Innovated Mask to Prevent the Spread of COVID-19

Ethon Deonarine, Jackaria Hossain, Tasnia Mosfique, Razaul Howlader

City College of New York

Summary

The COVID-19 virus has taken the world by storm, affecting us socially, economically, and even politically. The methods of transmission of the COVID virus, have affected activities and occupations globally. The respiratory particles we emit is the primary reason the disease spreads. To be extra cautious masks have been implemented to help reduce the spread of covid and offer protection against infected respiratory particles. Nevertheless, the ability of transmission has stayed constant and the necessity for protection in masks is apparent. Countries are advising citizens to protect themselves with masks. Although, the uncomfortability of the recommended masks prove to hinder its usage. Not only this, the recommended mask, the N95, can be more effective if utilizing SMS nonwoven filters compared to its nanometer filter. We consider the possible benefits of innovating such a product and include rudimentary costs for the first year of production with a budget of $1.5 million.

Author Note

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Introduction

Before the Coronavirus (COVID-19) pandemic, masks were used as an adherence to standard medical protocol in health conscious locations. These masks filtered out some airborne germs and dust. Today, it is one of the most essential items used in daily life. According to the Centers for Disease Control (CDC) and Prevention (2021), one of the most common ways coronavirus is spread is through respiratory droplets, which is also one of the main reasons for the virus's rapid rise. In order to slow down the rates, the government mandated everyone to wear masks in public, as it is also one of the fews ways to protect oneself from this deadly virus. The CDC also recommended using masks that have more than two layers. One of the commonly used masks is the disposable 3-layered blue mask. Many agree that it is cheap and easy to breathe in (Chao, 2020, p. 1).

However, as the rate of COVID-19 contractions increases, many governments around the world are requiring people to wear two masks. This means that most people would have to wear six layers of filters, which makes everything difficult for them in terms of their quality of life. For example, people with certain breathing issues would have a hard time to do simple tasks due to the lack of air intake. Another problem is that people would have a hard time hearing each other because of the masks' thickness.

Our team's goal is to design a solution to the difficulties of wearing two masks. There are 4 main parts that are considered in the design process: breathability, audio clearance, filtering properties, and cost. The mask should allow people to breath easily without the feeling of wearing a mask. People should be able to hear each other clearly without their voice being muffled. The mask should have the properties of two masks, meaning it contains the properties of six filters. And lastly, the mask should be as cheap as the disposable 3-layered masks.

One prototype mask that we took as inspiration for our masks is Razer's Project Hazel. Their prototype includes UV lights that would kill the bacteria entering the mask. It has active voice amplification, so the voice outputted by the wearer has an increased volume (Razer, 2021). It also contains air ventilation that lets in low temperature air when inhaled (Razer, 2021). Although these properties matched our goal, it is not cost effective.

Our design will have the goal of making the masks more comfortable. Most masks, especially the N96, use uncomfortable material on its last layer and straps, which irritates the skin (Purdy, 2019). In addition, the masks such as the N95, use an anti-microbial filter (Fig. 3), which can only protect someone from a virus to a certain extent. In our masks, we will use Spunbond Meltblown Spunbond (SMS) fabric to create a more effective filter than the conventional masks. We will also replace the straps with 80% organic cotton for comfortability and 20% polyester for flexibility.

Objective

Our objective is to study the faultiness of the N95 mask's design and research on ways to improve on it. First, we will review the design of the N95 masks through peer-reviewed articles from known scientific journals. Then, known fabrics used in high stakes medical procedures will be researched and implemented to the new design. If there is success, the design will be modified to create cost benefits by prolonging usability (Appendix B). This design will be then proposed to the FDA for approval of public use and mass production. Lastly, the masks will be advertised and available for purchase.

We will complete the Innovated Mask to Prevent the Spread of COVID-19 project within a reasonable timeframe. According to the charts in Appendix A, this project can be finished in one year. This will be enough time before another variant of COVID-19 starts to spread.

