Analyzing Healthcare Workers' Current Isolation Gown Features for Their Safety and Protection

Young-A Lee and Mir Salahuddin, Auburn University, USA

Keywords: isolation gown, healthcare workers, donning and doffing, design features

Introduction and background. In healthcare, protective gown, one type of personal protective equipment, acts as the first line of defense by blocking the transmission of organism between healthcare workers (HCWs) and patients (Whyte et al., 1983). Despite of having vast studies confirming the role of its safety and protection (e.g., Borkow & Gabbay, 2008; Kilinc, 2016; Loh et al., 2000; Nicas & Sun, 2006; Perry et al., 2001), there are still concerns on HCWs' self-contamination during the donning and doffing process of protective gown (Gurses et al., 2019; Kwon et al., 2017). Salehi et al. (2019) argued that the limitation within the gown design is one of the main reasons for HCWs' exposure of the unsafety environment; for instance, difficulty in removing isolation gown around the neck increases the chance of self-contamination during the doffing process (Osei-Bonsu et al., 2019). Thus, the purpose of this study was to identify key design features of isolation gown which should be improved for ensuring HCWs' safety and protection.

This study was grounded from two theoretical frameworks: (a) Adams et al.'s (1994) relational model of personal protective clothing on worker performance and (b) Branson and Sweeney's (1991) clothing comfort model, where clothing comfort was conceptualized as "a state of satisfaction indicating physiological, social-psychological and physical balance among a person, his/her clothing, and his/her environment" (p. 99). Adams et al.'s four relational factors affecting on worker performance and safety include clothing properties (e.g., fit and sizing, design), task requirements (e.g., movement), environmental conditions (e.g., harmful agents), and worker characteristics (e.g., anthropometry, physiology).

Method. An online survey using a Qualtrics platform was conducted with a convenience sample of U.S. healthcare professionals, directly interacting with patients and having experiences of wearing protective gown (isolation gown and coverall) in healthcare. The survey consisted of four sections: (a) demographics; (b) current usages of protective gown including the donning and doffing sequence; (c) close-ended questions about HCWs' opinions about current protective gown in terms of fit, mobility, comfort, donning and doffing, and aesthetic; and (d) open-ended questions on its design challenges and suggestions for their safety and protection. All measures were derived from the previous studies (Huck, 1991; Lee & Park, 2011) and modified to fit in the needs of this study. The 24 and 33 items related to the features of isolation gown and coverall, respectively, 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. SPSS 26 was used to perform basic descriptive statistics, frequencies, paired *t*-test. SAS 9.4 was used to run logistic regression for examining the effect of design features on overall acceptability of protective gown (isolation gown and coverall).

Results and Discussion. A total of 153 valid responses (76.5% female and 23.5% male) were used for data analysis. Participants' ages ranged from 23 to 74 years old with a mean age of 43. The majority was White/European American (73.2%), followed by Asian (11.1%), African American (9.8%), Hispanic American/Latino (5.2%) and others (0.7%). Of the participants, 64.7% were classified as professional nurses including registered nurses, licensed practical nurses, and nurse practitioner. The rest included medical doctor (8.5%), physio-therapist (7.8%), physician assistant (7.2%), occupational therapist (5.9%), and physician (5.9%). Their work experiences in healthcare ranged from 1 to 50 years with a mean experience of 18 years.

Results revealed that isolation gown was the most commonly used protective gown (83.70%), followed by coverall without hood (67.30%) and coverall with hood (62.1%). The paired *t*-test indicated that only aesthetic had no significant difference between isolation gown and coverall ($M_{isolation}$ = 2.60, $M_{coverall}$ = 3.71, p = .172) among the features of fit, mobility, comfort, donning and doffing, and aesthetic. On the 1 to 5 scale, the mean values of isolation gown were higher than those of coverall for donning and doffing ($M_{isolation}$ = 3.95, $M_{coverall}$ = 3.38, p = .000), comfort ($M_{isolation}$ = 3.25, $M_{coverall}$ = 3.05, p = .003), mobility ($M_{isolation}$ = 3.53, $M_{coverall}$ = 3.22, p = .000), and fit ($M_{isolation}$ = 3.48, $M_{coverall}$ = 3.36, p = .018). For example, HCWs thought the donning and doffing procedure was comparatively easier for isolation gown than coverall. Logistic regression analysis revealed the significant effects of donning and doffing and comfort on overall acceptability of isolation gown ($\chi^2(4)$ = 27.82, p < .001; $\chi^2(4)$ = 10.08, p = .0391, respectively). For coverall, the significant effects of donning and doffing, comfort, and aesthetic on its overall acceptability were revealed ($\chi^2(4)$ = 10.31, p = .0354; $\chi^2(4)$ = 10.05, p = .0395; $\chi^2(4)$ = 12.62, p = .0133, respectively). Results indicated that 75.81% and 60.13% of HCWs were correctly rank ordered the donning and doffing sequence of isolation gown, respectively. This means that HCWs face more challenges while its doffing than donning. In terms of the design challenges of current isolation gown, HCWs pointed out major concerns at the back closure (42.5%), sleeve length (28.1%), gown length (26.8%), and around the neck (26.1%).

