

Original Research Article

Novel real-time remote audio-visual aided technique for doffing of personal protective equipment and assessment of satisfaction level among front-line health care workers amid COVID-19 pandemic

Sukhpal Kaur¹, Damanpreet Kaur¹, Ajay Singh^{2*}, Michelle Shirin Lazar²,
Sushma Saini¹, Manju Dhandapani¹, Shiv Lal Soni², Naveen B. Naik²,
Venkata Ganesh³, Karobi Das¹, Goverdhan Dutt Puri²

¹National Institute of Nursing Education, ²Department of Anaesthesia and Intensive care, ³Anaesthesia, Intensive care and Pain Medicine, Post Graduate Institute of Medical education and Research, Chandigarh, India

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*Correspondence:

Dr. Ajay Singh,

E-mail: ajay.ydv2509@gmail.com

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ABSTRACT

Background: Appropriate and cautious doffing is vital to prevent self-contamination and infection from the highly contagious SARS-CoV-2 virus. In current study satisfaction levels of front-line health care workers regarding doffing assisted by a novel real-time remote audio-visual aided approach was assessed.

Methods: A questionnaire-based survey was carried out among 158 health care workers. The questionnaire was developed and validated to assess the participants' satisfaction level regarding the instructions being given remotely for doffing through the real-time remote audio-visual aided technique pertaining to the various facilities available for doffing, remote communication for doffing steps, audio-visual technical issues, rectification of the breach in safety and the level of anxiety.

Results: The survey received a 79% response rate. 74.6% of the respondents were highly satisfied. 61.9% agreed on the adequacy of doffing space, 70.9% strongly agreed/agreed regarding the availability of adequate equipment, 78.5% strongly agreed/agreed with the instructions. The overall median (IQR) satisfaction score was 9 (8-10).

Conclusions: Real-time remote audio-visual aided doffing approach is a simple, technology-aided strategy that is shown to enhance the satisfaction and motivation of the health care workers. This can potentially help in reducing the number of personnel required in directly monitoring doffing leading to freeing up more people to work with the patients while reducing unnecessary exposure. This translates to effective utilisation of resources. The high satisfaction associated with the use of this system boosts the feasibility of its implementation in every tertiary care setup.

Keywords: COVID-19, Doffing, Health care professionals, PPE, Real-time remote audio-visual aided approach

INTRODUCTION

Effective use of personal protective equipment (PPE) by healthcare workers (HCW's) is an integral part of COVID-19 prevention in the health care setting. Appropriate and rational use of PPE has been

recommended by the World health organization. Doffing of PPE is crucial as it is likely to be contaminated and damaged while caring for patients, thus; health care professionals need to be very careful and methodical while doffing. Self-contamination rates among HCW's as high as 46%–90% during doffing have been reported.^{1,2} Irrespective of the training of HCW's, several factors may

contribute to self-contamination during doffing like difficulty in differentiating between dirty (outside) and clean (inside) surfaces, poorly fitting PPE, forceful movements, incorrect doffing sequence, and inconsistent PPE training.³

Doffing of PPE is a high-risk process that requires a structured protocol, a trained observer, a doffing assistant in some situations, and a designated area for removal to ensure protection.⁴ Because each step in the doffing sequence is critical to avoid exposure, a trained observer should read aloud to the HCW each step in the procedure checklist and visually confirm and document that the step has been completed correctly. The trained observer has the sole responsibility of ensuring that the steps of doffing are adhered to; should be knowledgeable regarding the correct doffing procedures, including how to dispose the used PPE and qualified to provide guidance and recommendations to the HCW's. The trained observer needs to provide immediate corrective instructions if the healthcare worker is not following the recommended steps and remind the HCW's to avoid any reflexive actions that may put them at risk, such as touching their face or the front of the mask. The trained observer is also required to wear PPE while monitoring the doffing.⁴

An Artificial Intelligence (AI) system equipped with audio-visual communication system with Closed Circuit Television (CCTV) cameras in the doffing area has the potential to ensure HCW's safety from an offsite location through a trained observer who is qualified to guide and monitor doffing and can also provide the required instructions to the HCW in the doffing area from a console room that is remotely located. This communication system has the advantage of limiting the risk of direct physical contact of the observer with potentially contaminated PPE of HCW; limiting PPE usage and thereby decreasing the cost especially when there is a crunch in PPE availability in almost all nations. This novel method can also reduce the anxiety of HCW's in cases of error during doffing.⁵ Based on this new technique we planned a survey to assess the satisfaction level and the challenges faced by the front-line workers with the audio-visual communication system. Thus, the current study was planned and carried out to evaluate the satisfaction level of front-line HCW's regarding doffing instructions through real-time remote audio-visual aided (RT-RAVA) communication system.

