Ergonomic Design and Development of a Reusable Facemask: ASTM Level 3

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Background

Personal Protective Equipment (PPE) is defined as protective clothing that includes helmets, gloves, face shields, goggles, facemasks, and respirators or other equipment designed to protect the wearer from injury, the spread of infection, or illness (Center for Devices and Radiological Health, 2020). The disposal of PPE contributes to the nearly 17 million tons of clothing and textile waste generated each year (U.S. Environmental Protection Agency, 2020). In landfills, if healthcare waste is left untreated, it can lead to the possible contamination of drinking water, surface water, and ground water (World Health Organization, 2018). According to the World Health Organization (WHO, 2018), medical waste incineration causes large amounts of emissions, including dioxins, furans, and particulate matter. In order to fix these issues, the WHO continues to promote the reduction of waste.

Previous researchers have focused on the redesign of medical PPE (Han, Rhi, & Lee, 2004; Kim & Brandewie, 2015), usage of different textiles, and comfort testing of medical garments (Conroy, Klene, Koppa, & Park, 2017; Kim, Brandewie, & Kim, 2016). Goldfrank and Liverman (2008) investigated adequate designing PPE in order to reduce skin irritation, alleviate pressure point tension, and to improve breathability along with wickability. Despite PPE research efforts, advancements to medical-grade facemasks have been limited. Facemasks, which are worn anywhere from 10 minutes to several hours, can cause discomfort for the wearer. Due to their singular, one-size-fits-all design, wearers have frequently cited issues with fit, textile irritation, breathability, and closure function (Conroy et al., 2017; Kim et al., 2016).

Proposed facemask

We proposed a new facemask extending the life of a medical-grade facemask. A reusable sleeve made from a ProCool® athletic jersey mesh fabric that has been developed with a Silvadur™ technology would be added to reduce their impact on the environment and enhance the comfort for the wearer (see Figure 1). This component permits longer wear time by preserving the facemask and improving comfort. Further, issues with discomfort were explored, and an innovative design that improves fit by way of altering the nose and chin curve.

Additionally, a nonslip headband with buttons was added to allow for adjustable wear. This study will assess wearers' perceptions and acceptance of the proposed facemask compared to the current commercial facemask offerings.

Method

Data would be collected through a web-based survey. The proposed facemask will be made in small, medium, and large sizes with buttons to customize the fit (see Figure 1). A wear test will be performed to compare the prototype to a commercial facemask (Medline, n/d), ASTM Level 3 procedure masks with antifog foam and ear loops, which provides complete protection against fluids at the American Society for Testing and Materials (ASTM F1862M, 2017). The web-based survey administered to participants will consist of three sections: (1) participants' demographic characteristics, (2) physical fit and comfort during the wear trials, and (3) wearers' acceptance included 7-point Likert scales (Cao et al., 2014). Based on 80% power with $d = 0.3$ ($\alpha < 0.05$) in statistical power criteria (Cohen, 1988), approximately 34 human subjects will be recruited in this study.

Expected Results and Implications

The proposed facemask features will not only resolve issues of fit and comfort but also will result in a seamless experience for the user due to the proposed facemask being altered to accommodate a better fit with chin contouring and a nose curve with the wiring. The nose curve will feature an anti-fog strip to eliminate glasses from fogging during wear. Comfort will be increased, and sizing is expanded by adding a headband component with buttons to customize fit for the wearer. The headband also will alleviate ear discomfort that would occur after long-term wear. The proposed facemask will include a removable sleeve, which can be laundered and worn again, improving the comfort and sustainability of the mask itself. This sleeve is fabricated with the ProCool® athletic jersey mesh fabric to provide safe microbial protection, water-resistance, breathability, hypoallergenic, and eco-friendly elements, maximizing the benefits the proposed facemask. The expected results are increased fit for the wearer and an increase in comfort by alleviating pressure on ears and abrasion of mask skin. With the addition of the sleeve, it is expected that the facemask can be worn longer, leading to a decrease in the number of facemasks that end up in landfills. Therefore, this study's results will maximize wearers' comfort and better fit their needs while making the facemask last longer, which would lead to a reduction in facemask waste that ends up in landfills. Indeed, due to considerable increases in facemask sales in the COVID-19 pandemic, disposable and single-use of facemasks cause immeasurable problems to the environment. In this conceptual study, the proposed ASTM level 3 facemask prototype will generate valuable ergonomic design guidelines in the medical and protective clothing industries.

Figure 1. Proposed ASTM level 3 facemask.

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