ORIGINAL ARTICLE

Assessing personal protective equipment compliance in a polish healthcare setting during the COVID-19 pandemic – A pilot case study

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ABSTRACT

Objective: The purpose of this study is to identify failures in proper Personal Protective Equipment (PPE) usage in a healthcare hospital environment to enhance PPE compliance through proper donning and doffing procedures.
Methods: We used naturalistic observation (shadowing) of PPE donning and doffing by healthcare medical staff in their hospital work setting to identify non-conformities to compliant donning and doffing of PPE.
Results: We found an average of 1.84 non-conformances per healthcare worker across the donning procedures and 2.06 non-conformances in the doffing procedures per healthcare provider. Nurses experienced 1.94 average non-conformances in the donning procedures, while physicians average 1.75 non-conformances. Nurses experienced 2.29 average doffing non-conformances, while physicians averaged 1.85 average doffing non-conformances during the study. PPE compliance is critical to protect both healthcare workers and patients in the healthcare setting, as well as building a culture of safety.
Research implications: Appropriate training and compliance should be performed to ensure appropriate PPE donning and doffing protocols are adhered to, so that it reduces the transmission of disease and infections. Future studies will explore the environmental, cultural and operational factors that contribute to PPE compliance in healthcare.
Conclusions: This is the first study to quantify donning and doffing errors of personal protective compliance within the realm of environmental and cultural impacts.

Key Words: Ergonomic, Personal protective equipment, Safety in healthcare

1. INTRODUCTION

Patient and healthcare provider safety in healthcare units is currently one of the most important challenges. It requires the interaction of staff with different specialities at different levels of healthcare. Undoubtedly, workplace ergonomics is crucial in this case. The importance of ergonomic principles in ensuring safety in healthcare could be seen at work during the COVID-19 pandemic. According to the Polish Ministry of Health, since the beginning of the COVID-19 pandemic (March 4, 2020), 6,515,776 people have been infected with the SARS-CoV-2 virus and 119,590 lost their lives including 304 medical doctors and 257 nurses.[1] One example of how important ergonomic principles are for building a safety culture in healthcare is the use of personal protective equipment (PPE). Healthcare workers (HCWs) are at the front line of delivering care to infected patients and preventing further

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spread of disease. Personal protective equipment including gowns, gloves, and masks are intended to protect HCWs from hazardous agents in their day to day patient care responsibilities. For PPE to be effective, it must be properly selected and used.[2,3] Inappropriate use of PPE reduces its effectiveness in protection against infection.[4–6] Donning and doffing of medical PPE are critical in preventing spread of pathogens.[7] Therefore, public health agencies in different countries have established similar protocols for wear and removal of PPE.[8,9] Outbreaks including the SARS epidemic, Swine flu pandemic, and Ebola revealed the susceptibility of HCWs to self-contamination specifically due to improper use of PPE.[4,10,11] Recent studies show that due to the complexity of the process, deviation from the doffing protocol and self-contamination during PPE doffing is common.[12–15] Moreover, it has been shown that 90% of observed doffing was incorrect, with respect to the doffing sequence, doffing technique, or use of appropriate PPE.[16]

The COVID-19 pandemic increased public awareness about the importance of medical PPE, and the shortages in PPE supply engendered public debates.[17,18] Even with this increased awareness, concern has been raised about potential self and cross contamination in medical settings because of HCW divergences from proper PPE donning and doffing protocols.[19] A simulated study during the COVID-19 pandemic demonstrated high occurrence of self-contamination during doffing using the revised pandemic protocols.[20] This leads us to ask how non COVID-19 units adhere to donning and doffing protocols during the pandemic. To answer this question, has been used direct shadowing of a real world practice in one of the major hospitals in Poland.