METHODS

The survey was conducted among 200 HCW's from July 2020 to September 2020 at a dedicated COVID block of Post Graduate Institute of Medical Education and Research, Chandigarh, India. The doffing of HCW's was visualized and monitored from a console room utilizing CCTV cameras installed in the doffing area, and instructions were verbally communicated using an audio-sound system (Figure 1). The entire RT-RAVA system's plan was set-up and executed by qualified health care

professionals with experience in infection control and management who were also responsible for monitoring and providing stepwise instructions to the HCW's while doffing. Irrespective of the cadre of the HCW, all of them were given stepwise instructions and were carefully observed.

The study was designed to be an online questionnaire-based survey. The questionnaire constituted the participant's basic information profile and their consent to participate in the survey, followed by a 24-point questionnaire. Each question was followed by a five-point Likert score. The questionnaire was designed to assess the contentment of the HCW's regarding the novel system of doffing and the instructions given to them throughout their doffing utilizing the novel real-time remote audio-visual aided (RT-RAVA) technique.

The tool designed to assess the satisfaction consisted of 5 major categories, and each of these categories consisted of a set of queries followed by the scoring option. The categories evaluated included (number of questions in each category included in parenthesis): facilities provided for doffing (4), communication with the person who was monitoring the process (12), technical issues faced (3), breach rectification and management (2) and psychological assurance the HCW obtained (3). Each was to be allotted a score on a five-point Likert scale, i.e. highly satisfied scored 5; satisfied scored 4; uncertain scored 3; dissatisfied scored 2 and highly dissatisfied scored 1.

A particular category's aggregate score was done by adding the Likert value of all the items under a specific category and dividing it by the number of questions under the same category. Also, the overall satisfaction score was an average of the Likert values allocated to all the categories. Hence, both the overall score and the score of each domain ranged from 1 to 5 wherein a score of 4.1 to 5 was classified as Highly satisfied; 3.1 to 4 as satisfied; 2.1 to 3 was considered as dissatisfied, and a score of 1 to 2 score was considered as highly dissatisfied. The tool's content validity was established by experts in the field of nursing, medicine, and hospital administration. The overall rating regarding the audio-visual guided doffing was also assessed on a 0 to 10-point numerical rating scale wherein participants were asked to rate their overall satisfaction level with the real-time remote audio-visual aided technique. In this scale 0 to 2 indicated highly dissatisfied, 3 to 5 indicated dissatisfied, 6 to 8 indicated satisfied and 9 to 10 indicated highly satisfied. HCW's were also asked to report the problems faced during doffing while being monitored by the RT-RAVA technique. An option for constructive inputs from any of the participants was also included in the questionnaire. A copy of the entire questionnaire is available from the primary author. A list of the health care workers (HCW's) posted in the COVID unit was obtained from the concerned authority of the hospital, and a link to the online questionnaire was sent through Whatsapp and

e-mail to the physicians and nursing staff, and a telephonic interview was conducted with the hospital and sanitary attendants. The questionnaire and study details were sent to 200 HCW's, of which 158 responded, and the data obtained from these responses were analysed. The survey used SQUIRE 2.0 guidelines from the EQUATOR network. Though it was a voluntary decision of the HCW to participate in the survey detailed information regarding the survey was given to the HCW's and their consent to participate in the survey was obtained prior to the questionnaire. The participants were assured of the confidentiality/anonymity of the obtained data.

Statistical analysis

The frequency of responses in different domains of the questionnaire have been tabulated according to the Likert scale ranging from strongly disagree to strongly agree (1-5). Categorical and count data have been represented as number (percentage) and median (IQR) of the scores have been tabulated according to the different categories of participants. Binary logistic regression was used to predict the influence of certain independent variables (such as occupation category) on the overall average satisfaction score after binarizing the score into two levels as high (>4) and low (≤ 4). Hosmer-Lemeshow test showed a good fit and the model had a prediction accuracy of more than 70%. Odds ratios of getting a higher score have been presented. Analysis has been done using SPSS 25 (IBM Corp. Released 2017. IBM SPSS statistics for windows, version 25.0. Armonk, NY: IBM Corp.).

