Original Article

An innovative low-cost personal protective equipment gown made by biomedical trash bags

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ABSTRACT

Introduction: Personal protective equipment (PPE) refers to protective clothing, helmets, gloves, face shields, goggles, facemasks and/or respirators, fall protection devices, personal warning devices, and full body suits, as well as the head, eye, and foot protection. The recent coronavirus disease (COVID) pandemic has imposed the need of having low-cost production of PPE's. **Objectives:** The objectives of the study were to create an indigenous, cost effective, easy to make PPE gown for temporary use in neonatal intensive care unit during the COVID pandemic crisis and to assess the ease and comfort of working in the indigenously produced PPE gown. **Materials and Methods:** The PPE gown was made using readily available material such as biomedical trash disposal bags, adhesive tapes, and stapler pins. We used the larger bags, which measured 100 cm × 55 cm. The bags were sealed at the base and open on the top. Each bag has folds on each side to increase its capacity when opened up. A structured questionnaire that included 10 questions with responses on the Likert scale used the ease of use of the PPE gown. **Results:** There were a total of 30 participants including doctors and paramedical staff. There was good internal consistency between the responses in questions (Cronbach alpha = 0.88). The mean and median age of study participants were 30.2 years and 30 years, respectively. The response for various questions ranged from 56% to 80% with an overall mean score of 64.56±10. **Conclusion:** A simple low-cost innovative PPE gown that can be made from a trash bag was found comfortable on preliminary testing.

Key words: Gown, Innovative, Personal protective equipment

Personal protection equipment (PPE) is equipment that is used by a worker to eliminate or minimize exposure to a specific occupational hazard, when other control measures do not eliminate the hazard or if no other practical means exist for effectively controlling it [1]. PPE in health-care sector helps to protect the wearer from injury or the spread of infection or illness. PPE refers to protective clothing, helmets, gloves, face shields, goggles, facemasks, and/or respirators, fall protection devices, personal warning devices, and full bodysuits, as well as the head, eye, and foot protection [2].

The recent coronavirus disease 2019 (COVID-19) pandemic is one such infection that has caused extensive illness and death. It has also seriously affected the world economy not only by bringing all services to a halt but also by causing an immense burden on health care in terms of infrastructure, human resources, and medical supplies (PPE, sanitizers, masks, etc.). India is a country with the second-largest population and high population density has been affected by the pandemic. There is a continuous exponential rise in the number of cases [3]. It has become mandatory for health-care professionals to wear PPE while attending patients in the COVID facility and areas of high-risk exposure [4]. However, there is a gap in the demands and supply of this equipment as the number of cases has been increasing day by day. This imminent shortage has led to calls for having low-cost production of PPE's ensuring the safety of our health care workers (HCWs) as they care for the sick and potentially infectious patients.

The component of the PPE kit is essentially meant to protect from infective droplet exposure, which is the primary route of infection transmission in COVID-19. The PPE gown is identified as the second most used article of the PPE kit after the gloves [5]. The PPE gowns are usually single-use gowns prepared from a variety of fabrics and fibers which are chemically engineered to increase their impermeable and liquid-resistant properties [6]. The World Health Organization (WHO) has designed recommendations on PPE product consistency and standards for each of the individual PPE elements [7]. The list of preferred product characteristics is organized into three interdependent groups: Design features, material performance, and use desirability. It includes the engineering and human and

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environmental factors in the use of PPE to analyze its usefulness.

The present situation needs innovative design, new fabrics, adoption of new engineering approaches, and harmonized practices to meet the unmet public health demand for PPE which are safe and comfortable to work in tropical hot and humid climates [8,9]. Considering the above, we attempted to make an indigenous, cost effective, easy to make PPE gown for temporary use in neonatal intensive care unit (NICU) during the COVID pandemic crisis and to assess the ease and comfort of working in this indigenously produced PPE.

MATERIALS AND METHODS

Making of Innovative PPE Gown

The PPE gown was made using readily available material such as garbage disposal bags, adhesive tapes, and stapler pins (Fig. 1). Garbage disposal bags are made of biodegradable plastic which is made from corn and wheat starch and vegetable polymers which get degraded in 4–6 weeks under proper environmental condition. They are impermeable to liquid and provide a physical barrier to droplets which make it a good fabric to use for a PPE gown. Two sizes are available in our NICU. We used the larger bags, which measured 100 cm × 55 cm. The bags were sealed at the base and open on the top. Each bag has folds on each side to increase its capacity when opened up. Each bag cost around 10 INR and one PPE gown required three bags. The total cost of one PPE bag is estimated to be around 200 rupees, including the cost of sterilization with ethylene oxide (ETO) sterilization.

For making a gown, one of the bags was cut open from below and the folds were opened up (Fig. 2a). Then, the bag was folded into double and the sleeves were cut out (Fig. 2b and c). In another bag, the armholes were cut and the sleeves were stapled into it (Fig. 2d and g). In the same bag, a hole was cut out for the face at an approximate distance from arms holes for comfortable neck movement (Fig. 2e and f). Once the upper part of the gown was ready, another bag was cut from the base and stapled to it. The free edges from the top part were stapled together behind the head (Fig. 2g). The gown was donned from the top and doffed by cutting it open from behind (Fig. 2h).

