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Addressing the corona virus outbreak: will a novel filtered eye mask help?

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Highlights

- The CDC recommends not touching your eyes to prevent 2019-nCoV
- Non-hermetically sealed eye protection does not protect the eyes against airborne particulates.
- Hermetically sealed goggles protect the eyes, but tend to fog up, which is a barrier to use.
- A filtered eye mask (FEM) is a design to both protect the eyes from particulates and prevent fog.
- A FEM may help mitigating the spread of 2019-nCoV and should be researched further.

Journal Pre-proof

Addressing the corona virus outbreak: will a novel filtered eye mask help?

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Abstract:

Objective: Non-hermetically sealed eye protection does not fully protect the eyes from airborne particles. Hermetically sealed eye protection fully protects the eyes from particles, but tend to fog up rendering unusable. The purpose of this study was build and test a filtered eye mask (FEM) to protect the eyes from airborne particles while being usable without excessive fog build up.

Methods: The steps performed to build the FEM were described. A hermetically-sealed standard eye mask (SEM) and a FEM were examined at 1 minute, 5 minutes and 60 minute period for performance metrics relating to fog.

Results: The SEM showed minimal fog at 1-minute, very foggy at 5-minutes and dripping with condensation at 60 minutes. The FEM was clear at 1-minute, 5-minutes and showed minimal fog at 60 minutes.

Conclusion: The FEM may play an important role in preventing novel coronavirus (COVID-19) exposure by protecting the eyes from airborne particles and preventing fog, rendering it usable. Further research is strongly recommended.

Key words: Coronavirus; COVID-19; eye protection; filtered eye mask (FEM)

INTRODUCTION

A 2019 novel coronavirus (COVID-19) originated in Wuhan City, Hubei Province, China with clinical manifestations similar to those of the severe acute respirator syndrome (SARS) outbreak in 2003 (Huang et al., 2020, Li et al., 2020, Phan et al., 2020). In a matter of months, the COVID-19 outbreak has rapidly evolved into a global pandemic. At the time of writing this, COVID-19 has infected over 2,000,000 people and has claimed the lives of over 125,000 with the numbers growing daily (Worldometer, 2020).

Since there is no vaccine currently available to prevent a COVID-19 infection, the best method to prevent the infection is by avoiding exposure. The Centers for Disease Control and Prevention (CDC) has published information relating to prevention online (CDC, 2020). To prevent acquiring the infection through one's eyes, the CDC recommends that all people in the general public avoid touching your eyes. Many hospitals also recommend wearing eye protection to minimize risk of transmission. Unfortunately, a well-documented limitation of currently existing eye protection is it is either (1) non-hermetically sealed (i.e., not air tight) wherein viruses may contact the user's eyes or (2) hermetically sealed (i.e., air-tight) wherein the mask fogs up limiting the user's ability to perform tasks.

The purpose of this paper is to: (1) review strengths and limitations of eye protection currently available on the market; and, (2) introduce a novel filtered eye mask (FEM), which holds promise in overcoming limitations of conventional eye protection. A

technical discussion of how the FEM was built and the results of initial testing is provided along with a discussion on various design considerations.

Finally, the scope of this paper focuses on isolated eye protection devices. Full head gas masks or body suits, which protect the eyes along with other body parts, are not discussed in this paper. While such protection strategies may be effective, they are expensive, burdensome and hinder verbal communication and are not likely to be appropriate for long term use for the every day citizen.

CURRENT EYE PROTECTION OPTIONS

There are currently two main categories of isolated eye protection devices available for purchase in the market, which include (1) non-hermetically sealed eye protection (i.e., not air tight) and (2) hermetically sealed eye protection(i.e., air tight seal).

With respect to non-hermetically sealed eye protection, as illustrated in Figure 1A, some droplets will be stopped and some protection is achieved. For example, in the event of a sneeze directed towards the lenses of the eye protection device, many particles will be stopped. It is still possible, however, that airborne particles carrying the virus can pass around the lenses come in contact with the eyes. This is because the droplets from the external environment can pass over, under or around the lenses, enter the air mass in front of the eye and contact the surface of the eye, as illustrated in Figure 1B.

