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IP International Journal of Medical Microbiology and Tropical Diseases

Journal homepage: https://www.ijmmtd.org/

Original Research Article

Impact of doffing audit and onsite feedback in COVID-ICUs of a tertiary care facility, South India

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Abstract

Background: Personal protective equipment has a major role in reducing the transmission of infections to healthcare workers despite the fact that improper doffing techniques can pose a threat of acquiring nosocomial infections. Compliance to donning or doffing is an all or none phenomenon where lack of adherence to sequence or technique can result is transmission of infections. Conducting doffing audit with the help of trained supervisors (dofficers) can significantly improve compliance with doffing guidelines.
Materials and Methods: This quality improvement study, was conducted at a large-scale tertiary care hospital located in South India, for a one-year period in COVID-ICUs. Doffing audit was conducted by trained dofficers in designated doffing areas for proper technique & sequence of doffing and disposal all through the shifts.
Results: 5834 health care professionals were supervised over 8760 hours with a total doffing compliance of 66.6%. Nurses had better overall and individual component doffing compliance. Biomedical waste segregation compliance was also high among nurses (90.4%). Most common breach is with mask removal.
Conclusion: Nosocomial transmission of infections can be controlled with adherence to proper doffing techniques. Auditing and on spot interventions will help improve the compliance to doffing.

Keywords: Personal protective equipment, Doffing, Compliance, Audit, ICU

Received: 09-09-2024; **Accepted:** 15-10-2024; **Available Online**: 26-03-2025

1. Introduction

Healthcare workers (HCW) pose a significant risk of acquiring healthcare associated COVID infections.

The causative agent, SARS-CoV-2 virus is exceedingly infectious, had produced several nosocomial outbreaks. Transmission of SARS-CoV-2 virus in healthcare occur through respiratory droplets, contact as well as airborne particles, which is particularly noted in intensive care units (ICUs) environment, where working in close vicinity of the patient is required for at most care.[1]

HCWs working in COVID ICUs wear a recommended set of personal protective equipment (PPE) comprising of gloves, respirator, protective eyewear and body cover. After finishing their work, healthcare workers go to a designated doffing area where they carefully doff their gear in a specific sequence, adhering to guidelines established by the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO).[2,3]

However, COVID care locations have their own set of challenges, where implementing these otherwise reasonably simple interventions often appear to be difficult. Various research articles have consistently shown that hand hygiene

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http://doi.org/10.18231/j.ijmmtd.2025.016

adherence is low in COVID-19 care settings, largely due to the persistent use of the same gloves without changing them between patient care activities. The fast-paced and physically demanding nature of healthcare work, particularly in intensive care units (ICUs), often makes it challenging to maintain physical distancing. Additionally, healthcare workers frequently struggle with appropriate donning and doffing of personal protective equipment (PPE), leading to errors and potential exposure risks.[4]

Several guidelines have been laid down which provides recommendation on the technique followed for donning and doffing of PPE.[2,3,5,6] Doffing involves removal of PPE in a particular sequence and method along with discarding the PPE into appropriate biomedical waste receptacle. The aim of performing doffing appropriately is to avoid self-contamination. Doffing is an extremely important infection control measure in order to control the healthcare associated COVID infections. Any breach in doffing can be dangerous as it puts the HCWs into risk of contracting infection. However, COVID ICUs have their own set of challenges and adherence to the doffing protocol can be at times very difficult. The HCWs are often found to commit several errors during the doffing of PPE, which can be attributed to lack of knowledge or practice or attitude, exhaustion from work.[7]

Conducting doffing audit with the help of trained supervisors (dofficers) can significantly improve compliance with doffing guidelines. The trained supervisor's role to monitor doffing was first developed in response to viral haemorrhagic fever outbreaks.[8] However, there is paucity of studies available on conducting doffing audit under direct supervision in COVID-ICUs, which have shown a tremendous improvement in compliance.[9] Therefore, this study was designed to monitor the doffing practices of PPE under direct supervision in COVID ICUs.

