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Blare Offenbacker

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Creating Adaptive Face Masks with Clear Inserts to aid People with Hearing Loss

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Abstract

The purpose of this study is to create adaptive face masks with clear inserts to aid individuals with hearing loss. In early 2020, when the world went into lockdown and quarantine, guidelines were set by the Center of Disease Control (CDC) on how to protect yourself from Covid-19. Covid-19 is also known as SARS-CoV-2, which is severe acute respiratory syndrome corona virus 2. The main protection against Covid-19 at the beginning of the pandemic was the use of face masks that covered the nose and mouth. This has been a continued recommendation for protection against Covid-19 with the different variants of the disease that have evolved. The first thing you are recommended to do if you have symptoms of Covid-19, is to mask up.

Masks in general muffle sound and it makes it harder for individuals with hearing loss to communicate as they are also not able to read lips with the face covered. It also makes it harder to communicate through sign language since they still use facial expressions. At the moment, doctor's offices, clinics, and hospitals are still requiring people to wear face masks, so the need for face masks with clear windows is still relevant. Individuals with hearing loss and individuals who use sign language or read lips, deserve to have accessible accommodations, especially when it comes to treatment for their health. It is hard for patients to receive treatment if they can't communicate with their doctor or other health professionals in a safe manner. That is why the creation and development of these masks are important in accommodating individuals with hearing loss. This entire project was funded by a service learning grant through Bumpers Honors College.

Introduction

Background and Need

The Coronavirus, more specifically, Covid-19, developed in Fall 2019 and became a prevalent issue across the world in March 2020. Covid-19 is also known as SARS-CoV-2, which is severe acute respiratory syndrome corona virus 2. Symptoms of Covid-19 include fever, cough, sore throat, breathlessness, fatigue, and malaise; it can progress to pneumonia, acute respiratory distress syndrome and multi organ dysfunction (Indian Journal of Pediatrics, 2020). The first case was reported in Wuhan, China, in December 2019 (Journal of Medical Virology p.1). On January 21, 2020, a Washington state resident was reported as the first Covid-19 case in the United States (AJMC, 2021).

At the time of this study, the global total number of cases was 248,022,616, the number of total cases in the United States was 46,931,766, and the total number cases in the state of Arkansas was 513,352 (Worldometer, 2021; New York Times, 2021). Due to the infectious nature of the disease, nearly the entire global population went into lockdown and quarantined for roughly a month consecutively from March to April 2020 and continued to isolate and/or socially distance into the Summer of 2020, because of the many regulations the CDC mandated. Early CDC regulations asked United States residents to avoid large social gatherings, maintain at least 6 feet of social distancing, wear masks indoors and outdoors, and if at all possible, avoid anyone outside of one's household.

At the beginning of the pandemic, the United States government encouraged residents to reserve surgical face masks and N-95 masks for healthcare workers because personal protective equipment (PPE) was in short supply. When the United States issued a "14 day" quarantine period nationwide, people were trying to buy as many surgical face masks and N-95 masks as

possible because no one knew the seriousness and situation of the Covid-19. This then led to home sewers, fashion designers, and the retail industry devoting time and resources to create cloth face masks so the general public, essential workers, and healthcare officials had access to PPE. Plastic face shields began to be introduced and a variety of N-95 masks were manufactured, but other than these few options, PPE has not had any more advancements or improvements for use by the general public.

As society acclimated to living in a pandemic, people began developing opinions toward the use of face masks and their effectiveness, causing controversy between many people. According to Big Data and Society (2021), “For many anti-establishment, anti-government groups, the mandate to wear face masks in public was interpreted as an affront to personal liberty” (p.2). Many of these radical groups of people began using the phrase, ‘My Body, My Choice,’ in protest of the mask mandates, which is a phrase is usually associated with the pro-choice reproductive rights movement. In addition to some refusing to wear masks, there was also confusion about which situations require a mask. But as Covid-19 has progressed, restrictions have loosened and there is more research now on the issue, compared to the start of the pandemic.

