REPORT 21-21

FLUNKING COVID OUT OF SCHOOLS; A SYSTEMATIC REVIEW OF NON-PHARMACEUTICAL INTERVENTIONS TO MINIMIZE NOVEL CORONAVIRUS-2 IN EDUCATIONAL SETTINGS

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16. Abstract

A systematic analysis of almost 500 studies uncovers the breadth of non-pharmaceutical (non-vaccine) interventions that have been previously implemented or tested in an educational setting to reduce virus transmissions. This systematic review takes a sociotechnical systems approach and categorizes the interventions into personal, environmental, organizational, and communication interventions. Thus, this analysis recognizes the interactions among various factors that make up an educational institution and emphasizes the significance to adopt multiple interventions. Complementing the various interventions, a list of best practices for each intervention has been developed in detail for COVID-19 crisis management in an educational setting with the current knowledge of the virus to date.

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Introduction

COVID-19

Global pandemics have occurred multiple times throughout the 20th century; however, they have differed greatly in their severities and prevalence (Sandman, 2007). One of the worst cases in recent history was the 1918 influenza pandemic, which killed about 50 million lives worldwide and 675,000 lives in the U.S. (CDC, 2019). In addition to an increase in mortality rate and a decline in life expectancy, pandemics also damage the economy with short-term fiscal shocks and long-term negative shocks to economic growth (Madhav et al., 2017)social, and political disruption. Evidence suggests that the likelihood of pandemics has increased over the past century because of increased global travel and integration, urbanization, changes in land use, and greater exploitation of the natural environment (Jones and others 2008; Morse 1995. They cause social disruption by creating fear-induced aversions to workplaces and public gatherings (Madhav et al., 2017)social, and political disruption. Evidence suggests that the likelihood of pandemics has increased over the past century because of increased global travel and integration, urbanization, changes in land use, and greater exploitation of the natural environment (Jones and others 2008; Morse 1995. In countries with weak institutions and political instabilities, pandemics also have the potential to create political stresses and tensions (Madhav et al., 2017).

The novel coronavirus, SARS-CoV-2, found its first human host in Wuhan, China in December 2019 (WHO, 2020b). The disease has spread globally since then, and on March 11, 2020, the World Health Organization declared COVID-19 a global pandemic (Cucinotta & Vanelli, 2020). At this time, the transmission of the virus is not fully understood, but the consensus appears to be that close-contact, person-to-person respiratory transmission is the primary way of virus transmission (CDC, 2020b).

As of October 12, 2020, the World Health Organization reports over 1 million deaths worldwide, and the Centers for Disease Control and Prevention reports over 200,000 deaths in the U.S. COVID-19 affects people of all ages, but the effects have generally been more serious for older persons (i.e. over age 60) and persons with pre-existing medical conditions (WHO, 2020e). This is not to say that severe cases and deaths do not occur to adolescents and young adults, as there have been reported cases of such instances (WHO, 2020c). Furthermore, data from June to August 2020 revealed that ages 20-29 accounted for more than 20% of all confirmed cases, demonstrating a change in age distribution of COVID-19 (Boehmer et al., 2020). Evidence has shown that adolescents and young adults can be asymptomatic carriers and transmit COVID-19 to their families or close contacts, and they may often be index patients in their families (Liao et al., 2020).

Non-Pharmaceutical Interventions

Contrary to some beliefs, pandemics do not occur in regular, cyclic patterns (Sandman, 2007), so pandemics cannot be precisely predicted. Despite the unpredictability of pandemics, countries, states, and cities can prepare for pandemics by understanding non-pharmaceutical interventions. When a vaccine is not available, adopting non-pharmaceutical interventions at multiple levels is the best and only way to control and limit transmission of the virus (CDC, 2019).

Recommendation to adopt multiple interventions is based on Reason's Swiss cheese model, which explains the vulnerability at each level of a risk mitigation plan (Reason, 2000). In the context of COVID-19, this may be presented as an asymptomatic carrier who fails to follow mask protocol and stands too closely to another person, and these actions create higher probability for virus transmission.

Educational Settings

Implementation of non-pharmaceutical interventions is ultimately in the hands of the policymakers, and they must understand when, what, and how to implement non-pharmaceutical interventions. Guidelines of non-pharmaceutical interventions have been created and made available for the public, but there is a lack of clear guidance for educational institutions on everything that can be done. School campuses require contextual solutions because they are unique environments where many adolescents or young adults congregate into one area along with some adults in varying age groups.

At this time, many school campuses across the nation remain closed; however, there are schools that are beginning to welcome their students back on campus. There are risks in prolonged school closure (learning loss, social isolation, and other secondary effects), but there is an obvious risk to school reopening (Byrne et al., 2020). Without a proper risk mitigation plan, the consequences may be disastrous. Public administrators must work with state and local authorities to create a plan to deal with the pandemic. Data from past seasonal influenza reveal that schools with an influenza plan reported less influenza-like illness, ILI, (Miller et al., 2013).

It is important to note that a school reopening plan is not a one size fits all solution, and reopening of school campuses should only be considered when local COVID-19 community spread is controlled (e.g. less than one new case pers day per 100,000 people) (Byrne et al., 2020). This threshold should be carefully developed between local health departments and professionals (Byrne et al., 2020).

Research Objective

The goal of this paper is to conduct a systematic review to provide all the possible non-pharmaceutical interventions that an educational institution can implement, and the best practices for implementing the proposed recommendations. Research articles, historical records, and guidelines from public agencies are used to compile a list of past and present non-pharmaceutical interventions. Results from randomized controlled studies are analyzed and considered in the recommendations. Best practices of the NPIs are presented with the intention that they will guide policymakers to effectively implement them (see the supplemental materials published online alongside this manuscript Appendix A-N on the journal website).

Systematic Review

The goal of this systematic review is to identify non-pharmaceutical interventions, NPIs, that can be implemented in an educational setting. The reviewed articles included historical interventions done at schools from past pandemics or the seasonal flu, randomized controlled trials of a NPI, mathematical simulations of a NPI, and guidelines made by organizations such as the CDC.

In the current state, there are no effective vaccines for COVID-19. In such cases of dealing with novel viruses, the best way to prevent illnesses is to avoid exposure to the virus (CDC, 2019). The proposed NPIs are methods of limiting exposure to the virus when pharmaceutical solutions are not available. The goal of this paper is to conduct a systematic review to comprise a list of NPIs that have been suggested, have been implemented, and/or have been shown to be effective in order to improve safety protocols in an educational setting during a pandemic.

Methods

Five databases were used to search for journal articles to determine NPIs in educational and related settings. The databases used were: Google Scholar, EBSCO, Pubmed, JSTOR, and SAGE Journals. There was no restriction on the publication date or the type of research. Studies were not restricted based on the pathogen, as doing so would limit the already scarce numbers of studies on NPIs in educational settings. It was believed that preventative measures implemented and shown effective during past pandemics would be advantageous to use during COVID-19.

Inclusion Criteria

Studies were included if they (1) included a NPI to prevent the spread of an illness in relation to (2) a pandemic, a seasonal flu, or other infectious diseases in an (3) educational setting or related environments such as workplaces and (4) were available in the English language.

Exclusion Criteria

Studies were excluded if they (1) did not include a NPI, if (2) the purpose of the interventions were not to prevent an infectious disease, (3) school-closure interventions, or (4) not available in the English language.

Google Scholar. An initial search on Google Scholar was conducted using the keywords, *campus, pandemic, AND intervention OR NPI* anywhere in the article. In a subsequent search, *campus* was replaced by *school* in an attempt to locate more related studies.

EBSCO. On EBSCO, the keywords that returned the most relevant titles were *school, pandemic, AND NPI.*

Pubmed. On Pubmed, the keywords that returned the most relevant titles were also s*chool, pandemic, AND NPI.*

JSTOR. In an attempt to discover more unique titles, some of the search terms were required to be in the abstract. As a result, the most pertinent keywords, *school* AND *pandemic,* were required to be included in the abstract. In addition to the keyword, *NPI,* more specified terms such as *social distancing OR practices OR strategies OR measures* were included; however, these could be mentioned anywhere in the article.

SAGE Journals. For SAGE Journals, the keywords, *school, NPI,* and *pandemic* were required to be in the abstract. Other keywords included *measure* and *strategies,* which could be mentioned anywhere in the article.

Results

An initial search using the methods above and secondary references returned 508 titles. Removing duplicates resulted in 493 titles, which were screened for relevance based on the title and the abstract. This process, as shown in Figure 1, removed 450 additional articles and left 43 articles for full-text assessment. In-depth review of these articles against the inclusion and exclusion criteria removed 19 more articles and left 24 articles to be used for this systematic review.