2. Materials and Methods

2.1. Audit setting

This is a quality improvement study, conducted at a large-scale tertiary care hospital located in South India, in a one-year period from April 2021 to March 2022 coinciding with the second wave of COVID-19 infection. The study was conducted in nine COVID-ICUs, catering to nearly 50 beds. Hospital infection control and prevention (HICP) unit of the facility conducted the doffing audit for the HCWs posted in COVID ICUs. Under the direction of the infection control officer (ICO), the infection control nurses (ICNs) and infection control residents (ICRs) assigned to the HICP unit served as the supervisors for the study.

2.2. Pre-audit training of HCWs

Healthcare workers (HCWs), including doctors, nurses, and ancillary staff (engaged in cleaning activities), were assigned to different shifts throughout the day. The posting roster was previously prepared for a week at a time, meaning that each week, a fresh group of HCWs was assigned to COVID ICUs. Before being assigned to COVID ICUs, the HCWs received sufficient training on donning and doffing techniques and received certification. Together with the ICNs and ICRs of the HICP unit, the ICO conducted training that included a didactic lecture on the donning and doffing technique and simulation films that demonstrated the process. The doffing protocol used for this study has been adapted from the Centers for Disease Control and prevention (CDC) and World health organization (WHO).[2,3] A post-test assessment was used to reinforce the competency, and in order for HCW to be certified to work in areas requiring transmission-based precautions, they had to have a score of at least 90%.

2.3. Audit process

The doffing audit was conducted at the designated doffing zone. A supervisor station was created at a three-meter distance from the doffing zone where the supervisors conduct the doffing audit maintaining adequate distance from the HCWs. Supervisors donned with the essential PPE (i.e. gloves, 3-ply mask, goggles and gown) were posted to conduct the audit in three-shifts a day, in concordance with the posting of the HCWs. The doffing process of the HCWs was observed by the supervisors, while the HCW was performing the doffing procedure. Using the smartphone-based digital app for doffing audit, that JIPMER and Ibhar Pvt. Ltd. created, the data was collected during the doffing audit. The personal protective equipment (PPE) that was necessary for droplet and aerosol precautions were included for analysis: gloves (inner and outer pair), respiratory protection equipment (N95 respirator or 3-ply mask), protective eyewear (goggles or face shield), and body covering (coverall, gown, or plastic apron).

2.4. Assessment of doffing compliance

The supervisors monitored three key elements—method of doffing of each PPE, sequence of doffing and segregation of PPE into the BMW receptacle. Any breach occurred in any of these three elements were recorded. The doffing protocol used for this study has been adapted from the CDC and WHO.[2,3] The recommended method and sequence of doffing of PPE have been depicted in **Table 1** and **Figure 1** respectively.

1. Doffing method compliance: Each individual PPE when doffed as per the recommended method the HCW was considered as compliant for the doffing method for that particular PPE. When all four essential PPE were doffed as per the recommended method, the HCW was considered 'compliant for the doffing method' for all the PPE (**Table 1**).
2. Doffing sequence compliance: The HCW was considered *'compliant for the doffing sequence'* when all the four essential PPE were doffed as the recommended protocol. (**Figure 1**)

3. BMW segregation compliance: When each individual PPE was segregated into the appropriate BMW receptacle, the HCW was considered as *'segregation compliant'* for that particular PPE. When all four essential PPE were segregated into the respective appropriate BMW receptacles, the HCW was considered as *'overall segregation compliant'*. The segregation protocol was as per the biomedical waste management rule 2016 in combination with COVID BMW rule 2021 version 5, laid down by Government of India ().
    a. Red colored receptacle was considered appropriate for segregation of gloves, goggles and face shield, plastic aprons
    b. Yellow colored receptacle was considered appropriate for segregation of Gown, N95 respirator and 3-ply mask
4. Total doffing compliance (TDC): When the HCW is compliant to all three components of doffing process, i.e. sequence, method and segregation, he is said to be '*total doffing compliant'*.
5. Breach: The kind of breach that happened in the process of doffing each piece of personal protective equipment (with respect to sequence or method or segregation) was noted. The supervisor's main responsibility was to watch the PPE doffing process closely. However, they also actively provided feedback on any mistakes made so that the HCW wouldn't repeat them in the following days of the same posting cycle. The audit data were recorded as "error in the sequence or method or segregation" in accordance with the HCWs' original attempt, even though the supervisors immediately fixed the mistakes in the donning sequence and donning process on the spot.