Table 1. Number of participants

Department/Unit	Number of Nurses	Number of Physicians	Total Number Medical Staff
ICU Adults	35	33	68
Hematology Ward for Adults	29	31	60
Pediatric Oncology and Hematology Ward	31	21	52
Total	95	85	180

2. Materials and methods

The purpose of this study is to identify failures in proper PPE usage in a healthcare hospital environment to enhance PPE compliance through proper donning and doffing procedures. In this research study, we used naturalistic observation (shadowing) of PPE donning and doffing by healthcare medical staff in their hospital work setting. Shadowing is an effective method for enhancing quality of care and improving layout whilst reducing waste and costs.[21–24] For this method we wanted to identify types and the count of individual errors for each time the healthcare worker made an error within donning, and doffing. We observed a working hospital, so sometimes nurses and physicians are observed multiple times, within their working time. During COVID-19, there was also reduced staff as some healthcare workers were out sick and so staff were most likely working multiple shifts or extended time. We did not collect demographics information, such as age, sex, years of experience in the work unit, on each subject, since this was not a pre-planned experiment, and the staff that were working during the time period of observation were observed. The initial pilot study was conducted in July and August of 2021 in a hospital in Poland. Medical staff (physicians and nurses) from the following departments participated in the study: 1) Intensive Care Unit (ICU) Adult; 2) Hematology Ward for Adults; and 3) Pediatric Oncology and Hematology Ward. Table 1 shows the number of physicians and nurses involved in the study from each unit. Donning is defined as putting on PPE, and doffing is removing the PPE after use.

The following protocols were used during the study along with the specified assumptions.

1. For the purpose of the study, it was assumed that during each session, the individual (physician/nurse) who was observed was included in the study group. This means that if, for example, person X was on duty during all 4 sessions in the clinic then they were recorded as 4 persons - 4 observations.

2. Four sessions consisting of staff observations were completed for each unit (12 sessions total). Each session lasted no less than 2.5 hours and no more than 4 hours.

3. Only one type of disposable gown was used in the hospital - tied at the waist, with cuffs (no thumb space).

4. Environmental factors:

(1) The study was conducted during the summer (July-August). Not all rooms in the hospital were air-conditioned, but where patients stayed - especially in the three mentioned wards - there was air conditioning and air supply.
(2)At the ICU and in bone marrow transplantation rooms, there was a noticeable noise of medical equipment.
(3)Most rooms had windows and natural light.

(4) The patients' disposition was difficult to determine due to the specificity of the wards; many patients were in the state of serious illness, without aggression, and often weakened.
(5) There were no noticeable odors. Rather, there was the standard smell of chemicals used for cleaning.

5. Infrastructure

(1) Wards were in good technical condition.
(2) Doors opened automatically and manually.
Patient examination rooms were clean, spacious, with natural and artificial light.
(3) Within patient rooms, there were washbasins and dispensers with disinfectant liquid. Additionally, containers with disinfectant liquid were available in corridors, doctors' and nurses' rooms.
(4) Curtains and screens were used to divide rooms.
Closets to store clothing/personal protective equipment were located at the entrance to the unit and in a designated area in the unit.

Taking part in this research study was completely voluntary. If the HCWs wanted to withdraw from this study, they could communicate their intention with the researcher, and the research team excluded them from data collection. During this study, no identifying information from participants and patients were collected. We used position or role classifications such as Nurse or Physician to collect information and discern data.

The investigator observed the healthcare providers and collected data using a notebook on their observations of performed PPE donning and doffing. The collected data was used for thematic qualitative analysis and statistical analysis. We analyzed the data to identify types of non-conformities and challenges that occurred during donning and doffing, and the potential factors contributing to these non-conformities.

2.1 Data analysis

Statistical analysis was performed using the Minitab statistical software program. The critical value $p < .05$ was assumed to be the level of statistical significance. Two-proportion statistical tests were performed to assess if there was a statistically significant difference between the percent of non-conformances between nurses and physicians, overall, and between the units.