RESULTS

One hundred fifty-eight health care workers 53 doctors, 53 nursing officers and 52 hospital attendants participated in the study giving a response rate of 79%. The HCW's who were trained in the process of donning and doffing by simulation before being posted in the COVID block and those who had provided standard institutional care to the admitted COVID patients for at least seven days consecutively were included in the study.

Baseline characteristics of the participants

We noted some baseline characteristics of the HCW's who participated in the survey in order to observe whether some variable factors like the age, cadre, timings of shift and areas of work had any effect on the outcome of the study. Table 1 depicts the general characteristics of

the respondents. The age of the HCW's ranged from 25-31 years with a mean \pm SD of 30 \pm 6.01 years. 87 (55%) of the respondents were males and they outnumbered the female respondents (45%) by 16. As per the area of posting, 94 (60%) of the respondents worked in the ICU, 24 (15%) in general wards, 22 (14 %) in high dependency unit and 18 (11%) were in other areas which included emergency triage, private isolation wards and the control room. 45% (72) of the total respondents worked in the night shifts while the remaining 55% of the HCW's were posted in the day. A huge majority (91.7%) of the participants were posted at the COVID block for one week, while 13 HCW's constituting 8.1% were posted for 2 or 3 weeks.

Table 1: Personal profile of the participants.

Variables	N (%)
Age (years)	
18-24	25 (15.8)
25-31	90 (56.9)
32-38	32 (20.2)
39-44	11 (6.9)
Gender	
Male	87 (55.0)
Female	71 (44.9)
Designation	
Nursing Officer	53 (33.5)
Junior/Senior Resident	53 (33.4)
Sanitary/Health Attendant	52 (32.9)
Area of posting in COVID hospital	
ICU	94 (59.4)
General Ward	24 (15.1)
HDU	22 (13.9)
Emergency/ Isolation/others	18 (11.1)
Shift of posting in COVID hospital	
Morning (8:00 – 14:00 hours)	47 (29.7)
Evening (14:00 – 20:00 hours)	39 (24.6)
Night 1 (20:00 – 2:00 hours)	37 (23.4)
Night 2 (2:00 – 8:00 hours)	35 (22.1)
Number of days (in weeks) posted in COVID hospital	
One week	145 (91.7)
Two weeks	11 (6.9)
Three weeks	2 (1.2)

Table 2: Assessment of satisfaction level of the participants regarding doffing instructions through CCTV.

S. No.	Categories of the questionnaire	Strongly disagree N (%)	Disagree N (%)	Uncertain N (%)	Agree N (%)	Strongly Agree N (%)
A	Facilities for doffing					
1	Clean Doffing area	15 (9.5)	27 (17.1)	28 (17.7)	30 (19.0)	58 (36.7)
2	Adequate space for doffing	10 (6.3)	16 (10.1)	33 (20.8)	32 (20.2)	66 (41.7)

Continued.