2.5. Data analysis

With IBM SPSS Statistics Version 25, data analysis was done. The standard deviations and means were used to express the descriptive data. We utilized Welch's ANOVA together with Games Howell post hoc testing to compare means for repeat measures. Only those items that the ANOVA test revealed to be statistically significant were eligible for post hoc analysis.

Table 1: Recommended method of doffing of PPE[2,3]

PPE	Method
Gloves	• Do not touch the outside of the gloves (contaminated) • Using a gloved hand, grasp the palm area of the other gloved hand peel off first glove. • Hold removed glove in gloved hand slide fingers of ungloved hand under the other glove at wrist and peel off the second glove over the first glove. • First glove will remain inside the pouch of the second glove
	• Perform hand hygiene after removal
Gown	• Do not touch front part of the gown • Unfasten gown ties, taking care that sleeves don't touch the body when reaching for ties. • Pull the gown away from neck and shoulders, touching inside of gown only. • Turn gown inside out and roll into a bundle and discard. • Perform hand hygiene after removal.
Goggles	• Hold the goggles from the sides or top, avoiding touching the lenses. • Gently tilt and lift the goggles off the face, taking care not to touch face or eyes and dispose • Perform hand hygiene immediately after doffing the goggles.
Mask	• Do not touch front part of the mask. • Untie the lower knot first, then the upper knot and remove the mask by holding its straps, without touching the front • Hand wash after removal.
N95 respirator	• Do not touch front part of the respirator • Remove the lower strap first, then the upper strap and remove the respirator by holding its straps, without touching the front • Hand wash after removal.

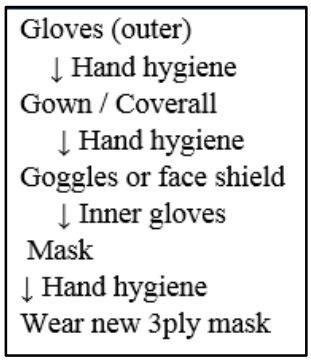

Figure 1: Protocol for sequence of doffing of PPE [2, 3]

3. Result

3.1. Baseline information

A total of 5834 healthcare professionals (2011 males and 2823 females) were under the direct observation of supervisors for doffing method during the study period; which comprised 1887 (32.3%) doctors, 3221 (55.2%) nurses, and 726 (12.4%) ancillary staff who were engaged in cleaning and housekeeping activities. Throughout the course of the three shifts during the study period, the supervisors audited for a total of 8760 hours.

3.2. Components supervised

Table 2 depicts the stratified doffing compliance of HCWs across professional cadres, gender and shifts. The total doffing compliance among all the HCWs was found to be 66.6% (3888/5834), whereas the overall compliance to individual three key elements of doffing, i.e. sequence, method, and BMW segregation were observed to be—80.8% (4713), 72.3% (4218), and 86.1% (5024), respectively. The total doffing compliance is found to be higher for nurses [74.0% (2384)] than doctors [61.1% (1153)] and ancillary staff [48.3% (351)]. Similarly, the stratified compliance to individual element of doffing were found to be higher for nurses [sequence (86.5%), method (79.8%) and BMW segregation (90.4%)] than doctors [sequence (80.7%), method (67.2%) and BMW segregation (82.7%)] and ancillary staff [sequence (55.6%), method (52.2%) and BMW segregation (76.0%)]. Total doffing compliance was found to be higher in female HCWs (71.4%), compared to males (57.5%); the same finding was observed for individual element of doffing (i.e. sequence, method and BMW segregation). There was a diurnal variation observed in the doffing—higher compliance in evening shift [total (72.7%), sequence (83.5%), method (79.5%) and BMW segregation (89.1%)], followed by morning shift [total (69.4%), sequence (80.3%), method (75.5%) and BMW segregation (86.4%)], and then night shift [total (46.7%), sequence (76.3%), method (48.5%) and BMW segregation (79.1%)].