2.2 Ethical considerations

The study was carried out in accordance with the tenets of the Declaration of Helsinki and guidelines of Good Clinical Practice (World Medical Association, 2013). The research project was approved by the independent Bioethics Committee at the Wroclaw Medical University (KB-167/2022). Written permission was received from the hospital director to conduct the study. Participation in the study was voluntary, with verbal consent given by each participant.

3. Results

The types and number of non-conformities observed when the HCWs donned (put on) and doffed (took off) their PPE are shown in Tables 2 and 3. The average number of non-conformity occurrences by nurses and physicians was calculated for each unit and role. We found an average of 1.84 non-conformances per HCW across the donning procedures and 2.06 non-conformances in the doffing procedures per HCW. Nurses experienced 1.94 average non-conformances in the donning procedures, while Physicians averaged 1.75 donning non-conformances. Nurses experienced 2.29 average doffing non-conformances, while physicians averaged 1.85 average doffing non-conformances during the study.

The highest occurrences of donning non-conformances were that the gowns were shaken when unfolding them, wrists and cuffs were not covered properly, gowns were inaccurately tied at the waist and the necktie was not appropriately secured. There were no issues with donning eyewear or face masks, shown in the Pareto chart in Figure 1. The highest non-conformance types for doffing were pulling the mask off first, not rolling the gown with the dirty side facing down, and not performing hand hygiene when removing the gowns, as shown in the Pareto chart in Figure 2. There were no issues observed with removing eyewear. Two-proportion statistical tests were performed to assess if there was a statistically significant difference between the percent of non-conformances between nurses and physicians, overall, and between the units. The results are shown in Table 4. There was not a statistical significance difference overall in the PPE non-conformances between nurses and physicians for donning or doffing (p-values = 1.00 and .186 respectively). There are statistical differences in PPE non-conformances by unit for donning and doffing. The ICU Adult unit had the highest non-conformance percentage for donning and doffing. The pediatric oncology and hemotology unit had the lowest percentages of PPE non-compliances.

4. Discussion

Self and cross contamination resulting from incorrect donning and doffing of PPE contributes to the spread of viral infections. Errors in the application of PPE can have negative consequences and can significantly reduce the level of patient and staff safety. The significant proportion of COVID-19 cases reported amongst HCWs highlights the importance of understanding how and why these errors occur. Our study contributes to the growing body of literature that investigates how, where, and how frequently errors occur in PPE usage by HCWs.

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Table 2. Donning observation results

Appropriate protocol	Donning PPE with tie gown								
	Donning non-conformity	ICU adult		Hematology ward adults		Pediatric oncology and haematology ward		Percentage by non-conformity type	Total occurrences
		Nurses	Physicians	Nurses	Physicians	Nurses	Physicians		
Unfold gown without shaking	Unfold gown with shaking	21	18	21	24	11	19	34%	114
Slide arms through the sleeves and secure at the neck	Not secured with neck tie	9	11	7	4	6	9	14%	46
Overlap gown as much as possible and tie waist ties securely	Inaccurate tying at the waist	19	21	11	14	7	11	25%	83
Don face mask, adjust metal strap over bridge of nose and secure position under chin	No issues donning face masks	0	0	0	0	0	0	0%	0
Don clean gloves last Pull gloves to cover the wrists and cuff	Does not cover the wrists and cuffs properly	29	17	15	11	9	7	27%	88
Don protective eyewear/goggles (if not combined with face mask)	No issues donning eyewear	N/A	N/A	0	0	0	0	0%	0
Total personnel observed by role		**33**	**35**	**31**	**29**	**21**	**31**		**180**
Total occurrences		**78**	**67**	**54**	**53**	**33**	**46**		**331**
Sum occurrences by unit		**145**		**107**		**79**			
Percentage occurrences by role		**54%**	**46%**	**50%**	**50%**	**42%**	**58%**		
Average non-conformity occurrences by role		**2.36**	**1.91**	**1.74**	**1.83**	**1.57**	**1.48**		**1.84**
Average non-conformity occurrences by unit		**2.13**		**1.78**		**1.52**			