S. No.	Categories of the questionnaire	Strongly disagree	Disagree	Uncertain	Agree	Strongly Agree
		N (%)	N (%)	N (%)	N (%)	N (%)
3	Adequate equipment for doffing (sanitizer, gloves, mask etc.)	17 (10.8)	10 (6.3)	19 (12.0)	32 (20.3)	80 (50.6)
4	Instructions of an assistant to doff	18 (11.4)	6 (3.8)	10 (6.3)	28 (17.7)	96 (60.8)
B	Communication domains					
5	Greeted me on entering the doffing area	21 (13.3)	14(8.9)	24(15.2)	32(20.3)	67(42.4)
6	Long waiting time to doff	63 (39.9)	33(20.9)	20(12.7)	17(10.8)	25(15.8)
7	Preferred language was used for instructions.	43 (27.2)	10(6.3)	5(3.2)	23(14.6)	77(48.7)
8	Instructions were clear.	16 (10.1)	8(5.1)	5(3.2)	31(19.6)	98(62.0)
9	Instructions was given politely	20(12.7)	4(2.5)	4(2.5)	23(14.6)	107(67.7)
10	Step wise instructions for doffing were provided.	18(11.4)	7(4.4)	5(3.2)	18(11.4)	110(69.6)
11	Adequate time was given between two doffing steps.	16(10.1)	18(11.4)	5(3.2)	34(21.5)	85(53.7)
12	In case of physical discomfort while doffing instructions were given to relieve discomfort.	16(10.1)	11(7.0)	12(7.6)	34(21.5)	49(31.0)
13	If needed help was provided to relieve discomfort (e.g.: sitting on the chair) if it was not managed by instruction	18(11.4)	12(7.6)	10(6.3)	26(16.5)	55(34.8)
14	Instructions were given along were rationales.	16(10.1)	18(11.4)	36(22.8)	37(23.4)	51(32.3)
15	Instructions for biomedical waste management were given	20(12.7)	7(4.4)	5(3.2)	29(18.4)	97(61.4)
16	Greeted with good bye/good day/good night at the end of doffing	24(15.2)	13(8.2)	14(8.9)	27(17.1)	80(50.6)
C	Technical Domain					
17	Voice of the instructor was audible	14(8.9)	10(6.3)	8(5.1)	34(21.5)	92(58.2)
18	Audio visual guided instructions helped in doffing accurately	22(13.9)	8(5.1)	4(2.5)	21(13.3)	103(65.2)
19	Audio visual guided instructions should be used for doffing in future	25(15.8)	2(1.3)	2(1.3)	19(12.0)	110(69.6)
D	Breech rectification					
20	In case of any breech, immediate rectification was told to perform.	20(12.7)	6(3.8)	10(6.3)	32(19.0)	90(57.0)
21	Rectification was instructed in supportive manner	17(10.8)	10(6.3)	10(6.3)	30(19.0)	91(57.6)
E	Psychological Domain					
22	Instructions helped in reducing anxiety while performing the steps of doffing	17(10.8)	10(6.3)	5(3.2)	35(22.2)	91(57.6)
23	Reducing the fear of getting infected while doffing,	18(11.4)	9(5.7)	8(5.1)	32(20.3)	91(57.6)
24	Enhancing confidence to perform your duty in COVID unit.	18(11.4)	7(4.4)	7(4.4)	31(19.6)	95(60.1)

Category wise contentment of the HCW's

The satisfaction level of respondents regarding audio-visual guided doffing based on the categories and the questions in the questionnaire is depicted in (Table 2). Under the category of facilities available for doffing, the authors wanted to evaluate the satisfaction of the health care workers (HCW's) in terms of adequacy and cleanliness of the surroundings, the sufficiency of the required equipment like gloves, hand sanitizer, masks

etc., along with proper instructions and the monitoring while they were doffing. 96 participants (61.9%) strongly agreed/ agreed on the adequacy of doffing space, 70.9% of respondents strongly agreed/agreed regarding the availability of adequate equipment, 78.5% respondents strongly agreed/agreed on the availability of instructions of an assistant while doffing. About 52-72% of the participants agreed or strongly agreed that the facilities like equipment and surroundings were adequate and clean, while 24-42% weren't satisfied.

In the domain of communication about two-third (62.7%) of respondents agreed/ strongly agreed regarding being greeted by the instructors, 60.85% of respondents disagree/strongly disagree that they have to wait for long in doffing area, 63.3% of the respondents agreed/strongly agreed with the language used during instructions, 81.6% agreed/ strongly agreed that clear and polite instructions were being given (81%).

Table 3: Assessment of satisfaction level of the participants under different domains of questionnaire.

Domains	Median satisfaction score	Rank
Facilities provided for doffing	4.5	1
Breech rectification and management	4.1	2
Communication with the monitoring personnel	4	3
Technical issues and management	4	3
Psychological assurance	4	3

Table 4: The influence of variable factors on the satisfaction of the HCW's.