Problem Statement

Throughout the course of the pandemic, there have been many protocols put in place to help stop the spread of Covid-19, including mask mandates, which have shown to be controversial globally, but especially the United States. In addition to exploring public attitudes toward mask wearing, some communities face limitations with traditional mask types, particularly individuals with hearing loss. Face masks muffle sound and many individuals with hearing loss have only been able to communicate with others when people pulled down their

masks to enunciate the words. However, this does not protect individuals from Covid-19 and defeats the purpose of a face mask. Individuals with hearing loss now experience a difference in hearing, as well as the ability to read people's lips. Many individuals with hearing loss rely on lip-reading, since ASL is not widely known. The Survey of Income and Program Participation (SIPP) is a national survey that frequently gathers data "identifying the American population of persons with hearing loss or deafness," (Mitchell, 2005, p.1). SIPP (2005) estimated that in the United States, "nearly 10,000,000 persons are hard of hearing and close to 1,000,000 are functionally deaf" (p.1). According to the British Medical Journal (2020), "Face masks with clear windows could allow access to facial expressions and lip movements, but there are few manufacturers and supplies are low" (p.1). The world needs to accommodate those with disabilities and the first step in this issue, is to create face masks that are clear, but will still protect the person wearing them.

Purpose of the Study

The purpose of this study is to create adaptive face masks with clear inserts to aid individuals with hearing loss.

Research Objectives

The following objectives guided this study:

- Identify the challenges people with hearing loss are facing in regard to the use of face masks during the pandemic
- Identify accommodations to current face masks that provide a superior product for the user
- Design and develop 5 prototype masks including modifications inserting clear panels to increase visibility of the mouth

Literature Review

With Covid-19, part of the safety regulations to help prevent transmission are mask mandates. However, there are adverse effects with mask mandates where interpersonal communication is negatively impacted, particularly within the community of individuals with hearing loss. This review of literature discusses the Covid-19 pandemic and national response, an overview of PPE, define deafness and hearing loss, states the audial and visual issues with masks, and the potential adaptations that can be made to face masks.

Covid-19 Pandemic and National Response

According to the Center for Disease Control (2021) “COVID-19 is a respiratory disease caused by SARS-CoV-2,” (p.1). This virus spreads through respiratory droplets from someone either exhaling, coughing, or sneezing and patients can also be asymptomatic with the virus (CDC, 2021). The current recommendations are to get fully vaccinated against Covid-19, wear masks indoors around others who are unvaccinated, and to social distance when necessary.

An Overview of PPE

According to the U.S. Department of Labor (2021) PPE is equipment worn to minimize exposure to hazards that can cause injury or illness. Some examples of PPE include gloves, goggles, helmets, and respirators. For Covid-19, PPE varies from fabric face masks, surgical paper masks, N-95 masks, KN-95 masks, and plastic shields (see Images 1, 2, and 3). Image 1 shows a cloth mask, a surgical mask, and a N-95 mask (iStock, 2020). Image 2 shows a KN-95 mask (School Health, 2022). Image 3 shows a face shield, and the CDC recommends if you are wearing a face shield, you also wear a face mask under it, as well (Communities 4 Children, 2022). For the general public it is recommend to use cloth face masks and paper surgical masks.

For healthcare professionals the most protection is provided by the use of N-95 masks with paper surgical masks over them, along with a face shield.

Hearing Loss and Deafness

There are various levels of hearing loss, and it can affect one or both ears. People can be born deaf or with hearing loss, and they can also develop these conditions later in life.

Individuals with hearing loss, which can be mild to severe, may rely on spoken language to communicate with others. Some treatments to help improve hearing loss include hearing aids, cochlear implants, and live captioning. People who are deaf, have little to no hearing and will use sign language to communicate (World Health Organization, 2021). There are 432 million adults and 34 million children affected by disabling hearing loss. Disabling hearing loss is when a person's hearing loss is greater than 35 decibels in the better ear (World Health Organization, 2021). According to the WHO, by 2050 1 in 10 people will have disabling hearing loss.