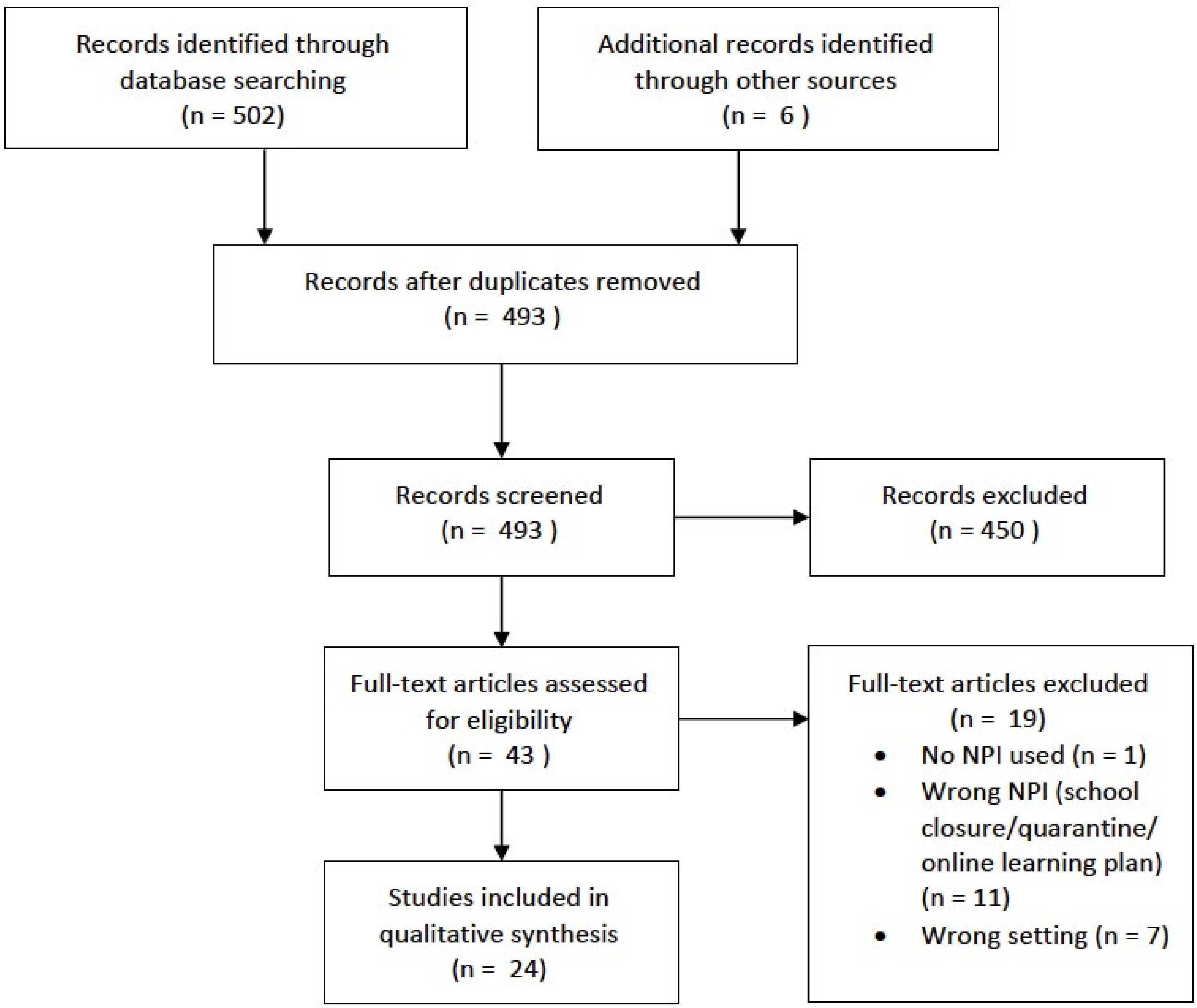

Figure 1. Flowchart Showing the Systematic Review Process and Outcomes

Categorization of NPIs

NPIs were organized into four categories: personal, environmental, organizational, and communication interventions. Personal interventions are those that can be carried out by individuals, including mask wear, hand hygiene (e.g. frequent hand washing and use of hand sanitizer), respiratory etiquette (e.g. covering coughs and sneezes), and physical distancing (e.g. keeping a distance). Physical distancing in this study is analogous to the more popularized term, social distancing. Physical distancing was deemed to be more appropriate for this paper, as social distancing may suggest social isolation whereas physical distancing is objectively more accurate. Environmental interventions are those that can be implemented by the institution to modify the surrounding environment. These include modifying classroom layouts, hallway restrictions, disinfecting surfaces, installing physical barriers, improving indoor air ventilation, closing communal spaces, putting up signage and posters, restricting entrance to campus buildings, and providing supplies to support good hygiene. Organizational interventions are policy changes made within the school to encourage safety behaviors and to lower the chances of virus transmission. These include promoting physical distancing through policy changes (e.g. canceling field trips, assemblies, sports, and concerts), screening symptoms and temperatures of students, staff, and faculty, restricting inter-mingling of students in other classes and other dorms, and sending sick individuals home or quarantined in dorms.

Table 1 provides the complete list of NPIs included in the reviewed studies along with the study counts. Because a single study encompassed multiple interventions, the total counts will add up to a number greater than the total number of articles.

Table 1. List of Non-Pharmaceutical Interventions

Category	Non-Pharmaceutical Intervention	Number of Studies
Personal interventions	Mask wear	4
	Hand hygiene	5
	Respiratory etiquette	4
	Physical distancing (avoiding sick people, keeping distance from one another)	7
Environmental interventions	Modified classroom layouts	2
	Hallway restrictions	3
	Disinfecting surfaces	4
	Physical barriers	1
	Improved indoor air ventilation	3
	Closing communal spaces	3
	Signage and posters	2
	Restricted entrance to campus buildings	2
	Supplies to support good hygiene & environmental restrictions	7
Organizational interventions	Promoting physical distancing through policy changes (canceling field trips, assemblies, sports)	2
	Screening of students, staff, and faculty	5
	Restricting inter-mingling among those outside of class or residential hall floor (support podding)	5
	Sick students sent home or in dorms	3
Communication interventions	Education	7
	Training	2
	Outreach	3

Over half (54.2%) of the collected studies were of historical accounts or recommended guidelines of NPIs. 11 studies (45.8%) experimentally tested the effectiveness of NPIs. These experiments were conducted with human subjects or with mathematical modeling/simulations. Table 2 lists the studies that tested the effectiveness of an NPI along with the study type, the study description, and the results.

Table 2. Effectiveness of Non-Pharmaceutical Interventions

Author	Study type	NPI	Description of intervention	Result
Duan et al., 2013	ACP (Artificial societies, Computational experiments, and Parallel execution) simulation	Podding	Academic classes isolated from each other based on proximities of dorm rooms	Slight decrease in number of admitted patients at hospital
		Temperature screening	Students conducted temperature screening each morning	Effective at preventing further spreading of H1N1 influenza. Significant drop in newly admitted patients the day after execution.
		Podding	Students could not contact with those who did not live in the same dorm room	Drop in newly admitted patients
Tang et al., 2012		Podding	Restriction on movement of university personnel outside of the campus	If implemented for a long time (until day 38), can greatly delay the epidemic peak and reduce the magnitude of the outbreak
Ridenhour et al., 2011	Individual-based computer simulation	Physical distancing	Hall restriction (HR): Children stay in a defined walking area between classrooms, lunchroom, and school yard.	
		Physical distancing	Classroom restriction (CR): Remain seated while in their classroom	Best single intervention at lower infection probabilities
		Physical distancing	Schoolyard restriction (SR): Stay in a specified schoolyard area	
		Physical distancing & Podding	Schoolyard restriction & classroom specified (SRC): Stay in a specified schoolyard area with classmates	

Table 2, continued

Author	Study type	NPI	Description of intervention	Result
		Podding	Lunchroom restrictions (LR): Eat only with classmates	
		Policy changes to support physical distancing	Different schedules (DS): Current schedule, shift of 45 minutes, and shift of 90 minutes	Best single intervention at higher transmission rates
		Multiple	All interventions (AI) (HR + CR + SRC + LR + DS)	Both AII + AI had the highest % of new infections prevented in one school day
		Multiple	Almost all interventions (AII): HR + CR+ SR + DS	
Talaat et al., 2011	Randomized controlled trial	Hand hygiene	Twice daily hand washing campaign. Schools implemented systems to ensure school children were washing hands.	Intervention group had reduced absences caused by ILI and laboratory confirmed influenza
Doornekamp et al., 2017	Non-randomized controlled study	Education	Attending lectures by experts, group research, developing prevention tool, asking questions to experts, giving presentations, attending presentations by peers	Preventative behaviors increased. No statistical significance at the chosen P-value of 0.05 (P = 0.062)
Aiello et al., 2010	Randomized control trial	Mask wear	Single intervention group	Resulted in a reduction in ILI, but it was not statistically significant
		Mask wear and hand hygiene	Combined intervention group	Significant reduction in ILI compared with control group

Table 2, continued

Author	Study type	NPI	Description of intervention	Result
Chen and Liao 2008	Mathematical modeling	Enhancing ventilation and mask wear	Enhanced ventilation and masking in an elementary school classroom	Enhancing ventilation and masking efficacies decreased the basic reproduction number (R0)
Lofgren et al., 2008	Agent-based computational model	Policy changes to support physical distancing	Classroom compared to no classroom (large common area)	Classroom had better outcomes (higher average health, lower mean number of students sent home, and lower total sick days but not the total number of students ever infected)
		Closing communal spaces	Closed playground and common area	Significantly halted the epidemic's spread
Stebbins et al. 2011	Randomized controlled trial	Training	Training in hand hygiene and respiratory hygiene	Intervention group had significantly lower laboratory-confirmed influenza A and total absences than control (no intervention)
		Supplies to provide good hygiene	Hand sanitizer provided for students	
Arinaminpathy et al., 2012	Mathematical modelling	Education	Advice on hygiene and increased hand washing	Implementation of all interventions reduced the infectious period to approximately 1 day.
		Supplies to support good hygiene	Provision of hand sanitizer	
		Disinfecting surfaces	Enhanced cleaning of communal areas	
		Screening	Assessment of symptomatic students	
		Promote physical distance through policy changes	Strict isolation of all symptomatic individuals and cancelation of social events	

Table 2, continued

Author	Study type	NPI	Description of intervention	Result
Miller et al., 2013	Survey	Education	Hand hygiene, respiratory etiquette, staying home when sick	Having an influenza plan associated with fewer reports of substantial ILI in the fall. May have reduced transmission of pH1N1 in schools and in the community
		Outreach	Includes letters, e-mails, meetings, social network	
		Screening for symptoms	Screening for ILI upon arrival	
		Supplies to support good hygiene	Increased availability of hand sanitizer, tissues, soap	
		Disinfecting surfaces	Increased disinfection of surfaces with frequent hand contact	

Effectiveness of NPIs

Personal Interventions

Aiello et al. (2010) conducted a study with real participants to test the efficacy of mask wear in preventing influenza-like illness, ILI, among university students living in residence halls. Compared to the control group, the use of face masks led to a reduction in ILI; however, the result was not statistically significant. A study in Cairo, Egypt tested the effectiveness of twice-daily hand washing at 60 elementary schools, which led to reduced absences caused by ILI by 40%, diarrhea by 30%, conjunctivitis by 67%, and laboratory confirmed influenza by 50% compared to a control (Talaat et al., 2011). Physical distancing was shown to be an effective intervention in an individual-based simulation study that models a typical school day among schoolchildren (Ridenhour et al., 2011). Classroom restriction intervention, where students remain seated inside the classroom to reduce contact counts, was shown to be the best single intervention at increasing the percentage of new infections prevented in one school day when the infection probability was low. At higher infection probabilities, however, classroom restriction intervention alone was no longer as effective (Ridenhour et al., 2011).

Environmental Interventions

Environmental interventions were tested concurrently with another intervention (see Multiple Interventions).