Checking of the Ease of Use

Subjects

HCW including doctors, nurses, and support staff.

Settings

Level 3 NICU.

Method of Use

The HCWs were informed and demonstrated about the innovative PPE. They were asked about the participation in the study to check for its ease for at least 6 h duration. The informed consent for the wearing of PPE was taken. The participants were assured that they could doff it off if they feel uncomfortable or intolerable before 6 h duration. The durability and comfort of the indigenously prepared PPE were assessed by a predesigned structured questionnaire on a Likert scale with the scores ranging from 1 to 6. A score of 1 was for the worst response and a score of 6 was for the best response. The questions in the questionnaire included questions on the ease of donning and doffing, fit and movement comfort, ease of working and breathing, amount of heat and sweating experienced, and the subjective degree of a barrier protection that they experienced. The demographic data such as age, gender, designation, educational qualification, and experience of intensive care working were recorded. Before the use of the PPE gown, the basic piece of information was noted regarding the knowledge of PPE equipment, the frequency of usage, the kind of PPE, the cost of PPE gown, and feasibility of innovative gown. The gown was used on top of the usual NICU scrub suits as an impermissive droplet-resistant layer, along with a face shield a N95 mask. After using indigenous PPE, the post-use questionnaire was filled up.

Statistical Analysis

Study participant's responses were recorded in 1–6 rating where 1 was lowest and 6 was the highest favorable score. Favorable response (%) was computed for each question and overall response for corresponding maximum possible score. Continuous variables are presented in mean±standard deviation or median (interquartile range) while categorical data in frequency (%) as appropriate. Median scores were compared between two participant groups by the Mann–Whitney U-test and three or more groups by the Kruskal–Wallis H test. Multiple comparisons (by Bonferroni corrections) were used to compare between the groups when the Kruskal–Wallis H test was significant. Box plot was used to present the positive response (in %) in terms of minimum, maximum, first,

Figure 1: The materials required to make personal protective equipment gown

Figure 2: The stepwise process of making innovative gown for personal protective equipment

second, and third quartile. $p<0.05$ was considered to be statistically significant. Statistical Package for the Social Sciences version-23 (SPSS-23, IBM, and Chicago, USA) was used for data analysis.

RESULTS

In the study, 30 respondents (study participants) were asked to fill the questionnaires (Fig. 3). There were 10 questions with each of the 1 to 6 ratings. There was good internal consistency between the responses in questions (Cronbach alpha = 0.88). Except for the two questions [easy with heat sweating (0.895) and wear to this PPE in case of shortage (0.890)], the remaining of the other questions were showing consistency as after deletion of these questions, Cronbach alpha was decreasing. The mean and median age of study participants were 30.2 years and 30 years, respectively. About 43.3% (n=13) HCWs were below the age of 30 years. Four (13.3%), 16 (53.3%), and 10 (33.3%) respondents were up to 12th pass out, undergraduate, and postgraduate, respectively. Similarly, 6 (20%), 15 (50%), and 9 (30%) respondents were supporting staff, nurses, and doctors, respectively. Nineteen (63.3%) respondents' experience was 2–3 years and the rest 11 (36.7%) for 3–4 years. Descriptive statistics of the individual questions and overall are given in Table 1.

Median scores were compared between age groups and experience using Mann–Whitney U-test. The results showed that there was no significant difference in score between the two age groups ($p=0.056$) and experience ($p=0.094$). Similarly, median scores were compared between three groups of HCWs and results showed that scores were significantly different between supporting staff to doctors and nurses as well as between doctors and nurses ($p<0.05$) (Table 2).