Audio and Visual Barriers to Communication

The American Speech-Language-Hearing Association (2021) defines communication as “the active process of exchanging information and ideas” (p.1). Communication consists of comprehension and expression and there are many visual cues that people, especially individuals with hearing loss, rely on to be able to communicate. The Mayo Clinic (2020) claims that wearing face masks degrade audio quality by muffling sound and covers half the face. Not only is the speech and audio quality affected, but any visual cues in communication on the face are hidden. Nursing Standard (2020) suggests that face masks will remain in use for the foreseeable future, necessitating the development of new forms of communication. Almost every public place, such as grocery stores and restaurants, have required people to wear a face mask or a face covering of some sort in response to national guidelines from the CDC, and potentially state and

city mandates. Many individuals with hearing loss or deafness rely on lip reading and visual cues of the face. The Ear, Nose, & Throat Journal (2021) argues that with the introduction of face masks, those who rely on lip reading find it much more difficult to understand and communicate with others. Additionally, face masks can cause issues such as glasses fogging up, hearing aids catching in the ear loops, and being uncomfortable for some people to wear, which stresses the need for an adaptive face mask that eliminate those challenges, (Nursing Standard, 2020).

There are few studies regarding masking and individuals with hearing loss. Naylor, Burke, and Holman (2020) state that there are vast amounts of unexplored issues in addition to using face masks with hearing loss, such as social distancing and face-to-face interactions, which obstruct speech and audio quality. Before Covid-19, individuals with hearing loss already relied on lip reading, having face-to-face conversations, and being in close proximity to communicate with others, and now it is even more of a struggle for individuals with hearing loss to communicate amidst the restrictions.

Potential Alternative Mask Designs

The Lancet (2021) states that “people with hearing loss who cannot lip read or people with visual impairment who use guide dogs” find it much harder to use face masks in daily life, because it makes it harder for them to communicate with others (p. 1332). Knollman-Porter and Burshnic (2019) state that, “results from a recent observational study found that staff working in nursing homes use speech approximately 80% of the time when engaging with patients” (p.7). In the medical field, communication between a patient and their doctor is important and there cannot be any confusion in what is said regarding someone’s health. The most basic solution is a clear, transparent face mask to help aid communication for individuals with hearing loss. Kratzke, Rosenbaum, Cox, Ollila, and Kapadia (2021) claim that “see-through or clear masks

have demonstrated improved understanding for patients with hearing impairment” (p.373).

Homans and Vroegop (2021a) also believe that “more research is needed to investigate the effect of face masks on speech perception and sound attenuation” (p.538).

Covid-19 is still a prevalent issue globally and we are over the two year mark since the first case. With different variants appearing, there may be future mask mandates if the spread of Covid-19 is as prevalent as it was early in the pandemic. Since masks muffle sound, individuals with hearing loss are at a major disadvantage because they are not able to use lip reading when others are wearing normal face masks. However, with clear face masks, it will allow people to lip read, fully understand ASL through facial expressions as well as tone and emotion, and it will overall improve communication.

Development Plan

There are a variety of masks available to purchase for PPE, however; there are very few options for accessible and adjustable masks that allow you to see the person’s mouth. According to the World Health Organization (2021), “Over 5% of the world’s population – or 430 million people – require rehabilitation to address their ‘disabling’ hearing loss...” (p.1). Individuals with hearing loss have some options for the betterment of their hearing, for example, hearing aids, cochlear implants, an assistive listening device, and live captioning (World Health Organization, 2021). An important way that individuals with hearing loss communicate with others, is through ASL and lip reading, which is impacted by the use of traditional face masks. In general, a company will have to step up and commercially make these clear face masks to accommodate individuals with hearing loss so they can effectively communicate with others. The use of clear face masks gives individuals with hearing loss the ability to still read lips and communicate clearly with others through ASL.

For this project, the following steps were taken:

1. Research face masks currently available for purchase commercially
2. Write a grant and secure funds to purchase materials to create the face masks
3. Purchase materials
4. Create a pattern for the mask
5. Document steps to create the mask by creating a step-by-step guide

I researched problems for individuals with hearing loss in regard to the use of traditional face masks and researched the available masks on the market. At the beginning of this research process in late 2020, there were few options available. At the time of this writing, there were more options available, however, they are still limited and tend to not be reusable.