With respect to hermetically sealed eye protection, as illustrated in Figure 1C, the droplets do not enter the air mass in front of the eye, as illustrated in Figure 1D.

However, a key limitation is the limited usability due to the fact that they fog up, which is well documented in the literature and is a top cause of poor compliance (Chughtai et al., 2020, Dain et al., 1999). This is because the lacrimal glands keep forming tears, which evaporate into the contained space. Condensation subsequently forms on the inner surface of the hermetically sealed eye protection and limits usability.

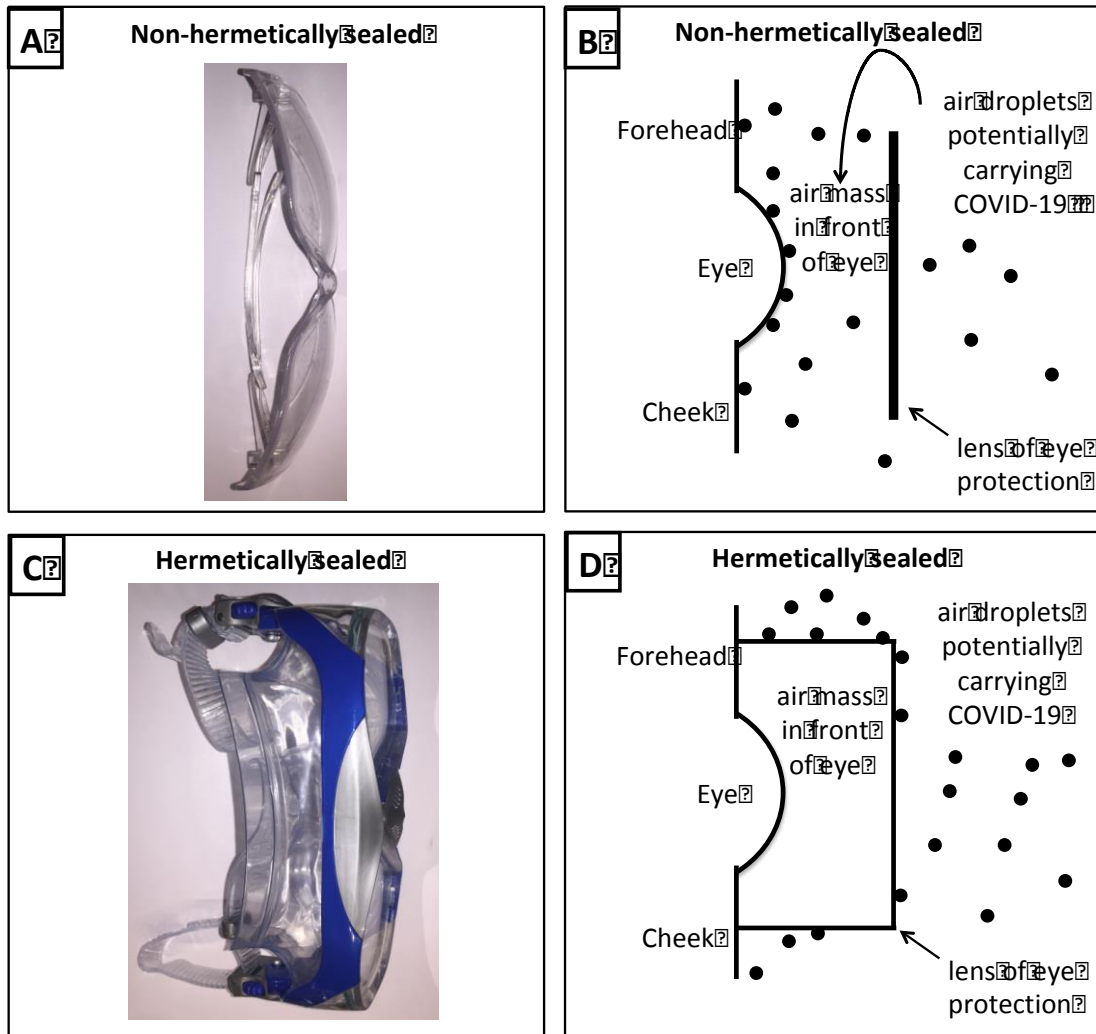


Figure 1. Pictures of non-hermetically sealed and hermetically sealed eye protection devices. In Figure 1A, a photo of a non-hermetically sealed eye protection device is shown. In Figure 1B, droplets potentially carrying COVID-19 are illustrated passing over the top of the lens into the air mass in front of the eye and contacting the surface of the eye. In Figure 1C, a photo of a hermetically sealed eye protection device is shown. In Figure 1D, droplets potentially carrying COVID-19 are illustrated contacting the outer surface of the lens; however, the air mass in front of the eye remains virus-free.

TECHNICAL DEVELOPMENT

Overview: The technical development is a filtered eye mask (FEM), which comprises an eye protection device with a filter to maintain a virus-free air mass in front of the eye and overcome the limitation of condensation build up in hermetically sealed eyewear, which is well documented to cause poor usability and poor compliance.

Participant: Testing was performed on a single user, author D.D.

Methods: Two devices were used for testing. The first device was a hermetically-sealed standard eye mask (SEM) straight out of the box, which could be hermetically sealed to the face. The second device was the filtered eye mask (FEM), constructed using the steps below.

