

Design of a Fan-Powered Face Mask with Advanced Filtration Capability
(Technical Paper)

The Effects of SARS-CoV-2 on Mental Resilience and Physical Health
(STS Paper)

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Introduction

The proverb “Good things come to those who wait... greater things come to those who get off their ass and do anything to make it happen,” really speaks to the current status of society. Simply put, society cannot feasibly wait around for a change; scientists, engineers, and everyone must take an active role to make a desired difference occur in society. SARS-CoV-2 (Covid-19) has plagued the world in 2020, and has left many feeling isolated and more sedentary as almost every aspect of life has transitioned online. This shift is shown through the work of Nicholas Bloom, a Stanford economist, which shows that 42% of full-time US labor is now working from home (Wong, 2020). Covid-19 has ultimately taken over two-hundred thousand American lives, many freedoms, and even left society as a whole physically, mentally, socially, and emotionally broken or stressed (Rossen, 2020). The impacts of the pandemic on the entire world have been severe and it will most likely take years to return to the old state of normalcy from a pre-Covid-19 world.

Because of high global death rates and the contagious nature of the virus, many countries have imposed, sometimes extreme, restrictions on citizens to mitigate its spread. Many steps have been made to make society as normal as possible while still trying to reduce the spread of the deadly virus. Even with regulations and new technologies, like social distancing and face coverings, the virus continues to spread as people become more complacent with and even numb to the potential effects of Covid-19.

The most apparent change to daily life has been the introduction of wearing face masks. However, while it may seem apparent that wearing a face mask offers protection from the virus, over a quarter of people interviewed in a Gallup Poll said that they seldomly or never wear a mask; some claims for not wearing masks stem from the examples that several public figures

previously set, existing health conditions, or claiming masks take away American freedoms (Brenan, 2020). Many masks offer less than ideal protection when compared to medical grade masks (Ablondi, 2020). Therefore, issues with effectiveness and aesthetics led to the inception of the proposed capstone project; designing a powered-air face mask that will filter intake air, exhaust air, and will be easier to breathe in compare to other recommended masks while maintaining a more aesthetic appearance.

Even with an ideal face covering, other social rules and policies seem to vary by culture, state, city, and establishment, especially in exercise facilities. Most gyms have a slightly different policy for Coronavirus prevention. The goal of the proposed STS project is to analyze how Corvid-19 has had an impact on humans with a focus on physical fitness, mental health, and the overall effectiveness of safety protocols at stopping the spread of the virus. The face mask proposed by the technical project will help address the STS research question by creating a technology that is safer, aesthetically pleasing, and more comfortable than previous designs, which will result in greater public use and hopefully a swifter end to Covid-19.

Technical Topic

The Coronavirus has extended far beyond the boundaries of the United States, with over one million deaths worldwide. However, there have been over 29 million cases globally of people that have recovered from the virus (Johns Hopkins, 2020). The number of recoveries is almost more important now than the number of deaths because scientists and health officials still do not know the long-lasting effects of contracting Covid-19. The unknown impact on our bodies could potentially damage the human heart, lungs, and brain (Mayo Clinic, 2020). In order to prevent this potential, unknown harm, or even more deaths, face masks have been implemented in most public settings around the world. Face masks help prevent spreading aerosolized

particles, very small droplets that can remain suspended in the air for long periods of time, by minimizing exposure to other people's breathing, which could be contaminated with the virus. However, not all masks are made equally, and there currently is not one that is 100 percent effective at preventing the spread of Coronavirus.

There are currently two categories of face coverings being used all around the world: non-powered and air-powered systems. Non-powered masks are broken down into even more categories such as medical grade, homemade, or respirators. However, in all of these masks the main idea is to have a filter material that can stop viruses in the air from entering and exiting the body. These masks should fit snugly to cover the mouth and face, but often result in an uncomfortable sensation, specifically those with high grade filter material like N95, after hours of wear (Mayo Clinic Staff. 2020). To overcome this stuffiness and discomfort, powered-air fans, such as in Powered Air Purifying Respirators (PAPRs), blow filtered air across the face and result in a more comfortable wear after a long time of use. This system allows an individual to stay focused on their work rather than the discomfort they may experience throughout the day (3M United States, 2018). Unfortunately, the issue with PAPRs is that they do not filter exhaled air; meaning if you have the virus and you are wearing one, you just shoot it into the air for others to breathe in (CDC, 2020). Currently, PAPRs are quite expensive and are mainly used in the medical field; in one study, PAPRs cost \$768.20, while an N95 respirator only cost \$1.50 (Radonovich, n.d.). While N95 respirators are much more cost effective, they are disposable and do not offer all day comfort like their more expensive PAPR counterparts.