Table 3. Doffing observation results

Appropriate protocol	Doffing PPE with tie gown								
	Doffing non-conformity	ICU adult		Hematology ward adults		Pediatric oncology and haematology ward		Percentage by non-conformity type	Total occurrences
		Nurses	Physicians	Nurses	Physicians	Nurses	Physicians		
Remove gloves first, avoiding contamination of hands. Perform hand hygiene	Did not perform hand hygiene	17	12	12	8	6	8	17%	63
Remove protective eye wear, without contaminating self	No issue removing eye wear	Do not use	Do not use	0	0	0	0	0%	0
Untie gown: first lower ties (at back), followed by upper ties (do not remove gown yet) Remove gown grasping from inside of neck, pull down smoothly over shoulders Roll gown with soiled (outer front) side inwards, avoiding contamination of clothes	First, untie the top of the gown, do not roll the gown with the dirty side facing inwards	30	23	23	21	15	12	33%	124
Perform hand hygiene	Did not perform hand hygiene	7	9	5	4	3	4	9%	32
Remove face mask last. Perform hand hygiene	Pulls the mask first	27	31	24	29	26	15	41%	152
Total personnel observed by role		**33**	**35**	**31**	**29**	**21**	**31**		**180**
Total occurrences		**81**	**75**	**64**	**62**	**50**	**39**		**371**
Sum occurrences by unit		**156**		**126**		**89**			
Percentage occurrences by role		**52%**	**48%**	**51%**	**49%**	**56%**	**44%**		
Average non-conformity occurrences by role		**2.45**	**2.14**	**2.06**	**2.14**	**2.38**	**1.26**		**2.06**
Average non-conformity occurrences by unit		**2.29**		**2.1**		**1.71**			

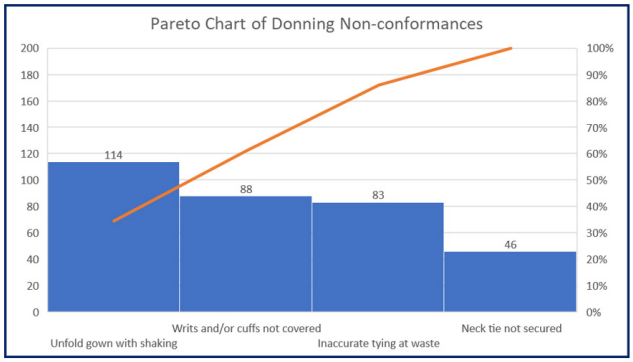

Figure 1. Pareto chart of donning non-conformances

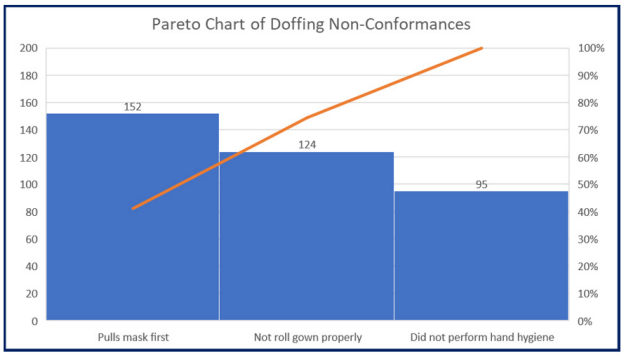

Figure 2. Pareto chart of doffing non-conformances

Table 4. Two-proportion test results to assess statistical significance of differences in non-conformances by role and unit