Organizational Interventions

Tang et al. (2012) conducted a study at a university in China and took a rather drastic measure of podding by implementing a campus wide quarantine where movement outside of the university was restricted. After over a month (38 days), the results were apparent and the intervention reduced the magnitude of the outbreak, suggesting the effectiveness of a long-term use of podding (Tang et al., 2012)very strict interventions including campus quarantine (Fengxiao. An ACP (Artificial societies, Computational experiments, and Parallel execution) simulation by Duan et al. (2013) implemented policies that supported podding by limiting inter-mingling between students in different classrooms and residential halls. Initially, academic classes were isolated based on the proximity of the student's dorm rooms and eventually, contact among students was limited only to those who shared the same dorm room. These two interventions led to a slight decrease in the number of admitted patients at the hospital and a further drop in newly admitted patients, respectively. Following the podding interventions, a new intervention, temperature screening, was added and students had their temperatures screened every morning, which led to a significant drop in newly admitted patients the day after execution (Duan et al., 2013). It is important to point out that the simulation study by Duan et al. (2013) layered one intervention after another and did not test the interventions separately; however, each intervention is judged to be effective because the drop in newly admitted patients was apparent following the execution of a new intervention. An agent-based computational model study by Lofgren et al. (2008) explored the effect of having elementary school children in 10 separate classrooms as opposed to a no classroom intervention where students remained in a large common area all day. Results showed that classroom structure had statistically significant results in all but one measured outcomes; the intervention led to higher average health, lower mean number of students sent home, and lower total sick days, but statistical significance was not found for the total number of students ever infected (Lofgren et al., 2008). Additionally, closing the playground when 4% of the students were symptomatic and closing the common area when 2% of the students were symptomatic significantly halted the epidemic's spread (Lofgren et al., 2008).

Communication Interventions

A study by Doornekamp et al., (2017) tested the effectiveness of an educational intervention in a non-randomized controlled study. 684 secondary school students in the Netherlands, Suriname, and Indonesia attended lectures by disease experts, asked questions to disease experts, participated in group research, developed prevention tools, gave presentations, attended presentations by peers, and participated in a competition. After the educational intervention, preventative behaviors increased statistical significance was not shown at the chosen P-value of 0.05 (P = 0.062). A cluster randomized controlled trial was conducted by Stebbins et al. (2011) at 10 elementary schools in Pittsburgh, PA during seasonal influenza season to measure the effects of hand hygiene and respiratory hygiene training intervention. To the five schools that had the interventions, there was significantly lower laboratory-confirmed influenza A and lower total absences when compared to the control group (Stebbins et al., 2011).

Multiple NPIs

The study by Aiello et al. (2010) included a second intervention group that used both face masks and alcohol-based hand sanitizer, and this intervention group had significant reduction in ILI ranging from 35% to 51% than the control group. This result is substantially more significant than the single face mask intervention that was done in the same study. A mathematical modeling study by Chen and Liao (2008) studied efficacies of increased indoor ventilation and mask wear simultaneously. The study saw decreased basic reproduction number (R0) by enhancing the indoor ventilation to remove the virus from the indoor environment and by enhancing the efficacy of face masks to decrease virus shedding to the indoor environment (Chen & Liao, 2008). Reduction of the basic reproduction number (R0) is considered to be a positive outcome, as R0 is an indicator of contagiousness (Delamater et al., 2019). It is reasonable to conclude that limiting the virus output with the use of face masks and increasing the indoor ventilation to remove the virus present indoors is an effective method to decrease the contagiousness of an illness. Ridenhour et al. (2011) tested four interventions in an individual-based computer simulation study. The interventions were: hall restrictions, where children walked in a defined walking area in hallways, schoolyard restriction, where children stayed in a specified area, classroom specified schoolyard restriction, where students not only stay in a specified schoolyard area but also are separated by classrooms, lunchroom restriction, where students only eat with their classmates, and different schedules, where arrival times are staggered. The combination of multiple interventions led to the highest percentage of new infections prevented in one school day than any other single interventions (Ridenhour et al., 2011).

A mathematical modeling study by Arinaminpathy et al. (2012) estimated the impact of five interventions: education (advice on hygiene and increased hand washing), provision of hand sanitizer, enhanced cleaning of communal areas, assessment of symptomatic students, and strict isolation of all symptomatic individuals and cancelation of social events. Implementation of all interventions were shown to reduce the infectious period to approximately 1 day.

A survey study by Miller et al. (2013) assessed the use of recommended NPIs in response to the 2009 H1N1 Pandemic at all public schools in Pennsylvania. The NPIs implemented by the schools included: education (hand hygiene, respiratory etiquette, staying home when sick), communication of prevention methods (letters, emails, meetings, social network), screening for ILI upon arrival, increased availability of hand sanitizer, tissues, soap, and increased disinfection of surfaces with frequent hand contact (Miller et al, 2013). It was found that the schools that actively implemented these NPI interventions were less likely to report substantial ILI during the fall wave of influenza than schools without a spring influenza plan (P = 0.02).

The results from the studies demonstrate that the combined effects of implementing multiple interventions far outweigh the effectiveness of a single intervention as shown in Figure 2 (Ishihara et al, 2020).

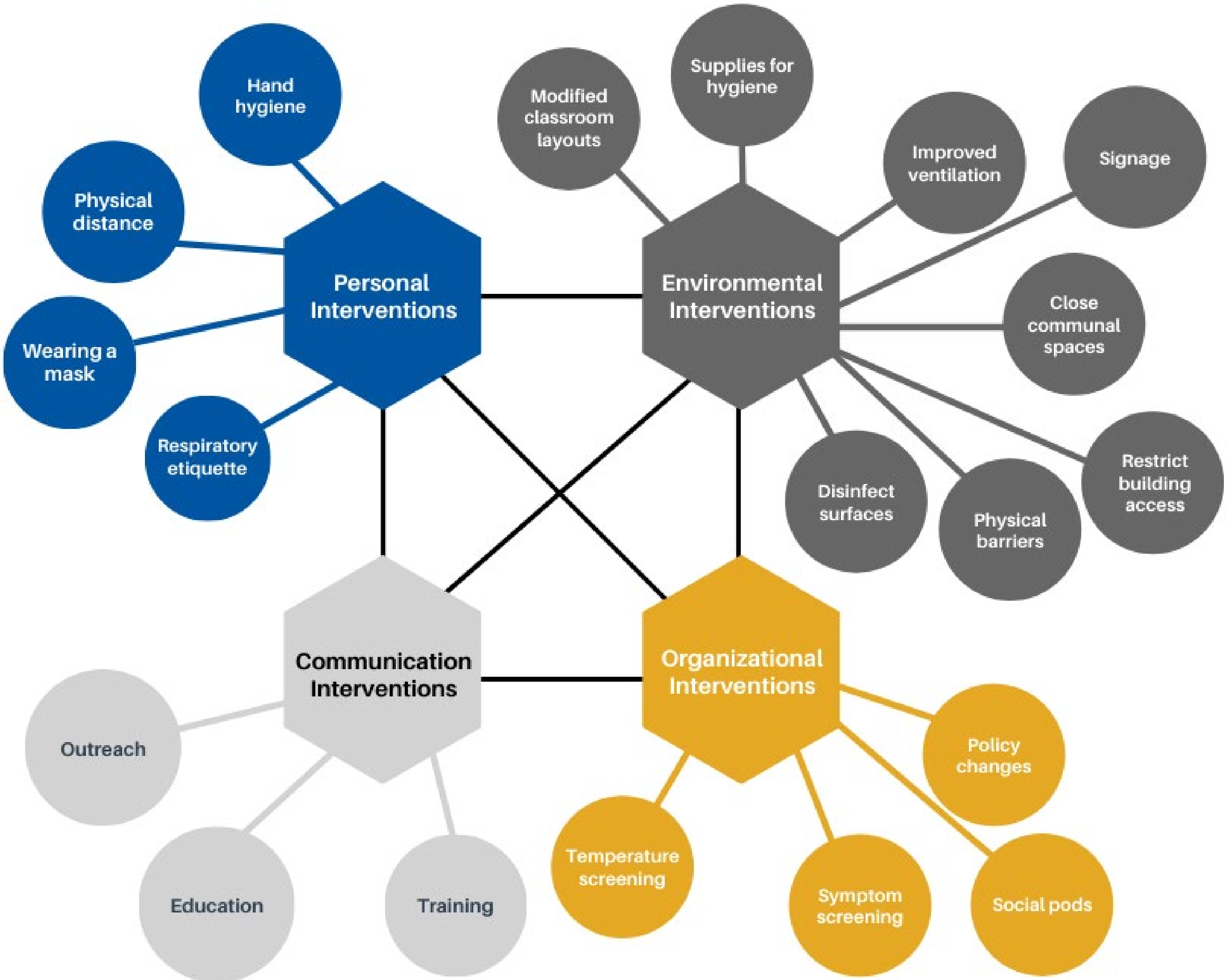

Figure 2. A Sociotechnical System Model of Non-Pharmaceutical Interventions Found

Discussion

In this paper, a systematic review of non-pharmaceutical interventions in educational settings was conducted based on historical trends, guidelines from public health agencies, and experimental data to compile a complete list of NPIs. The NPIs were categorized into personal, environmental, organizational, and communication interventions. Studies that experimentally tested the effectiveness of an intervention were highlighted as well.

Significance and generalizability of the paper

The findings from this paper will guide policymakers to create policies and design an effective risk mitigation plan to be used in educational settings. The paper takes a socio-technical systems (STS) perspective, which acknowledges the complex interactions between individual, social, organizational, and technical factors that make up an entire system. This approach is believed to be an effective way to design a robust risk management plan.

The list of non-pharmaceutical interventions and the best practices of each are applicable beyond the educational settings; therefore, places such as workplaces, libraries, and retail stores may also benefit from following the provided recommendations.

Limitations

It is important to note that not every recommendation may be feasible or effective for all types of educational settings. For example, the educational interventions may not be as effective for younger grade school students when compared to students in higher education, as younger children may lack the discipline to carry out more difficult interventions. Another limitation is that facts about the virus and the illness are changing every day, and current interventions may become irrelevant after new findings. The viral load that causes illness is currently unknown (Alex, 2020) and viruses, including SARS-CoV-2, change over time through mutations (WHO, 2020f).

Although the transient nature of the facts is important to be acknowledged, many of the recommendations presented in this paper were interventions that were demonstrated to be effective experimentally or historically with other viruses. The combination of information provided goes beyond any current guidelines developed as it is not equivalent to the recommended best practices. Certain pharmaceutical labs have remained open; however, no details are shared regarding how they approach lab procedures making it difficult to learn and adopt strategies that may be effective in preventing transmission (Johnson, 2020).

Future Research

With the current pandemic, discovery of new information about the virus will continue to increase and perhaps change some of the recommended interventions. Future research should consider the various changes in the understanding of the virus and carefully assess the priorities of the proposed interventions against the most up-to-date information. Current best practices should continually be updated when knowledge of new findings regarding SARS-CoV-2 is available. However, despite the limitations, the current findings from this study are important to consider for current and future viral pandemics.

