Emerging Evidence on COVID-19

COVID-19 Summary of Face Shields to Prevent Transmission of SARS-CoV-2

Introduction

How effective are face shields at preventing SARS-CoV-2 virus transmission, with and without additional mask wearing?

This evidence brief summarizes the relevant research on face shields in preventing the transmission of respiratory droplets and aerosols from infected individuals to susceptible individuals, published until July 7, 2020. Eye protection and goggle use are not captured in this review.

Key Points

- Face shields are a form of personal protective equipment that has been used in healthcare settings (e.g., surgical/medical, dental, veterinary) to cover the face and mucosal membranes (eyes, nose, mouth) and prevent infectious particle exposure from aerosols and body fluid spatter. A face shield is often used when performing medical procedures that increase the risk of aerosols or patient body fluid splashes, sprays or splatter and is worn with other personal protective equipment (e.g., medical masks, respirators, medical gowns) (Roberge, 2016).
- All studies included in this review are experiments conducted under controlled conditions. With the exception of one study which used influenza (Lindsley et al., 2014), the studies in this review did not use virus contaminated fluids.
- Studies on face shield use by healthcare workers report a protective effect particularly from patient generated splatter during specific medical procedures when used in combination with other protective equipment such as a surgical mask (Table 1 and Table 2) (Mansour et al., 2009; Mostaghimi et al., 2020; Shoham et al., 2016). Face shields have also been designed for the patient to wear when undergoing an aerosol generating procedure to contain the aerosols and protect the health care workers doing the procedure from exposure (Anon, Denne, & Rees, 2020;)
- Two simulation studies reported on droplet inhalation and exposure when wearing face shields as the only protective equipment (Table 1). Both studies report 90% of the large droplets were blocked by a cough aimed at the middle of the face shield (Lindsley et al., 2014; Ronen et al., 2020), however the protective effects decreased when the direction of the cough was varied (higher/lower/side). Over time (30 minutes) inhalation of small droplets was only reduced by 23% by the face shield (Lindsley et al., 2014).
- Three studies simulated coughing in an individual wearing the face shield and reported the level of contamination resulting from respiratory particles released (Table 1 and Table 2). Two studies report

the release of droplets and aerosols from around the openings in the face shield (Anon et al., 2020; Viola et al., 2020), while the third reports that the face shield provided a good forward barrier as no droplets reached a simulator 60 cm away (Ronen et al., 2020).

- The design of the face mask is reported to be important. Face shields that wrap further around the face, fully shielding the cheek area, wrap under the chin and any enhancements that minimize bioaerosol leakage/entry around the edges of the mask were more protective (Viola et al., 2020; Anon et al., 2020; Mostaghimi et al., 2020).

Overview of the Evidence

Few studies examine and report on the protective effects of face shields with or without masks. All identified studies report findings from simulation studies conducted in controlled laboratory settings, and do not necessarily account for real-world parameters (e.g., height differences among individuals, temperatures, humidity, wind velocities etc.) or the infectious dose. None of the studies used SARS-CoV-2 in the simulation. Variation across studies in their design, how and what outcomes were measured and what face shields were used meant the findings are not directly comparable. Although the available body of evidence does support the use of face shields alongside medical masks in health care settings, results of face shields alone were less consistently protective.

CONTENTS

EFFECTIVENESS OF FACE SHIELDS

There were no studies identified that evaluated the efficacy of face shield use in the field to prevent respiratory infection transmission.

In health care settings, two simulation studies evaluating various medical procedures find face shields, usually worn with a medical mask, protect healthcare workers' faces from fluid splatters by providing a physical barrier, and some protection from the inhalation of small aerosols and droplet nuclei (Table 1) (Mansour et al., 2009; Shoham et al., 2016). One study found the combination of a face cover and face shield to be more effective than either alone (Mansour et al., 2009), while the other found a full face shield provided better protection than the combination of an eye shield and a surgical mask (Shoham et al., 2016).