Variable	Odds ratio	P value
Day shift/Night shift	2.443 (1.155-5.168)	0.019
Waiting time < 5 minutes/>5 minutes	0.783 (0.216-2.838)	0.709
No of days posted	1.055 (0.817-1.277)	0.587
Being a nursing officer	0.166 (0.062 - 0.446)	0.001
Being a Senior resident	3.328 (1.140-9.173)	0.028
Being a Junior resident	10.367 (3.281-32.759)	0.001
Being a Sanitary/Health Attendant	6.018 (2.244-16.139)	0.001

90% of the respondents agreed/strongly agreed that stepwise instructions and adequate time was given during doffing (75.2%). In case the respondents had discomfort, instructions were given to relieve the discomfort (31%) and the required help was provided to relieve the discomfort (34.8%). Around one third of the respondents strongly agreed with the rationality of the instructions, more than half (60%) with instructions regarding biomedical waste, and about half (50.6) of them on being greeted at the end of the doffing. Most of (79.7%) the participants agreed/ strongly agreed that the instructions were audible, while 78.5% agreed/ strongly agreed on the statement that audio-visual guided doffing helped in doffing correctly and it should be used in future (81.6%).

Most of the participants (76%) agreed/strongly agreed that steps for immediate rectification were suggested in case of breech, and that it was in a supportive manner. Under the psychological support category, 79.8% agreed/strongly agreed that instructions reduced their anxiety and fear of getting infected while 79.7% strongly agreed that instructions through audio-visual guided doffing enhanced their confidence.

Table 5: Median (IQR) overall satisfaction score (subjective).

Parameters	Total number	Median (IQR) overall satisfaction score
Overall	158	9 (8-10)
Nursing officer	53	7.25 (1.72-9.22)
Senior Resident	24	8.88 (8.18-9.63)
Junior Resident	29	8.92 (7.77-9.75)
Sanitary/Health Attendant	52	9.64 (9.09-10)

Category wise satisfaction

The median Likert scores of five categories that were analysed in the questionnaire is depicted in (Table 3). The maximum average score was 4.5/5, while the lowest was 4/5. The HCW's were most satisfied with facilities and cleanliness of the doffing area, followed by the breech rectification and management that followed. Communication of the personnel monitoring the doffing process, technical details of the audio-visual doffing approach and the psychological support and assurance the HCW's achieved through this novel doffing approach were all awarded an average Likert of 4/5.

The influence of certain variables on the satisfaction

The variables day or night shift (12-hour time period), waiting time before doffing, number of days posted in the COVID hospital and their designation and their effect on getting a higher Likert score satisfaction score was assessed (high being 4.1 to 5). The respective Odds ratios of belonging to a high overall satisfaction score group have been presented (Table 4). Based on the shift of the HCW: it was found that the Odds ratio of having an overall higher average satisfaction score >4.1 was higher, i.e., 2.443 (1.155-5.168, 95% CI, $p=0.019$) if the HCW was posted during the day. This could mean that there might have been some laxity in the way the entire system was implemented during the night time. 86 out of the total 158 participants were posted during the day while 72 of them worked in the night shifts. Based on the number of days, the HCW was posted in the COVID unit: it was noticed that as the number of working days in the COVID unit increased, the comfort satisfaction of the HCW's did not correspondingly increase.

Table 6: Suggestions given by respondents for improvement of audio-visual guided doffing.

Suggestions given	N (%)
Environmental: Improve space at doffing area, temperature control	2 (1.2)
Sanitation: Buckets should be empty every time after doffing/ Frequent cleaning, total segregation of dirty and clean area (different rooms for each), Provision to keep clean masks in clean area (the slabs were dirty where masks were kept), the tile walls also to be cleaned with disinfected solution, Proper education to be given to freshly appointed Sanitary/Health Attendant regarding COVID area job description and doffing area cleaning and etc.	6 (3.7)
Equipment: Make clear audio sound, availability of sanitizer in night shift.	4 (2.5)
Managerial: There should be some alarm system in the doffing area when person enters for doffing, so that instructors get notified, a greater number of instructors to be employed, there should be some provision for sitting near dirty area of emergency, Posting SA in doffing area so that we don't have to search for them here and there in wards, one person for doffing at one time, removal of N95 mask in different room.	8 (5)

**Figure 1: Audio-visual monitoring of doffing using real-time remote audio-visual aided technique.**

With every single day rise in the days of being posted the chance of attaining a higher satisfaction with the RT-RAVA technique increased by only about 5.5%, which could indicate that the HCW's may or may not adapt to the newer approach with due course of time. Based on the designation of the HCW: (95% CI, $p < 0.05$ = statistically significant). We noted that the Odds of getting a higher satisfaction rating was least in the nursing officer group (0.166; 0.062-0.446), when compared to the senior residents (3.328; 1.140-9.173), sanitation or hospital attendants (6.018; 2.244-16.139), and junior residents (10.367; 3.281-32.759). The Odds of getting a higher satisfaction score from nursing officers could be low due to their educational status or their close involvement in establishing and working on the RT-RAVA system, which makes them best suited for scrutinizing such systems. The Odds of getting a higher satisfaction score from junior residents was very high from that of nursing officers, which could imply their less active involvement in setting up the system and also made them more prone to errors while doffing. While concerning the hospital and sanitation attendants, their comparatively inferior

educational status and knowledge of infectious diseases could have been the cause. These two groups thus seem to be more prone to errors and might require strict monitoring.