Materials: The materials include: a swimming mask; an medium-sized N95 respiratory

mask (i.e., for the nose and face); a drill with a dime-sized drill bit; a roll of double-sided tape; and, a role of packing tape.

Construction: The FEM was created with the following five steps. First, the site of the drilling was determined, as shown in Figure 2A. The side of the swimming mask was selected so that it did not block the field of view. Second, a dime-sized hole was drilled into the side of the swimming mask, as shown in Figure 2B. Third, a quarter sized air filter was cut out of the N95 mask. Fourth, a layer of double-sided tape was placed, such that one sticky surface of the tape contacted the outside of the swimming mask near the hole and the other sticky surface of the tape contacted the inner portion of the cut-out N95 filter. Care was taken not to cover the opening in the swimming mask with tape. Fifth, the sides of the cut-out N95 filter were reinforced with packing tape.

Analysis: Three time points were assessed including: after 1 minute of wear; after 5 minutes of wear; and, after 60 minutes of wear. At each time point, two data points were assessed. The first data point was whether or not the mask fogged up and the subjective degree of fog. The second data point whether or not the user could read the words in a book.

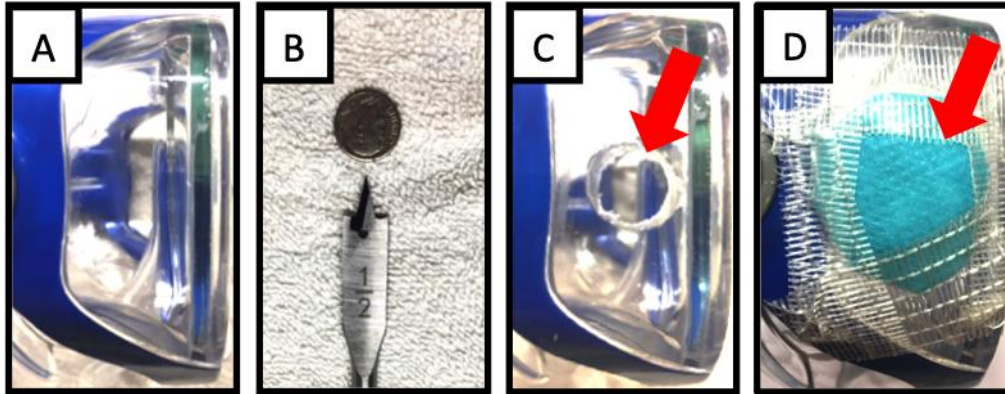


Figure 2. Pictured obtained during the materials and methods. Figure 2A illustrates the side of the mask. Figure 2B illustrates the drill used, showing that the drill bit was approximately the size of a dime. Figure 2C illustrates the hole, as indicated by the red arrow, in the side of the mask created by the drill. Figure 2D illustrates the cut-out N95 mask, as indicated by the red arrow, reinforced with packing tape.