Preliminary Literature Review

_____The coronavirus disease, better known as COVID-19 is a respiratory illness that with contact of respiratory particles can spread between individuals. The virus is more likely to be spread when people are within close contact with each other. CDC guidelines and the media have emphasized a socially distanced 6 feet within all gatherings. The necessity for 6 feet is due to the nature of the spread, which is through the infected respiratory droplets. These respiratory droplets include transmissions from coughs and or sneezes.

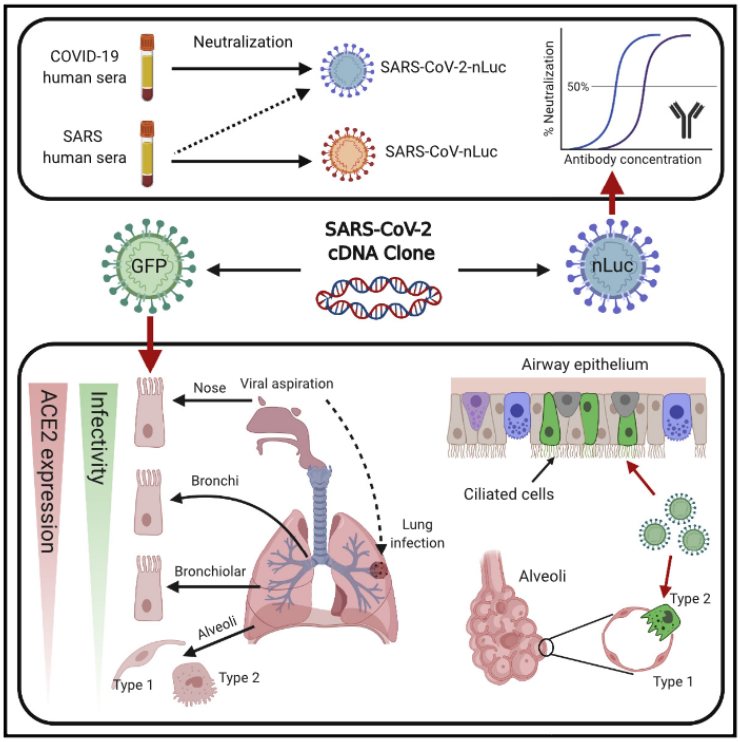

Fig. 1 COVID-19 variable that fixates on the respiratory tract. Reprinted from "Reverse Genetics Reveals a Variable Infection Gradient in the Respiratory Tract" by Hou et al., 2020, https://doi.org/10.1080/02786826.2021.1915466

_____Although COVID-19 may affect people in different ways, the way that it is spread has always stayed consistent. The ability for covid to be spread in close quarters have put many activities and occupations at a quick halt. Specifically, the ciliated airway cells are shown to be

the primary targets for the virus that are at risk in close distance (fig. 1). Since the spread of the virus is primarily based on respiratory tracts, the proper solution is to implement masks. The usage of masks can block said infected respiratory droplets and as a result stop the spread of COVID-19. The filtering capability of masks can vary as masks can be made of "different materials" which "influence their filtering capability". However, the "N95 respirators are recommended for health workers" due to their "ability" to "protect the wearer from infectious particles" (Howard et al., 2020). While the protection exists from the N95 respirators they are not as effective and or comfortable as they can be.

COVID-19 has only grown throughout 2020 and currently nearing mid 2021, and that continues the fear and necessity for safety. However, a common constraint that mask users unanimously agree on is, it's comfortability. In fact, even though some masks may prove to be effective, the added discomfort leaves users more dissatisfied with the idea of wearing masks. In a comparison of a variety of facemask characteristics it is found that the "two straps" are "made of elastic or stretchable plastic" specifically on the "N95 FFR" model. Although after further surveys "N95 FFRs are often considered uncomfortable" and at times are "not worn by workers" due to this fact (Purdy, 2019). Comfortability is a large necessity when it comes to masks that citizens, workers, or even athletes must consider as they are wearing masks for long hours.