Overall subjective satisfaction score

The HCW's who participated in the survey were also requested to score their satisfaction with the system on a 11-point scale of 0-10. The median (IQR) of the subjective overall satisfaction score was 9 (8-10). Table 5 shows the median (IQR) score allocated by the HCW's who are categorized as nursing staff, the senior and junior residents and the supporting staff which included the hospital and sanitation attendants in the COVID unit. The supporting staff seemed to have been most satisfied, followed by the residents and the nursing staff. We further classified the score into categories of highly dissatisfied (0-2), dissatisfied (3-5), satisfied (6-8) and highly satisfied (9-10). 74.6% of the respondents were highly satisfied followed by 10.7% respondents who were satisfied; whereas 10.1% respondents were highly dissatisfied and 2.5% respondents were dissatisfied.

Suggestions for improvement received

Table 6 depicts the suggestions provided by the HCW's. Most of the respondents did not give any suggestion. Five per cent suggested improvements in the managerial issues, i.e. installation of an alarm system in the doffing area so that a HCW can notify the instructors when he/she enters for doffing, more number of instructors to be employed, some provision for sitting near the dirty area of emergency, having a sanitation attendant available near the doffing area so that help is available in case of emergency, allowing only one person to doff at one time, and removal of N95 mask in a different room. Suggestions regarding sanitation issues were given by 3.7% respondents, 2.5% respondents suggested on equipment issues, and only 1.2% gave suggestions for managing environmental issues, i.e. improve space at doffing area, temperature control.

DISCUSSION

Cautious doffing of PPE by HCW's is vital to prevent contamination and infection during the COVID-19 pandemic. In our institute, doffing was monitored and guided using a novel technique called "real-time remote audio-visual aided doffing approach" wherein a trained observer monitors and guides the HCW through a remotely located control room.⁶ This prevents self-contamination and ensures the safety of the HCW's. In this survey, we assessed the satisfaction of HCW's while this novel technique monitored them, and also explored various problems faced by the HCW's and their suggestions for further improvement.

HCW's involved in COVID care are thoroughly trained in donning and doffing; however, due to the multiple steps involved in the doffing of PPE, there is a very high likelihood of making errors. The multiple steps of doffing after a tiresome duty can result in errors and increase infection risk. This is a cause of stress, anxiety and HCW's are reported to suffer from panic attacks related to donning, doffing and use of PPE.⁷ This psychological dysfunction or stress itself can result in poor working memory and lead to errors while the HCW is doffing.⁸ Therefore, the CDC guidelines stress that the doffing process needs to be monitored and verified by trained personnel.³

At our institute, we have been using RT-RAVA doffing approach to guide the HCW's throughout the doffing process wherein the trained observer could monitor the doffing from a remotely located control room via CCTV surveillance and provide the required instructions by an audio system, in addition to supervision and overall management of the doffing area. RT-RAVA facilitated the availability of gloves, sanitizers and other necessary resources required at the doffing area, segregation and timely disposal of biomedical waste and regular cleaning and maintenance of the doffing area. It helped the trained observer to identify any breach during doffing and counsel the employees who did not follow the doffing instructions. Depending on the severity of breach, HCW's were asked to perform necessary steps to rectify it or to proceed for quarantine as per institutional protocol. Majority of the HCW's who participated in our study were satisfied with audio-visual aided doffing. High level of satisfaction was reported in terms of psychological assurance, technicality of the technique, available facilities, communication, and breach rectification which was imperative because fear, anxiety and stress are common psychological status experienced by HCW's while doffing.^{9,10}