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Supplemental Materials to Flunking COVID out of Schools; a Systematic Review of Non-Pharmaceutical Interventions to Minimize Novel Coronavirus-2 in Educational Settings

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Appendix A: Best Practices for Masks

Mask wear is one of the fundamental interventions in preventing the spread of COVID-19. Masks act as a source control by preventing the infected wearer from transmitting the virus to others as well as a prevention tool that offers protection to healthy wearers against the infection (WHO, 2020d). Both purposes of the mask in conjunction create a safer community during a pandemic. Masks come in many different forms, and the appropriate type of masks depend largely on the wearer and their situation. Medical-grade or surgical masks are those that are flat or pleated. These are not to be confused with commercial disposable masks, which have similar appearances to surgical masks, yet the material, quality, and efficacy of these commercial masks vary greatly depending on the manufacturer. In contrast, medical-grade or surgical masks are certified according to standards, and they must be able to filter down to 3 micrometre (μm) droplets (WHO, 2020d). It does not, however, filter or block very small particles in the air that may be transmitted by coughs, sneezes, or certain medical procedures (Hui et al., 2012). Medical-grade and surgical masks are appropriate for healthcare workers providing direct care to COVID-19 patients, first responders, persons with any symptoms suggestive of COVID-19, and vulnerable populations (ages ≥ 60 or those with underlying comorbidities) (WHO, 2020d). These masks are single-use and cannot be washed (Maragakis, 2020). N95 Filtering Facepiece Respirators (FFR) fit closely and seal around the wearer's face and can filter 0.075μm solid particles (WHO, 2020d). These should be reserved for healthcare workers where AGP, Aerosol-Generating Procedures, are performed and cloth covering masks are recommended for the general population in public settings (e.g. grocery stores, work, schools), general public on transportation (e.g. bus, train), and people in cramped conditions such as refugee camps, camp-like settings, slums (WHO, 2020d). Cloth coverings vary in the fabric material, layering sequences of the fabrics, and shapes (WHO, 2020d). The recommended number of layers also vary between the CDC and the WHO with two or more layers and three or more layers, respectively. There is a consensus that more layers offer greater protection and are recommended as long as it does not obstruct the breathing. Study has shown that clothes such as nylon blends or 100% polyester provides 2-5 times more filtration efficiency when it is folded into two layers as opposed to a single layer (WHO, 2020d). According to the WHO, ideal material includes a hydrophilic material as its innermost layer (e.g. cotton or cotton blends), a hydrophobic layer of synthetic non-woven material as its middle layer (e.g. polypropylene or cotton layer), and hydrophobic material as its outermost layer (e.g. polypropylene, polyester, or their blends). A study by Verma et al., (2020) used qualitative visualizations of emulated coughs and sneezes to test the efficacy of different materials and design choices in blocking droplet-laden respiratory jets. It was shown that a stitched mask made of quilting cotton was observed to be the most effective, followed by a commercial mask (CVS Cone Face Mask), the folded handkerchief (cotton), and lastly, the bandana (elastic T-shirt material). This is consistent with the recommendations made out for the general public to wear cloth masks with appropriate fabrics for maximum protection. Porous materials such as gauze are not recommended, as they provide only 3% filtration efficiency (WHO, 2020d). To determine whether the material is porous, the mask can be held up to the light, and porous materials will appear to have small holes (Maragakis, 2020). To avoid internal and external air from penetrating through the edges especially when speaking, the mask should fit closely to the face and over the nose (WHO, 2020d). Cloth coverings should be washed frequently or after each use (CDC, 2020h) in the highest permitted washing temperature, depending on the fabric used (WHO, 2020d). There have been complaints about the mask being uncomfortable (Ferng et al., 2011), and to alleviate this issue, cardboard cutouts can be used to increase comfort (Kashyap et al., 2020).

Appendix B: Best Practices for Hand Hygiene:

Hand hygiene best practices vary by the method of hand hygiene.

Best Practices for Hand Washing

The WHO describes hand hygiene as “any action of hand cleansing” (Surgeoner et al., 2009). Handwashing with soap and water allows the ingredients to remove existing microbes on the hand. However, hand washing involves the action of scrubbing the fingers and nail in multiple rotations which generate friction and remove existing microbes (CDC, 2020e; Lawson & Vaganay-Miller, 2019). Doing so helps lower the transmission of disease as a result from improper hand hygiene (Lawson & Vaganay-Miller, 2019). It also allows people to stay healthy, as demonstrated by the (CDC, 2018), several people that could get diarrhea is reduced by 23-40%, school children that are prone to gastrointestinal issues are reduced by 29-57%, while other respiratory issues are reduced by 16-21% with proper hand hygiene. Surveys show that 63% who claimed they washed their hands regularly did not get sick often and was shown with fewer trips to the health center (Taylor et al., 2010). As most people are not aware of how long adequate handwashing should be, the CDC recommends a good rule of thumb is to sing the happy birthday song at least twice, which guarantees that you have scrubbed for at least 20 seconds (CDC, 2020e). The temperature of water is irrelevant in how much germs it could remove from the hand, however warmer water is found to be more costly and could possibly irritate the skin (Mbroh, 2019). In general, regular soap is capable of cleaning hands as there is no data that shows additional benefits to using antibacterial soaps and There is very little data that explains the transfer of germs from clean hands to the faucet (CDC, 2020e), however, according to Lawson & Vaganay-Miller (2019), the process of drying hands is just as important as washing hands to remove any leftover pathogens that might still be present. Inadequate hand washing could potentially transfer viruses onto various surfaces (Surgeoner et al., 2009). The CDC (2020f) explains that handwashing with soap and water are most effective at removing germs compared to using hand sanitizer. A big issue that arises is that people are not aware of the amount of hand sanitizer that is required or that the product must dry completely on the hands for it to be effective.

Best Practices for Hand Sanitizing

Hand sanitizer acts as a second line of defense when hand washing is not readily available. It involves an alcohol-based gel to kill bacteria (Anderson et al., 2008) or inactivate viruses. Hand sanitizer needs to have a minimum of 60-70% ethyl alcohol to be sufficient to inactivate viruses whereas anything less will only reduce the growth (CDC, 2020d; Fournier & Berry, 2012). It has been shown that transmission of flu-like illnesses were reduced by 48-75% each week with the use of hand sanitizer in combination with face masks (as cited by Fournier & Berry, 2012). As travel size hand sanitizer can be given out during pandemics, it is more advantageous and useful for students to practice proper hand hygiene when it is difficult to locate a public dispenser or restroom (Botta et al., 2008; Fournier & Berry, 2012; Oldfield, 2017). Effective usage requires it be rubbed on the hands for at least 30s as this is the time it takes for inactivation of the virus; however, this recommendation is not always taken into consideration within the field (Kratzel et al., 2020). Instead, people will try to wipe their hands on clothing so that the sanitizer will dry faster thus rendering its ability to fully disinfect the hands (CDC, 2020f).

Placement of hand sanitizer dispensers require strategic planning ahead of time. Dispensers placed in restrooms become ineffective as some people mistake the dispenser as soap dispensers (Anderson et al., 2008). During a pilot study done by Fournier and Berry (2012), a change agent, who was a student that assisted in interventions, was incorporated to provide informational pamphlets about the benefits of handwashing to decrease transmission but found that there were no improvements to hand washing behavior. In a second experiment, deliberate placement of hand sanitizer dispensers, along with an informational poster, and a change agent who asked passersby if they would like to disinfect their hands right before students entered the food service line increased hand sanitizing behavior from 17.96% to about 60% compared to just having an informational poster and a hand sanitizer dispenser (Fournier & Berry, 2012). With the placement of the dispenser right before students enter the food service line, students can naturally encounter the dispenser which cues them to disinfect their hands without them having to leave their space in the line to locate a restroom. However, in another study, Caris et al. (2018) found that utilizing signage near hand sanitizer dispensers with purposeful messages were able to increase adherence for doctors when they were completing rounds further explaining the importance of multiple interventions. Placement of the dispenser should not disrupt a person's daily behavior, but it should still be conspicuous and accessible. However, the improvement in hand sanitizer usage may be to avoid negative social consequences as most people were more likely to practice proper hand washing due to the Hawthorne effect (Ballweg, 2013; Oldfield, 2017). Oldfield (2017) explains that there is an 'invisible audience' and 'ought incentives' that explains why people behave either to avoid humiliation or be accepted or to obey a law and if people believe that a certain behavior will be perceived as more socially acceptable, then behavior can be changed. Chen et al. (2013) demonstrated this by implementing a directly observed hand hygiene audit program which resulted in increased adherence to hand hygiene. The study observed about 88% of the healthcare professionals who adhered to proper guidelines for hand hygiene. However, due to the Hawthorne effect, workers tended to adhere to hand hygiene regulations when they knew an auditor was present on the floor collecting data. It is possible to nudge humans to behave more pro-socially through indirect surveillance (Clack et al., 2019; Melissa Bateson et al., 2006; Nettle et al., 2012).

One of the biggest barriers to inadequate hand hygiene which occurred 90.6% of the time is not having enough supplies (Okello et al., 2019; Surgeoner et al., 2009). Incorporating automatic soap and sanitizer systems can help provide the appropriate amount of solution. Other systems such as automatic faucets, dryers, doors can also help eliminate any additional exposure of transmission by having to touch a shared system (Anderson et al., 2008). However, automatic systems can make people less likely to practice hand hygiene as there are fewer touch points (Berry et al., 2012; Oldfield, 2017).

Best Practices for Hand Hygiene: Education, Training, Reminders

There is an obvious inconsistency between knowledge of adequate hand hygiene and practice of hand hygiene (Wichaidit et al., 2019). According to the CDC (2020i), adequate hand washing requires washing the hands with soap and water for at least 20 seconds. Anderson et al. (2008) showed that about 52.4% of university students used soap when washing hands but only 26.1% of these students had adequate hand washing. Hand washing procedures developed by the CDC were able to help lower the amount of microbes that were found on the hands of university volunteers who were previously sick from 66.7% to about 29.2% (Prater et al., 2016) further explaining the importance of proper education on hand washing (do Prado et al., 2015).

Many students perceived that their own personal hygiene had a 14% impact on others and a 10% impact on themselves (Surgeoner et al., 2009) which further explains why adequate hand hygiene is low. Interpersonal communication that occurs between peers can help impact behavior change as it strengthens the message from educational campaigns (Botta et al., 2008). Ballweg (2013) utilized a video, an informative PowerPoint, a quiz with prizes, along with signage when educating students and reinforced the 'why' and the 'how' of proper hand hygiene. The study incorporated the use of glitter and how it spreads when shaking hands with others. The visual feedback along with quizzes and indirect interventions such as signs and prompts can greatly improve hand hygiene behaviors (Fournier & Berry, 2012). For example, Armellino et al. (2012) looked at how healthcare worker's hand hygiene compliance improved when they were visually informed of how well they were practicing hand hygiene through a LED board displayed at the nurse's station each day (Armellino et al., 2012).