Table 3 depicts compliance of HCWs to individual steps of doffing method. The highest compliance as noted for (in that order)—performing hand hygiene after removal of inner gloves (i.e. last step, 99.4%), followed by doffing of inner gloves (98.9%)→ doffing of outer gloves (86.4%)→ performing hand hygiene after removal of outer gloves (82.1%) →removal of goggles (80.1%) → doffing of gown (76.7%) →removal of mask/N95 respirator (73.8%).

Table 4 depicts compliance of HCWs to biomedical waste segregation of individual PPEs. The highest compliance as noted for (in that order)—performing hand hygiene after removal of inner gloves (i.e. last step, 99.4%), followed by doffing of inner gloves (98.9%)→ doffing of outer gloves (86.4%)> performing hand hygiene after removal of outer gloves (82.1%) →removal of goggles (80.1%) → doffing of gown (76.7%) →removal of mask/N95 respirator (73.8%). Overall, the total PPE segregation compliance was 86.1%; which was highest for segregation of gown (97.3%) → mask/respirator (92.3%) → gloves (90.0%) → goggles (87.3%). Profession-wise stratification revealed that the highest segregation compliance for each of the individual types of PPE was noted for nurses, followed by doctors and ancillary staff.

Table 5 depicts the frequency distribution of the types of breaches occurred during doffing of PPE. As per the doffing method is concerned, the maximum breaches occurred while removal of mask/respirator (**26.2%**) followed by gown (**23.3%),** goggles (19.9%), and gloves (13.6%). The common breaches recorded during mask removal include touching the outer surface (10.2%), overhead removal/eyes open (5.9%), removing the upper elastic (5.6%) and not bending forward (4.5%). While doffing the gown, the frequent error happened were—touching outer surface (10.4%), not rolled into a bundle (7.3%) and not turning inside out (5.1%). The repeated breaches for goggles removal were—not bending forward (11%) and overhead removal (8.9%). Breaches in glove removal were—fast removal (7.2%) and 2nd glove removed by touching outer surface (6.4%). The proportion of errors was found to be higher on the first day of the posting and was much lower from the second day onward, according to the week-wise trend analysis.

Table 2: Stratified doffing compliance across various professional cadres, gender and shifts [% (n)]

Components	Number	Overall compliance %(n)			Total doffing compliance
		Doffing sequence	Doffing Method	Biomedical waste Segregation	
All HCWs	5834	80.8% (4713)	72.3%(4218)	86.1%(5024)	66.6% (3888)
Profession					
Doctor	1887	80.7% (1523)	67.2% (1268)	82.7% (1561)	61.1% (1153)
Nurse	3221	86.5% (2786)	79.8% (2571)	90.4% (2911)	74.0% (2384)
Ancillary staff	726	55.6% (404)	52.2%(379)	76.0% (552)	48.3% (351)
Gender					
Male	2011	61.5% (1236)	66.0%(1327)	78.9% (1587)	57.5% (1157)
Female	3823	90.9% (3477)	75.6%(2891)	89.9% (3437)	71.4% (2731)
Shift					
Morning	2719	80.3% (2184)	75.5%(2054)	86.4% (2348)	69.4% (1886)
Evening	2108	83.5% (1761)	79.5%(1676)	89.1% (1879)	72.7% (1532)
Night	1007	76.3% (768)	48.5%(488)	79.1%(797)	46.7% (470)

Ancillary staff include the staff involved in cleaning and housekeeping activities

