Assessment of Current Personal Protective Equipment for Healthcare Workers

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Introduction. The world is currently experiencing a widespread outbreak of COVID-19 pandemic that is highly contagious from person to person transmission (WHO, 2020). In such a pandemic situation, healthcare workers (HCWs) face challenges on patient care, handling of infectious samples for diagnostics, and work with dead bodies exposing them to potential health risks (Loibner et al., 2019). To provide safety and protection, personal protective equipment (PPE) is used to prevent the transfer of microorganisms and body fluids (Whyte et al., 1983), and thus acts as the first line of defense against infection prevention for HCWs. Though PPE is a critical component of isolation precaution, current PPE is not ideally suited to the needs of HCWs due to limitation in protection and comfort, such as insufficient capture of airborne pathogens, difficulties in communication through materials, potential fluid penetration, poorly executed fit and sizing, and complicated procedures for donning and doffing (e.g., Kilinc, 2016; Salehi et al., 2019). Thus, the purpose of this study was to identify major issues of current PPE and assess HCWs' PPE needs within a healthcare setting.

Background. There are documented overexposures to microorganisms that are commonly carried through blood, body fluids, and other potentially infectious materials such as COVID-19 (Bell, 1997; WHO, 2020). Extensive studies demonstrate how materials of PPE and its proper use can play a significant role in the transmission of bacteria and viruses (e.g., Borkow & Gabbay, 2008; Kilinc, 2016; Loh et al., 2000; Nicas & Sun, 2006; Perry et al., 2001) Though the Centers for Disease Control and Prevention (CDC) (2018) provides a step-by-step guidance about how to put on and take off PPE to protect HCWs from severe infective environments, HCWs are challenged to follow the protocol under their urgent work environment, which leads them to expose at the high risk of infection. This becomes the critical challenge to develop novel PPE design that can be easy to don on and take off, and minimize the complicated procedure of wearing PPE within a short period in an urgent healthcare setting. There are numerous studies on PPE assessment and design for the population such as firefighters and agricultural workers (e.g., Barker et al., 2012; Forst, 2008; Huck, 1991; Lee & Park, 2011); however, limited studies have been conducted on PPE design for HCWs.

Methods. An online survey, using a reliable market service company, was conducted with a convenience sample of healthcare professionals who interact with patients and live in U.S. For this study, we focused PPE for body protection, including scrubs (tops/pants), gown, coverall, and disposable or reusable apron for HCWs. The survey consisted of three sections: (a) questions on demographics; (b) open-ended questions about the challenges HCWs face while wearing PPE; and (c) close-ended questions about PPE use, maintenance, and opinions of its

features including fit, mobility, comfort, donning and doffing, and aesthetic. All measures were derived from the previous literature (Huck, 1991; Lee & Park, 2011) and modified to fit in the needs of this study. The 34 PPE feature related items were measured using the 5-point Likert-type scale, ranging from "strongly disagree" (1) to "strongly agree" (5). Data from the open-ended questions were analyzed using content analysis approach. The quantitative data were analyzed using SPSS 26 to perform basic descriptive statistics and frequencies.

Results and Discussion. A total of 200 valid responses were used for the data analyses. Participants' ages ranged from 19 to 73 years old with a mean age of 38. Ninety percent of the participants were females and 10% were males. The majority was White/European American (83.5%), followed by African American (9.0%), Hispanic American/Latino (5.0%), and others (2.5%). Of the participants, 36% were classified as professional nurses including registered nurses, certified nursing assistants, and licensed practical nurses. The rest included student nurses (12.92%), medical assistants (11%), caregivers (9.57%), medical technologists (8.13%), administrators (8.13%), therapists (5.74%), and others including physicians, pharmacists, and nutritionists (8.15%). Their working experiences in a healthcare setting ranged from 1 to 50 years with a mean experience of 13 years.

Results revealed that the mean values of PPE were higher than 3 (on the 1 to 5 scale) for the following: fit (M = 3.45, SD = 0.56), comfort (M = 3.38, SD = 0.72), mobility (M = 3.44, SD = 0.69), and donning and doffing (M = 3.71, SD = 0.87). These quantitative results demonstrate that HCWs think that current PPE (scrubs, gown, coverall, and apron) meet their needs of fit, comfort, mobility, and donning and doffing. The mean value of PPE in terms of the aesthetic feature was lower than 3 (M = 2.53, SD = 0.87), which reveals that HCWs are not pleased about aesthetics of their current PPE. Despite these mean differences, the mean values of all PPE features scored in a neutral range from 2.53 to 3.71. In contrast, in response to the open-ended question, 31% of the participants considered comfortability as the biggest challenge when wearing PPE, followed by fitting (27.34%), donning and doffing (14.39%), movement (12.33%), material durability (11.52%), and others such as easy to use and PPE weight (3.42%). The findings from the qualitative data symbolize that HCWs currently face challenges in the area of PPE's comfortability, fit, and donning and doffing. Especially, the challenge in donning and doffing of PPE is crucial because virus transmission can be occurred through the improper PPE donning and doffing process in a healthcare setting.