Two studies reporting on the effectiveness of face shields used as the only protective equipment compared face shields to other face covers report face shields are effective barriers for the short term blockage of droplets (Lindsley et al., 2014; Ronen et al., 2020). The study by Ronan et al., describes the short term protective effects of a face shield blocking 90% of splatter from a cough 60 cm away directed at the center of

the face shield. A face mask in the same simulation blocked half the droplets. The protective effect of the face shield decreased significantly when the direction of the cough (higher/lower/side) was varied. (Ronen et al., 2020). Similarly, Lindsley et al., reported face shields reduce inhalation of large droplets by 90% and small droplets by over 60% immediately following a cough. However, the inhalation of smaller droplets was only reduced by 23% as the time since coughing (i.e. aerosol generation event) increased to 30 min. This increase in aerosol and small droplet inhalation risk is attributed to the formation of smaller droplet nuclei over time that can leak in from the face shield edges (Lindsley et al., 2014).

The three simulation studies evaluating the level of contamination by respiratory particles from an individual wearing a face shield reported a good forward barrier to projecting respiratory droplets (Ronen et al., 2020), however powerful backward and downward bioaerosol leakage jets were measured (Viola et al., 2020; Anon et al., 2020). Gross droplet splatter and contamination below the neck and chest area took place when a patient wearing a standard face shield underwent a simulated aerosol generating procedure, like flexible endoscopy (Anon et al., 2020). Observations of airflow and bioaerosol ejection while wearing different types of face shields find front airflow generated from breathing, loud speaking and coughing to be largely reduced, but substantial aerosol leakage to still take place. Powerful leakage jets of bioaerosols were identified near the wearer's brow region and in the downward direction (Viola et al., 2020). However, despite the leakage measured in two studies, the third reported a good forward barrier based on experimental results from a breathing simulator positioned 60 cm from a coughing simulator wearing a face shield that did not inhale or detect splatter droplets (Ronen et al., 2020). Thus, bioaerosols escape into the environment when an individual wears a face shield.

Table 1: Literature on face shield performance

Publication Title	Key Outcomes	Reference
Experimental and Simulation Studies		
Efficacy of Face Shields Against Cough Aerosol Droplets from a Cough Simulator	Simulation experiment (face shields only): Effectiveness of face shields in blocking the transmission of aerosols is measured using a breathing simulator intended to mimic a healthcare worker, and a cough aerosol simulator loaded with Influenza virus. The study finds more than a 90% reduction in larger aerosol (mean diameter of 8.5 μm) inhalation risk from face shield use, and an over 60% reduction in the risk of inhaling smaller aerosols (size of 3.4 μm) immediately after coughing. Face shields led to only a 23% reduction in smaller aerosol inhalation risk when the coughs generating the aerosols occurred within the previous 30 min, the increase in risk was due to smaller particles staying airborne longer and floating around the face shield to be inhaled.	(Lindsley et al., 2014)
Face Coverings, Aerosol Dispersion	Simulation and human experiment (face shield vs. surgical mask, homemade mask, and respirator)	(Viola et al., 2020)

and Mitigation of Virus Transmission Risk	Researchers use a background oriented schlieren technique to investigate airflow ejection by individual volunteers and manikins using different face coverings during breathing, coughing and aerosol generating procedures. Bioaerosol leakage with different face covers (i.e. homemade and surgical masks, filtering facepiece respirators (FFP1, FFP2), N95 respirators, and light and heavy weight face shields) was visualized. Overall, the study finds all face covers substantially reduced the front flow of bioaerosols. Only the tested FFP diminished backward and downward leakage jets, whereas the tested surgical masks, homemade masks, N95 respirators and face shields demonstrated backwards and downward jets to various degrees. Specific to face shields, bioaerosol containing airflow was found to leak through the seams and joints of the tested face shields and be minimally displaced horizontally (a distance of few centimetres). Face shields also generated upward (brow region), downward, sideway, and strong backward leakage jets. Backward jets occur when air escapes from the side of face covers and are projected backwards at high speed, potentially resulting in a significant displacement. Powerful downward leakage jets were noted for face shields that did not curve below the chin, which allowed for unobstructed air flow in and out.	
Examining the Protection Efficacy of Face Shields Against Cough Aerosol Droplets Using Water Sensitive Papers	Simulation experiment (face shield only vs. mask, respirator or no equipment) This simulation experiment reported on the effectiveness of face shields used as the only protective equipment, with the objective of this study informing use of face shields by the general population outside of a health care setting. The study used a cough simulator that was carefully tuned to replicate human cough in terms of droplet size distribution and outlet velocity. The tested personal protective equipment were placed on a manikin head simulating human breathing. An Aerodynamic Particle Sizer (APS) and water sensitive paper were used to analyze the concentration and size distribution of particles that reach the manikin head. The study reports face shields are as effective as face masks in successfully blocking respiratory droplets (3µm in diameter) from a cough, and blocked fine particles (0.3µm) better than medical masks in the short term. In other words, while the medical mask	(Ronen et al., 2020)

