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Impact of Personal Protective Equipment on Surgeon's Performance during COVID-19 Crisis: Qualitative Exploration of Challenges and Solutions

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Original Investigation

IMPORTANCE The pandemic caused by the Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has exposed surgeons to hazardous working conditions, imposing the need for personal protective equipment (PPEs) use during surgery. The use of such equipment may affect their technical and non-technical skills, augment fatigue and affect their overall operative performance.

OBJECTIVE This study aimed to assess the perceptions of surgeons in regards to the impact of wearing PPEs during emergency surgery, in tertiary care settings, throughout the pandemic and to explore the solutions recommended to cope with emerging issues.

DESIGN This is a Mixed Method Qualitative Study

METHODS A cross sectional survey having both qualitative and quantitative components was administered through an online form which was circulated around the world through emails and social media among surgical communities. Purposive sampling with "snow-balling" was used in order to obtain quality input. Surgeons and surgical trainees who were performing emergency and elective surgeries during the pandemic were included to obtain a meaningful input.

RESULTS Responses to the survey (n=28) were received from surgeons from all over the world. The vast majority (99%) were males. Despite wearing PPEs, only 50% individuals felt safe suggesting high level of anxiety and unpredictability among surgeons. Most of the surgeons (67.9%) felt adversely affected by PPEs in terms of their surgical performance. The four most common problems encountered were problems related to vision (82.1%), breathing and temperature (67.8% each). Mobility and comfort were the 4th most affected factors (60.7%). Common suggestions included prioritizing emergency surgeries over elective procedures (46.42%), performing procedures 4 hours or shorter (42%), taking frequent breaks (32.1%) along with the use of alternative forms of PPEs to suit infection control and surgical performance both. 42% percent responses showed that provision of training for proper usage of PPEs can minimize most problems associated with PPE use. Few suggested avoiding use of PPEs if prior screening for coronavirus turned out negative; however majority were still inclined to observe protective measures. Other suggestions included selection of individualized PPEs suited to various surgeons, adequate training to use them and counseling of peers (10.7%) to curb anxiety in the operation theatre.

CONCLUSION PPEs, although necessary for surgeon and staff safety, have adversely affected the operative performance of surgeons and surgical teams during the pandemic. The use of better suited PPEs, appropriate training and following necessary protocols for infection control advised by various surgical societies can be helpful adjuncts to prevent surgeon fatigue and improve their operative performance.

KEYWORDS Personal protective equipment; non-technical skills; operative performance; vision, fatigue;

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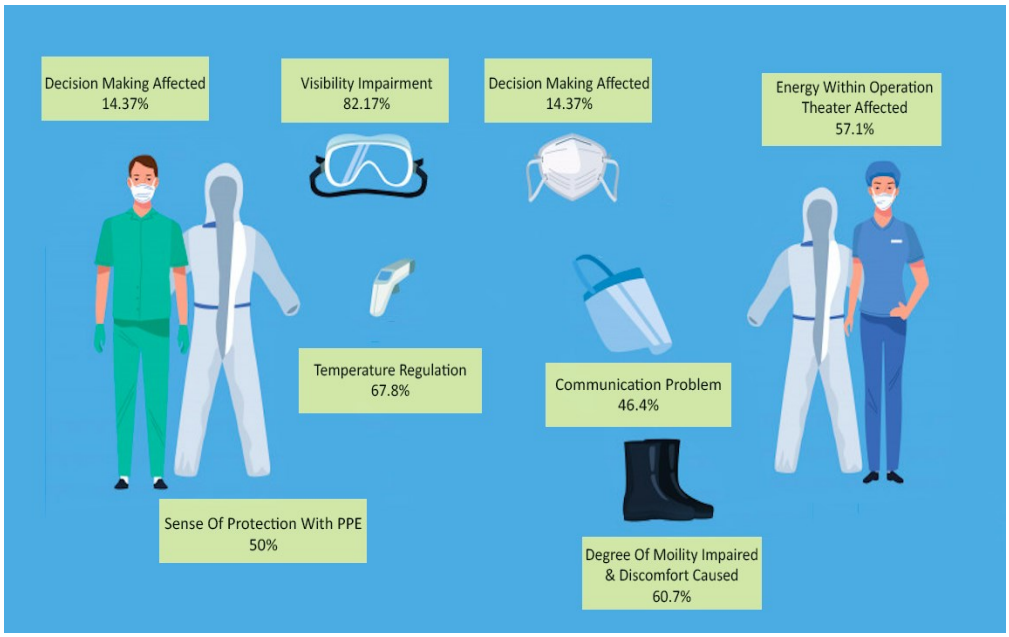
On 31st December 2019, the World Health Organization (WHO) was formally notified about a cluster of cases of pneumonia in Wuhan City, home to 11 million people and the cultural and economic hub of central China. The cause of the severe acute respiratory syndrome that became known as COVID-19 was a novel coronavirus, SARS-CoV-2. SARS-CoV-2 is transmitted via droplets in respiratory aerosol, contact with surfaces and possibly via fecal-oral contact. Worldwide, about a million people have died as of this writing, and a total of 28.6 million infected with the virus. Both surgeons and the patients undergoing surgery are at higher risk of developing COVID related morbidity and mortality.

