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COVID-19 Impact on Surgical Resident Education and Coping



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ABSTRACT

Background: Healthcare systems and surgical residency training programs have been significantly affected by the novel coronavirus disease 2019 (COVID-19) pandemic. A shelter-in-place and social distancing mandate went into effect in our county on March 16, 2020, considerably altering clinical and educational operations. Along with the suspension of elective procedures, resident academic curricula transitioned to an entirely virtual platform. We aimed to evaluate the impact of these modifications on surgical training and resident concerns about COVID-19.

Materials and methods: We surveyed residents and fellows from all eight surgical specialties at our institution regarding their COVID-19 experiences from March to May 2020. Residents completed the survey via a secure Qualtrics link. A total of 38 questions addressed demographic information and perspectives regarding the impact of the COVID-19 pandemic on surgical training, education, and general coping during the pandemic.

Results: Of 256 eligible participants across surgical specialties, 146 completed the survey (57.0%). Junior residents comprised 43.6% ($n = 61$), compared to seniors 37.1% ($n = 52$) and fellows 19.3% ($n = 27$). Most participants, 97.9% ($n = 138$), anticipated being able to complete their academic year on time, and 75.2% ($n = 100$) perceived virtual learning to be the same as or better than in-person didactic sessions. Participants were most concerned about their ability to have sufficient knowledge and skills to care for patients with COVID-19, and the possibility of exposure to COVID-19.

Conclusions: Although COVID-19 impacted residents' overall teaching and clinical volume, residency programs may identify novel virtual opportunities to meet their educational and research milestones during these challenging times.

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Introduction

A cluster of pneumonia cases of unknown etiology was reported on December 31, 2019, in Wuhan City, Hubei Province of China, and later identified to be the first presentation of a novel coronavirus disease 2019 (COVID-19).¹ On January 20, 2020, the first case of COVID-19 in the United States was confirmed.² This respiratory infection, mild for some but life-threatening for others, has continued to spread rapidly throughout the world. As of July 19, 2020, there are over 14.4 million confirmed cases worldwide, with 605,000 deaths.³ In California, rapidly increasing case numbers and evidence of community transmission prompted shelter-in-place orders on March 19, 2020.^{4,5} Many medical schools temporarily suspended clerkship programs,⁶ whereas resident trainees continued working through the pandemic.

Residents providing clinical care during the pandemic have faced multiple challenges. Similar to the human immunodeficiency virus or acquired immunodeficiency syndrome, severe acute respiratory syndrome (SARS), and middle east respiratory syndrome, fear of exposure to infectious disease and risk of transmission to loved ones is common.⁷⁻⁹ Studies have also shown that treating patients with advanced respiratory diseases during pandemics results in greater levels of stress, higher levels of burnout, and post-traumatic stress among providers.¹⁰ Providers directly treating such infections are at risk for higher levels of chronic stress, depression, and anxiety years after the conclusion of the outbreak.¹¹ More specifically, recent studies have shown that women, nurses, and those directly involved in the care of patients afflicted with COVID-19 in hard-hit areas such as Wuhan, China, are more likely to experience adverse mental health outcomes than their peers.¹²

Institutional policies may negatively impact medical training during a pandemic. During the 2003 SARS outbreak in southeast Asia, residents reported their education was compromised as many teaching sessions, and interactive educational activities such as grand rounds were canceled.¹³ In the United States, residency programs have adopted similar policies that decrease gatherings of large cohorts, thus impacting resident-educator contact. As a consequence, resident didactics have either been canceled or moved to virtual-based platforms. In addition, clinical volume has been impacted, as non-urgent patient encounters such as outpatient clinics and elective surgeries have been postponed while paradoxically, urgent surgical care has also decreased. It is not yet clear whether adaptations to resident curriculum will enable residents to achieve necessary medical education milestones as mandated by the Accreditation Council for Graduate Medical Education and the American Board of Surgery (ABS). Accommodations have been made for 2020 graduates' case requirements, but the continued impact of COVID on future graduates remains unknown. Guidance regarding hardship modifications from both associations continues to evolve, as do standards for successful resident promotion and residency program accreditation.¹⁴⁻¹⁶

Research is necessary to investigate the impact of the changes in surgical resident education, including caseload, surgical didactics, and faculty interaction. Our study aimed to

assess the surgical resident's perspective toward modifications to their training during the initial phase of the COVID-19 pandemic (March 15 to May 15, 2020). Providing perspectives from residents will better inform policy at the regional and national level, allowing educators and professional associations to better plan for the continued modifications to surgical curriculums that will be required as the pandemic evolves.

Materials and methods

Study design and setting

We surveyed all surgical residents and fellows from our institution regarding their perceptions of the impact of COVID-19 on their education and coping during the pandemic. The shelter-in-place order for our county went into effect on March 16, 2020, and we conducted our survey approximately 2 mo later to evaluate the early impact of the ordinance. Surgical residents and fellows from the Cardiothoracic, General Surgery, Neurosurgery, Orthopedics, Otolaryngology/Head and Neck Surgery, Plastics, Urology, and Vascular Surgery programs were recruited through a secure email from program coordinators, which included study purpose and anonymous link to Qualtrics (SAP, Seattle, WA). The questionnaire was secured within Qualtrics via a dual-authenticated connection by the user and our institution, allowing anonymous responses to be collected. Participants were not compensated for completing the survey. The Stanford University Institutional Review Board approved this research study and provided an exemption waiver for participation in the survey (Protocol #56168).