Table 3: Compliance to individual steps of doffing method

Components	Doctors	Nurses	Ancillary staff	Total
% Performed HH after removal of gloves	77.5% (1462)	87.7% (2826)	69.0% (501)	82.1% (4789)
% Doffed outer gloves correctly	82.9% (1564)	92.1% (2965)	70.5% (512)	86.4% (5041)
% Doffed gown correctly	70.2% (1325)	83.3% (2682)	64.2% (466)	76.7% (4473)
% Doffed goggles correctly	73.4% (1385)	86.9% (2798)	67.4% (489)	80.1% (4672)
% Doffed inner gloves correctly	99.2% (1871)	99.7% (3210)	94.8% (688)	98.9% (5769)
% Doffed mask correctly	68.3% (1289)	80.4% (2591)	58.4% (424)	73.8% (4304)
% Performed HH after removal of gloves	98.7% (1862)	99.9% (3219)	99.2% (720)	99.4% (5801)

Ancillary staff include the staff involved in cleaning and housekeeping activities; HH, hand hygiene

Table 4: Biomedical waste segregation compliance of PPEs

PPE	Doctors	Nurses	Ancillary staff	Total
% Gloves segregated correctly	88.1% (1662)	92.8% (2988)	82.9% (602)	90.0% (5252)
% Gowns segregated correctly	96.5% (1821)	98.3% (3166)	94.6% (687)	97.3 % (5674)
% Goggles segregated correctly	84.4% (1593)	90.9% (2927)	78.7% (571)	87.3% (5091)
% Masks segregated correctly	91.3% (1722)	93.8% (3022)	88.6% (643)	92.3 % (5387)
% Total PPE segregated correctly	82.7% (1561)	90.4% (2911)	76.0% (552)	86.1% (5024)

Ancillary staff include the staff involved in cleaning and housekeeping activities.

Table 5: Common breach occurred during doffing of PPE

Breach categories	% of HCWs (N=6834)
Breaches in glove removal	**13.6% (793)**
-Fast removal	7.2% (420)
-2nd glove removed by touching outer surface	6.4% (373)
Breaches in gown removal	**23.3%(1361)**
-Touched outer surface	10.4% (607)
-Not rolled into a bundle	7.3% (426)
-Not turning inside out	5.1% (298)
-Untying the up knot first	0.5% (29)
Breaches in goggles removal	**19.9% (1162)**
-Not bending forward	11% (642)
-Overhead removal	8.9% (519)
Breaches in mask removal	**26.2%(1530)**
-Touched the outer surface	10.2% (595)
-Overhead removal/ eyes open	5.9% (344)
-Removing the upper elastic	5.6% (327)
-Not bending forward	4.5% (263)
Sequence errors	**19.2% (1120)**
Gown doffed earlier	10.2% (595)
Goggles doffed earlier	5.3% (309)
Inner gloves doffed earlier	2.2% (128)
Mask doffed earlier	1.5% (88)

4. Discussion

Nosocomial transmission of COVID-19 has resulted into numerous cases of healthcare associated COVID among the HCWs worldwide. In COVID ICUs, the transmission risk to HCW is significantly high, these locations cater to sick patients, many of them are ventilation, posing a high risk of aerosol, droplet as well as contact transmission. Appropriate donning and doffing of PPE play a paramount role in preventing the contraction of the virus in the workplace. Doffing is more risker than donning because of several reasons such as higher risk of self-contamination, greater complexity of method of removal, stress and fatigue of HCWs etc. Adherence to PPE doffing among HCWs varies greatly depending on a range of factors, including risk perceptions, institutional culture, auditing mechanisms, and availability of HH supplies. The implementation of a trained

supervisor combined with a donning audit in COVID ICUs is a unique and first-of-its-kind study conducted to identify, evaluate, and communicate potential breaches occurring during the donning process. Through this quality improvement study, we were able to earmark several potential areas where significant improvements can be possible.[9,10]