Donning				Doffing			
Sample	**N**	**Non-Conformances**	**Sample *P***	**Sample**	**N**	**Non-Conformances**	**Sample *P***
Nurses	331	165	.50	Nurses	371	195	.53
Physicians	331	166	.50	Physicians	371	176	.47
P-value	1.00	Not significant		*P*-value	.186	Not significant	
ICU Adult	331	145	.44	ICU Adult	371	156	.42
Hemotology	331	107	.32	Hemotology	371	126	.34
P-value	.003	Significant		*P*-value	.028	Significant	
ICU Adult	331	145	.44	ICU Adult	371	156	.42
Pediatric Oncology & Hemotology	331	79	.24	Pediatric Oncology & Hemotology	371	89	.24
P-value	.000	Significant		*P*-value	.000	Significant	
Hematology Adult	331	107	.32	Hematology Adult	371	126	.34
Pediatric Oncology & Hemotology	331	79	.24	Pediatric Oncology & Hemotology	371	89	.24
P-value	.019	Significant		*P*-value	.004	Significant	

Our observations at a major Polish hospital during the COVID-19 pandemic illustrate that even with increased awareness about its importance, correct donning and doffing of PPE by HCWs continues to be a potential source of contamination. Both nurses and physicians were observed across three medical units to determine what errors were occurred in the donning and doffing procedures and at what frequency.

The rate of non-conformance appears to be higher for doffing than it does for donning. Although it also appears to be higher for nurses than it does for physicians, this is not statistically significantly different. When comparing the three medical units, the rate of non-conformance is higher in both the adult units than the paediatric unit. Overall, the ICU had the highest rate of non-conformance. These findings indicate that factors in the working environment such as stress, fatigue, room layout, interruptions, and culture could affect proper PPE usage.

When looking at the individual non-conformities, removing the mask first when doffing (as opposed to last) is the most frequently occurring non-conformance. The next two most frequently occurring errors involve the gown: rolling the wrong side down during doffing, and shaking it during donning. In conjunction with the other observed occurrences, these findings suggest that cyclical training should be undertaken for medical personnel regarding the principles of proper PPE usage. Particular attention should be focused on gown usage and the appropriate timing of mask removal.

It is important to highlight some of the study's shortcomings with respect to the potential risks of a lack of scientific monitoring and observation bias. Although observers are trained in the study protocol and familiarized with the principles of data collection, some margin of error must be assumed. Nevertheless, this is a pilot study, which serves to assess the validity of the protocol and methodology adopted, and will

be refined for further research and simulation of the use of PPE.

5. Conclusions

The subject matter undertaken by the authors is mainly concerned with work ergonomics, which directly or indirectly affects patient and medical staff safety. The results of the pilot study showed that the rules for the use of PPE can be a significant problem for medical staff. The result demonstrated high level of noncompliance with the guidance on PPE established by CDC and adopted by the hospital which we observed. Despite available educational material and guidelines, numerous errors were observed. It is likely that the reason for these results may be a lack of knowledge of the principles that make up a broad culture of safety in healthcare.

In the next step, we will investigate common reasons for PPE noncompliance and use the results to increase patient safety and reduce the self-contamination threat to workers.

5.1 Study limitations

Limitations exist due to the nature of a preliminary study. Our pilot study collected data from only one hospital in Poland that had three different types of units: an ICU for adults, a Hematology ward for adults, and a pediatric and hematology ward for children. Results may not be representative or generalizable to all units and healthcare settings. Additionally, factors and root causes that contribute to PPE non-compliance were not recorded or investigated in this study.

5.2 Practical implications and future research

PPE compliance is critical to protect both healthcare workers and patients in the healthcare setting. Appropriate training and compliance should be performed regularly to ensure appropriate PPE donning and doffing protocols are adhered to, with the goal of reducing the transmission of disease and infections. Future studies will explore the environmental, cultural and operational factors that contribute to PPE compliance in healthcare.

6. Institutional review board statement

The study was fully anonymous and voluntary. The study was carried out in accordance with the tenets of the Declaration of Helsinki and guidelines of Good Clinical Practices (World Medical Association, 2013).

Conflicts of Interest Disclosure

The authors declare they have no conflicts of interest.

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