If a mask is deemed uncomfortable, many will overlook the health risks and not wear said mask. Purdy explains that the "extent that a N95 FFR will affect a worker's perception of comfort is related to its [the masks] physical properties" (Purdy, 2019). The physical properties of a mask holds great value in one's mind in terms of comfort. Therefore, the more comfortable a mask is, the longer the user can wear the mask and reap its protection. In the mask that we intend to make, the design follows a similar blueprint of the N95 mask (fig. 3). In the final layer, there

is included a skin-friendly material that consists of organic cotton. The final layer is one that would be the origin of many's discomfort, hence utilizing organic cotton will alleviate such irritation. Cotton is arguably the "'best fabric' because of its potential to be versatile, comfortable and sustainable, both for consumers and the planet" (Hewett, 2021). Cotton is utilized in a majority of the clothing that we wear because it's a material that does not irritate the skin as other products tend to do. Not only this, organic cotton is sustainable for the Earth and does not cause irreversible damage when harvesting. The mask should contain organic cotton specifically, as if a cotton does irritate your skin it may be from the inorganic "chemicals" included in normal cotton clothing. Additionally, there exists "technology and special processes" that can "make cotton softer" but regardless, natural cotton is "fluffy and soft in the first place" (Hewett, 2021).

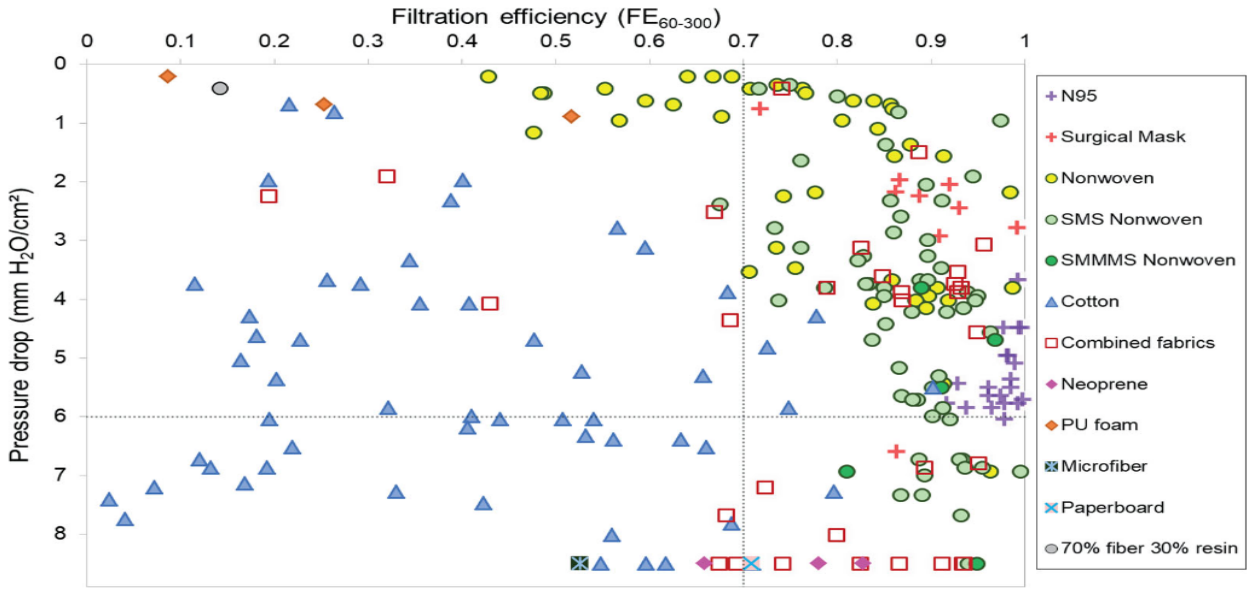

Fig. 2 Pressure drop as a function of 12 groups of face masks. Reprinted from "Filtration efficiency of a large set of COVID-19 face masks commonly used in Brazil" by F. Morais, 2021, https://doi.org/10.1080/02786826.2021.1915466

The research found in Brazil, contains a comparison of 12 groups of masks that consist of different materials. The group of 12 masks are compared by their pressure drop and filtration

efficiency (fig. 1), which minimum values are provided by the World Health Organization (WHO) who are most knowledgeable on the COVID-19 virus (Morais et al., 2021). The minimum pressure drop given by the WHO is 6 mm H_2O/m^2 , anything higher is considered unsafe. Adding onto that, the filtration efficiency's minimum is 0.7 FE60-300, and anything lower is deemed unsafe as well. Henceforth, anything in the top right quadrant of the dotted lines is more than adequate to WHO. The study intends to evaluate the "performance of different types and materials for facial masks" and its ability of "filtrating airborne particles". In professional masks, it is concluded that the "N95 respirator" has the highest values of filtration efficiency and pressure drop. Not only this, the "best overall performance is from the non woven materials" specifically the "nonwoven SMS" that contains a "layer of melt-blown microfibers" that allow it to have the "best overall performance" (Morais et al., 2021).