The SARS-CoV-2 pandemic has exposed surgeons to hazardous working conditions, imposing the need for personal protective equipment (PPEs) use during surgery. They require proper donning and doffing of airborne infection control PPEs for optimal safety during surgical procedures. The use of such equipment may affect a surgeon's technical and non-technical skills, augment fatigue, and affect their overall operative performance[1–9]. Exploring the impact of PPE on the performance of surgeons (technical and non-technical both) and to extrapolate possible solutions for these issues are of highest research priority. Non-technical skills include communication, decision making, situational awareness, and anxiety and fatigue control. The use of PPEs during surgery has also raised concerns about their impact on surgical performance through worsening of quality of vision, temperature regulation, level of anxiety, breathing problems/exhaustion, mobility, decision making, quality of dissection, energy in theatre, research, ability to perform longer operations, quality of assistance and feelings of safety. The purpose of this study was to assess surgeons' perceptions in relation to the impact of wearing PPEs during surgery throughout the pandemic, in tertiary care settings and to find solutions for these problems.

METHODS:

A detailed literature review was done under expert supervision and potential impacts of PPEs were identified and summarized. This literature review was used to form the basis of the questionnaire. The questionnaire items were expert validated through 8 experts and then were distributed among the participants for data collection. The questionnaire containing 22 items was uploaded on Google Forms and issued internationally as an online survey. A draft of the questionnaire which was designed can be found at: https://docs.google.com/forms/d/e/1FAIpQLSereQBlD9UNobHwLoqrSdOEmWLB4_-_joo8v_mb9HxsYxzjg/viewform.

It was a cross sectional survey having both qualitative and quantitative components. Purposive sampling with "snow-balling" was used in order to obtain quality input. Data was collected from surgeons of different tertiary hospitals from around the world. The sample size consisted of approximately 28 surgeons considering more dominant components of qualitative data which was eventually subjected to thematic analysis. Surgeons and surgical trainees who were performing emergency and elective surgeries during the pandemic were included to obtain a meaningful input. Those surgeons and their trainees who were not performing surgeries, either because they are quarantined or because of any other issue or those who declined to participate were excluded. The vast majority of participating surgeons were specialized in general, plastic, neurosurgery, and orthopedic surgery. The survey collected demographic data (age, gender, specialty, qualification, institutional affiliation, city and country of clinical practice) along with the surgeons self-impressions of PPE usage and the feeling of safety, visual impairment, temperature regulation, level of anxiety, breathing problems/exhaustion, mobility, decision making, quality of dissection, energy in theatre, research, ability to perform longer operations, quality of assistance and surgical performance during the COVID-19 pandemic. The questions were formulated so that respondents could give their responses in detail. Frequencies and percentages were calculated



from the collected quantitative data as appropriate.

RESULTS:

A total of 28 surgeons took part in the study. This study population consisted of 9 general surgeons, 2 neurosurgeons, 2 urologists, 2 hepatobiliary and pancreatic surgeons, 2 orthopedic surgeons and 11 plastic surgeons (total=28). Male surgeons were 27 in number and the study population consisted of 1 female surgeon. 6 out of the total fell into the age group of 20-30 years, 12 were of the ages in between 30-40 years, while 10 were aged between 40-50 years. 25 of 28 participants felt that PPEs have significantly affected their ability to perform adequately within the operation theater for various reasons. Moreover, 5 out of 28 did not feel safe enough to perform surgery even after wearing the PPEs. Figure 1 and Table 1 highlight the most common problems encountered along with their percentages according to our study.

Table 1: Which of the aspects listed below have been adversely affected by wearing personal protective equipment in operating room?