Encouraging hand hygiene as a preventative measure is the most cost-effective method (Biran et al., 2014) but it should never be the only intervention as about 22.6% of people did not adhere to proper hand hygiene after using public restrooms (Surgeoner et al., 2009). There are motivational drivers (e.g. fear, disgust) that were able to improve hand hygiene behavior (Biran et al., 2014; Okello et al., 2019; Purnell et al., 2015; Wichaidit et al., 2019). Students were more affected by the thought of urine or fecal matter on hands compared to how they would get sick if they did not practice proper hand hygiene (Botta et al., 2008). However, a likely reason for why adequate hand hygiene is not practiced is because viruses are not visible on the hand (Oldfield, 2017). Even with proper hand hygiene itself, it is not enough in stopping the transmission of influenza, instead a combination of interventions such as hand hygiene and masks are required (Wong et al., 2014). On the other hand, researchers have also found that a more positive framed message focused on addressing cognitive biases is more effective than fear driven ones (Botta et al., 2008; Caris et al., 2018).

Signage itself is also not successful in improving hand hygiene, and instead should be combined with other educational interventions as well (Anderson et al., 2008). According to Lawson and Vaganay-Miller (2019) it is useful in acting as environmental cues for certain behaviors but only when utilized correctly. After implementing a poster intervention, basic hand washing of university students increased from 51.09 to 55.39% and adequate handwashing went from 7.88% to 7.97%. The poster was designed with the disgust factor in mind and required about 20 seconds to read through the description. However, students spent around 11.43 seconds washing hands before poster intervention and around 12.12 seconds after signage intervention further demonstrating that signage intervention alone is not effective in improving hand hygiene (Lawson & Vaganay-Miller, 2019). Certain incentives were brought up such as installing timers that would signify appropriate hand washing has been completed or UV lights that can provide direct visual feedback of how much microbes still exist on the hand (Oldfield, 2017).

Appendix C: Best Practices for Physical Distancing

Many schools that are planning to reopen are requesting a lot from students such as practicing physical distancing, having proper hand hygiene, wearing masks, and avoiding gatherings. In order to help prepare students as much as possible, many universities are providing safety kits which generally include masks, hand sanitizer, thermometers, along with information about how to practice physical distancing (Badger, 2020). The information can be used to inform returning students of changes and implementations that have occurred on campus to prepare students for a safe return. Schedules should be adjusted to accommodate for the maximum occupancy within a building. To limit occupancy, buildings can implement security measures where students and faculty are required to swipe their ID card in order to enter, where each swipe designates one person to enter the building (UCSF, n.d.).

In addition to informing students about building restrictions, specific walkways can be implemented such as one-way stairwells or staying on the right side of a travel path and dining areas can also switch to grab and go options (Northwestern, n.d.). To properly practice physical distancing, students need to be informed of these changes to the school. Some universities are also considering what repercussions to implement if students don't comply with regulated guidelines. Forms of disciplinary action along with possible restrictions to come back onto campus can be considered, however, there are no guidelines on what the best course of action to take in managing noncompliance at schools (Badger, 2020; University of North Carolina, n.d.).

In addition to providing the necessary information to students, utilizing routine communication to create campaigns through social media, student and campus leaders can help promote a more positive impact through social support by demonstrating how they are trying to tackle the problem through physical distancing. Around 40% of schools are incorporating a pledge as an agreement for the students to ensure they practice social distancing while they are on school grounds (Badger, 2020). Utilizing pledges can help students hold themselves accountable as many others are trying to do the same (Wichaidit et al., 2019). Educational institutions that are planning to reopen are still trying to come up with solutions to ensure the safety of students such as using rapid testing technology before students return to campus and developing a timeline for testing afterwards instead of focusing on students that exhibit symptoms (Strauss, 2020).

Appendix D: Best Practices for Room Layouts

Classrooms need modifications to accommodate for physical distancing guidelines. According to the CDC (2020g), seating should be spaced at least 6 feet apart while desks should face the same direction. Any unused tables or chairs should be either taped off, representing ‘safe seats’, or removed so students won’t be tempted to use them. Ohio State University (OSU) (2020) has created guidelines for their school by utilizing a 7’-0” diameter hexagon to represent proper physical distancing space and allows for easy room resets if anything has been moved. Remove computer equipment from lab spaces to signal physical distancing limits. For fixed seating it is recommended to skip 3 seats and every other row in lecture halls for proper physical distancing. An instructor zone that measures 6’-0” wide from the front of the classroom should be created (OSU, 2020). Any areas that are utilized for study should limit occupancy to 25% or have a maximum of 100 people, the less preferred (California Department of Public Health & CALOSHA, 2020; Occupational Health Branch, 2020). Other modifications include physical barriers such as partitions if it becomes difficult to keep students 6’-0” apart and utilizing tape and stickers on floors to guide students on where to go and stand (CDC, 2020h). The Occupational Health Branch (2020) and California Department of Public Health & CALOSHA (2020) also provides some guidance for schools that offer housing but rooms should be occupied by one student at a time unless it is family housing.

Working remotely from home is preferred, however there are institutions that still need to run experiments or be in labs. The University of Rochester Medical Center (URMC) (n.d.) limits lab space to 300 square feet per person. Any lab procedures that require two people should be minimized. Offices within lab spaces should be limited to one person, but considerations can be made depending on university approval. Lab schedules should be created and staggered to limit occupancy (Johnson, 2020; University of Rochester Medical Center, n.d.) while also providing a schedule for proper cleaning and disinfecting in between shifts. Steps on escalators need to be marked off (CDC, 2020k). Stairs are recommended over elevators but if necessary, the URMC (n.d.) recommends limiting elevator occupancy to one person unless they require assistance.

Appendix E: Best Practices for Signage

There are many physical aspects of a sign to consider such as typography, sizes of characters, and types of colors to use. The ADA (2010) recommends that words be uppercase, lowercase or a mixture of both and a sans serif font and avoid any decorative form (e.g. Italic, script). Standards for character proportions, minimum character heights that are required at certain distances, stroke thickness, character and line spacing are also provided. Characters that are spaced closer together can have bigger fonts, while those that are spaced out more, should utilize smaller fonts (Rodrigues et al., 2019). Titles on signs should allow viewers to decide if they need more information and thus should stand out (Kasperek, 2014). One way of emphasizing information is to make contrast more prominent. For example, people are not going to perceive a difference between font size 20 versus 22. Focus on the important words or phrases and change the bold or underline typeface to make it more relevant (Kasperek, 2014). The ISO (2001) has information for calculating how big a sign should be for people standing at a specific distance and still be able to read it (Rodrigues et al., 2019).

Information presented on a sign should be organized by importance. Contrasting colors, sizes, and typeface can make important information stand out (Martins & De Melo, 2014; Rodrigues et al., 2019). A common issue that arises with signs is the information it portrays. A sign that says 'Unstable cliffs, keep clear' don't give enough information to the viewer about how close they can be, thus resulting in noncompliance to keep clear (Aucote et al., 2012). Avoid any abbreviated or challenging words and stay consistent in names and word usage to not create confusion (Ministry of Health, 2014). Signs should also be specific with instructions or actions that are required of viewers (Aucote et al., 2012; Geller et al., 1973).

Signs should still be consistent throughout an organization by following certain standards for colors (Ministry of Health, 2014). Refer to ANSI Z535.1 and ISO 2001 provides standards for colors and shapes in public facilities (ANSI, 2017; ISO, 2001). It is recommended to work with a professional in choosing the right colors when it comes to signage because of the effect colors can have on people as well as making sure it meets a standard requirement (Kasperek, 2014). Positive signage can be more memorable depending on the word choice and the ages of the viewers (Schindler-Ruwisch & Gordon, 2020). Warm colors (e.g. red) are more prominent where it pops on a sign while cool colors (e.g. blue) tend to fade away (Kadavy, 2011). Color choices should also be inclusive as some people might experience color blindness. Avoid placing signs that have a white background on a white wall, but a solution would be to create a border to break up the sign and the wall (Rodrigues et al., 2019). Noticeability of signs can increase through different contrast styles as people are drawn towards differences (Hall et al., 2010; Kasperek, 2014; Slywester & Cho, 1992).

Generally, signs provide quick information to the viewers (Meis & Kashima, 2017). There is a higher chance of people interpreting pictograms correctly if it depicts a specific action (Bagagiolo et al., 2019). Pictograms need to be at least 6 inches tall and text should be located below that explains the meaning (ADA, 2010). ISO 7001 recommends that symbols be between 3-8 inches (Rodrigues et al., 2019). Pictograms that depict body parts should be done so with a side view versus a frontal view (Rodrigues et al., 2019). Symbols that depicted the entire body versus just a pair of hands were more easily understood (Clack et al., 2019). A combination of symbols with prompts provide more guidance and understanding (Aucote et al., 2012) particularly for those of different educational or cultural backgrounds (Burt et al., 1999; Clack et al., 2019).

Placement of signage in one area may capture attention but can change in another location (Hall et al., 2010). Depending on if a sign is hung or placed on a wall, it should be apparent from all directions (Ministry of Health, 2014). Signs need to measures at least 40 inches from the actual text to the floor (ADA, 2010). They should be placed at locations where a decision is going to be made, usually called 'decision points' (e.g. intersections, doors) so that viewers can decide at that moment (Greenroyd et al., 2018; Kasperek, 2014). It can also inform viewers of information such as encouraging college students to drink more water by placing a water sign right above the water dispenser on a soda machine (Montuclard et al., 2017). If signs are printed on paper it should be protected from environmental factors. It should be easy to switch out or update as new protocols or information arise (Clack et al., 2019). Visibility, placement and illumination need to be considered as legibility will change from outdoor to indoor signs. The ADA (2002) provides information on calculating illumination levels and contrast for signage (ADA, 2002). Legibility can be improved with contrasting colors (e.g. white text on dark background) and having a matte finish to prevent glare (ADA, 2010).

Repetitive information should be avoided (Kasperek, 2014). According to Ferrari and Chan (1991), signs should consist of a signal word (e.g. warning, caution), a statement on the health hazard, the aversive consequences of noncompliance, and instructions for a specific "should do" response to avoid danger. They found that signs with a message that explained the consequences of not lowering the volume on headset devices, resulted in an increase of compliance from 59.1% to 84.5%. Signs that provided a specific message were more accepted when compared with a general message (Grimstvedt et al., 2010). However, if interpretations of current signs do not translate well, it can lead to signs being ignored (Clack et al., 2019) or if the message doesn't match the viewer's current judgement of what they believed was right (Aucote et al., 2012). Signs should also be easy enough to understand so that a person's routine is not disrupted (Clack et al., 2019). ANSI requires a comprehension score of at least 85% for a symbol to be considered universally understood (Bagagiolo et al., 2019; McDougald & Wogalter, 2014) and ISO 9186 has procedures for testing whether a sign is universally understood by its viewers (ISO, 2014). Safety signage that was familiar can also lead to noncompliance as people were more likely to dismiss it if they believe they are safe (Hall et al., 2010). In general, signage serves as a nudge that calls for voluntary behavior change where it addresses nonadherence from a cognitive perspective (Caris et al., 2018; Grover et al., 2018; Oldfield, 2017). In order to fully change behavior, people have to be willing to get involved, there should be social support along with extrinsic and intrinsic control (Ferrari & Chan, 1991).