To secure funding, I applied for a service-learning project grant through the University of Arkansas Honors College. I sourced the materials and purchased them following university protocol. Unused materials were donated to the Apparel Merchandising and Product Development Program to allow other students to continue this service learning project.

The following steps were taken to create the prototype face mask with the clear insert:

1. Create a flat pattern for a face mask with a clear panel that can be mass produced.
 - a. Draft the flat pattern for the face mask prototype
 - b. Produce prototype
 - c. Modify the flat pattern
 - d. Produced modified prototype
 - e. Repeat steps c and d until the finalized design is achieved
2. Create a digitized version of the pattern through Adobe Illustrator

The following steps were followed to create a guide:

1. Document in writing the exact sewing process and instructions, including seam allowances for the masks
 - a. Create a draft copy of the production process
 - b. Follow the steps while creating a prototype
 - c. Make appropriate changes to original steps
2. Create a guideline using Microsoft Word for a step by step guide to creating the masks with a list of materials used
3. Convert the guideline into a PDF with the steps of the final production processes listed (see Appendix)

Design Process and Creative Works

The first thing I did was research what masks were available on the market now and what designs were used. My first prototype was a pleated mask with a clear vinyl insert with a nose piece and adjustable ear loops. However, as I was creating these, I ran into problems with how to effectively construct them and they did not achieve what I was trying to do. The mask did not sit right on the face structurally, so I developed a different design. I used muslin fabric while I was sewing the masks to try to figure out the best way to produce them. I wanted to make a mask that would also be comfortable for the user to wear. I used 100% cotton fabrics for the masks and used matching thread for each mask. I created a “boxed U” shape for the pattern of the cotton fabric piece (see Figure 1). The vinyl pattern is shaped like a diamond and has two tiny darts at the top and bottom near the nose and chin (see Figure 2). The two darts in the vinyl make it extend out from the face, so the mask does not press against the user’s face, and it is more comfortable. This also allows the user to speak and enunciate their words more clearly since the

mask does not stick to their mouth, like traditional masks do. I incorporated the use of adjustable elastic ear loops. There is also an option for the mask to be tied on with straps that go around the head instead of around the ears if that is more comfortable for the user.

I cut out 4 of the “boxed U” patterns and one of the clear vinyl patterns. I then sewed the two middle seams together and pressed the seams open. Then I pinned the two elastic ear loops, or two long straps of stretch fabric if you want it to tie around the head, to the corners of the mask. The elastic ear loops were sandwiched between the two fabric pieces right sides together. I used a ¼ inch seam allowance for all of my sewing. After this, I sewed around the outside edges with my ¼ inch seam allowance and turned the mask inside out. Once both sides of the mask were together, I clipped along the line on the pattern, in the corners of where the clear vinyl panel is placed. I pressed the edges down so it would be a clean edge that is top stitched around the vinyl. I then inserted the nose piece into the nose bridge of the mask and top stitched it in place. The last step was to insert the vinyl in the mask and top stitch it in place.

The mask can be machine washed but will need to be air dried. To keep the mask from fogging up, I used defogger spray on the vinyl. It is also recommended to rub dish soap on the vinyl and let it dry to prevent the vinyl from fogging up while wearing the mask. Absolutely do not put the mask in the dryer as it will melt the vinyl and can cause a fire. Images 4 through 9 document my prototype process and show the final end result.

The first prototype was a pleated mask (see Image 4). This mask fit tight on the face and did allow adjustments or easy enunciation of words. The second prototype was the first design using the boxed “U” pattern for the mask; however it became a rectangle shape and I had over anticipated how much fabric to cut from the mask for the vinyl insert (see Image 5). The third prototype was the boxed “U” pattern design; however, I did not make the mask wide enough or

long enough for the face, and it was too small (see Image 6). The fourth prototype was the boxed “U” pattern and the fabric piece for that was the right size, but the vinyl pattern did not fit into the mask itself (see Image 7). To fix the problem with prototype four, darts were added to the vinyl flat pattern. The fifth prototype was the final prototype made. The front view of the final prototype is shown in Image 8 and the side view in Image 9.