Results of content analysis presented that 41.35% of HCWs considered comfort as the main challenge for the current isolation gown, followed by donning and doffing (26.67%) and fit (22.67%). The main concerns within comfort, fit, and donning and doffing were related with increasing body heat while wearing (70.97%), inappropriate size range (76.47%), and difficulties to fasten and untie drawstrings at the back neck (60.0%). To overcome these challenges for their safety and protection, 49.26% of HCWs suggested its design improvements within fit and sizing, followed by donning and doffing (38.97%). Within fit and sizing, HCWs suggested providing various size ranges (82.09%), modifying wrists or cuff area (10.45%), and providing full body coverage (7.46%). Related with the donning and doffing process, the suggested design improvements were the way to easily tie and untie drawstrings at the back neck (49.06%), adjusting neck closure and shoulder length (33.96%), and providing better closure options such as button, Velcro, or elastic for the easy removal of isolation gown (13.21%).

Conclusion. Isolation gown was the most commonly used protective gown in healthcare. Among the features of fit, mobility, comfort, donning and doffing, and aesthetic, HCWs were not concerned much about its aesthetic. For HCWs, utilitarian features (e.g., donning and doffing, fit

and sizing, comfort) that directly influence their work performance are much important for its design consideration. The findings present the needs of improving the gown's design features including closures at the back, sleeve length, gown length, and around the neck for better body protection. HCWs shared their design suggestions more toward the way to provide better body coverage from the external hazard environment by wearing isolation gown. They emphasized on improving its back closure area to easily fasten and untie drawstrings, which are closely related with the donning and doffing performance. Further research is needed to examine the relationship between these design features and the donning and doffing performance. The findings of this study showcase the interrelationships among isolation gown properties, HCWs' task requirements, environmental conditions, and their characteristics, and how comfort can be achieved while interacting among HCWs, isolation gown, and the environment for their better work performance and safety. Despite having some limitations, this study provides critical insights for a novel isolation gown design and development by considering more of its utilitarian, task-related features to ensure HCWs' safety and health.

References

Adams, P. S., Slocum, A. C., & Keyserling, W. M. (1994). A model for protective clothing effects on performance. *International Journal of Clothing Science and Technology*, *6*(4), 6-16.

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

Branson, D. H. & Sweeney, M. (1991). Conceptualization and measurement of clothing comfort: Toward a metatheory. In S. Kaiser & M. L. Damhorst (Eds.), *Critical linkages in textiles and clothing: Theory, method and practice* (pp. 94-105). International Textile and Apparel Association.

Gurses, A. P., Dietz, A. S., Nowakowski, E., Andonian, J., Schiffhauer, M., Billman, C., & Xie, A. (2019). Human factors–based risk analysis to improve the safety of doffing enhanced personal protective equipment. *Infection Control & Hospital Epidemiology*, *40*(2), 178-186.

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.

Kwon, J. H., Burnham, C. A. D., Reske, K. A., Liang, S. Y., Hink, T., Wallace, M. A., & Dubberke, E. R. (2017). Assessment of healthcare worker protocol deviations and self-

contamination during personal protective equipment donning and doffing. *Infection Control and Hospital Epidemiology*, *38*(9), 1077.

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.

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

Osei-Bonsu, K., Masroor, N., Cooper, K., Doern, C., Jefferson, K. K., Major, Y., & Stevens, M. P. (2019). Alternative doffing strategies of personal protective equipment to prevent self-contamination in the health care setting. *American Journal of Infection Control*, *47*(5), 534-539.

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