Measures

The questionnaire consisted of 38 questions, intending to obtain demographic information and perspectives regarding the impact of the COVID-19 pandemic on surgical training, education, and general coping during the pandemic. Participants were asked to recall their experiences from the previous 4 wk of training when answering the survey. More specifically, the questionnaire aimed to assess the impact of COVID-19 on the following domains: surgical and clinical volume, faculty supervision, formal and informal education opportunities, and resident coping during the pandemic, including perceived exposure risk to COVID-19 on themselves and family members.

Items such as "How concerned are you about possible exposure to COVID-19?" were answered on a five-point Likert scale ranging from "not at all" to "extremely," with extremely demonstrating the perceived greatest levels of concern to the respondent. Similarly, items such as "Please indicate the impact that COVID-19 has had on your operative volume in the past month" were answered on a five-point Likert-type scale ranging from "significantly decreased" to "significantly increased." Respondents also described in free text their perceived impact of the COVID-19 pandemic on their overall education.

Before distribution, the questionnaire was peer-reviewed for expert validation by Stanford Medicine faculty previously unfamiliar with the aims of the study following AMEE guidelines.¹⁷ The questionnaire underwent cognitive interviews and pilot testing with 10 randomly selected surgical trainees (7% of the total sample), who provided question-by-question feedback to ensure the survey was clear and accurate.

Analysis

After the results were compiled, descriptive analysis was performed using Excel (Microsoft Corp., Redmond, WA). Distributions were stratified according to the level of training and surgical specialty. For the analysis, we categorized trainees into three levels based on their years of training “experience level”: juniors (PGY-1 and -2 and those on research/development years), seniors (PGY-3 and above), and clinical fellow. In addition, we tested the association between impact on performance/education and the resident level using IBM SPSS Statistics (IBM Corp., Armonk, NY).

We asked participants to explain the impact of COVID-19 on the quality of their overall education. We coded and analyzed their open-ended responses, using NVivo (Version 12, QSR International Pty Ltd, 2018, Burlington, MA). We performed content analysis, a research approach to categorize and count frequencies of narrative text to identify core categories and meanings.¹⁸ The codes were developed inductively, derived from the responses, and iteratively developed. The codes were then quantified for core categories and counted for frequency. This type of qualitative analysis—objective, systematic, and quantitative description of text—allowed us to conduct a quasi-statistical analysis of textual material. Representative examples of each category were included to illustrate the full context of trainee statements (Table 3).

Results

The questionnaire was open from May 11 to 25, 2020, and distributed to 256 eligible participants across all surgical specialties. A total of 146 individuals completed the entire survey and were included in the analysis (57.0% response rate). Table 1 contains demographic data of all participants.

All surgical subspecialties were included, with representation at all training levels from each discipline, as seen in Table 2. Junior residents comprised 43.6% ($n = 61$) of our sample, compared to seniors 37.1% ($n = 52$) and fellows 19.3% ($n = 27$), which were stratified according to the experience level variable mentioned previously.

Residents within our surgical training program rotate at several sites throughout their training but spend the bulk of their training at our primary teaching hospital and academic center.

At the time of survey response, most residents were currently rotating at our main teaching hospital (70.2%, $n = 80$) and were clinically active (82.9%, $n = 116$). Of those not clini-

Table 1 – Descriptive demographic characteristics.

Variable	n	%
Age, y	139	95.2
Min-Max = 25-40		
Mean (SD) = 32.1 (2.9)		
Median (IQR) = 32.0 (4.0)		
Gender	140	95.9
Male	87	62.1
Female	52	37.1
Gender nonconforming	0	0.0
Transgender	0	0.0
Do not wish to specify	1	0.7
Ethnicity*	139	95.2
Latino/Hispanic	9	6.5
White	75	54.0
Black/African American	9	6.5
Asian	47	33.8
American Indian/Alaska Native	1	0.7
Native Hawaiian/Pacific Islander	1	0.7
Multiracial	3	2.2
Other: Arab, Indian, South Asian	6	4.3
Experience level	140	95.9
Junior	61	43.6
Senior	52	37.1
Fellow	27	19.3
PGY level	140	95.9
PGY-1	20	14.3
PGY-2	24	17.1
PGY-3	21	15.0
PGY-4	13	9.3
PGY-5	11	7.9
PGY-6	6	4.3
PGY-7	6	4.3
Research/Professional Development	12	8.6
Clinical Fellow	27	19.3
Specialty	140	95.9
General Surgery	44	31.4
Plastic Surgery	10	7.1
Vascular Surgery	8	5.7
Urology	17	12.1
Neurosurgery	13	9.3
Cardiothoracic Surgery	12	8.6
Otolaryngology/Head and Neck Surgery	14	10.0
Orthopedic Surgery	21	15.0
Other: Transplant Surgery	1	0.7
Location	114	78.1
Primarily location	80	70.2
Off-site location	34	29.8

* Multichoice question, sum greater than 100%.

Table 2 – Resident experience level and specialty, n = 140.