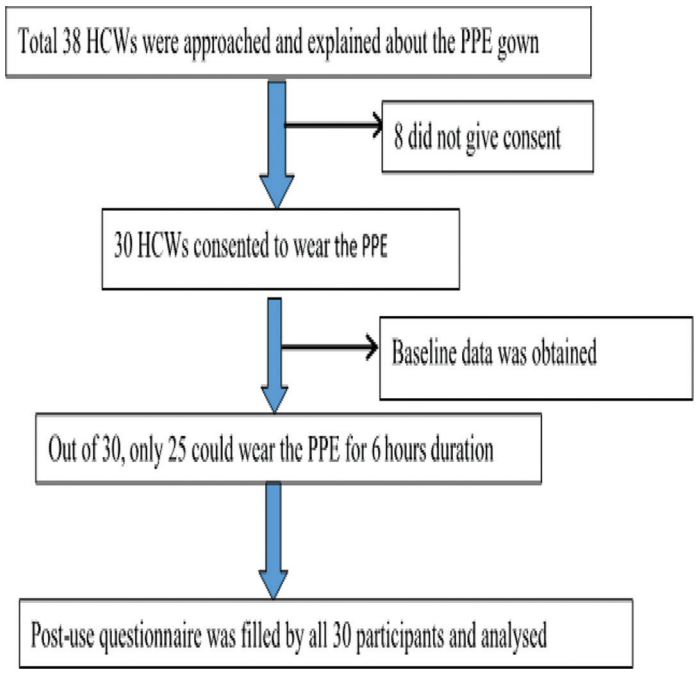

Figure 3: The study flowchart

DISCUSSION

The COVID pandemic has affected the worldwide working of HCWs in an altogether different way. In the present situation, almost all health-care facilities have been converted into COVID and non-COVID facilities. The PPE has become an integral component of working in the COVID facility. Even in the non-COVID areas, it is important to be careful because of the widespread community spread and high positivity rate even among the HCWs. With the enormous burden on health care, low-cost innovations need to be made, tested, and used with the changing situations.

With the expected gap in demand and supply, it is imperative to look for alternatives for PPE [10]. Our PPE gown design was a piece of an experiment that was intended to meet the shortage of commercial PPE in the crisis condition. Although newer designs being proposed for PPE gowns, they need to be tested on the WHO standards to be effectively useful in clinical settings. In comparison to the WHO standard, our gown had various junctions that were secured with stapler pins with no zips. The stapling was done after infolding the edges at least twice to provide more resilience and impermeability at the place of junctions. Furthermore, our gown material had enough tensile strength to avoid easy tearing while working. It was made of environment-friendly biodegradable plastic which is non-toxic. It was used after the ETO sterilization process to make it sterile before use; although, PPE had a difficulty doffing due to no use of zips and easily opening junction. The actual protection provided by the gown was unpredictable, as it was used in low-risk settings. For efficacy, formal microbiological testing is needed. It was a single-use gown. The human factors in design like size and fit can be customized as per the need of the HCWs.

Some of the HCW approached to take part in the study showed reluctance due to various reasons such as the discomfort of donning, the excessive noise, and sweating associated with it and the doubts about the degree of protection that it will offer. Some HCWs who agreed to participate in the study had to doff the PPE before 6 h as they did not find it comfortable. In the study by Loibner *et al*., reduced dexterity, impaired visibility, and back pain were important factors that negatively affected the performance while working in PPE [8]. Long duration PPE use also leads to various forms of cutaneous irritation [11,12]. The assessment in our study was for ease and comfort of wearing. We can conclude from our study that simple and easily available materials can be used to prepare PPE that can be used in crisis. The limitation of our study was that our innovative gown was not tested microbiologically to look for its efficacy in infection prevention.

Although most of the participants agreed to use the PPE in situations of acute crisis, the degree of protection that it offers still needs to be established. However, the PPE can be used in low-risk settings where there is less likely exposure in case commercial PPE is unavailable. The wearing of PPE poses several physical, psychological, and behavioral stresses on HCW and innovations must be done in PPE components to make it more wearable and also to look for adaptation in a crisis.

Table 1: Distribution of demographic and response variables in study participants (n=30)

Variables	Median (IQR)
Age (years)	30.0 (25.0, 34.5)
Experience in NICU (years)	1 (2, 3)
Ease of breathing with the PPE (%)	50.00 (66.67, 66.67)
Ease of donning of PPE (%)	50.00 (50.00, 66.67)
Ease of movement with the PPE (%)	50.00 (66.67, 66.67)
Ease of working with the PPE (%)	66.67 (50.00, 66.67)
Fit of the PPE (%)	50.00 (50.00, 66.67)
Willing to wear this PPE in case of a shortage (%)	83.33 (66.67 ,83.33)
Thermal comfort while wearing the PPE (%)	83.33 (66.67, 83.33)
Ease of doffing of PPE (%)	66.67 (50, 66.67)
Degree of protection of the PPE (%)	66.67 (50.00, 66.67)
Hearing comfort while wearing the (%)	66.67 (50.00, 83.33)
Overall score (%)	63.33 (56.25, 71.67)

Data are expressed as median IQR: Interquartile range; PPE: Personal protective equipment; NICU: Neonatal intensive care unit

Table 2: Distribution of demographic and response variables in study participants (n=30)

Profession	Median (IQR)	p-value	Mul. comp. (p<0.05)
Age groups (%)			
<30 (13, 43.3)	61.67 (55.00, 66.67)	0.056#	–
≥30 (17, 56.7)	66.67 (60.00, 79.17)		–
Profession (%)			
Supporting staff (6, 20)	65.83 (62.50, 72.09)	<0.001	SS versus nurse
Nurse (15, 50)	56.67 (55.33, 61.67)		SS versus doctor
Doctor (9, 30)	76.67 (66.67, 82.50)		Doctor versus nurse
Experience (%)			
2–3 years (19, 63.3)	66.67 (60.00, 73.33)	0.094#	–
3–4 years (11, 36.7)	60.00 (55.00, 61.67)		–

IQR: Interquartile range

CONCLUSION

In this preliminary testing, we showed the method to make a simple low-cost innovative PPE gown from a trash bag and also showed that it was easy to use and comfortable to work in this indigenously produced PPE.

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