RESULTS

There was a clear difference in the amount of fog seen in the SEM and the FEM, as shown in Figure 3 and Table 1 below.

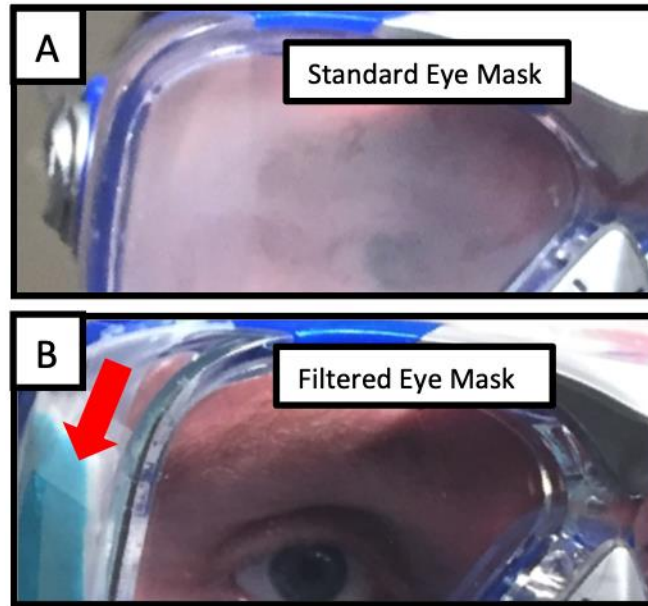


Figure 3. Photograph of Standard Eye Mask (SEM) and Filtered Eye Mask (FEM) at 5 minutes. Figure 3A illustrates the SEM after 5 minutes of wear. Note the fog build up in the mask. Figure 3B illustrates the FEM after 5 minutes of wear. Note that there was no build up of fog.

	1-minute time point	5-minute time point	60-minute time point
Standard Eye Mask (SEM)	Slightly foggy; difficult to read a book	Very foggy; unable to read a book	Dripping with condensation; unable to read a book
Filtered Eye Mask (FEM)	Clear; easy to read a book	Clear; easy to read a book	Minimal fog; easy to read a book

Table 1. Comparison between the Standard Eye Mask (SEM) and the Filtered Eye Mask (FEM) over 3 time points.

DISCUSSION

Eye protection is critical for preventing person-to-person spread of COVID-19. The ideal eye protection method would meet three important criteria.

First, and foremost, it must be effective at preventing the virus from causing infection through the eye. The exact risk of the infection through airborne particles is still unknown; however, the goal of eye protection must be to prevent the virus from contacting the surface of the eye. Eye protection will also help remind the person not to touch their eye out of habit. It should be noted that the experiment in this article did not test for viral concentration or droplet concentration in the air mass in front of the eyes. The hypothesis that the FEM would result in as good of protection against transmission as the hermetically sealed SEM is therefore untested. Thus, it is quite crucial to test the efficacy of the filter attaching system in terms of airborne particle transmission through the edges of the filter/mask attachment side before commercializing such a product. Otherwise wearing such a mask would not protect being infected through the eyes.

Second, the eye protection must be designed in such a way that a user wears it with high compliance. For example, a user would need to be able to do the daily tasks of living (e.g., delivering medications, drawing blood, going to the grocery store, reading small print, etc.) while wearing the eye protection. If the eye protection fogs up, then a user's compliance has been shown to drop (Chughtai et al., 2020, Dain et al., 1999), which will

render the user at higher risk of infection.