Surgical Specialty	Junior			Senior			Fellow			Total	
	n	%	% Of all	n	%	% Of all	n	%	% Of all	n	% Of all
General Surgery	27	61.4	19.3	14	31.8	10.0	3	6.8	2.1	44	31.4
Plastic Surgery	3	30.0	2.1	4	40.0	2.9	3	30.0	2.1	10	7.1
Vascular Surgery	3	37.5	2.1	1	12.5	0.7	4	50.0	2.9	8	5.7
Urology	3	17.6	2.1	9	52.9	6.4	5	29.4	3.6	17	12.1
Neurosurgery	9	69.2	6.4	3	23.1	2.1	1	7.7	0.7	13	9.3
Cardiothoracic Surgery	2	16.7	1.4	8	66.7	5.7	2	16.7	1.4	12	8.6
Otolaryngology/Head and Neck Surgery	7	50.0	5.0	2	14.3	1.4	5	35.7	3.6	14	10.0
Orthopedic Surgery	7	33.3	5.0	11	52.4	7.9	3	14.3	2.1	21	15.0
	0	0.0	0.0	0	0.0	0.0	1	100.0	0.7	1	0.7
Total	61		43.6	52		37.1	27		19.3	140	100.0

cally active (17.1%, $n = 24$), the vast majority (95.8%, $n = 23$) were pursuing research or professional development. Only 0.7% ($n = 1$) of all participants were not clinically active due to COVID-19–related infection or because they were a person under investigation, or a member of a high-risk group. A total of 86.3% of participants ($n = 120$) denied having high-risk groups in their household, defined as age > 65 y, pregnant partners > 36 wk, or a person with a high-risk medical condition. In general, residents who had risk groups in their household were more concerned about possible exposure to COVID-19 (37.5% [$n = 9$] stated that they were “very” or “extremely” concerned, compared to 16.7% [$n = 20$] among those without any high-risk household members).

By the time of the survey, 97.1% of respondents ($n = 133$) had participated in at least one web-based virtual learning session, including web-based lectures through their surgical program, web-based lectures through an outside program such as American College of Surgeons or Society of American Gastrointestinal and Endoscopic Surgeons, and video-based live demonstrations or simulations, or surgical videos. Web-based lectures through the residency program were the most popular virtual education activities with 81.1% ($n = 107$) participation rate among respondents. Overall attendance at all didactic sessions increased during our study period from 3 mo prior (63.7% to 74.3%). We observed a fairly even distribution of respondents’ opinions regarding virtual learning as a teaching modality during the COVID-19 pandemic. A total of 39.8% ($n = 53$) believed virtual learning sessions during the COVID-19 pandemic were “much better” or “somewhat better” compared to traditional teaching methods, while 35.3% ($n = 47$) stated they were “about the same.” Virtual learning was rated as “somewhat worse” or “much worse” by 24.9% of respondents ($n = 33$). A total of 43.9% of juniors ($n = 25$) stated that they perceived virtual learning “much” or “somewhat” better than traditional teaching methods, compared to 36.8% ($n = 28$) of seniors and fellows combined (Fig. 1).

In total, 97.9% of participants ($n = 138$) anticipated being able to complete the current academic year on time, whereas 1.4% ($n = 2$) were uncertain, and 0.7% ($n = 1$) did not anticipate being able to complete the current academic year on time.

Although almost all participants did not doubt that they would complete this academic year, more than 32.5% ($n = 41$) experienced some level of concern about meeting requirements for matriculation to the next level of training. The majority (67.5%, $n = 85$) were not at all concerned about meeting their requirements for the academic year to graduate to their next level of training, but the remainder admitted that they were slightly, moderately, very, or extremely concerned (respectively, 23.5% [$n = 29$], 7.1% [$n = 9$], 1.6% [$n = 2$], and 0.8% [$n = 1$]). Generally speaking, senior trainees were less concerned about graduation to the next educational level than junior trainees (80% [$n = 20$] of fellows were not concerned at all, compared to 72.9% [$n = 35$] of seniors and 55.6% [$n = 30$] of juniors).

The impact of COVID-19 on surgical experience, work duty hours, patient volume, and supervision was also assessed, and results are depicted in Figure 2.

COVID-19 negatively impacted operating room (OR) and clinical volume but allowed more time for self-study and research activities. Notably, 67.2% of residents ($n = 88$) stated that work duty hours during COVID-19 had “significantly decreased” or “somewhat decreased,” whereas 91.3% ($n = 116$) reported that patient volume had “significantly decreased” or “somewhat decreased.” According to 85.4% participants ($n = 105$), operative volume had also decreased. Conversely, 48.2% of participants ($n = 67$) reported that their research activities had “significantly increased” or “somewhat increased,” and 59.4% ($n = 82$) reported an increase in their ability to self-study while on service.

We found a correlation between COVID-19 impact on scheduled resident educational activities and experience level to be statistically significant (Fisher exact test = 16.6940, $P < 0.05$).

Participants also reported on their coping and concerns regarding the COVID-19 pandemic, summarized in Figure 3.

In general, residents expressed a low level of concern on when coping with the pandemic, especially regarding having time for research (67.2% [$n = 90$] were not at all concerned), having sufficient faculty clinical supervision in and outside the operating room (respectively, 76.7% [$n = 92$] and 80.8%

Table 3 – Qualitative themes.