	reduced the number of inhaled particles by roughly a factor of two, the face shield provided superior protection by blocking more than 90% of the otherwise inhaled particles when a simulated cough was directly at the face shield. These blocking effects were reduced when contamination of areas beyond the middle of the face (i.e. cheeks and neck) were considered. Furthermore, in experiments where the vertical distance between the cough and breathing manikin simulators were varied, droplet deposits on the face was no different from droplets deposited over the shield, and blocking efficacy was as low as 45% in some instances. No respiratory contamination of the surroundings was noted when the cough simulator was covered by a face shield (simulating an infected person wearing the face shield).	
Eye Protection in Orthopaedic Surgery	Simulation Experiment (face shield with a mask): Mannequin heads outfitted with different personal protective equipment and sprayed with fluorescent dye sprays find face shields that cover the eyes worn in combination with facemasks to be effective barriers. This combination of personal protective equipment reduced contamination by macroscopic droplets and/or debris by 64% during simulated femoral osteotomies.	(Mansour et al., 2009)
Comparison of Protection Against Ocular Contamination with Disposable Eyewear Products	Poster Presentation - 2016 (Face shield vs. eye protection with a mask) A simulation study of manikin heads outfitted with eye shields or face shields, with and without face masks and N95 respirators. Using a Glogerm fluorescent dye system, eye contamination from micro droplet occurred with combination surgical mask and eye shield, but no face contamination (i.e. eyes, nose or mouth) occurred when a full face shield was used.	(Shoham et al., 2016)
Review Literature		
Face Shields for Infection Control: A Review	A literature review on face shields as a form of personal protective equipment for healthcare workers, and discusses various face shield designs. All outlined evidence predates the emergence of COVID-19.	(Roberge, 2016)
Facial Protection for Healthcare Workers During Pandemics: A Scoping Review	A scoping review of face protection for healthcare workers. The review identified one study on efficacy of face shields (Lindsley et al., 2014) and concluded that face shields should not be used by health care workers as the primary protection for preventing	(Godoy et al., 2020)

	transmission of respiratory diseases, but they can be used with other facial protection.	

NOVEL FACE SHIELD SYSTEMS

Alternative face shield systems are presented as physical barriers that provide better protection from patient generated body fluid splatter.

Table 2: Novel face shield systems

Publication Title	Key Outcomes	Reference
Patient-Worn Enhanced Protection Face Shield for Flexible Endoscopy	Simulation experiment (face shield vs. enhanced face shield) A simulation proof of concept study compares aerosolized dye exposure and contamination when a patient wears a standard face shield vs. face shield of enhanced design with a tab closure system (covering the space under the chin) during endoscopy procedures. The enhanced design is reported to have contained simulated respiratory splatter within the confines of the enclosed space around the patients face and prevented bioaerosol escape under the neck/chin area.	(Anon et al., 2020)
Rapid Prototyping and Clinical Testing of a Reusable Face Shield for Health Care Workers Responding to the COVID-19 Pandemic	Development/evaluation of enhanced face shields The clinical utility and user comfort of 3 face shield prototypes among healthcare workers are surveyed. The effectiveness of each design in preventing droplet splatter was not investigated.	(Mostaghimi et al., 2020)

Methods:

A daily scan of the literature (published and pre-published) is conducted by the Emerging Science Group, PHAC. The scan has compiled COVID-19 literature since the beginning of the outbreak and is updated daily. Searches to retrieve relevant COVID-19 literature are conducted in Pubmed, Scopus, BioRxiv, MedRxiv, ArXiv, SSRN, Research Square and cross-referenced with the literature on the WHO COVID literature list, and COVID-19 information centers run by Lancet, BMJ, Elsevier and Wiley. The daily summary and full scan results are maintained in a Refworks database and an Excel list that can be searched. Targeted keyword searching is conducted within these databases to identify relevant citations on COVID-19 and SARS-CoV-2. Search terms used included: (Face and Shield). An additional search was conducted in PubMed to identify older, non-COVID-19 research on face shields using: (face and shield and (virus or respiratory)).

Each potentially relevant reference was examined to confirm it had relevant data and relevant data is extracted into the review. This review contains research published up to July 7, 2020.

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