The nonwoven SMS has features that provide excellent protection when it comes to filtration efficiency and pressure drop. The material has high value in regard to the spread of coronavirus and in comparison to other masks like the N95. However, the N95 design is not one that is inadequate. Although, with the right modifications it will provide more protection than it does currently, and can combat new strands and mutations of COVID-19. What separates the N95 mask from other competitors is due to its usage of filters such as the antimicrobial filter, and the nanometer protective filter. Though, to improve the design of the N95, removing the nanometer protective filter and replacing it with a SMS nonwoven filter will create a mask that has little to no pressure drop and an extreme filtration efficiency.

Technical Description of Innovation

The mask might seem complex, however, it is simply constructed. Firstly, it has a nonwoven protective coating which acts like a membrane. Secondly, a dust filter which blocks airborne particles like dust or dust alike. Thirdly, an antimicrobial filter that captures microbes. Fourthly, a nanometer protective filter that filters in and out air. Lastly, a skin friendly material with a strap/loop for the ears. The first layer and the last layer are visible while the 3 layers in between are seeped in and protected from damage.

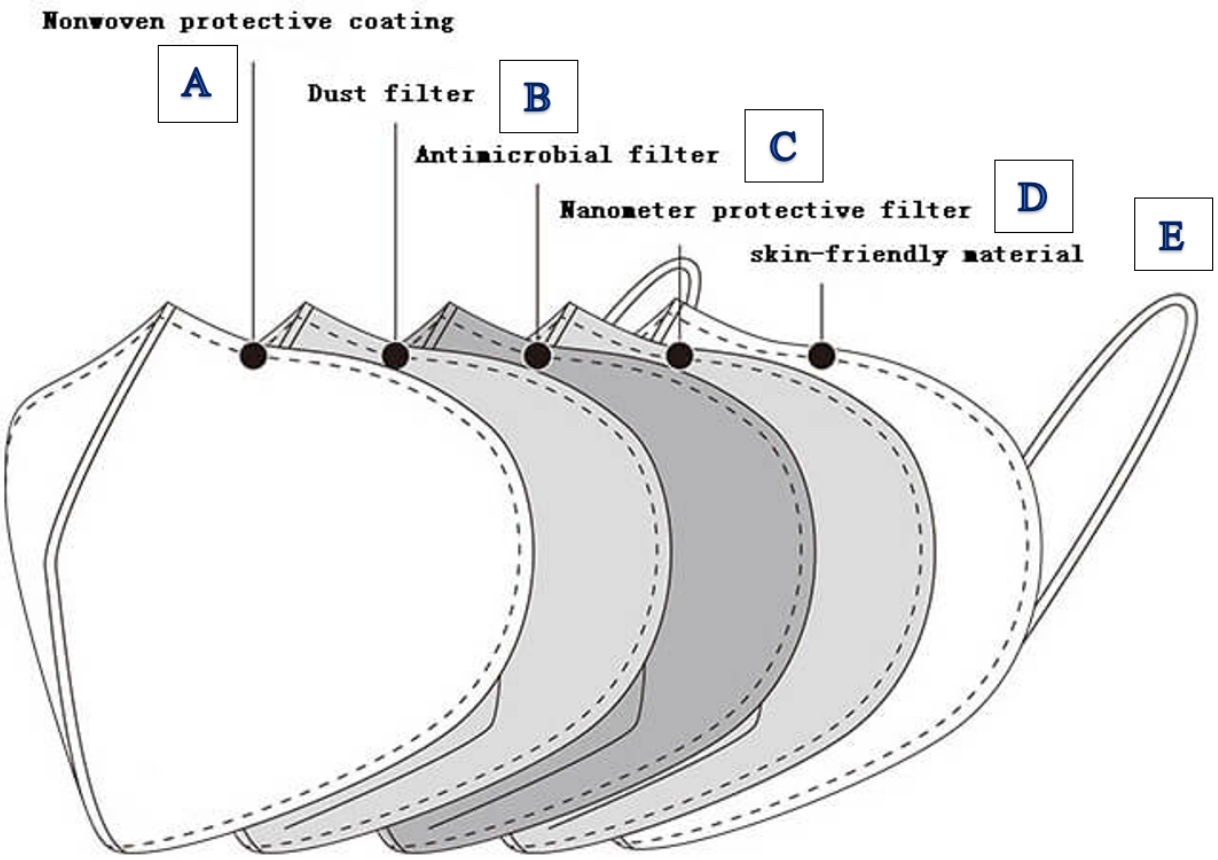

Fig. 3 Altered N95 mask with specifications. Reprinted from "N95 Mask, KN 95 Respirator Mask*",* by. BSD Corporation 2021, https://n95maskn95.com/

Fig. 3A - The nonwoven protective coating acts like a membrane and protects the front of the mask and lets air in when inhaling.

Fig. 3B - The air passes through the Dust filter that filters out the dust and other small particles that should not be inhaled.

Fig. 3C - The filtered air goes to the Antimicrobial filter which picks up microbes and kills them and prevents them from growing.

Fig. 3D - Nanometer protective filter which is an ultra-fine filter that delivers air to your lungs.

Fig. 3E - On the other side of the mask there is a soft layer that is placed on your face and is skin-friendly.

The design of the N95 is very similar however, we are planning on keeping most of the design, but changing a layer and replacing another layer. We will add an SMS nonwoven layer (after fig. 3C) and remove its nanometer protective filter. The sms nonwoven layer is thicker than the antimicrobial filter (fig. 3C), so particles that pass through will have more difficulty (fig. 3D). The activated carbon in the dust filter (fig. 3B), helps the filtration process of the mask. Its active ventilation helps bring in cool air inside the mask and releases heat produced from exhaling. This results in preventing build up of carbon dioxide in the mask. These materials are very useful for protecting against non-oil based aerosols and block particles from grinding, sanding and sweeping. This ensures that the user is having a comfortable time breathing and also being more protected.