Category	Explanation	No. (%) (n = 160)	Examples of participants' responses
Impact on surgical activities	<ul style="list-style-type: none"> - Decrease in surgical and clinical volume. - Not a large impact on overall education due to high volume at baseline. 	51 (31.9%)	<p>“Decreased quality. Minimizing double scrubbing [...] impacts junior learning. Not seeing patients in [the] clinic negatively impacts clinical learning. Decrease case volume also negatively impacts learning.” (Clinical Fellow, General Surgery)</p> <p>“Less surgical volume but I do not expect that this will lead to an overall worse training experience given the high volume we already have at baseline.” (PGY-2, Plastic Surgery)</p>
Impact on self-study & didactics	<ul style="list-style-type: none"> - Increased time for reading, self-study, and didactics. - More online resources available. - Seen as an unexpected opportunity. 	26 (16.3%)	<p>“A golden opportunity for increased self-study, research productivity and multi-institutional educational conferences.” (PGY-2, Orthopedic Surgery)</p> <p>“I actually have time to read now.” (PGY-5, Plastic Surgery)</p> <p>“Appreciate having a lot more virtual learning opportunities from our program as well as sister programs and national organizations”. (PGY-5, Plastic Surgery)</p> <p>I have participated in more educational activities via zoom because I can multi task, e.g., drive home on nights and cook while listening to a lecture whereas pre-covid, it would miss the entire lecture and drive home and sleep. (PGY-2, General Surgery)</p> <p>As for didactics, I actually quite like the online meeting format. It would be particularly useful for when we are rotating off-site. (PGY-3, Cardiothoracic Surgery)</p>
Impact on laboratory & research activities	<ul style="list-style-type: none"> - Change to research and lab time, largely dependent on the type of research (wet lab versus clinical research). 	9 (5.6%)	<p>“I did use that time to increase my research productivity which was an unexpected benefit.” (Clinical Fellow, OHNS)</p> <p>“I’m on research. Research [is] very much impacted. May need to change direction.” (Research/Professional Development, OHNS)</p>
Impact on quality of education & skills	<ul style="list-style-type: none"> - Decrease in quality of education due to reduced OR time and case volume. - Importance of learning coping skills during a pandemic. - Increased flexibility with virtual learning. 	19 (11.9%)	<p>“Decreased quality. Minimizing double scrubbing (even if helpful to case) impact junior learning. Not seeing patients in clinic negatively impacts clinical learning. Decrease case volume also negatively impacts learning.” (Clinical Fellow, General Surgery)</p> <p>“It did not affect my overall education, rather I do believe it enriched it by learning to cope with a severe medical crisis and how my role will look in that scenario in the future.” (Clinical Fellow, General Surgery)</p> <p>Some things have been better- easily accessed videos, been able to watch from home. When on clinical duties, have been able to watch and then if needed, enter simple orders instead of having to leave an in-person teaching session to go enter an order for example. Faculty who have given talks have been enthusiastic and tried their best to make it interactive. (PGY-2, General Surgery)</p> <p>“As a research resident, it’s actually been easier to attend the online/Zoom-based education sessions. [...] Now I have fewer other commitments, so it’s easier to be available during the teaching times...” (Research/Professional Development, General Surgery)</p>
Impact on future plans	<ul style="list-style-type: none"> - Changes to resident exams schedules, research blocks, job searching after graduation. 	4 (2.5%)	<p>“I was required to study for my board exam twice, which although inconvenient, has actually been a means of reinforcing concepts.” (PGY-4, Neurosurgery)</p>
Impact on residents' morale	<ul style="list-style-type: none"> - Demotivation, demoralization, anxiety in response to pandemic. - Frustration regarding national response to pandemic. 	3 (1.9%)	<p>“Most of the impact to me personally has been just demoralization and lack of motivation to read/study.” (PGY-5, General Surgery)</p> <p>“The whole situation with the bungled federal response to the pandemic has my mind wandering toward disaster prep and social activism being more imminent/pressing matters.” (PGY-2, General Surgery)</p>
Impact on work-life balance	<ul style="list-style-type: none"> - Difficulty balancing work and family life, especially with childcare unavailable. 	4 (2.5%)	<p>“Balancing childcare with work has been much harder.” (Clinical Fellow, Urology)</p>

(continued)

Table 3 – (continued)

Category	Explanation	No. (%) (n = 160)	Examples of participants' responses
No major impact	- COVID-19 pandemic disruptions felt to be mild and temporary. - Pandemic well-handled by resident programs.	44 (27.5%)	"On ICU which I am glad of – didn't end up affecting my case numbers that much." (PGY-3, General Surgery) "Overall my program has done a fantastic job to make appropriate changes so my training is not affected." (PGY-7, Cardiothoracic Surgery)

ICU = intensive care unit; OR = operating room.

[n = 97] were not at all concerned), and meeting requirements to graduate to the next level of education (67.5% [n = 85] were not at all concerned). Participants were most concerned about their ability to have sufficient knowledge and skills to care for patients with COVID-19, as well as the possibility of exposure to COVID-19. More experienced residents seemed to be less concerned than junior colleagues (55.6% [n = 15] of fellows stated they were "not at all" or "slightly" concerned, compared to 52.9% [n = 27] of seniors and 38.3% [n = 23] of juniors). When asked to explain why they were "very" or "extremely" concerned through free response, their sentiments included concern regarding infecting family and friends (27%, n = 6), lack of experience in intensive care unit settings (23%, n = 5), decreased OR training time (23%, n = 5), research laboratory closures due to COVID-19 (18%, n = 4), increased stress outside the workplace (5%, n = 1), and lack of personal protective equipment (5%, n = 1).

Qualitative analysis of free-text responses, as shown in Table 3, suggests that COVID-19 hugely impacted a variety of resident activities, including surgical and clinical duties, self-study and didactics, as well as laboratory and research activities (mentioned 86 times, 53.8% all of the sentiments). During the initial phase of the pandemic, residents faced a sharp decline in case volume, which raised concerns about valuable hands-on experience. Laboratory closures negatively impacted residents because of setbacks or slow-down in research work. In addition, some residents noted that COVID-

19 negatively impacted a smooth transition to the next level of education or the start of their professional career. Residents mentioned demotivation and anxiety, particularly about coming to the hospital and maintaining work-life balance, especially with childcare unavailable.

