

## Development of Novel Face Masks for Children: A Study on User Preferences Over Time

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**Introduction.** With the outbreak of the Covid19 pandemic, wearing face masks became part of the daily routines not only for adults but also for children. American Academy of Pediatrics advices that cloth face coverings should be worn by all children age 2 years and older and face masks can be safely worn for extended periods of time, such as the school day or at child care. Yet, there exists no research on design preferences for children's cloth face masks. So far design efforts have focused on adults' face masks and the literature on cloth face masks have clustered under two categories of material and fit. Studies that focused on material reported on mechanical and electrostatic filtration effectiveness based on fiber type, textile structure, porosity, layering of textiles and novel fibers such as those with antiviral properties (Davies et al., 2013; Konda et al., 2020; Kumar et al., 2020). The second category of studies which are limited in number in comparison reported on the effect of mask fit on filtration efficiency. Dato et al. (2006) and Mueller et al. (2020) compared how an additional overhead strap and a second layer of nylon overlay on a traditional cloth face mask improved filtration effectiveness. There has been no study that focused on the user preferences and design features about face masks from a broader perspective in the context of long-term use. In addition, children interact with face masks in much different ways than adults and they have unique needs. This study aimed to determine design preferences for children's face masks and to develop a novel and user-friendly protective face mask design for children focusing on fit, donning/doffing, comfort and aesthetics features. The specific objectives of this study were 1) to lay out the design preferences of children's cloth face masks, 2) to develop novel children's face masks, 3) to test user reaction on the developed novel face masks over time.

**Method.** This study was conducted in three phases in accordance to methodology approved by the UC Davis, IRB (no.1638978-1): 1. user interviews, 2. prototype development, 3. prototype testing. In the first stage, an hour-long online video interviews were conducted with 11 parents, 15 children (5 boys, 10 girls) ages ranging between 5 to 10 years old. The interviewees were invited to bring all the face masks that they owned to the interviews which were then used as probes to question the most and the least favorite features and also to observe donning/doffing and fit of the masks in action. The interview questions for kids focused on likes and dislikes about the face masks they owned in a comparative way and for parents focused on face mask selection criteria for their children, challenging aspects of having the kids wear face masks as well as care and cleaning. The interviews were transcribed and coded to determine design criteria for an ideal face mask for children.

In the second phase of the study, the design criteria were used to develop prototypes for novel face masks through multiple iterations. Each iteration of the prototypes was tested on 1 to

3 children and further developed until 2 final prototypes that feature 2 different donning/doffing styles were created.

In the third phase of the study, prototypes were tested by employing cultural probes method. Cultural probes are a qualitative research tool where open-ended activities are provided to users in the form of a diary kit which may include video recorders, worksheets with a set of instructions to gather a narrative about the users' lives in a specific context (Gaver, Dunne & Pacenti, 1999). The cultural probe kit designed for this phase of the study was a playful activity book that introduced the features of the mask prototypes and allowed children and their parents provide feedback about different aspects of the face masks over 5 uses in two weeks of time through set of activities. 10 children were selected from first phase interviewees to represent different age ranges and genders, and each were mailed 2 different face mask design prototypes and 2 associated activity books. The completed activity books were mailed back to the researcher which were then analyzed to determine the positive and negative feedback that led to final iteration of the novel face mask design.

**Results and Discussion.** The findings from the interviews showed that the biggest concern about children's face mask was the fit. Large gap around the nose, pulling behind the ears, slippage during talking or while active, mask moving into the mouth during talking and breathing, mask getting wet and soggy were the user comments coded under fit category. The second cluster of data were coded under comfort and main user problems listed in this category were difficulty of breathing, skin discomfort, thermal discomfort and smell discomfort. The third category emerged from interviews was donning/doffing which referred to negative user comments about finding the right orientation, putting on and adjusting without adult help. The fourth category was the care of face masks with comments about difficulty of keeping track of dirty vs. clean, masks losing their shape after washing, losing masks frequently and difficulty of tracking ownership. The final category was the aesthetics the with major concern about the lack of personalization.

Based on these results, through an iterative process two different mask alternatives with different donning/doffing features were developed. The mask design featured optimized pattern shape and size, an embedded boning structure between the two layers of the cotton fabric that provided a gap between the mouth and the mask, elastic loops tunneled across the face mask that can be scrunched to adjust to a custom fit to the face, memory foam padded nose clip and color-coded design to indicate orientation. Since the findings of the study showed that the preference about ear loop versus gaiter style wearing is very personal, two versions of the mask with two wearing styles were developed. The first mask featured adjustable ear loops with an optional adjustable lanyard that allows mask hang around neck and also functions as an alternative head strap. The second version featured a gaiter style worn over the head which is then adjusted by pulling the neck straps that can move through one and other. Both masks were manufactured using two layers of 100% cotton material as the focus of this study was on the structure of the design and the fit of the mask designs would be evaluated in future stages against store bought traditional cloth masks that are widely made from two layers of cotton fabric.

In the third stage, the results gathered from the cultural probe kit, which was an activity book, showed that there is a learning curve and masks were perceived more and more positively

at the end of the 5 uses. The boning structure, nose clip and the custom fit adjustment features of the mask were very positively perceived both by children and their parents. There was room for improvement in identifying the up and down orientation and the closure for the second gaiter style mask version which caught the long hair during donning and doffing. The prototypes were reported to hold their shape well and stand the multiple washing and drying cycles during the 2 weeks of data collection process. Based on these feedbacks minor adjustment to the designs were made by laminating well-known shapes in the inside of the mask to indicate top and bottom, and by switching the closure to a cord lock.

**Conclusion.** This study demonstrated an in-depth exploration of design preferences for children's protective face masks through user interviews, iterative prototype development and cultural probe method to gather user feedback over a 2-week period of use process. The resulting design offers a much more improved and comfortable user experience for the children by eliminating or minimizing major problems that came out of the interviews. In the future stages of this project, developed face mask prototypes will be comparatively fit tested against store bought face masks using 3M's Qualitative Fit Test apparatus and revised testing protocol.

## References

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