4.1. TDC and compliance to individual elements of doffing

Overall, for all HCWs, the total doffing compliance (TDC) was observed to be 66.6% (**Table 2**). The compliance to individual three elements of doffing was found to be highest for BMW segregation (86.1%), which was statistically significant with p<0.05, compared to sequence (80.8%) and method (72.3%) and TDC (66.6%). TDC is an all-or-none phenomena, i.e. when the HCW is compliant to all three components of doffing process; i.e. sequence, method and segregation, he is said to be 'total doffing compliant'. As a result, TDC of all HCWs will be obviously lower than the compliance to individual elements of doffing. Because HCWs are more exhausted from their work, it will be challenging for them to execute the tedious procedure of doffing, which calls for a fresh mind and excellent memory recall. In an exhausted mindset, memory recalling the doffing method is even more difficult than sequence and BMW segregation, which are easier and get better with experience. Therefore, the brilliant and innovative notion of doffing under close supervision with on-site feedback and correction makes the HCW feel relieved that someone will handle the doffing process.

4.2. Profession-specific compliance

Nurses had a statistically significant TDC compared to doctors (74.0% vs 61.1%, p<0.05) and ancillary staff (74.0% vs 48.3%, p<0.05). The same observation was found for individual components of doffing, i.e. sequence, method and BMW segregation. Nurses generally demonstrate a high degree responsibility to various components of infection control including hand hygiene and PPE. The higher doffing compliance in nurses can be attributed to factors such as—regular prior receipt of extensive training on doffing at undergraduate level and workplace, more frequent and direct patient contact of nurses leading them to use and remove PPE more regularly than doctors, greater infection control awareness and a strong culture of compliance to IPC measures in nurses compared to doctors.

4.3. Gender-specific compliance

Females had a statistically significant TDC compared to males (71.4% vs 57.5%, p<0.05). The same observation was found for individual components of doffing, i.e. sequence, method and BMW segregation. The grater doffing compliance in females can be attributed to factors such as—exhibit greater attention to detail, particularly in tasks that require precision and adherence to procedures, show higher concern for personal safety and possess a greater health-conscious behaviour than males.

4.4. Shift-specific compliance

The doffing compliance was found to vary between the different shifts of duty. HCWs had statistically significant TDC in evening shift compared to morning shift (72.7% vs 69.4%, p<0.05) and night shift (72.7% vs 46.7%, p<0.05). The individual doffing components, such as sequence, method, and BMW segregation—all showed the same observation. This diurnal variation could be attributed to various factors. Poor doffing compliance during the night shift may have been caused by a lack of monitoring mechanisms, which may have given the HCWs a false sense of relaxation; whereas in morning shift, the HCW were more exhausted due to high work pressure which would be the reason for their poor compliance during doffing. The HCWs were informed that appropriate removal of the attire serves as a safeguard against infection, and as such, accountability should originate internally, even in the absence of supervision, irrespective of the shift in which they are assigned.

Additionally, it was observed that the percentage of errors was higher on the first day of the posting and drastically decreased from the second day of the posting week onward. This suggests that conducting a doffing audit and providing onsite feedback can significantly enhance doffing compliance. But because the roster would change each week, the auditing's effects would not carry over to the next week. In the follow-up, it was found that none of the HCWs have contracted SARS-CoV-2 in the next two weeks.

4.5. Doffing method compliance

When observed the method of doffing of individual PPE (**Table 3**), it was noted that maximum doffing compliance wad found for gloves (98.9% and 86.4% for inner and outer gloves respectively) followed by goggles (80.1%), gown (76.7%) and mask/N95 respirator (73.8%). The lower compliance to mask/respirator and gown/coverall was attributed to complexity involved in their doffing process and partly due to lack of knowledge (especially in the ancillary group).