Free-text responses also contained a few positive changes to resident life as a result of the pandemic. Residents highlighted that additional time for reading was much needed and usually neglected because of busy schedules. Still, the reduction in case volume allowed some to catch up on self-study. More resources, such as webinars and other virtual learning opportunities, were created and made available, which helped residents to "fill in [the] previous gap in education" (PGY-2, Orthopedic Surgery). Decrease in the quality of more practical training was inevitable, due to reduced OR time and limited exposure to new cases. However, didactic opportunities offered via Zoom (zoom.us) and other virtual platforms, although less engaging than in-person classes, were perceived as enriching in many ways (e.g., attending lectures conducted by world experts was very beneficial). Online classes were also more easily incorporated into residents' busy calendars.

The pandemic did not affect residents uniformly; their experiences differed and depended on their current status (type of rotation, specialty, clinical status) and experience level. Some residents noted that the impact of COVID-19 was nonexistent, marginal, or only temporary: "I am fortunate that COVID occurred during my research block so I was already

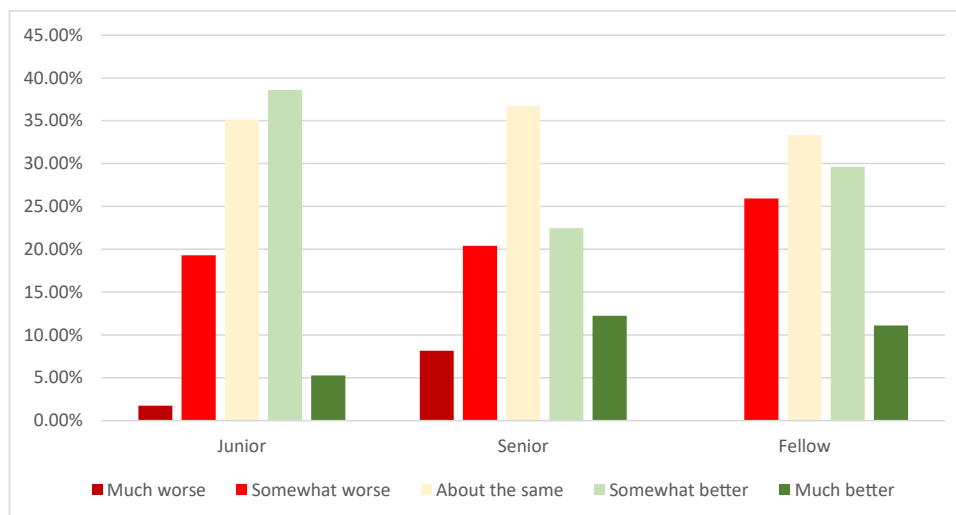


Fig. 1 – Perceptions of virtual learning versus traditional learning by experience level. (Color version of figure is available online.)

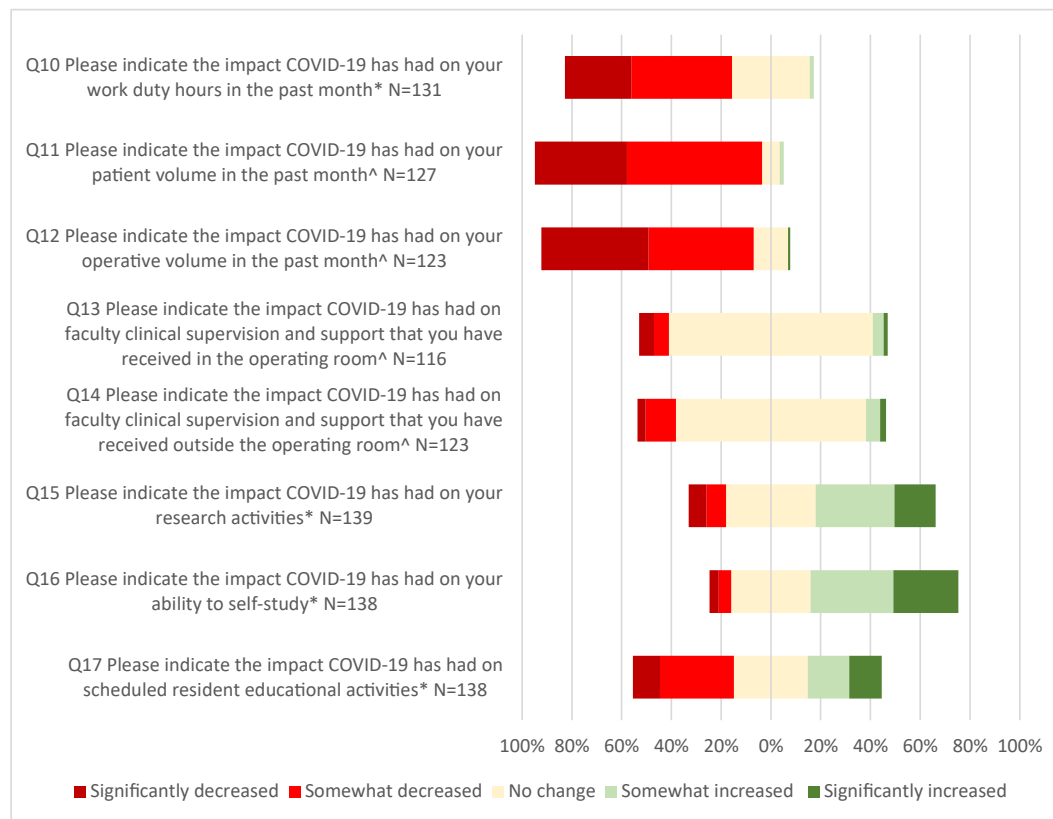


Fig. 2 – Impact of COVID-19 on surgical learning and case volume. ^included all active residents AND research/development residents who participate in clinical activities, unless specified differently; * included all active residents AND all research/development residents. (Color version of figure is available online.)

scheduled to be away from clinical duties.” (PGY-3, Orthopedic Surgery). Lastly, residency programs and department authorities’ efforts were seen by participants as helpful in reducing the negative impacts of COVID-19 on overall education.