Conclusions

Over the course of the developing strains of Covid-19 and the ongoing pandemic, there have been many issues that have come up. From being able to stay safe from the virus to not being able to communicate and feeling isolated with quarantine and social distancing that was put into place. The Covid-19 pandemic has been around for over 2 years now and we are still learning new things about the virus and how to adjust to this new life. For people with hearing loss in particular, it has been very difficult to communicate with others while wearing normal face masks that cover the mouth, and do not allow for lip reading. This is why I chose to create face masks that have a clear vinyl insert that allows the mouth to be visible while still protecting the user from the contagious virus.

After I constructed my prototype masks, I tried them on myself to see how comfortable it was to have on the face. For future uses, there will need to be grading of the masks so it will fit different people’s faces, like a women’s, men’s, and children’s size. As more people become aware of this issue and create these masks, there will be additional improvements to my design. This was what I was capable of creating in a short time frame and I know the design will be even better for future use when others recreate and work on the project. Other people have already laid the groundwork to create these masks, now it just needs to be perfected so it can be created in mass manufacturing by a company like Walmart.

I believe these masks can be mass produced by a bigger corporation like Walmart or Amazon for consumer use. The clear masks that are available now are completely plastic and cost over \$40 for one face mask. With the normal face masks, they muffle sound and hide the person's lips and facial expressions. There are a few face masks with clear windows available to purchase online from a few independent sellers who sell them on Etsy and other sites like that. However, there are still needed improvements to be made to the design and quality of the face masks and the process for creating them. As we continue in this era with Covid-19, we will need to have accessible PPE for individuals with hearing loss and/or use lip reading for communicating with others. If we have future outbreaks of another disease or virus, there will already be prototypes available to use for reference, so we do not run into this issue and problem like we did in April 2020 at the beginning of lockdown and quarantine.

Limitations and Recommendations

I had some limitations when it came to developing and creating this project. After quarantine happened in March 2020, I started work on this honors project in October 2020 and there have been many changes with Covid-19 and the world since then. Over time there were less restrictions in place as vaccines were becoming available and the world as whole was getting a better handle of living in a pandemic. I also had a limited amount of time to work on this project and was just one person working on this myself. I know there will be more improved versions of this mask as I am not capable of doing so. I had a limited amount of time to work on this as I had less than 2 years to do this and there wasn't a lot of research about the topic when I first started, so it was a bit of learning process. Just within 2 years, there have been more options available on the market now, that were not before.

If I had more time to work on this project, I would definitely recommend it be a group project that has multiple collaborators from the apparel aspect and audiology and medical aspect. I only knew so much about the medical field and what it was like to work in that environment during the pandemic, and it would have sped up the development process being able to bounce ideas off of medical professionals who were dealing with this on a daily basis. If I didn't have my limitations, I would have created different sizes of masks for men, women, and children. I also would have had developed different ways a person could wear the mask so it would be more accessible and adaptable. Due to the limitations of this study, further research is recommended. The final design chosen for these adaptive face masks should be evaluated by clinical professionals and its effectiveness should be studied in depth.