Problems	Percentage of surgeons encountering them
Wearing n95 mask for longer periods	67.8%
Permissible length of surgical procedure	50.0%
Energy within operation theatre	57.1%
Degree of mobility and discomfort	60.7%
Quality of visualization	82.1%
Quality of dissection	32.1%
Quality of assistance	32.1%
Quality of communication	46.4%
Preoperative decision-making process	14.3%
Temperature regulation	67.8%
Level of anxiety	28.6%
Sense of protection	25.0%
Financial compromise	17.8%
Surgical training practices affected?	35.7%
Surgical education practices	35.7%
Surgical research practices	21.4%

Among general surgeons as well as specialty surgeons, the top three most encountered problems at an individual level were a decrease in the quality of vision (82.1%), problems with temperature regulation (67.8%) and breathing issues with wearing N95 masks for a prolonged period of time (67.8%) (Table 1). Other problems that seemed to affect the majority consisted of PPEs causing restricted mobility and discomfort (60.7%), energy within operation theatre (57.1%) while financial compromise and preoperative decision-making process were the least frequent problems encountered by the surgeon (17.5% and 14.3% respectively). An important observation regarding PPEs was noted about how much our study population felt safe with the usage of PPEs.

Summary of solutions as suggested by the participants (Quantitative)

Top 3 most commonly provided solutions were: prioritizing emergency surgeries over elective procedures (46.42%), performing procedures 4 hours or shorter (42%), taking frequent breaks (32.1%) along with the use of alternatives to PPEs. 42% results also showed that training for proper usage of PPEs can minimize most of the problems associated with its use. Solutions to all of the physical problems revolved around frequent changing and/or cleaning the gear i.e. the goggles to prevent fogging, and getting better quality equipment with antifog mechanism and respirators was suggested. Methods to curb anxiety in the operation theatre included taking frequent breaks (32.1%), dividing teams into multiple smaller sections to complete longer surgeries and counseling peers (10.7%) was thought to provide help to reduce the stress levels. 28.7% suggested avoiding use of PPEs if prior screening turned out to be negative. For all the complaints relating to increased room and body temperatures, it was unanimously suggested that thermostats to air conditioners be adjusted accordingly and surgeons be placed in the most ventilated part of the room. Along with extra pedestal fans being a favorite to resolving heat problems (21.4%).

QUALITATIVE FINDINGS

Challenges encountered by the Surgeon as an individual with Solutions

Most of the general surgeons suggest that their visibility during operating procedures was compromised due to their goggles getting fogged by their own breath or sweat. For example, one respondent quoted, "my visibility is reduced because vapors are condensed in the goggles" –while other surgeons did not seem to have much of a problem and in fact stated, "our vision gets clearer with goggles". To curb these visibility problems, one expert said "we clean goggles every few minutes" while another suggested, "we can use [Jupiter] hoods instead". Similarly, surgeons faced severe anxiety as the PPEs posed an adaptability challenge. One expert was of the view, "it elevated the level of [my] anxiety of getting infected with Covid19." While another thought, "I did not feel anxious while wearing them". However, majority of the younger experts unanimously answered that "adaptability was not very problematic in my age group but was for older surgeons" and "with age, wearing PPEs is more challenging especially in surgeons with high BMI and comorbidities". A few also claimed "Age has no role whatsoever." Suggestions that followed these problems were worded as, "Screening before the surgery provides a sense of relief". A second expert suggested, "Strong nerves and faith after taking precautions played a significant role (in curbing anxiety)".

In the same way, general surgeons reported no change in their decision-making abilities with the addition of PPEs to their routines. They said, "I found no difficulty in timely decision making with PPEs". Some disagreed by saying, "being visually affected delays judgment in identifying structures, securing hemostasis [and can negatively impact your operative performance]". Suggestions included, "Establishing effective two-way communication between assistants and primary surgeons can help overcome this barrier". It was vastly reported that no change in their quality of dissection was observed; an expert said "we can dissect as well as before" For those encountering problems they suggested, "I have noticed changing masks often can help with maintaining focus and quality dissection" while another expert tipped, "We can take breaks in between operations."