Discussion

In this study, we report the impact of the COVID-19 pandemic on training experiences of all surgical specialties at one institution. All specialties reported decreased operative and patient volume for a month-long period during which our academic teaching institution ceased all nonemergent operative cases, in accordance with state guidelines.¹⁹ The decrease in overall case volume at our local institution and within our county is exemplified in our recent publication of reduced trauma volumes in Santa Clara County, CA.²⁰ This pattern is similar to the decrease in case volume seen at other institutions across the country.^{21–24} This change in operative case volume is consistent with prior work surrounding resident trainees and the COVID-19 pandemic.²⁵ Work duty hours decreased, as many specialties consolidated their services and teams to minimize resident trainee exposure. These findings verify our hypothesis that operative volume and patient caseload decreased during the COVID-19 pandemic.

Pandemic-related restrictions limiting nonemergent surgeries largely resulted in a decrease in clinical volume for residents and fellows at our institution. This decrease in operational and patient volume led to resident concern regarding completing educational requirements for their surgical program. While one-third of respondents expressed some level of overall concern, less than 1% were concerned about not being permitted to advance to the next year of training. Surprisingly, fellows were the least concerned out of any experience level, despite the potential month-long interruption to their 1-y program. Our findings suggest residents were meeting their operative case volume and education requirements before COVID-19, and therefore did not perceive themselves as substantially at risk for meeting their clinical and educational milestones for the year. In addition, several specialty surgical boards made COVID-19–related adaptations to their minimum case requirements for graduation. For example, the American Board of Surgery announced that it would accept a 10% decrease in chief resident case volume to meet graduation requirements.²⁶

We found that many resident trainees were able to reappropriate their time toward other academic activities, with the majority having increased time for self-study while on service, and almost half reporting an increase in research time. Interestingly, changes to resident research activities appeared to rely heavily on the type of research conducted, as several