Third, an important, yet overlooked aspect of an outbreak is the adverse mental health effects including high levels of stress (Douglas et al., 2009). Personal Protective Equipment (PPE) is critically important to both health care workers' physical and mental health (Gold, 2020). In fact, nurses across the country have protested due to lack of PPE (McNamara, 2020). Having appropriate equipment including quality eye protection (i.e., effective and good compliance) will help a user perform the activities of daily living and mitigate the stress.

So, how could a FEM work in with the overall prevention strategy? The FEM is meant to be worn along with a high efficiency respiratory mask (e.g., N95). The FEM will prevent exposure of COVID-19 through the eyes. The high efficiency respiratory mask will prevent exposure of COVID-19 through the respiratory system. Together, the FEM plus the high efficiency respiratory mask yield a more comprehensive protection.

With respect to the FEM design, the materials and construction methods in this paper were meant to be illustrative to clearly convey the concept of a FEM to readers. A wide range of designs could achieve the function as described in this paper, such as shown in Figure 4. Several design considerations to maximize effectiveness and compliance and minimize costs are discussed in Table 2 below.

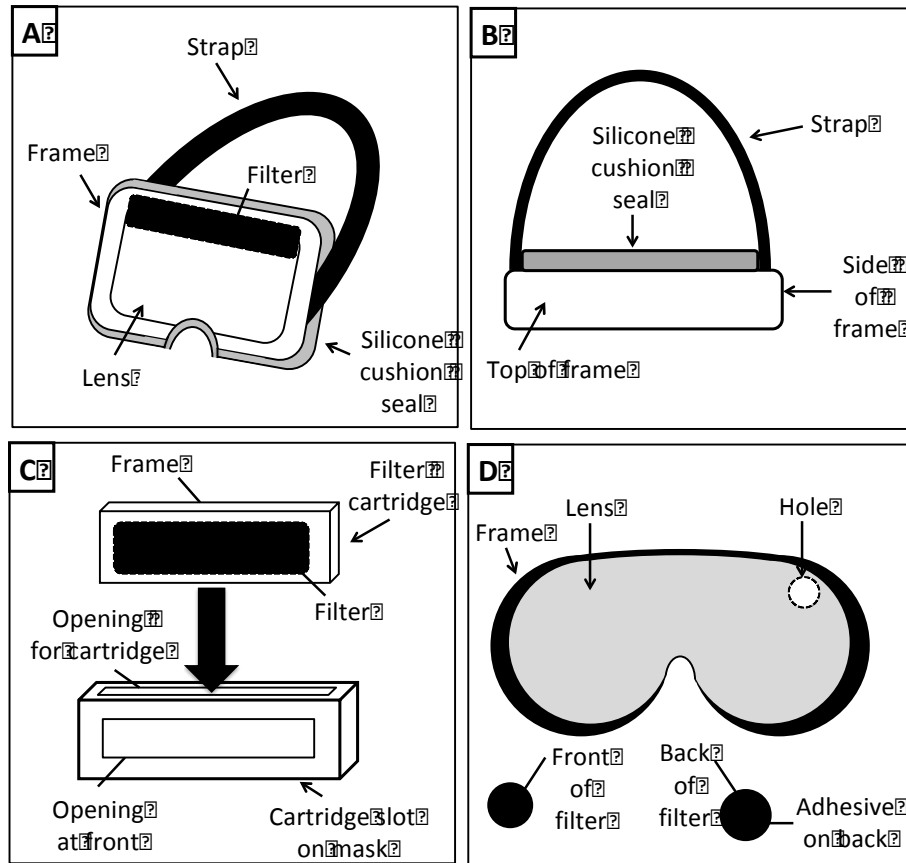


Figure 4. Figure 4. Illustration of various design considerations for a filtered eye mask (FEM). Figure 4A illustrates a front, oblique view of a FEM design with a large, high-efficiency filter on the top portion of the lens of the mask. The top position of the filter could potentially help eliminate water vapor more efficiently. An air-filled silicone tube is utilized to create an air-tight silicone cushion seal with the user's face. Figure 4B illustrates a top down view of the design in Figure 4A. Note that the frame creates a separation between the face and the lenses, which is designed to fit over one's prescription glasses. Figure 4C illustrates a front view of a filter cartridge with a frame and filter. The filter cartridge is placed (large arrow) into the cartridge slot on a FEM. Note that there is an opening at the top where the filter cartridge is slid in and an opening at the front for ventilation wherein the air mass in front of the eyes remains clean and