Table 2: Challenges encountered by the Surgeon as an Individual		**Coping strategies suggested**
	Responses by Surgeons	Responses by Surgeons
Quality of vision	Most affected - "My visibility is reduced because vapors are condensed in the goggles." - "They are difficult to wear with spectacles" - "they have no effect." - "our vision gets clearer with goggles"	"we should Get better quality shields and goggles" "we can Clean goggles every few minutes" "we can use hoods instead"
Temperature regulation	Mostly affected - "PPEs cause increased Sweating leading to irritation" - "You get sweaty within half an hour, you feel hot, palpitations, dizziness, the heat of it starts killing you.	"Standing in well ventilated parts of the theatre" "Installing extra pedestal fans and lowering thermostat of A/C can help cool down."
Level of anxiety	Mostly unaffected. - "I am not affected at all" - "I Did not feel anxious" - "It elevated the level of anxiety due to having the risk of getting infected with covid-19."	"Avoid wearing PPEs when patient is Covid Negative" "Screening before the surgery provides sense of relief" "Peer counseling helps a lot" "Wearing PPEs provides sense of relief"
Breathing Problems/exhaustion	Mostly affected "Feeling of shortness of breath during long procedures." "N-95 mask is very tough as it makes rashes on the face, especially on the nose, it was much irritating" "We have stopped performing long procedures because of n95 masks" -"It caused shortness of breath during operation, which in return caused decreased energy."	"by Changing masks every hour, we are able to solve this problem" "Using Green 3M Masks as they are less suffocating" "Using Surgical Masks only without n95 masks" "By resting after every surgery"
Mobility	Mixed responses -" Surgeons don't have to move this much that PPES have this effect" - "it restricts my mobility significantly"	"Getting patients screened prior so we don't have to wear PPEs" "Wearing surgical gowns instead of PPEs can curb this problem" "Keeping less number of assistants and number of other staff in OR" "Getting good size and quality of PPEs" "Limiting no. of patients in one day"
Decision making	Unaffected - "My Decisions are not much affected" –"Visuals affecting your senses and delays the judgments in identifying structures, securing hemostasis". - "our focus is lost." - "I found no difficulty in timely decision making with PPES"	"Establishing effective two-way communication between assistants and primary surgeons can help overcome this barrier," "by Taking frequent breaks our team can handle the decisions better."
Quality of dissection	Mostly unaffected -"They don't have any effect" -"We Can dissect as good as before" - "Free movement cannot be done" - "Restricts Fine movement so difficult to perform quality dissection"	"We can Take breaks in between operations." "By paying more attention to surgical practice." "I have noticed changing masks often can help with maintaining focus and quality dissection" "we should always adapt to changing environments"
Age and the adaptability to wearing PPEs have some role to play?	Mixed responses - "Maybe these are interrelated." - "Age has no role whatsoever" - "I don't think so" - "It's not a that much problematic in my age group than older surgeons" - "With age, wearing PPEs is more challenging	"By motivating peers and fellows to provide a safe environment for everyone" "Strong nerves and faith after taking precautions played significant role"

	especially in surgeons with high BMI and comorbidities.. "	
Covid 19 has affected hugely in terms of research practices?	Mixed responses - "It's badly affected as no surgeries, so no data of patients for research" -"I Have ample time to gather data from ER and do our research" -"Research work is very much slowed due to limited work" -" Stopped research because of it" -" Absolutely, in my personal research, patients for my sample of study were not available. And so research paper is delayed. " -"Completed previous research papers in the free time available during Covid, wrote two more new papers, one related to Covid"	"We can still conduct research by Connecting with patients online" "we can Keep electronic record of data" "We should focus on Completing past researches" "we should be a part of webinars"
Energy in theatre	Mostly affected "Yes, unable to perform longer surgeries now" "It has increased the level of depression and stress among surgeons." "They cause a lot of Exhaustion" "They have not affected me to a great deal"	"I Spitted my team in small groups to perform long surgeries in steps..." "Good hydration before starting operation & control of room temp. while doing surgery helps energy levels." "By only wearing surgical gowns with masks and not wearing PPEs" "By sitting on stools and performing surgeries"
Psychologically Affected?	Mostly Affected	"Encourage Exercise at home" "everyone should Get good amount of sleep" "By keeping 1-2 cases on list everyday" "Spend more time with family and minimizing exposure to patients to keep safe from Covid"

Every participant was significantly affected by the rising temperatures from wearing PPEs and reported, "You get sweaty within half an hour, you feel hot, palpitations, dizziness, and the heat of it starts killing you..." One participant said, "N-95 mask is very tough as it makes breathing difficult and gives rashes on the face, especially on the nose. It is very irritating". The surgeons were agitated so much by N95 masks that they ended up performing fewer surgeries, "we have stopped performing long procedures because of N95 masks". suggestions included, "Installing extra pedestal fans and lowering thermostat of A/C can help cool down." Along with two others saying, "by changing masks every hour, we are able to solve this problem" and "Using Green 3M Masks as they are less suffocating".