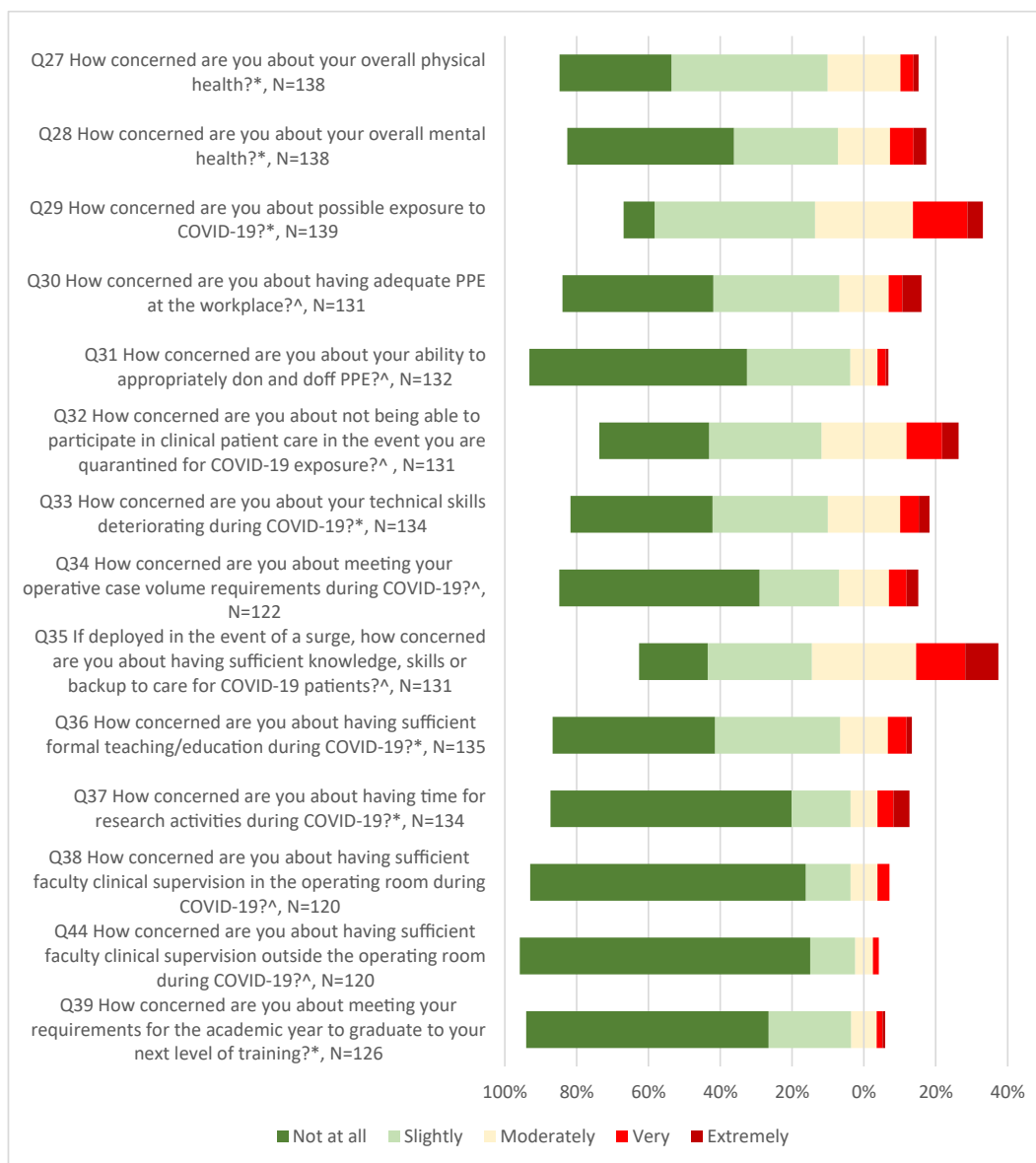


Fig. 3 – Impact of COVID-19 on resident coping. ^ included all active residents AND research/development residents who participate in clinical activities, unless specified differently; * included all active residents AND all research/development residents. (Color version of figure is available online.)

residents commented they were unable to access bench, or “wet,” laboratories due to closures on the university campus. However, other respondents reported increased research activity, such as time spent writing manuscripts for previous projects or conducting research that does not require physical laboratory space on campus. Despite constraints, the pandemic provided an opportunity for both faculty and trainees to identify novel ways of maintaining research productivity, most commonly by virtual means.

Resident learning quickly transitioned to a virtual format because of the pandemic. Most respondents attended virtual sessions and perceptions of benefit were evenly split on the utility of online learning when compared to traditional teaching methods. However, residents also indicated that virtual learning platforms were easier to integrate into a busy schedule, as evidenced by the 11% increase in attendance at

didactic sessions. Several residents felt the increased flexibility allowed them to attend more sessions. As the pandemic evolves, mandated social distancing is likely to become a part of our “new normal.” Developing quality virtual learning experiences and research meetings should be a consideration for many program directors during the pandemic and beyond. Surgical residency programs can be demanding and increasing attendance in educational sessions in a way that promotes flexibility may be beneficial to resident work-life balance. Although it is important to maintain surgical case volume to train confident and technically proficient surgeons, virtual learning opportunities can be time-saving and develop the skills necessary for independent study.

The COVID-19 pandemic continues to affect surgical trainees in a variety of ways, as demonstrated by the qualitative responses. Our residents demonstrated adaptability,

albeit with some anxiety in response to the COVID-19 pandemic. Their most substantial concerns involved the risk of being exposed to the COVID-19 virus, especially those with family members living at home. They were also concerned about having sufficient skills if deployed in the event of a surge, with free response sentiments mentioning lack of knowledge and experience when treating critically ill patients. Equipping surgical trainees with emergency preparedness training may be advisable as the pandemic continues.²⁷ We incorporated the feedback from this study and developed a longitudinal curriculum regarding the critical care management of COVID-19 patients and presented it to residents as a three-part series during their weekly educational half days.²⁸ Incorporated in these sessions were town halls where faculty and trainees could voice mutual concerns and obtain support regarding common stressors such as exposure risk, availability of testing, and personal protective equipment. The results of our study also reinforce the need for more structured psychosocial support programs available to surgical trainees. Our institution has adopted several wellness initiatives in place, including the availability of private sessions with psychologists. Furthermore, within the past year, the General Surgery division has initiated a structured coaching program for residents, where trainees have a dedicated faculty member available to coach them on nontechnical skills and provide longitudinal support.

There are several limitations to our study. The survey was voluntary, and thus the responses do not include the entirety of resident trainee experiences within our institution's surgical programs. Therefore, it may fail to adequately reflect individual sentiments in response to the COVID-19 pandemic. However, this study contains responses from every experience level and training specialty, so we propose that they are a representative sample. As with any survey, it is subject to response bias related to question order, and persons who did respond may have felt more strongly about the impacts on their training experience during the pandemic. Finally, it is important to note that our local healthcare system thus far has endured a relatively modest COVID-19 patient burden, such that intensive care unit beds did not reach capacity, and no resident trainees at our academic teaching institution were deployed to manage critically ill COVID patients. Therefore, the responses illustrated in this study may not be representative of the harder-hit areas of the country.

Conclusions

Our study illustrates changes to resident education amid an unprecedented pandemic. Although COVID-19 impacted residents' training in various ways, including a decrease in caseload and operative time, many of them did not perceive this as a non-navigational obstacle but rather took advantage of opportunities to grow academically during these challenging times. Our findings revealed that residents were able to self-direct to other areas of interest (self-study, research) when needed and successfully engaged in remote educational opportunities that did not jeopardize meeting their graduation requirements to the next phase of training. Virtual learning opportunities were well-received and allowed flexibility for

residents of all training levels. With this in mind, incorporating virtual learning as a cornerstone of future educational planning should be considered by surgical program directors as we prepare for the long-term impacts of COVID-19 and other future pandemics.