Appendix F: Best Practices for Education & Training

Many theoretical models of health behavior change have been proposed over the years. A classic example is the KAB model (knowledge-attitude-behavior), which states that increase in knowledge and change in attitude are positively correlated with health behaviors though to a small degree (Bettinghaus, 1986). Enhancing perceived self-efficacy has also been shown to improve behavior change (Bandura, 1990). The common team among many of these theoretical models is that they point to an idea that education and training are important components to health behavior change.

To begin planning for an educational and training program for health behavior change, it is important to identify the target audience of whom the program will be geared toward. In an educational setting, the target audience may include students, faculty, staff, and community members. Identifying the target audience is important when creating an educational program because characteristics and factors of learners such as their literacy, language proficiency, cultural differences, and educational backgrounds may influence the outcome (Withers et al., 2012).

Planning the content of the health behavior change educational program is the most critical part. A survey study conducted at two universities in Texas during the 2009 H1N1 pandemic revealed that the students with greater perceived susceptibility of the virus, the public health threat of the virus, and symptom knowledge engaged more frequently in NPI behaviors (Zottarelli et al., 2012). Statistical significance was found for the correlation between greater perception of public health threat and frequent hand washing, frequent hand sanitizing, avoiding sick people, avoiding gatherings, avoiding touching eyes, nose, and mouth. Greater perceived susceptibility to the virus was associated with all NPI behaviors except avoiding gatherings. Similarly, increased knowledge about the virus was associated with all NPI behaviors except avoiding touching the eyes, nose, and mouth (Zottarelli et al., 2012). More than a decade later, a similar study conducted for COVID-19 has demonstrated comparable results. A cross-sectional and panel survey was conducted involving eight Western democracies: Denmark, France, Germany, Hungary, Italy, Sweden, the UK, and the US to determine the factors associated with protective behaviors during COVID-19. Results showed that perceived threat measured by the extent to which the respondents fear the consequences of the virus, efficacy determined by the respondent's knowledge in the virus and preventative measures, and institutional trust were positively correlated with protective behaviors. Out of the three characteristics, perceived efficacy was most strongly correlated with protective behavior (Jørgensen et al., 2020). Interestingly, this result ties well with the theory of self-efficacy (Bandura, 1990). Both studies by Zottarelli and Jørgensen, despite their slight dissimilarities in the study design, make it clear that an education and training program should aim to emphasize the susceptibility to the virus and its public health threat and to increase perceived efficacy. The degree to which these factors should be emphasized in an educational and training programs are up for debate, as stronger emphasis may inadvertently result in increasing the mental health burden during a pandemic (Jørgensen et al., 2020). An educational and training program should understand the barriers that prevent a person from performing target behaviors and provide solutions. A program that directly addressed barriers to target behavior led to statistically higher knowledge and behavioral compliance at post-intervention than baseline and lecture-based training (York et al., 2009). Additionally, it is recommended to offer an alternative behavior that can replace the prohibited behavior such as demonstrating a bow or a nod in a video to replace a handshake (Finset et al., 2020).

Delivery method of the educational and training program is another factor that must be considered. In times of a pandemic such as COVID-19, an online program is the safest and most viable method, but delivery method not only points to the platform of which the program is delivered but it also categorizes the methods by their levels of engagement: low, medium, and high (Withers et al., 2012). Low engagement methods include lecture-based modules, which have been shown to be the most limiting in growth of knowledge due to a lack of feedback (King et al., 1997). More evidence pointing to the ineffectiveness of lecture-based training has been demonstrated in a restaurant industry study observing compliance with food-safety behaviors. An online 4-hour ServSafe module was not sufficient to promote hand washing or thermometer usage (York et al., 2009). Medium engagement methods allow the learners to use a feedback mechanism to demonstrate their knowledge (Withers et al., 2012). An example is to incorporate quizzes or tests along with the online modules for increased engagement. High engagement methods allow learners to actively apply their knowledge and involve modification of behavior (Withers et al., 2012). An example of a high engagement method is a training method created by Johns Hopkins University in partnership with the CDC to train healthcare workers in donning and doffing personal protective equipment (Gurses et al., 2019). The presence of a trained observer who supports and ensures a safe and successful donning and doffing procedure is a unique component of this study, where providing feedback makes this a high engagement method.

Appendix G: Best Practices for Communication across all topics

Outreach is the third intervention under the communication interventions category. A study by Finset et al. (2020) has outlined important factors for health communication during COVID-19. It is stated that first, it is important to clearly communicate what is currently known and what is unknown about the illness. It is also important to be as objective as possible and refrain from opinions or interpretations. Notwithstanding the significance of objectivity, the temporality of facts as a work in progress must also be communicated, as these so-called facts are subject to change. Second, the messages should be easy to understand and clear without the use of nebulous, confusing, or vague language. Research has shown that in health communication about an illness, unclear and ambiguous messages can pose issues. Third, the message should communicate to the people that the institution is able to make decisions in a situation with uncertainty with confidence and honesty. An example would be to publicly acknowledge and praise politicians, scientists, and healthcare providers to highlight their ability to solve the immediate issue. Fourth, it is crucial to acknowledge the emotions of people during a pandemic where feelings of uncertainty are at peak levels. Uncertainty in illness has been associated with anxiety, depression, and distress that can result in panic and passivity.

The content and the delivery of the outreach messages are important factors to consider, as these have been shown to affect emotions in different ways (Heffner et al., 2020)one critical behavior is to self-isolate. Public health messages often use persuasive language to change attitudes and behaviors, which can evoke a wide range of negative and positive emotional responses. In a U.S. representative sample (N = 955. The content of the messages can be largely divided into prosocial messages and threatening messages. A study by Heffner et al. (2020) explored the outcomes between these two types of messages. The study recruited 955 participants from the US and conducted a within-subjects design study. The goal of the threat intervention was to tap into the fears of COVID-19 in order to increase participant's willingness to self-isolate. The threat intervention message was, *"The coronavirus is coming for you. When it does, your healthcare system will be overwhelmed. Your fellow citizens will be turned away at the hospital doors. Exhausted healthcare workers will break down. Millions will die. The only way to prevent this crisis is social distancing today."* It stressed the severity of COVID-19 by highlighting the negative consequences as well as the reader's susceptibility to these consequences. On the other hand, the prosocial intervention stressed the internal efficacy, which was defined as actions that an individual can take to mitigate the spread of COVID-19, and the response efficacy, which was defined as the effectiveness of a group effort. The message sent was, *"Help save our most vulnerable. Together, we can stop the coronavirus. Everyone's actions count, every single person can help to slow the crisis. We have the tools to solve this problem. Together, by self-isolating we can save millions of lives."* The results showed that both threatening messages and prosocial messages increased willingness to self-isolate, and there were no statistically significant differences between them. The differences were apparent in the emotional responses of which the messages evoked. The threat intervention led to reported feelings of unpleasantness and highly arousing feelings while the prosocial intervention was fairly pleasant and moderately arousing. The results in the study demonstrate the importance of the content and the delivery of these outreach messages, and it is important to not only look at reported willingness of behavior but also at other outcomes such as emotional response.

Appendix H: Best Practices for Surface Cleaning & Disinfecting

Ensure that when cleaning or disinfecting, proper personal protective equipment is utilized if required, however, always wear gloves when cleaning and disinfecting. The CDC has created a 3-part framework that serves as a guide for proper cleaning and disinfection (CDC, 2020i). First, continue with routine cleaning with normal soap and water particularly if an area is visibly dirty. This initial step in cleaning reduces any existing germs and dirt on surfaces.

In addition to routine cleaning, incorporate disinfectants to kill germs on any high touch surfaces daily. These surfaces can include tables, hard-backed chairs, doorknobs, light switches, handles, desks, faucets, toilets, sinks, electronics (e.g. phones, tablets, touch screens, remote controls, keyboards, ATM machines) and others depending on the location and usage (CDC, 2020a). The EPA has provided a *List N: Disinfectants for Use against the SARS-CoV-2* for reference (EPA, n.d.). The list is expected to kill the SARS-CoV-2 as it can kill a harder-to-kill-pathogen or it can kill related coronaviruses (ASHRAE, 2020a). As of writing this paper, the EPA is continuously updating the list with certain disinfectants that have been tested on SARS-CoV-2. Physical labels on disinfectants will provide additional information on proper usage for it to be used effectively and safety precautions that need to be followed (CDPR, 2016). For any porous items, it is recommended to either remove them or wash them utilizing hot water if possible. If items can't be removed or washed, disinfecting is recommended. Electronics should be followed according to the manufacturer, but if there are no instructions, it is recommended to utilize 70% alcohol solution (CDC, 2020g).

Finally, if an institution does not have access to the disinfectants provided by the EPA utilize a bleach mixture or 70% alcohol. According to the CDC (2020f) if a bleach disinfectant is going to be used, ensure a proper mixture of "5 tablespoons of bleach per gallon of room temperature water" and should be left on surfaces for a minimum of 1 minute. Any bleach mixtures should still be followed according to instructions on labels for safety precautions and proper application. Always verify expiration dates of bleach solution and ensure it has the ingredient sodium hypochlorite with a concentration range between 5 - 6% which acts as the disinfectant (CDC, 2020g). Cleaning schedules will need to be established to ensure workers do not overuse a product or under-clean an area (California Department of Public Health & CALOSHA, 2020; Occupational Health Branch, 2020).

List N can be harmful for people that are asthmatic, instead focus on products that contain hydrogen peroxide, citric acid, or lactic acid and avoid ingredients such as sodium hypochlorite, peroxyacetic (peracetic) acid, or any quaternary ammonium compounds as these can be problematic for some (Occupational Health Branch, 2020). Cleaning should be done with proper ventilation by opening windows and doors and preferably when people are not present. The CDC (2020f) states disinfection of an outdoor areas is not necessary (e.g. sidewalks, play structures, benches, tables), but routine cleaning should still be done. However, outdoor areas that are considered high touch and made of plastic or metal material should still be disinfected as there is evidence of SARS-CoV-2 having various survival rates on different materials (van Doremalen et al., 2020).