Regarding PPE use and maintenance, 87% of the participants disposed of their PPE after a single use; among them, 61% disposed it to a trash can or garbage bag, and the rest put it into a biohazard bag. Thirty-one percent of the participants laundered their PPE after the use; among them, the majority of PPE laundering were done at their home (54.8%) or taken care by their workstation (38.7%) and professional laundering services (6.5%). In terms of incorporating wearable devices with PPE to detect virus transmission, 91% of the participants were not interested because of their less usefulness (51%) and unfamiliarity (30%). These findings show that the post maintenance of PPE after its use has not been properly instructed in a job site, which leads to critical concerns about the exposure of contaminated PPE in various locations without much awareness and care.

Conclusion. The findings of this study reveal the needs of current PPE improvement in terms of fit, comfort, mobility, and donning and doffing for HCWs' safety and health. Although CDC (2018) provides the step-by-step guidance for proper donning and doffing of PPE, HCWs' working in an urgent situation seems not to have sufficient time to follow this protocol. Novel PPE design that can minimize this procedural complexity is needed for HCWs to easily don on and take off their PPE within a short period. This study also reveals that most HCWs dispose of their PPE in a trash can in a healthcare unit and non-disposed PPE is laundered at home, which may expose their family members to a health risk if a proper precaution is not followed. Thus, further research is needed to examine the PPE maintenance practice and its impact on HCWs and their family members' safety and health. Despite having some limitations (e.g., assessment of the current PPE only for body protection), this study provides crucial insights for PPE designers, developers, and producers to conduct extensive research for developing more functional, comfortable, and protective PPE to ensure HCWs' safety and health.

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References

Barker, J., Boorady, L., Lin, S-H., Lee, Y. A., Esponnette, B., & Ashdown, S. P. (2012). Assessing user needs and perceptions of firefighter PPE. *Performance of Protective Clothing and Equipment: Emerging Issues and Technologies, STP1544*, 1-18. https://doi.org/10.1520/STP104099

Bell, D. M. (1997). Occupational risk of human immunodeficiency virus infection in healthcare workers: an overview. *The American Journal of Medicine, 102*(5), 9-15.

Borkow, G., & Gabbay, J. (2008). Biocidal textiles can help fight nosocomial infections. *Medical Hypotheses*, *70*(5), 990-994.

Centers for Disease Control and Prevention. (2018, August 30). *Guidance on Personal Protective Equipment (PPE) To Be Used By Healthcare Workers during Management of Patients with Confirmed Ebola or Persons under Investigation (PUIs) for Ebola who are Clinically Unstable or Have Bleeding, Vomiting, or Diarrhea in U.S. Hospitals, Including Procedures for Donning and Doffing PPE.* https://www.cdc.gov/vhf/ebola/healthcare-us/ppe/guidance.html

Forst, L., Noth, I.M., Lacey, S., Bauer, S., Skinner, S., Petrea, R., & Zanoni, J. (2008). Barriers and benefits of protective eyewear use by Latino farm workers. *Journal of Agromedicine, 11*(2), 11-17. https://doi.org/10.1300/J096v11n02_04

Huck, J. (1991). Restriction to movement in fire-fighter protective clothing: evaluation of alternative sleeves and liners. *Applied Ergonomics*, *22*(2), 91-100.

Kilinc, F. S. (2016). Isolation gowns in health care settings: Laboratory studies, regulations and standards, and potential barriers of gown selection and use. *American Journal of Infection Control*, *44*(1), 104-111.

Lee, Y. A., & Park, S. M. (2011). Comparative analysis between 3D visual pant fit and wearers'

subjective acceptability. *Proceedings of the 2nd International Conferences on 3D Body Scanning Technologies*, 174-184. https://doi.org/10.15221/11.174

Loh, W., Ng, V. V., & Holton, J. (2000). Bacterial flora on the white coats of medical students. *Journal of Hospital Infection*, *45*(1), 65-68.

Loibner, M., Hagauer, S., Schwantzer, G., Berghold, A., & Zatloukal, K. (2019). Limiting factors for wearing personal protective equipment (PPE) in a health care environment evaluated in a randomised study. *Plos One*, *14*(1), e0210775. https://doi.org/10.1371/journal.pone.0210775

Nicas, M., & Sun, G. (2006). An integrated model of infection risk in a health-care environment. *Risk Analysis*, *26*(4), 1085-1096.

Perry, C., Marshall, R., & Jones, E. (2001). Bacterial contamination of uniforms. *Journal of Hospital Infection*, *48*(3), 238-241.

Salehi, H., Pennathur, P. R., Da Silva, J. P., & Herwaldt, L. A. (2019). Examining health care personal protective equipment use through a human factors engineering and product design lens. *American Journal of Infection Control*, *47*(5), 595-598. https://doi.org/10.1016/j.ajic.2018.10.008

Whyte, W., Bailey, P. V., Hamblen, D. L., Fisher, W. D., & Kelly, I. G. (1983). A bacteriologically occlusive clothing system for use in the operating room. *The Journal of Bone and Joint Surgery*, *65B*(4), 502-506. https://doi.org/10.1302/0301-620X.65B4.6874723

World Health Organization. (2020, March 11). *WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020.* https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020