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REFERENCES

1. WHO. Pneumonia of unknown cause – China. WHO. 2020. Available at: <http://www.who.int/laneproxy.stanford.edu/csr/don/05-january-2020-pneumonia-of-unkown-cause-china/en/>. Accessed April 9, 2020.
2. Holshue ML, DeBolt C, Lindquist S, et al. First case of 2019 novel coronavirus in the United States. *N Engl J Med*. 2020;382:929–936.
3. Coronavirus COVID-19 (2019-nCoV). Coronavirus COVID-19 global cases by the center for systems science and engineering. Available at: <https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6>. Accessed April 9, 2020.
4. Burke RM, Midgley CM, Dratch A, et al. Active monitoring of persons exposed to patients with confirmed COVID-19 - United States, January-February 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69:245–246.
5. Governor Gavin newsom issues stay at home order. 2020. Available at: <https://www.gov.ca.gov/2020/03/19/governor-gavin-newsom-issues-stay-at-home-order/>. Accessed May 18, 2020.
6. Whelan A, Prescott J, Young G, Catanese V, McKinney R. Interim guidance on medical students' participation in direct patient contact activities: principles and guidelines. 2020. Available at: https://www.aamc.org/system/files/2020-03/meded-March-30-Interim-Guidance-on-Medical-Students-Clinical-Participation_0.pdf. Accessed April 9, 2020.
7. Rambaldini G, Wilson K, Rath D, et al. The impact of severe acute respiratory syndrome on medical house staff. *J Gen Intern Med*. 2005;20:381–385.
8. Link RN, Feingold AR, Charap MH, Freeman K, Shelov SP. Concerns of medical and pediatric house officers about acquiring AIDS from their patients. *Am J Public Health*. 1988;78:455–459.

9. Hayward RA, Shapiro MF. A national study of AIDS and residency training: experiences, concerns, and consequences. *Ann Intern Med.* 1991;114:23–32.
10. Maunder R, Hunter J, Vincent L, et al. The immediate psychological and occupational impact of the 2003 SARS outbreak in a teaching hospital. *CMAJ.* 2003;168:1245–1251.
11. McAlonan GM, Lee AM, Cheung V, et al. Immediate and sustained psychological impact of an emerging infectious disease outbreak on health care workers. *Can J Psychiatry.* 2007;52:241–247.
12. Lai J, Ma S, Wang Y, et al. Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. *JAMA Netw Open.* 2020;3:e203976.
13. Sherbino J, Atzema C. “SARS-Ed”: severe acute respiratory syndrome and the impact on medical education. *Ann Emerg Med.* 2004;44:229–231.
14. Residency in a pandemic: how COVID-19 is affecting trainees. American Medical Association. Available at: <https://www.ama-assn.org/delivering-care/public-health/residency-pandemic-how-covid-19-affecting-trainees>. Accessed April 10, 2020.
15. ACGME resident/Fellow education and training considerations related to coronavirus (COVID-19). ACGME. Available at: <https://acgme.org/Newsroom/Newsroom-Details/ArticleID/10085/ACGME-Resident-Fellow-Education-and-Training-Considerations-related-to-Coronavirus-COVID-19>. Accessed April 10, 2020.
16. FAQs - hardship modifications to general surgery training requirements | American board of surgery. Available at: https://www.absurgery.org/default.jsp?faq_gshardship. Accessed November 24, 2020.
17. Artino AR, La Rochelle JS, Dezee KJ, Gehlbach H. Developing questionnaires for educational research: AMEE Guide No. 87. *Med Teach.* 2014;36:463–474.
18. Patton MQ. *Qualitative research & evaluation methods.* 4th ed.; 2015 SAGE Publications, Inc.; 2015. Available at: https://www.academia.edu/28766598/Qualitative_evaluation_and_research_methods. Accessed November 20, 2020.
19. Resuming California’s deferred and preventive health care. Available at: <https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/COVID-19/ResumingCalifornia%E2%80%99sDeferredandPreventiveHealthCare.aspx>. Accessed June 28, 2020.
20. Forrester JD, Liou R, Knowlton LM, Jou RM, Spain DA. Impact of shelter-in-place order for COVID-19 on trauma activations: Santa Clara county, California, March 2020. *Trauma Surg Acute Care Open.* 2020;5:e000505.
21. Adesoye T, Davis CH, Del Calvo H, et al. “Optimization of surgical resident safety and education during the COVID-19 pandemic – lessons learned. *J Surg Educ.* 2020.
22. Coyan GN, Aranda-Michel E, Kilic A, et al. The impact of COVID-19 on thoracic surgery residency programs in the US: a program director survey. *J Cardiovasc Surg.* 2020.
23. Juprasert JM, Gray KD, Moore MD, et al. Restructuring of a general surgery residency program in an epicenter of the coronavirus disease 2019 pandemic: lessons from New York city. *JAMA Surg.* 2020.
24. Meneses E, McKenney M, Elkbuli A. Reforming our general surgery residency program at an urban level 1 Trauma Center during the COVID-19 pandemic: towards maintaining resident safety and wellbeing. *Am J Surg.* 2020;220:847–849.
25. Fero KE, Weinberger JM, Lerman S, Bergman J. Perceived impact of urologic surgery training program modifications due to COVID-19 in the United States. *Urology.* 2020. S0090429520306464.
26. Modifications to training requirements - COVID-19 update. Available at: http://www.absurgery.org/default.jsp?news_covid19_trainingreq. Accessed July 19, 2020.
27. Ellison EC, Spanknebel K, Stain SC, et al. Impact of the COVID-19 pandemic on surgical training and learner well-being: report of a survey of general surgery and other surgical specialty educators. *J Am Coll Surg.* 2020;231:613–626.
28. Nassar AK, Lin DT, Spain DA, Knowlton LM. Using a virtual platform for personal protective equipment education and training. *Med Educ.* 2020;54:1071–1072.