There are also cleaning and disinfecting recommendations for areas that have been occupied by an individual that tested positive for COVID-19. According to the CDC (2020f), close off the general area for at least 24 hours and try to clean and disinfect any surfaces the person might have come into contact with while keeping windows and doors open. Please refer to the CDC (2020f) if areas are carpeted and require vacuuming. If an infected area has been unoccupied for at least 7 days, routine cleaning and disinfecting methods that were utilized before the COVID-19 pandemic will be sufficient. There are other options for disinfecting by using UV radiation in order to disinfect surfaces. However, this method is not recommended by the CDC as the efficacy against SARS-CoV-2 has not yet been determined (CDC, 2020g).

Appendix I: Best Practices for Indoor Air Quality

As SARS-CoV-2 can survive in the air for up to 3 hours (van Doremalen et al., 2020) it is important to find ways to improve indoor air quality as people spend most of their time indoors. Improving ventilation is one way of improving indoor air quality. There are three different types of ventilation methods: natural, mechanical, and hybrid ventilation. Hybrid ventilation utilizes both natural and mechanical methods (Atkinson & WHO, 2009). Natural ventilation is most effective in buildings with open areas and utilizes the differences in temperature and pressure between the interior and exterior to increase indoor ventilation (Wolny-Koładka et al., 2019). A study looked at mechanical ventilation of 12 air change hour (ACH) compared to how open windows and doors at various hospitals with low wind speeds (2km/h) excelled at improving the ACH (e.g. 20 ACH) (Escombe et al., 2007) which can be optimized through climate (e.g. wind speed, seasons), the building itself (Atkinson & WHO, 2009; IES Photobiology Committee, 2020; Linnes et al., 2014) and also depends on if external air pollutants are present (CDC, 2020k). ASHRAE provides information regarding the minimum ventilation rates that are required according to various locations (ASHRAE, 2003). However useful natural ventilation is compared to mechanical in improving ACH, not all buildings have accessible windows and many rooms are situated in hallways making it difficult for airflow when there are directional changes particularly on multiple floors resulting in idle airflow (Atkinson & WHO, 2009).

Ventilation design can help direct airflow away from people or to filter out particulates (Yuguo Li et al., 2015). There are three ways mechanical ventilation works in: supply, exhaust, and balanced systems. Outdoor air can increase airflow, but may not be from environmental contaminants (Dietz et al., 2020; Lee & Chang, 2000). Depending on the building itself, different ventilation systems can be utilized (energystar, n.d.). Lobby areas should be pressurized which results from a supply system (ASHRAE, n.d.), while bathrooms utilize an exhaust system that draws air out (energystar, n.d.). Ventilation systems in bathrooms do need to be fully operational (CDC, 2020j) as flushes can easily produce droplets leading to airborne transmission (ASHRAE, 2020a). Mathematical modeling has shown that natural and mechanical ventilation can lower the infection rates if transmission occurs through the air (Gao et al., 2016). As airflow can move airborne particles around, outdoor air should be directed from clean to dirty areas (Atkinson & WHO, 2009). ASHRAE also recommends to keep airflow in rooms to a minimum of 1 CFM (ASHRAE, 2020c). Some buildings that are focused on energy saving protocols can have lower ventilation rates which poses a hazard for airborne transmission (Yuguo Li et al., 2015). If buildings have a 'demand-control ventilation' system that regulates airflow based on people within a building, it should be disabled as airflow should not be reduced (CDC, 2020j Schoen, 2020).

General precautions will need to be taken during HVAC maintenance (ASHRAE, 2020a). After reopening, a 'flush out' period is required where HVAC systems are run for 48-72 hours before the area can be occupied (CDC, 2020c). HVAC experts can determine if systems need to be recalibrated or balanced due to the shutdown (Colombo, 2020). Any filters should be assessed and replaced if necessary. In addition, systems should be operating 2 hours before and after an area has been used (CDC, 2020j). If possible, HVAC systems should run 24/7 to improve central air and outdoor air dampers should be open at 100% to prevent recirculation of air (Schoen et al., 2020). ASHRAE standard 52.2-2017 provides information regarding filter efficiency, where the higher the rating, the better (ASHRAE, 2017a; Zhang, 2020). Non-healthcare buildings utilize MERV filters between 8-11 (Dietz et al., 2020) but most buildings including schools are not built to fight against potential viral transmissions (Yuguo Li et al., 2015). MERV 13 filters were shown to be 90% effective at filtering out 0.3-1 µm sized particles in a study conducted in residential HVAC filters (Zhang, 2020). Since airborne SARS-CoV-2 particles can range in size due to changes in temperature and humidity, ASHRAE recommends using a MERV 14 filter, but if an existing system cannot handle the filter upgrade, the airflow decreases to compensate for the pressure drop when air is pushed through filters (ASHRAE, 2020a). When maintaining filters, check to ensure that no gaps exist for air to flow through without being properly filtered (Schoen et al., 2020). High efficiency particulate air (HEPA) filters are more effective where they filter out 99.97% of 0.3 µm particles (ASHRAE, 2020a) but have a higher cost and require stronger system accommodations for effective filtration (Colombo, 2020). Air cleaners with a HEPA filter can be utilized (Schoen et al., 2020) but not all airborne pollutants can be removed (US EPA, 2014). Placement of these portable air cleaners is also crucial in reducing transmission. Chen et al. (2010) looked at how dental healthcare workers can still be safe while working around aerosols that can become airborne and found that placing air purifiers right next to the patient's head was able to help control the amount of aerosols that would be found in the air . Continuing this study, Zhao et al. (2020) found that HEPA (H12 class) filters were able to filter out at least 83% of SARS-CoV-2 particles (Zhao et al., 2020).

Larger sized particles would naturally fall, however, some of the smaller particles can be resuspended into the air after they have evaporated in size on surfaces due to indoor humidity levels (Y. Li et al., 2005; Yang & Marr, 2011). SARS-CoV-2 survivability depends on certain temperatures, humidity and different surfaces. Humidity should be kept as low as possible but not to surpass 50% (CDC, 2020c) however, Sarah Maston, PE, BCxP, QCxP, LEED AP recommends humidity levels to be around 40-60% (Colombo, 2020). ASHRAE recommends that winter classrooms should be at 40-50% humidity and 72°F while summer classrooms should be at 50-60% humidity and 75°F (ASHRAE, 2020c). The virus can be inactivated on its own after a couple of days depending on surface and temperature (CDC, 2020j). Medical advisors from the Condair group explain that low temperatures and low humidity increase the rate of survival of SARS-CoV-2 while high temperatures (e.g. 86° F) can inactivate the virus (Condair, 2020). Chan et al. (2011) looked at how low temperature and low humidity prolonged the survival of SARS-CoV-2 compared to high temperature and moderate humidity. They found that 82-91°F and humidity >95% did not inactivate the virus. At 100°F and 80-90% humidity, the virus was inactivated at a rate of 0.25~2log10, but at 95% humidity the virus was inactivated at a quicker rate. In the same study at 72-77°F and 40-50% humidity, the virus survived up to 5 days on a plastic surface (Chan et al., 2011). SARS-CoV-2 has been found to survive on various surfaces with different inactivation times at 70-73°F and 40% humidity levels. In particular, plastic surfaces allowed the virus to survive up to 72 hours but slowly loses infectivity after that (van Doremalen et al., 2020). An experiment that looked at the influenza virus with simulated coughing in an enclosed room showed that about half of the virus lost infectivity at 40% humidity compared to 20% humidity levels at a constant 68°F within the first 15 mins (Noti et al., 2013). Influenza virus copies were significantly higher in control rooms compared to humidified rooms and also higher on surfaces in humidified rooms compared to in the air (Reiman et al., 2018). Casanova et al. (2010) demonstrated that at around 68°F, there was inactivation of similar coronavirus at 50% humidity by day 5 but at 80% humidity, viruses survived anywhere from 11-14 day. ASHRAE Standard 55-2017 provides information regarding temperature for indoor occupancy (ASHRAE, 2017b, p. 55). As of right now, there are interactions between temperature and humidity in the inactivity of SARS-CoV-2, however there is not enough evidence to specify a certain temperature and humidity level that the virus can survive in.

Ultraviolet germicidal irradiation (UVGI) is able to kill airborne viruses but has harmful side effects if exposed to people (Columbia University Center for Radiological Research, 2020; Columbia University Irving Medical Center, 2018). UV light that ranges from 200 - 280nm are known as UV-C light that is considered germicidal and has the ability to inactivate viruses and kill bacteria (IES Photobiology Committee, 2020). ASHRAE (2020a) explain that 265nm is considered germicidal, while others have found around 254nm to be the most effective instead (Buonanno et al., 2013; IES Photobiology Committee, 2020). UVGI in air ducts, portable units, and upper room units have been implemented into mostly healthcare settings (IES Photobiology Committee, 2020). UVGI within air ducts are able to help improve indoor air quality but also helps in reducing viruses or bacteria that exist on surfaces within the air ducts (ASHRAE, 2020a; Rodgers & Saputa, 2017) and becomes an additional control measure in addition to filters in air ducts (Saran et al., 2020). The reason UVGI is not as effective in air ducts is because it is only responsible for disinfecting recycled air or outdoor air, it does not help if there is a possible transmission risk within a room (IES Photobiology Committee, 2020). ASHRAE standard 185.1 provides information on utilizing UV lights within HVAC systems for cleaning and disinfecting (ASHRAE, 2020b; Zhang, 2020) and ASHRAE Handbook - HVAC Applications provide information on utilizing UV to disinfect air and surfaces (ASHRAE, 2019).

UVGI within upper rooms as an additional method of control have been found to be effective in decreasing bacteria found in air in the upper part of rooms (CDC, 2020j), but limitations show that lower amounts of bacteria in the air could be due to the temperature and humidity levels (Su et al., 2015). UVGI in upper rooms are the most effective at disinfecting air if standards for proper room height requirements are met, but consultation with an expert is still required (IES Photobiology Committee, 2020). UVGI upper room fixtures need a minimum of 7 feet or more before it can be installed (ASHRAE, 2020a; IES Photobiology Committee, 2020). Additional fans can help increase airflow and are beneficial in areas considered high risk. IES Photobiology Committee (2020) states that upper room UVGI is most effective when there is a combination of fans and ventilation to help with the airflow in the upper area of rooms.