Have research practices been affected?

In an online discussion on whether COVID-19 affected research activities, out of a total 98 responses a clear majority of answers discussed how research practices have been negatively affected due to lack of data etc.10 Among our study population, 60.7% subjects claimed that their research practice did not get affected by the pandemic and instead one expert said, "I have ample time to gather data from ER and do our research". It was also suggested that COVID-19 has provided opportunity for newer research topics.... "during COVID, wrote two more new papers, one related to COVID". Only 39.3% subjects reported that their practice had suffered in the pandemic. They said, "It's badly affected as no surgeries, so no data of patients for research". Suggestions on fixing this problem included, "We can still conduct research by connecting with patients online". Another participant said, "We should focus on completing past researches" with a unique suggestion of "we can keep electronic record of data".

Challenges encountered as a team

The ability to perform longer operations was by far the most common challenge that our subjects faced (50%). One response said, "Yes, as long time stay in OR increases exposure" while another explained, "Operative stamina is decreased". As a result of which they suggested, "Avoid[ing] longer procedures for the time being" and "...Take frequent breaks in between procedures". 46.7% of the subjects claimed their communication between the team during surgeries got affected. One stated "PPEs caused muffling of voices so we are unable to hear voices", another countered "I don't think it is a problem". It was proposed "by talking loudly it helps a little." along with "manage all staff talks before surgery so I don't need to rush during case fixes the worry" (10.7%). Surgical training and educational practices were the third most common problem faced because of bringing PPEs into surgical practice as 82.1% subjects thought due to lesser opportunities in theatre, "online classes have covered a lot, though not 100%". To overcome

this one answered, "encouraging everyone to attend webinars both national and international" and another suggested "recording surgeries and sharing with staff later; conduct Zoom meetings"

Rest of the results are tabulated in table 2.

DISCUSSION:

In this study we analyzed the impact of PPEs use on surgeons performing surgeries and identified the common problems they faced in the setting of an operation theatre. Current PPE recommendations for operating room staff consist of protection of droplet, contact, and airborne routes[11]. This includes the use of N95 respirators, eye protectors, face shields, gloves, surgical gowns and shoe covers[12]. Since there is little literature available scrutinizing the consequences of PPE usage for surgeons, exploring their impact on performance of the surgeon (technical and non-technical both) and to explore possible solutions for those issues should be of interest and a need of the time.

Results are classified as 'mostly affected' for challenges encountered the most, 'mixed responses' where the answers of the study population were divided between the proposed challenge causing problems to some and no problems to the rest, 'mostly unaffected' for those where participants did not feel challenged by a certain issue.

The answers revealed that 67.9% of the respondents asserted that their physical performance was significantly impaired as they found themselves avoiding procedures that take longer than 4 hours. Even so, when they performed, they were forced to take frequent breaks due to PPEs causing visual compromise, breathing impairement, limited mobility, affected communication, overall discomfort and the energy within operating theatre being decreased. The use of full body suits and double gloving, in addition to the use of N95 masks disturbed temperature regulation of the body and resulted in extreme sweating, early exhaustion, and increased anxiety levels.

N95 masks are proven to be the best at blocking viral particles but they can also reduce the amount of available oxygen by up to 20%[13]. This corresponds to the claims made by majority of our subjects who reported breathing problems and suggested the use of simple surgical masks instead of these respirators. Infectious disease expert Amesh A. Adalja, MD senior scholar at the Johns Hopkins Center for Health Security in Maryland claimed, "someone wearing an N95 mask for a prolonged period of time may have alterations in their blood chemistry that could lead to changes in the level of consciousness if severe"[14]. Thus, for those facing severe exhaustion and headaches after prolonged use of such masks need to be provided with safety measures to mitigate health risks. There is good evidence that improved access and use of PPEs vastly reduced healthcare worker infections in both Italy and China.[15] However, as important as they may be for the protection of individuals and the entire hospital setting, they pose difficulties for surgeons. Suggestive alternate for N95 masks was the use of Powered Air-Purifying Respirator (PAPR) by the study subjects. As explained in an article about worker's safety by 3M, a powered air purifying respirator uses a blower to force the ambient air through air-purifying elements to the inlet covering. A PAPR system typically includes a motor/blower, filter/cartridge, battery, headgear and a breathing tube.[16] It is proven that these respirators are more effective in protecting the user from breathing contaminated air when compared with N95 masks and their use causes less breathing problems making them competent alternatives to N95 masks.[17] There is, however, a need for proper training when donning PAPR, as the greater protection provided by these over N95 masks is reduced if one self contaminates with a disease that is transmitted via contact[17], a point which has also been emphasized by our study results (42% suggested providing training for usage of PPEs).