4.6. Hand hygiene compliance

The hang hygiene compliance during the doffing process was found to be excellent after removal of the mask (99.4%) but found to be lesser after doffing the outer gloves (82.1%). Nurses were more compliant than doctors and ancillary staff. The HCWs were explained the importance of hand hygiene and were instructed onsite to perform hand hygiene.[11]

4.7. Segregation compliance

The overall compliance rate for PPE segregation (**Table 4**) was 86.1%; the greatest percentages were seen for gown (97.3%), mask/respirator (92.3%), gloves (90.0%), and

goggles (87.3%). Nursing professionals had the highest segregation compliance for each of the different PPE categories, followed by doctors and ancillary workers. The poor compliance to goggles and gloves could be attributed to lack of knowledge and attitude, which can be improved by repeated reinforcement training sessions.

4.8. Common breach in method of PPE doffing

Root cause analysis was performed to determine the common breach occurred during doffing of PPE.

13.6% of HCWs did not doff gloves appropriately. Among all the PPE, the maximum breaches noticed were while doffing the mask/respirators (26.2%). The most frequent breaches during mask doffing were touched the outer surface (10.2%), overhead removal/ eyes open (5.9%), removing the upper elastic (5.6%) and not bending forward (4.5%). %). While not bending foreword increases the risk of contamination of body clothing; overhead removal or / eyes open during removal increases the risk of contaminating eyes with the droplets released during the doffing process. Touching the outer surface while removal increases the risk of self-contamination. For N95 respirator, ideally the lower strap has to be removed first, followed by upper strap. Removing the upper strap first would make the respirator hang while removing the lower strap.

Breach in gown removal was found to be (23.3%), out of which the common errors touched outer surface (10.4%), not rolled into a bundle (7.3%), not turning inside out (5.1%) and untying the up knot first (0.5%). Care must be taken not to touch the outer surface of gown so as to prevent self-contamination. The purpose of turning the gown inside out while doffing is to ensure safe removal without self-contamination. Rolling the gown into a bundle helps in fitting it well into the BMW receptacle. Up knot should be untied later as if it is untied first, it will start hanging while untyping the second known, which may increase the risk of self-contamination. The breaches in goggles doffing were 19.9%, which comprised of—not bending forward (11%) and overhead removal (8.9%). While not bending foreword increases the risk of contamination of body clothing; overhead removal increases the risk of contaminating eyes with the droplets released during the doffing process. Common errors in glove removal were fast removal (7.2%) and touching outer surface while removal of the second gloves (6.4%). The errors noticed during the doffing of individual PPE were corrected on-site with adequate explanation provided so as to prevent occurrence of such errors in the subsequent posting.

4.9. Errors in sequence of PPE doffing

Sequence errors were noticed in 19.2% of HCWs; the commonest being gown doffed earlier to gloves (10.2%), followed by goggles doffed earlier to gown (5.3%), inner gloves doffed earlier (2.2%) and mask doffed earlier (1.5%). The outer glove has a tremendously high microbial load on its surface, therefore should be the first PPE to be doffed. Doffing gown earlier to outer gloves increases the risk of self-contamination with the organisms present on gloves surface. If goggles is doffed earlier to gown, it poses a huge risk of eyes getting infected with the droplets produced during doffing of the gown. This error is more commonly observed with coverall compared to gown, because of a flawed practice during donning of putting on the goggles over the coverall hood. In such case, the HCW is forced to doff the goggles earlier to doffing off the gown. The inner gloves should be removed after doffing the goggles. Earlier removal of inner gloves along with outer gloves will unnecessarily increase the risk of contamination of hands and would require frequent hand hygiene between each step of doffing.[12,13] 3-ply mask/respirator is the last PPE to be doffed and its removal should be performed in a separate ‘mask removal area’ present outside the doffing area, which will prevent the HCW to being exposed to the droplets present in doffing area. Earlier removal of the mask inside the doffing area would pose the HCW to a tremendous risk of inhaling the virus through the droplets dispersed in the doffing area.[14,15]

5. Conclusion

In conclusion, we implemented a doffing audit program in COVID-ICUs in conjunction with onsite correction and feedback. We observed a higher doffing compliance to the BMW segregation, followed by doffing sequence and method. Higher doffing compliance was observed among nurses, females and in staff working in evening shift. Poor doffing compliance was noted for mask followed by goggles. In the context of HCWs being extremely exhausted after a hectic posting inside COVID ICU, the use of dofficers (supervisors) is an innovative idea of reducing the errors in doffing method, sequence and BMW segregation, thereby decrease the risk of self-contamination. To ascertain whether this extra protection is clinically meaningful and whether the strategy can be sustained financially, additional research is necessary.