The skin-friendly layer (fig. 3E) should be made out of cotton or even a mix of 80% cotton and 20% polyester for better flexibility. The straps for the mask would be a soft line of cotton or polyester mix just so it does not hurt the users' ears or is left with any mark. Cotton straps ensure less pressure on the ears and comfortable fit for a variety of face shapes and sizes. The fitted cotton straps are not expected to become loose very often like the elastic bands used for the basic surgical masks. With our new innovation to this particular N95 mask users can freely enjoy being protected as well and breathe comfortably in these dire times.

Time Constraints and Budgets

Emily Shugerman's (2020) article stated that the department responsible for the implementation of masks has nearly a $1.5 million budget. However, their workload is only set to increase due to the changes needed to be executed to the upcoming changes to the N95 mask assembly. With budgets and factories already existing from local N95 production centers our budget can alleviate the changes in production. Moreso, the newly attained budget assists in the addition of workers and qualifications from the CDC. After the first year of production we will evaluate supply and demand as we receive more information about COVID-19 and it's new mutations.

The budget intends to use all resources, as extensive testing is necessary to have our product truly achieve what it sets out to accomplish, being a more effective and more comfortable N95 mask. The intention is to have production facilities that can mass produce our product and multiple scientists that are knowledgeable on the COVID-19 variants to test our product to the fullest extent. The unit can range anywhere from 500 to 1,500 employees, depending on the size and demand for production. The experimentation will be done in a

separate space with scientific supervision and not to be contaminated with our manufacturing sites. The other expenses will cover labor expenses, covid tests for employees, salaries for workers and other miscellaneous expenses that are deemed necessary for our longevity. There exists a time constraint to produce said masks in under a year, as new covid variants may exist and require a mask that guarantees protection from respiratory particles.