Research by Bryce and colleagues (2008) found that even though healthcare personnel may use appropriate PPEs, they often do so incorrectly or incompletely.[18] So when our study population was inquired if age and adaptability to wearing PPEs was a challenge, subjects in the age group 40-50 years reported that age did not have any effect on adaptability and usage of PPEs and disregarded this as a concern. On the other hand, subjects in the age groups of 20-40 years old reported how they themselves were not encountering any issues but believed their colleagues senior in terms of age to them do face a great deal of challenges.

According to our conducted survey, only 50% individuals felt safe wearing PPEs. This lack of confidence could be explained by the extreme working conditions which more than half our study population faced owing to working in operating facilities with infrastructure not equitable with the rest of the world's. The responses of our subjects working in local government hospitals in Pakistan is testament to the fact that difficult working conditions pose a bigger threat to the surgeons as compared to the pandemic itself. However, provision of appropriate PPE and training does protect doctors treating COVID-19 patients from exposure to the infection[19] and no matter how difficult working conditions are, 60.7% of our subject population suggested PPEs cannot be avoided; instead alternatives should be used to minimize the stress caused by it.

We also found that PPE use under the given circumstances also affects a team's performance as communication and mobility is hampered by way of muffled voices, fogging of goggles, crowding of the operating rooms causing surgeons to take additional measures to make their surgeries successful. Measures like improving ventilation by way of adding extra fans, reducing number of assistants and even talking loudly to make their instructions heard help yet also add to the already difficult working conditions. Adequate judgment in surgical practice is established as the capacity to make accurate decisions with the available information.[20] This decision-making capacity was one of the least affected aspects of PPE usage.

Additionally, as mentioned earlier it was reported by our subjects that the usage of goggles impaired their visual capabilities by way of fogging. This resulted in subjects frequently cleaning their goggles or avoiding their use altogether if prior PCR screening of the patient turned out to be negative (28.6%). However, it is an established fact that 90% of the 2000 daily workplace eye injuries could be prevented if the victim had been wearing protective eyewear, such as safety glasses or goggles,[21] making it an important part of PPE. So, if a high-performance antifog is not a part of your organization's planning for safety in the workplace, one could be putting workers in significant danger [21].

Engelmann et al. suggests taking short intermittent breaks to help maintain excellent performance, lower error rates, and increase the surgeon's well-being[22] 32.1% of our subject population suggested likewise and 3 subjects (10.7%) further suggested of splitting their teams into 2 shorter teams for longer procedures. This would help keep up the energy levels within the operating rooms as declining energy is a frequent complaint. Hence the use of such equipment in the surgeons' working environment generates biochemical stress resulting in fatigue and exhaustion.[1] According to the results of our survey, it is felt that more focus needs to be given on making guidelines for the usage of PPEs rather than only focusing on donning and doffing them. Particular attention is also needed to improve the infrastructure of operating theatres of local hospitals so surgeons feel safer while performing lifesaving procedures. Solutions to problems caused by PPEs need more attention as their need has increased exponentially in the past months.

Lastly, it is important to note our assessment method is subject to bias as it relies on the perception and memory of each individual response. However, even though our study is international, our sampling method recruited a higher number of Pakistani surgeons and consequently issues faced by our local surgeons are highlighted more.

CONCLUSION:

Our findings suggest that even though viewpoints of different surgeons may vary from one specialty to another, there are significant issues stemming from the use of PPEs in our surgical practice. From health concerns regarding exhaustion from sweating, breathing difficulties and vision problems, a very significant proportion of surgeons are psychologically affected by the use of PPEs as body suits, goggles and masks despite providing a sense of protection, also prove to be barriers to successful surgeries, resulting in a surgical environment where more focus, more resources, and more time is required to overcome all these difficulties. Consequently, performing shorter procedures and prioritizing emergency cases over elective procedures along with taking frequent breaks and using alternatives like antifog and PAPR have become the need of the hour to reduce problems caused by PPEs.

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