6. Source of Funding

None.

7. Conflict of Interest

None.

References

1. Rothan HA, Byrareddy SN. The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak. *J Autoimmun*. 2020:109:102433. doi: 10.1016/j.jaut.2020.102433.
2. World health organization (WHO). Coronavirus disease (covid-19) pandemic. Available at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019. Accessed August 15, 2024..
3. "World Health Organization. Hospital infection control guidance for severe acute respiratory syndrome (SARS).WHO 2003".
4. Seto WH, Tsang D, Yung RW, Ching TY, Ng TK, Ho M et al. Effectiveness of precautions against droplets and contact in

prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). *Lancet*. 2003;361(9368):1519–20.
5. Sequence for putting on personal protective equipment (PPE); https://www.cdc.gov/infection-control/media/pdfs/Toolkits-PPE-Sequence-P.pdf, 2020.
6. COVID-19: How to put on and remove personal protective equipment (PPE);https://openwho.org/courses/IPC-PPE-EN, 2020.
7. John TJ, Hassan K, Weich H. Donning and doffing of personal protective equipment (PPE) for angiography during the COVID-19 crisis. *Eur Heart J*. 2020;41(19):1786–7.
8. Rational use of personal protective equipment for COVID-19 and considerations during severe shortages; Interim guidance; 23 December 2020, pp. Accessed on Aug 20th, 2024, https://iris.who.int/bitstream/handle/10665/338033/WHO-2019-nCoV-IPC_PPE_use-2020.4-eng.pdf.
9. Mulvey D, Mayer J, Visnovsky L, Samore M, Drews F. Frequent and unexpected deviations from personal protective equipment guidelines increase contamination risks. *Am J Infect Contr*. 2019;47(9):1146–7.
10. Phan LT, Maita D, Mortiz DC, Weber R, Fritzen-Pedicini C, Bleasdale SC et al. CDC Prevention Epicenters Program. Personal protective equipment doffing practices of healthcare workers. *J Occup Environ Hyg*. 2019;16(8):575–81.
11. Graham M. Frequency and duration of handwashing in an intensive care unit. *Am J Infect Control*. 1990;18(2):77–81
12. World Health Organization (WHO). Infection prevention and control of epidemic- and pandemic-prone acute respiratory diseases in health care. Geneva, WHO, 2007 (http://www.who.int/csr/resources/publications/swineflu/WHO_CD_EPR_2007_6/en/index.html).
13. World Health Organization (WHO). Infection prevention and control during health care for confirmed, probable, or suspected cases of pandemic H1N1 2009 virus infection and influenza-like illness. Geneva, WHO, 2009 (http://www.who.int/csr/resources/publications/swineflu/swineinfincont/en/index.html).
14. Johnson DF, Druce JD, Birch C et al. A quantitative assessment of the efficacy of surgical and N95 masks to filter influenza virus in patients with acute influenza infection. *Clin Infect Dis*. 2009, 49(2):275–7.
15. Dharmadhikari A, Mphahlele M, Stoltz A et al. Surgical face masks reduce multidrug-resistant tuberculosis transmission from patients on a hospital ward. *Am J Respir Crit Care Med*. 2012;185(10):1104–9.

Cite this article: Priyadarshi K, Dhandapani S, Rajshekar D, Vinothini BA, Punnen SA, Veerappan K, Jamir I, Sastry AS. Impact of doffing audit and onsite feedback in COVID-ICUs of a tertiary care facility, South India. *IP Int J Med Microbiol Trop Dis.* 2025;11(1):108-115.