To acquire the skills with multiple sequential steps such as doffing to a level of automation is an enormous task and guidance benefit learning and performance of motor skills.^{11,12} WHO, CDC and other scientific organizations have recommended that HCW's should be provided training on doffing and their doffing should be directly

supervised by a trained observer. In the flare of a pandemic like COVID-19, most organizations have used the standard buddy system. In contrast, maybe a few remotely located hospitals with scarce resources did not have any provision to guide doffing.^{4,13}

The high satisfaction reported by the HCW's could be due to the step-by-step instructions provided to them during the doffing. The awareness of the importance to follow the right sequence to prevent self-contamination is another stress factor reported by the HCW's. The stepwise instructions make the HCW's free from stress of remembering the multiple steps (approximately 30 steps) and sequence of doffing. The work fatigue may be an additional reason that prompts the HCW's to hurry the doffing process resulting in errors. The trained observer monitors the HCW's while instructing them stepwise throughout the process and ensuring that they perform proper hand hygiene. The trained observer also aids, if the HCW's face any difficulty or physical discomfort while doffing such as difficulty in removing the hazmat suit, shoe covers or mask. HCW's not following the doffing instructions were identified and counselled as they are likely to increase the risk of disease transmission to themselves and others. Hence, the HCW's are enforced to follow the instructions, which is beneficial to them, the patients and other HCW's.

HCW's reported that doffing area was clean, the biomedical waste was effectively managed at doffing area and that there was the availability of adequate equipment that enabled smooth doffing. This could have been the reason of satisfaction for most of the HCW's, and we would mention that this was possible because the trained observer could visualize the entire doffing space from the control room and then take required steps to ensure its maintenance and replenish the required resources from time to time. As the trained observers were also ensuring physical distancing at the doffing area, there was adequate space for everyone to doff efficiently. All these stringent measures facilitated via RT-RAVA doffing to reduce infection were perceived as highly beneficial by the HCW's. Majority of the HCW's were content with the step-by-step doffing instructions given with rationales in a polite manner which was clear and audible. Breach was rectified in a very supportive manner. As the HCW's were greeted and thanked at the beginning and end of the doffing process, they felt valued and morally boosted to serve mankind during this pandemic. HCW's also reported that the safety and security ensured by audio-visual aided doffing reduced their anxiety and fear and enhanced their confidence to perform duty in COVID units. Our study also explored the lacunae associated with RT-RAVA doffing approach. Few HCW's suggested that instructions should be in their preferred language. Some other problems faced included less space for doffing, inadequate equipment supply, improper location of camera, poor sound quality, long waiting time, insufficient sanitation and BMW management. They also gave suggestions to increase the space in doffing area,

improve BMW management and training of hospital attendants. There are also other benefits of audio-visual aided doffing as compared to the buddy system. The video recordings during audio-visual aided doffing can also be used for research and quality control purposes. This novel technique reduced the exposure of the trained observer to aerosols generated in the doffing space and reduced the consumption of PPE, which is paramount in a pandemic where resources are limited. The negligible infection rate and enhanced satisfaction promote and encourage the HCW's to perform their duty with ease in COVID units. This along with other innovative techniques, reduces the burden of the hospital administration.¹⁴ Thus, along with the various preventive, diagnostic and treatment strategies, RT-RAVA also plays a vital role in enhancing the health care delivery during this COVID pandemic.¹⁵ The survey participants form a representative sample of all the HCW's who worked at COVID unit of our tertiary care centre. The survey demonstrated that the new technique provided a high level of satisfaction to the HCW's and reduced their levels of anxiety and stress. Nearly 80% of the HCW's were satisfied with the novel practice, which promotes the HCW's to perform their duties efficiently and reduces the burden on the hospital administration. Our technique not only reduced the exposure of the trained staff who monitored the doffing but also reduced the PPE usage.

Limitations

Current study has certain limitations. The survey would have benefitted from increased participants as this would have increased the power of the study. Also, increased participation would have helped us to compare the novel technique with the standard "buddy" technique.

CONCLUSION

Novel RT-RAVA is a simple technology-aided doffing technique which represent role of AI amid current pandemic. Real-time remote audio-visual aided doffing approach is a simple, technology-aided strategy that is shown to enhance the satisfaction and motivation of the health care workers. This can potentially help in reducing the number of personnel required in directly monitoring doffing freeing up more people to work with the patients while reducing unnecessary exposure. This translates to effective utilisation of resources. The high satisfaction associated with the use of this system boosts the feasibility of its implementation in every tertiary care setup.

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