Ideally, the proposed capstone group would like to combine the filtering capabilities of intake and exhaust air with long lasting comfort, all the while making sure the design is small and aesthetically pleasing so everyday people will be comfortable wearing it over a long period

of time. The final technical deliverable will include an integrated mask design with fans to aid breathing and filters cleaning air coming in and leaving the mask. This fan-filter device will be attached to different current face mask designs, such as half-face respirators and continuous positive air pressure (CPAP) masks, which have already gone through rigorous fit testing. The design will be assembled and contained in a 3D printed housing and will include a fan, filter material, and potentially a battery.

The final air-powered facemask deliverable will be obtained through several iterations of prototypes and computational fluid dynamic (CFD) analysis on SolidWorks. The overall success of this proposed mask design will depend on three main metrics: CFD analysis, ease of breathing while wearing the mask, and a mock fit test that is used for current mask systems. CFD will be used to assess the overall airflow throughout the system and help to determine if a proper amount of air is being supplied for the user. As CFD cannot supplement real world application, an actual test will assess the ease of breathing through a qualitative comparison between the final deliverable and a N95 mask. Finally, a mock fit test will be performed to determine if the final system properly filters inhalation and exhalation air. This fit test will consist of spraying a bitter, Bitrex, solution within an enclosed environment. If the user cannot smell the solution, then the mask functions properly and effectively filters air (OSHA, 2020). Once these criteria are tested for and met, the mask could be printed and used by university students and the Charlottesville community to engage in physical and social activities more safely, and without the threat of transmitting Covid-19.

STS Concept

Even though the proposed capstone project is designing a better a face mask design, that is not to say that face masks as a whole are completely useless. A study from Texas A&M

University used statistical analysis to estimate how effective facemasks would be at preventing the spread of the infection of the Corona Virus. This study estimated that face masks reduced over 66,000 infections in New York City from late April to early May (Larcon A. B., 2020). However, in order to give the highest level of protection, social distancing and regular sanitation should be practiced, in addition to wearing a face mask, to further lower the chances of contracting the virus (Ablondi, 2020). Unfortunately, these practices cannot always be maintained when participating in fitness activities, especially at the gym.

Working out and staying active has numerous benefits to physical, social, mental, and emotional health (Rucker, 2020). Covid-19 has made going to the gym and staying active more difficult due to businesses closing and individuals following strict quarantine guidelines. Even from personal experience, day to day life has become more sedentary. This change is extrapolated to society and the world as a whole, where jobs and school have moved to an online platform. Besides physical inactivity, which could be even more dangerous for those with preexisting health concerns, quarantining leads to people feeling socially isolated from others, and experiencing degraded mental and emotional health (Rossen, 2020). Therefore, working out and staying active offers more health benefits other than to just build physical strength and cardiovascular endurance; which is also believed to preserve our health and make individuals more resilient to the virus (Rucker, 2020).

The proposed STS research will investigate the conflict of interests between staying physically and socially active and minimizing the spread of the Coronavirus. Observing this dichotomy led to the question, “In what ways has Covid-19 affected the health of society and how safe are current virus mitigation practices at preventing its transmission?” People have different opinions on how to safely stay active and social, if they chose to at all. Overall, the 4

W's can be followed to help mitigate the spread of the virus, especially when working out: "washing your hands, wearing your mask, working out 6 feet apart, and wiping down equipment" (Rucker, 2020). Using an autoethnographic approach, social practices and technology like these tend to vary from establishment to establishment; such as, certain gyms requiring mask wearing during a set or which equipment needs to be sanitized and which do not. Additionally, sanitation practices are not always universal and often not conducted properly to maximize the elimination of viruses and harmful bacteria (CDC, Cleaning and Disinfecting Your Home, 2020).