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Images

Image 1

Examples of Masks



Image 2

K-95 Mask



Image 3

Face Shield



Image 4

1st Prototype: Pleated Mask



Image 5

2nd Prototype: Muslin Mockup



Image 6

3rd Prototype: Mask was too Small



Image 7

4th Prototype: Vinyl Shape did not Fit



Image 8

5th Prototype: Front Picture of Final Design



Image 9

5th Prototype: Side Picture of Final Design



Figures

Figure 1

Face Mask Fabric Piece Pattern

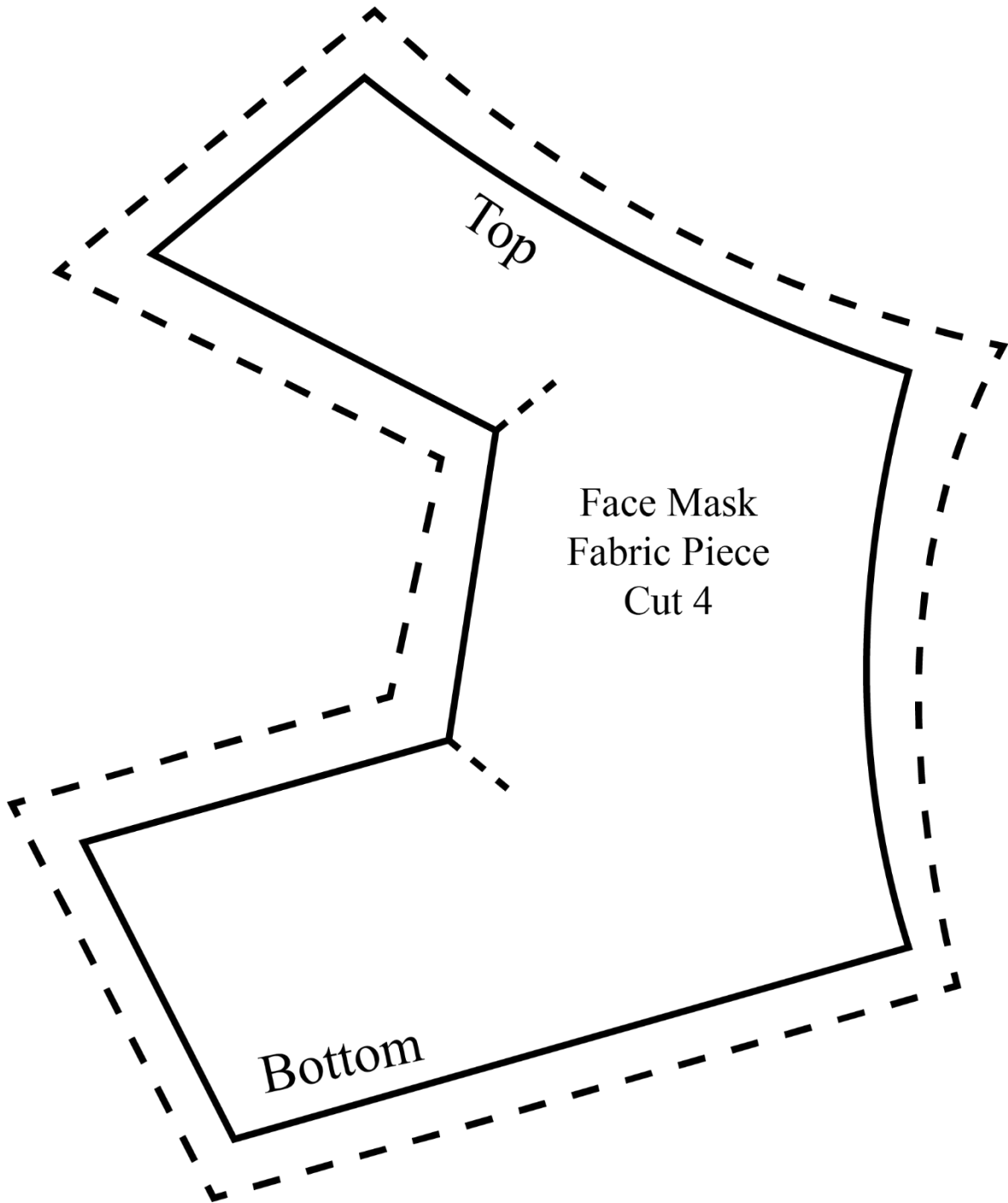
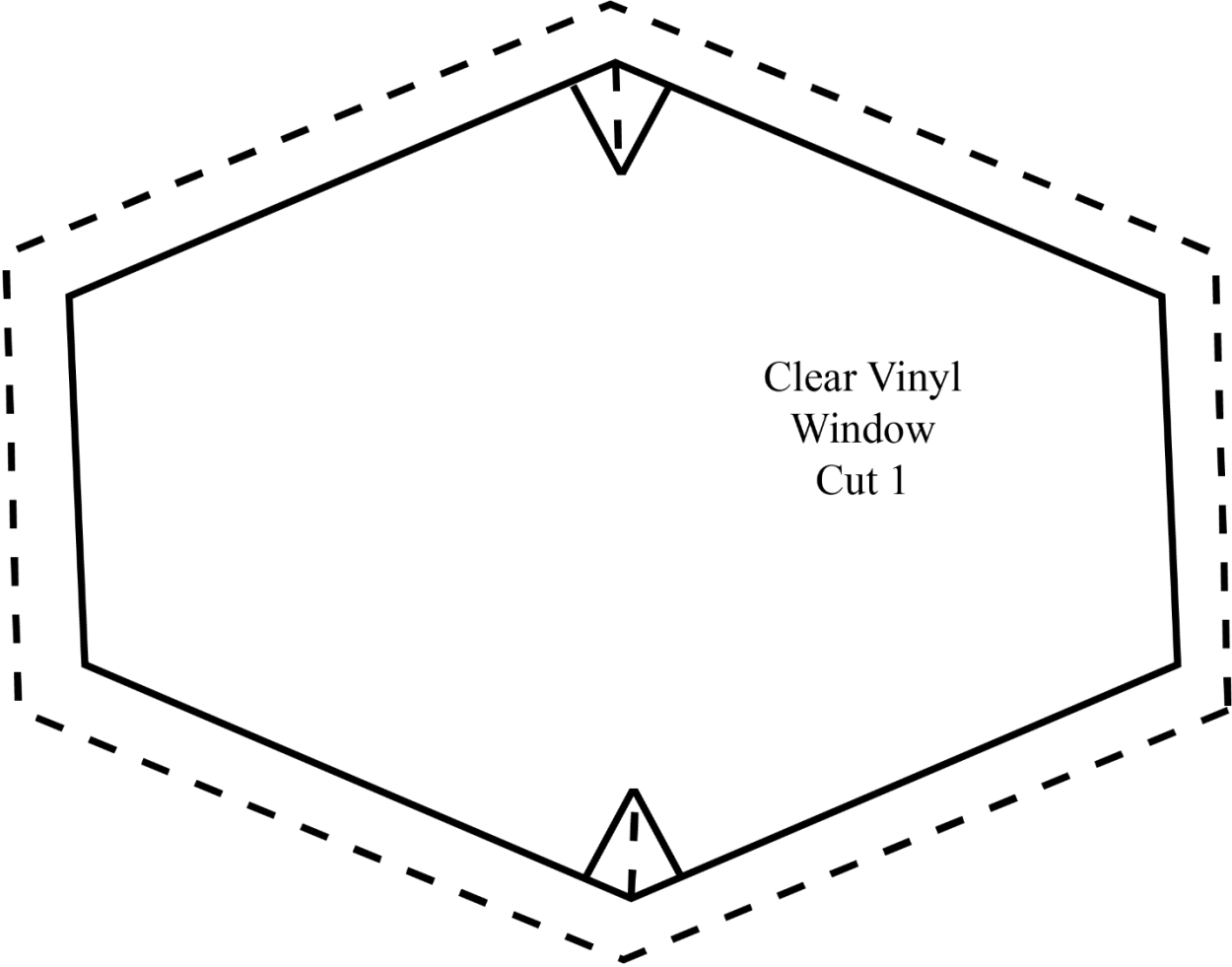


Figure 2

Clear Vinyl Window Panel Pattern



Appendix

Creating the Face Mask with Clear Inserts Guideline

Materials Used: 100% Cotton fabric, Clear Vinyl 10 Gauge, Aluminum Nose Bridge, Adjustable stretchy woven ear loops, and defogging spray.

Steps:

- Mark and cut 4 of the face mask fabric pattern pieces and one of the clear vinyl window patterns
- Pin two of the face mask pieces right sides together, and do the same thing for the remaining two pieces
- Sew the darts on the clear vinyl mask with white or clear thread
- Sew the middle seams of the face mask fabric at a $\frac{1}{4}$ inch seam allowance and clip the edges at a diagonal where the window panel will go, while it is folded
- Pin the ear loops at the corners of the mask and sandwich it between both the face mask fabric
- Sew around the outside edges at a $\frac{1}{4}$ inch seam allowance and flip the mask right side out
- Press the clipped edges of mask so clean edge is on the right side of fabric
- Insert the nose piece at the bridge of the face mask and top stitch around the piece to secure it
- Insert the vinyl piece between the two layers of fabric and top stitch around the edge
- Spray defogging spray or rub bar soap on the vinyl to prevent fogging of the mask