. Figure 4 demonstrates that 32% of survey respondents indicated that they could voluntarily elect to not work with COVID-19 patients. Reasons to be excluded from working with COVID-19 patients included the anesthesia provider's age, medical comorbidities, pregnancy, breastfeeding, and household members with comorbidities.

Our data indicate pediatric anesthesiology faculty also saw a reduction in their salary, incentive pay, decreased retirement matching and loss of nonclinical time during the pandemic. As stated by Krukowski et al, the pandemic disrupted academic productivity in many areas of science, technology, and medicine.²⁵ Evidence shows that trainees have been affected similarly, and pediatric anesthesia fellows reported anxiety over contracting COVID-19 and securing employment after graduation in an uncertain job market.¹¹

Our study has several limitations. Although not a random sample, the study design is prospective, and consequently recall bias

was not a limiting factor. Due to the novelty of COVID-19, national and institutional guidelines have been revised to reflect evolving medical knowledge, and healthcare staffing challenges have developed. Nevertheless, the results of this study will help inform clinical decision-making. Our survey and results represent a snapshot (September-October 2020) in an ever-changing healthcare environment affected by COVID-19. However, it provides temporally relevant information as medical knowledge regarding the COVID-19 pandemic evolves and requires reassessment.

An aspect of selection bias may be built into the survey as well. Our respondents were all members of an international pediatric anesthesiology research collaborative, and therefore anesthesiologists not part of the collaborative may have answered differently. Membership into the Pediatric Anesthesia COVID-19 Collaborative arose from individuals actively participating in other research registries (Pediatric Craniofacial Collaborative Group, Difficult Airway Registry) that were established through the Society of Pediatric Anesthesia. It was done mainly through this mechanism which may have caused inadvertent selection bias. It is a voluntary professional group of pediatric anesthesiologists interested in how COVID-19 is affecting our specialty. Membership is free and requires interest and availability to meet over Zoom video conferencing. However, given the heterogeneity of pediatric anesthesiology practices, we feel our sample does have validity because it is an international survey with a high response rate representing hospitals ranging in size and type.

Our survey elucidates differences in personal protective equipment and COVID-19 testing availability in institutional safety practices and economics that directly affect pediatric anesthesia practices and providers. The majority of hospitals followed national guidelines. As COVID-19 vaccine development is completed and vaccination programs are implemented, new safety practices, and the results of our survey will be carried forward to confront new challenges ahead for pediatric anesthesiology. Careful consideration of safety practices and their implementation will help inform optimal decision-making and patient management. Further investigation into the long-term consequences of COVID-19 on our specialty is warranted.

5 | Pediatric Anesthesia COVID-19 Collaborative: Collaborating Authors

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6 | Pediatric Anesthesia COVID-19 Collaborative: Participating Institutions

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of Pediatrics, Mexico City, Mexico Nationwide Children's, Columbus, The Ohio State University (OSU), OH, USA NYU Langone Health, New York City, NY, USA Omaha Children's Hospital & Medical Center; University of Nebraska Medical Center, Omaha, NE, USA Perth Children's Hospital and The University of Western Australia, Perth, Western Australia, Australia Royal Children's Hospital & Murdoch Children's Research Institute, University of Melbourne, Victoria, Australia Seattle Children's Hospital, University of Washington School of Medicine, Seattle, WA, USA Sheffield Children's Hospital, UK Shriners Hospital for Children, Chicago, USA Sidra Medicine, Weil Cornell Medical College, Doha, Qatar Universitäts-Kinderspital beider Basel (UKBB), Basel, Switzerland University Hospitals Rainbow Babies and Children's Hospital, Cleveland, OH, USA University of Arkansas for Medical Sciences (UAMS), Arkansas Children's Hospital, Arkansas, USA University of California Davis, UC Davis Children's Hospital, Sacramento, CA, USA University of California, San Diego (UC San Diego), and Rady Children's Hospital, CA, USA University of Illinois at Chicago, Chicago, USA University of Kansas Medical Center, USA University of Mississippi Medical Center (UMMC) Jackson, MS, USA University of New Mexico (UNM), Albuquerque, New Mexico, USA University Texas Health Science (UTH) Houston, McGovern Medical School at UT Health, TX, USA University of Wisconsin-Madison American Family Children's Hospital, WI, USA University of Texas Southwestern Medical Center, Dallas, TX, Children's Health Medical Center, Dallas, TX, & Outcome Research Consortium, Cleveland, OH, USA West Virginia University School of Medicine (WVU), USA

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DISCLOSURES

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ETHICS

Boston Children's Hospital and Harvard Medical School IRB Institution exempt.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study may be available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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