virus-free. An air-tight design of the cartridge is important to prevent any non-filtered air from entering into the FEM. Figure 4D illustrates an alternative design wherein the FEM has a hole on the front of the lens. This hole can be covered with a small replaceable filter with an adhesive portion to secure it to the lens. Additional filters could be implemented, so as to improve virus-free air flow through the mask. Note that the FEM is meant to be worn in conjunction with a separate respiratory mask during times at which a user is exposed, such as working in the intensive care unit on active COVID-19 patients. Then, after the high risk exposure is completed, the filter can be discarded after use and the goggles washed. The goggles can be reused with a fresh filter placed prior to a subsequent exposure.

Design options	Considerations for optimization
Mask material	Capable of being washed to eliminate build-up of potentially dangerous particles on the outside of the mask (e.g., with soap and water).
Filter types	Optimal protection against virus particles contacting eyes is via a high efficiency air filter (e.g., N95 and N100). The higher protection efficiency filter (e.g., N100) may be used for higher risk activities (e.g., prolonged direct contact with an active COVID-19 patient).
Technique of filter replacement	A removable and replaceable filter would be cost effective (e.g., filters could come in small packages, opened and be secured in place via clamps, buckles or straps).
Frequency of	Optimal protection will be achieved when a new filter is placed on the

filter replacement	eye protection each time it is used, although if supplies are short reuse of filters can be performed under specialized protocols (e.g., quarantine used filters for a specified period of time)
Securing filter to the mask	Reliable seal during use is essential to keep the air mass in front of eyes virus-free (e.g., cartridge fixation may prove more effective than tape, which has potential to fall off and ruin the seal)
Size of filter	Optimum size may depend on multiple factors including moisture content of user (e.g., amount of natural tears, perspiration, etc.) and environment (e.g., temperature)
Positioning of filter on mask	Optimal positioning would be in a location (e.g., side of mask) capable of adequate ventilation (e.g., not covered by head cover) and providing adequate field of view (e.g., not blocking user's view).
Mask seal to face	A comfortable seal is important for good user compliance (e.g., an air-filled, silicone balloon for contact with the face)
Variations in securing mask to head	An air tight seal with the face is needed to prevent air from leaking in along skin surface of face (e.g., a strap coursing over the back lower and back upper portions of the user head)

Table 2. Design considerations for a Filtered Eye Mask (FEM).

Finally, the use of proper PPE including eye protection is very important, especially for the health workers who are in close contact with the patients with active COVID-19 infections during a pandemic or even an outbreak. Additionally, such an eye protection would also be quite useful for research personnel around the world who must wear eye

protection with a face shield or full head respirators, such as Powered Air Purifying Respirators (PAPRs).

CONCLUSION:

First, and foremost, heeding the recommendations of the CDC is of paramount importance in mitigating the COVID-19 outbreak. See <https://www.cdc.gov/coronavirus/index.html> With respect to minimizing transmission through the eyes, the CDC recommends avoid touching your eyes with unwashed hands. It is important to consider that even basic, non-hermetically sealed can prevent some of the droplets. In this article, we discussed a novel FEM, which holds promise in reducing the spread of COVID-19. It is important that rigorous testing be performed to maximize effectiveness and compliance (Wong, 2013). Further research, especially on the efficiency of the FEM to protect against transmission of infection, is needed. And, rapidly.

CONFLICTS OF INTEREST: Author Dr. David Douglas is a medical doctor and his father, Dr. Robert Douglas is an engineer. They co-authored a non-provisional patent pending (#16/773,960) including a variety of designs disclosed in patent pending, and would be more than happy to collaborate with any and all parties in efforts to try and mitigate the spread of COVID-19.

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