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Appendix A - Task Schedule

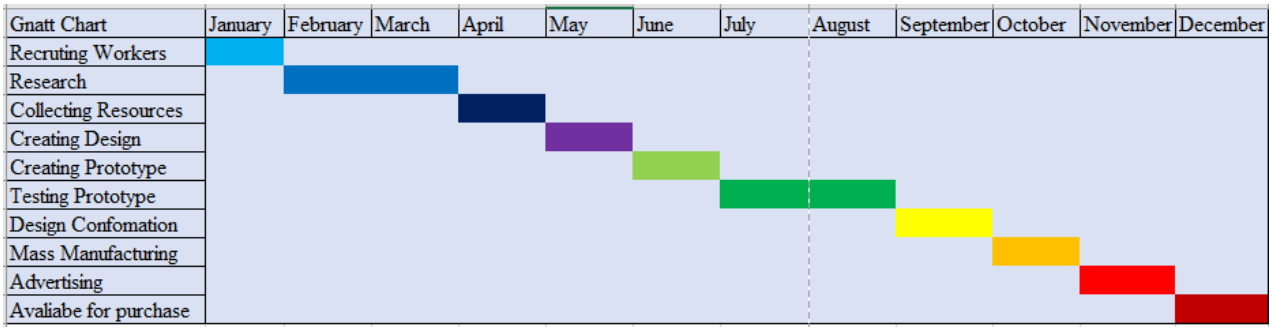

Table 1: Project evaluation schedule, created by Tasnia Mosfique, (2021).

The chart above represents the project evaluation schedule. It includes the time necessary to execute the plans accordingly. The planning for the project includes recruiting workers, research, collecting resources, creating designs, creating prototype, testing prototype, designing conformation, mass manufacturing, advertising and available for purchase. According to the chart the very first step of the project is recruiting workers. This part will require looking for designers, inverters and manufacturers. It will take almost a month to recruit workers for the project. The next step is to research for the project which might take more than two months to execute. Collecting resources is to collect the instruments and materials required for this project. This will take most likely a month to collect the resources required for manufacturing of the mask. Next is creating the design for the mask. This is one of the most important parts as many things need to be taken into consideration while designing a product. Therefore, it might take almost like a month to come up with the design of the mask. Creating and testing a prototype comes right after creating a design. Testing a prototype is the most time consuming part for this product. The testing period will include testing the efficiency of the mask. The researchers will have to determine its efficiency, cost and labor power during this time. Therefore, testing the prototype of the mask would take almost 2 months to finish. The confirmation needs to go in

right after the testing as by then the researchers would learn about the efficiency of the mask. Therefore, they will have to confirm the design as soon as possible to start the manufacturing process. Lastly manufacturing and advertising of the mask will take almost 2-3 months as it has to be broadcasted for people to know about the new product. The manufacturing company will have to put the mask up in television and newspapers for advertisement. Then the product will be available for people to purchase it.

Appendix B - Innovated Mask Potential Benefits and Costs

Benefits	Costs/Problems
Increased protection and offers customization. The masks that we provide will be able to combat the new mutations of the COVID-19 spread along with adding options to what color mask you prefer.	*Increased stress.* With new strains of the COVID-19 virus, tensions are becoming high and the desire for a better mask may create panic.
Increased usage in medical circumstances. Areas which have seen a spike in hospitalizations may be more emphasized to wear a mask with better protection.	*Increase mask costs.* Requires additional material compared to surgical masks.
Supports multiple uses. The material intended to use will be durable and washable for multiple uses.	*Breathing concerns.* While it remains difficult to breathe in two masks it is difficult to combat this issue without sacrificing safety.
Reduces waste and reduces constant costs. Having to repurchase masks every so often becomes more of a hassle in the long run.	*Reduced support for other solutions.* If the mask we provide becomes a success it may discourage others from seeking the surgical masks.
Prices for similar masks will decrease. As more companies enter the market and become FDA approved masks of the same quality will become cheaper.	
Increased employment. Factories and manufacturers will need employees to create this product.	

The effect of creating a mask that is designed to act as two can be impactful to people and society.