Another option, far UV-C light ranges from 205-230 nm where inactivation of viruses can be found around 207-222nm (ASHRAE, 2020a). There are conflicting studies as to whether or not UV light at 222nm is harmful to humans still (IES Photobiology Committee, 2020) as there are some effect of 222nm on human skin (Woods et al., 2015). Far UV-C light at 222 nm has been shown to be effective in killing bacteria and inactivating viruses similar to UVGI at 254 nm while many say it does so without the harmful side effects to humans as demonstrated in human skin models (Buonanno et al., 2017). While looking at human cells between 207nm, harm to human cells were significantly less compared to at 254nm (Buonanno et al., 2013). Another study found through various doses of far UV light at 222nm, influenza viruses were eventually inactivated (Welch et al., 2018). According to Dr. Brenner from the Center for Radiological Research, far UV-C is able to kill SARS-CoV-2. Now, Brenner's research is focused on looking at the long-term effects and safety of using far UV-C light to further stop the virus (Columbia University Center for Radiological Research, n.d.).

UVGI and HEPA air filters are comparable to increasing indoor ventilation as seen through mathematical modeling (Gao et al., 2009). Dr. Bahnfleth, who is a part of ASHRAE's epidemic task force, recommends that buildings need to increase natural ventilation, improve existing air filters to compensate for SARS-CoV-2 particulates, and consider UVGI systems for disinfecting (Colin, 2020). UVGI should not be the primary means in reducing transmission as there are hazards if

UV is exposed to people in occupied rooms (Schoen et al., 2020). ASHRAE (2020) has a Position document on filtration and air cleaning which provides more information on other methods to improve indoor air quality (Wargocki et al., 2015). Priority in decreasing transmission should be given to physical distancing, practicing proper hygiene, and cleaning and disinfecting of surfaces before focusing on improving ventilation rates (Schoen et al., 2020). Overall, increased airflow is required if an area is occupied by students or faculty (CDC, 2020j). Any further information regarding reopening of universities can refer to Sandman (2007) for ensuring that a building is ready to be reopened.

Appendix J: Best Practices for Screening & Symptoms

Symptom screening and temperature screenings are NPI methods that can either be self-reported or actively screened, and both methods have been implemented during past pandemics. During the 1918 Spanish Flu, public schools in New York City implemented a system where teachers screened students for flu-like symptoms (Stern et al., 2010). Schools in New York City during the 2009 H1N1 Pandemic created a system where students, staff, and faculty would exchange emails about their self-reported ILI symptoms with the New York City Department of Health and Mental Hygiene (Vorou et al., 2009). Another study in 2009 revealed that 56% of public schools in New York City actively screened students and staff for signs and symptoms of the flu (Agolory et al., 2013). Screening was not limited to schools, as it was also implemented at MIT during the 2009 H1N1 pandemic where trained undergraduate student health liaisons called med-links took temperatures of students who were experiencing flu-like symptoms (Hashmi et al., 2016). For the current COVID-19 pandemic, Bayer Corporation’s branch at Berkeley, California has implemented symptoms and temperature screening for all personnel who enter the company site. The symptom screening complies with CDC guidelines and includes key questions related to COVID-19 symptoms and risks (Wondering How to Re-Open Your Business Safely? Learn from the Experience of an Expert, 2020). The temperature check is done using a non-contact thermometer. These screening processes are done by medical personnel from their occupational medical team who are working on-site and remotely over the phone (Wondering How to Re-Open Your Business Safely? Learn from the Experience of an Expert, 2020).

CDC provides the following guidelines to conduct proper temperature screening in an educational setting: have sufficient quantities of equipment (i.e. thermometers, PPE), clean screening area, maintain a safe distance, set protections for those who are more susceptible to COVID-19, set a process of how the results of the screening will be verified, and train staff for screening procedure and removal of PPE (CDC, 2020k). Thermal cameras are in development for mass screening (“Foresight to Enable Mass Screening for Detection of COVID-19 Pandemic Symptoms Using Thermal Cameras and Artificial Intelligence Expertise,” 2020)

CDC facilities COVID-19 self-reported screening includes four yes-or-no questions (Godfrey, 2020). The questions are based on two topics: symptoms and close contacts or potential exposure (CDC, 2020l). The first question asks if a person has experienced any of the following symptoms in the past 48 hours: fever or chills, cough, shortness of breath or difficulty breathing, fatigue, muscle or body aches, headache, new loss of taste or smell, sore throat, congestion or runny nose, nausea or vomiting, and diarrhea (Godfrey, 2020). The second question asks if a person has been in close physical contact, defined as 6 feet or closer for at least 15 minutes, with a person who is known to have laboratory-confirmed COVID-19 or with anyone who has symptoms consistent with COVID-19. The third question asks if the person is isolating or quarantining because of exposure to a person with COVID-19 or is worried that the person has COVID-19. The fourth question asks if the person is waiting on the results of a COVID-19 test (Godfrey, 2020). For high volume symptom screening, a chatbot may serve to streamline the process. Dennis et al. (2020) carried out a study to compare screening hotlines conducted by either a human agent or a chatbot. Users responded positively to both a human agent and chatbot as long as they understood their abilities, which was mainly determined by the user’s trust in the hotline provider with a slight negative bias against chatbot’s ability. When the ability was viewed as equal, users did not view chatbots differently from human agents, suggesting a possibility for the use of chatbots to easily screen a large population.

With self-reported symptom screenings done at home, it is important to determine how the results will be reported and verified (CDC, 2020l). Symptom screening may also be conducted through observations by others. In a K-12 setting, CDC has recommended for staff and faculty to visually and safely monitor students for overt symptoms When others are responsible for the screening of a student's symptoms, it will be crucial to strategize for scenarios of false identifications of symptoms, as such instances can have unintended harm (CDC, 2020l). Due to the possibility of false identification, universal screening at schools are not recommended by the CDC (CDC, 2020l).

There are other considerations to make while conducting symptom screening and temperature screening that are unique to an educational setting. When conducting the screening process on campus, other students may find out about other student's results; therefore, screening must be done strategically as to not cause stigmatization to symptomatic students (CDC, 2020l). Implementation of daily screenings may create emotional burdens among students, so considerations of ways to reduce fear of the new protocols are required (CDC, 2020l). Isolation and quarantine must be reinforced to students, staff, and faculty who are experiencing symptoms, and educators must be mindful about the ill students and also allow them to make up missed classwork without penalty (CDC, 2020l).

After symptom and temperature screening, clinicians and doctors can make a decision of whether or not a COVID-19 laboratory test is warranted (CDC, 2020l). It is important to note that despite the advantages of symptom screening and temperature screenings to identify possible cases and avoid others from exposure to the virus, a viral test is needed to confirm if a person has COVID-19 (CDC, 2020l).

Appendix K: Best Practices for Testing Frequency

The CDC has provided various recommendations for current testing frequency as of writing this review. However, with limited testing locations and supplies it is difficult to keep up with the demand and need for testing, therefore testing is recommended for people that were in contact with another that tested positive for COVID-19 regardless of symptoms. The CDC provides information for testing for resolutions as well as instructions for resolution if no symptoms have occurred. Antibody tests should not be used to determine status for return to work as there is no data to show that antibodies provide immunity to COVID-19 yet (CDC, 2020k). Testing all students and faculty before they are allowed on campus is not recommended either since there is no information explaining how it can help prevent the spread of COVID-19 in an educational setting, therefore the CDC recommends testing symptomatic and asymptomatic individuals with possible exposure.

Looking to the future for testing would require more testing supplies and more testing locations to be available especially in high-risk communities and for people that are asymptomatic (Huang, 2020). Currently there is no correct standard for testing that needs to be done or when testing should take place (Barnes & Sax, 2020), but there are guidelines that have been created that serve as recommendations for the number of tests conducted. The WHO set a standard that the number of positive tests that come back should be 10% or less as the positive tests only serve as a confirmation of those that are symptomatic meaning that not enough testing is done (WHO, 2020a). There is a huge focus on testing patients and first responders within the healthcare system, other symptomatic carriers, and those in contact with someone that tested positive, essentially ignoring asymptomatic individuals (Huang, 2020).

With an increase in testing, widespread testing is not always reliable as false negative results can occur. Hierarchical modeling was able to estimate the false negative tests and found that the best time to get tested is between the 3rd and 5th day from when symptoms first arise (Kucirka et al., 2020). Siddarth and Weyl (2020) recommends testing everyone at least once every 3-4 days. This helps prevent the spread if someone was infected as symptoms arise approximately around the 5th day. However, once symptoms arise, it would be too late to isolate as the infection could have already spread. Testing before symptoms occur can lower the probability of the infection spreading (Siddarth & Weyl, 2020). Romer (2020) has also run computer simulations of false negative tests to try to demonstrate the benefits of testing even if results return false negatives. The simulations demonstrated testing with an 80% false negative will keep the fraction of those that could get infected lower compared to if no testing was done (Romer, 2020). For this reason, testing with a high chance of false negative results is still more beneficial than not getting tested to determine self-isolation. Accuracy of results also depends on the who collected the sample and the lab itself (Barnes & Sax, 2020).

Appendix L: Best Practices for Contact Tracing

The amount of contract tracers needed can vary from population, location, and capacity of trained workers. Other countries have better implementation and control of the transmission of COVID-19, but the US leads in the number of positive cases (Watson et al., 2020). The purpose of creating a contact tracing program is to find the source of transmission when it first starts and to prevent it from spreading. If those that are symptomatic and at least 40% of those that were in contact with someone symptomatic can be identified, then the transmission of the virus can be controlled (Joseph, 2020). Health officials approximate that for the US, there should be about 100,000 - 300,000 contact tracers for the program to be efficient which equates to a minimum of 30 contract tracers per 100,000 residents. However, the US is understaffed where in June, there were about 27,000 tracers in the US overall (Hlavinka, 2020). Other locations have implemented contract tracers per 100,000 residents, such as 81 in Wuhan, 15 in Massachusetts, 4 in New Zealand, but with the rate that the US is at, more contact tracers are needed (Sreenivasan & Chen, 2020).

The amount of money that is required would depend on the size of the program and how many people they have to train and hire. The Association of State and Territorial Health Officials (ASTHO) and the John Hopkins Center for Health security state that the minimum of $3.6 billion dollars could hire 100,000 workers (Watson et al., 2020). Salomon & Reingold (2020) proposes that there should be at least $20 billion set aside for a contact tracing plan. Half would go to testing those in the program, but the majority should be provided to healthcare systems so that proper training can be conducted to run the program. $20 billion dollars is a bigger estimate to cover a bigger workforce for the program especially when physical distancing protocols are slightly alleviated (Salomon & Reingold, 2020).

Marcus Plescia of ASTHO stated contract tracing requires planning, training, and enough workers for the program to be successful and current planning is left to the hands of the state governments (Fox, 2020). Training would include teaching workers about how the transmission of COVID-19 occurs, the importance of isolation as well as collecting data without compromising a person's health information. Workers would have to keep in contact with each case and develop relationships as these individuals have to share information about who they were in contact with and where they have been (Watson et al., 2020).

Supplemental Appendices References

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