Sanitation is another safety factor for slowing down the spread of harmful viruses, yet it is not always practiced to the extent as recommended by medical authorities. Essentially, most sterilizers and disinfectants require a "wet time" where the fluid is to remain on a surface, in order to effectively kill all or most of the pathogens, before being wiped off (Cheatham, 2020). When sanitizing, most people spray a disinfectant then immediately wipe it away and think that the surface or equipment they are about to use completely sterilized. An additional consideration to sanitization with chemicals is the long-term effects on human health. Alcohol based sanitizers dry out the skin, causing bacteria to enter the body through damaged skin, and over use causes an antimicrobial resistance as bacteria mutates into harder to kill forms of themselves (Mahmood et al., 2020).

The entire shift in day-to-day life for most people, over the past year, due to Covid-19 is an example of a Paradigm Shift. A Paradigm Shift is a change in perspective or practice due to the introduction of a new method or technology, in this case the virus itself. This framework was created by Thomas Kuhn, an American Philosopher who emphasized these shifts open up new ways to observe situations and could result a backlash or critiques. One main critique of the

Paradigm Shift is that there is a complete abandonment of previous thought to a new and novel one (Kuhn, 1962). In the context of Covid-19, this critique will be considered while moving forward with research. New scientific research comes out almost daily and shifts in response to new findings are necessary to prevent further spread of the virus.

Additionally, differing perspectives about the Coronavirus and how society should deal with it is considered a Wicked Problem. A Wicked Problem, originally introduced by Horst Rittel and Melvin Webber, is one that has no clear definition, involves many different perspectives, and has changing constraints over time (Seager, 2011). As some people believe the virus is completely made up and others believe this virus is the black plague, it is clear that there is not a unified stance on what the problem actually is or how we should go about fixing it. One critique of the Wicked Problem framework is that it promotes an idea that there is no true, successful answer to a problem. In order to address this problem, it must be noted that there will never be a unified problem framing or solution to the Coronavirus. However, this does not mean that steps should not be taken to help prevent the transmission of the virus; having an agreed upon, correct answer or not, taking any steps forward is better than remaining stagnant.

Research Question and Methods

Considering the current state of the world and personal passion for exercising, how has the Corona Virus impacted the health of society as a whole? More specifically, the proposed research question is, “How has Covid-19 affected the health of people and society, with a focus on mental and physical health, and how effective are situational factors, like safety, prevention, and protection from the virus, from one place or person to another?”

The research methods for this project will include autoethnography, discourse analysis of other existing literature, and wicked problem framing. All of the proposed methods are meant to

gather as many perspectives and opinions about Covid-19 as possible in order to track common thoughts and misconceptions about the virus. Responses and information found online will help to answer the research question by gathering personal testimonies about the effects of the virus on health and wellbeing as well as how general belief about sanitization differs from expert and manufacture recommendations. Research on this topic will be focusing on words like “exercise” and “health” and their interactions with “sanitization practices” and the “Coronavirus” in order to get the most relevant information as possible. Scholarly articles will be sought after the most, but realistically the effects of the Coronavirus are possibly still too recent and may be more common on blogs or other website articles than scholarly journals.

Conclusion

The impacts of Covid-19 are continuous and still felt today by people all over the world. From losing a loved one, to hampered mental and emotional health, and even unknown future medical side effects, the battle against the Coronavirus is far from over. The STS deliverable will analyze mental and physical health changes due to the virus and how effective current preventative virus spreading practices actually are. In a more hands on attempt to improve current Coronavirus prevention technology, the capstone deliverable will be an air-assisted face mask which is aesthetic, comfortable, and filters air intake and exhaust.

The completion of both projects will hopefully help to educate individuals about becoming and staying physically and mentally healthy during the Covid-19 pandemic, virus prevention techniques, more effective, standardize sanitization practices, and the benefits of wearing masks. The capstone design deliverables and research done should help to more effectively prevent the spread of the virus and hopefully shorten the amount of time until society is able to return to a Covid-19 free environment; one that everyone lived just a year ago.

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