THE *LANCET* COVID-19 COMMISSION
TASK FORCE ON SAFE WORK,
SAFE SCHOOL, AND SAFE TRAVEL

Six Priority Areas

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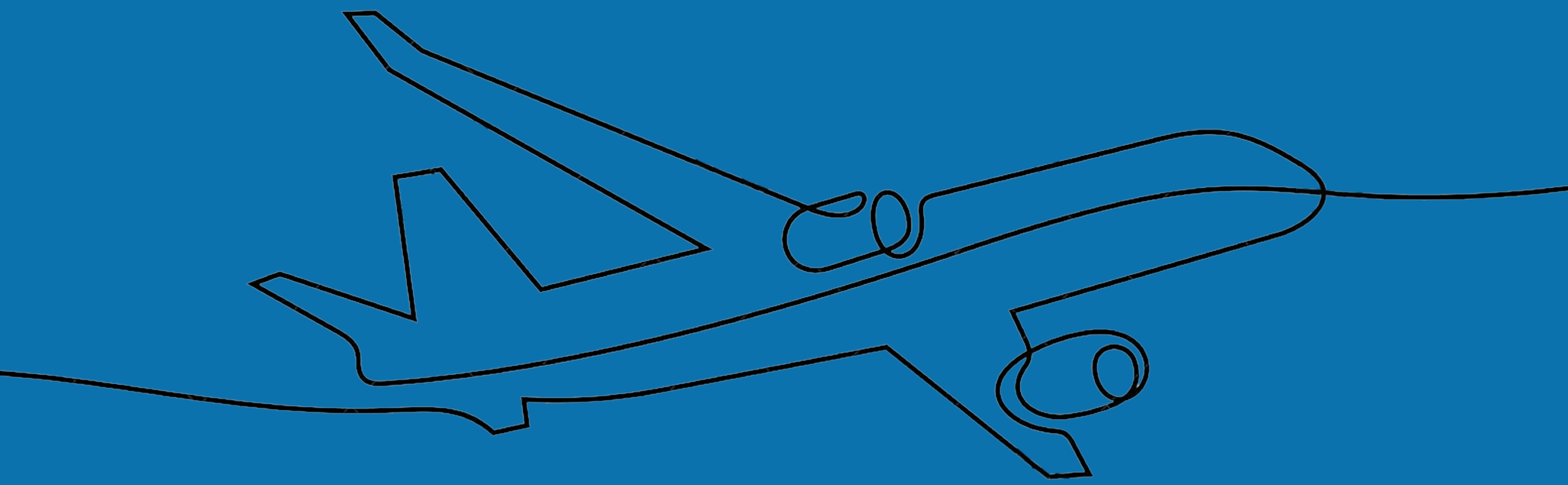

The *Lancet* COVID-19 Commission

Task Force on Safe Work, Safe School, and Safe Travel

THE *LANCET*
COVID-19 COMMISSION

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For more information about the *Lancet* COVID-19 Commission, please visit www.covid19commission.org.

The following report has been posted online by the Commission Secretariat, and has not been peer-reviewed or published in *The Lancet,* nor in any other journal. This reports intends to bring together expert views on key topics as the COVID-19 pandemic unfolds.

INTRODUCTION

Understanding what has gone right and what has gone wrong in the COVID-19 pandemic response, focusing on the places we work, learn, and travel, is critical to helping the world navigate this current crisis and address future threats. To advance this understanding, the *Lancet* COVID-19 Commission, established in mid-2020 with a goal of "assist[ing] governments, civil society, and UN institutions in responding effectively to the COVID-19 pandemic,"[1] created the Task Force on Safe Work, Safe School, and Safe Travel. This Task Force is one of several created by the Commission to address specific areas of the COVID-19 crisis.

This short report represents a summary of the work of the Task Force on Safe Work, Safe School, and Safe Travel and is intended to support the broader work of the Commission. This report is not, and was never intended to be, a full review of the scientific literature. Rather, it represents a distillation of scientific evidence and accumulated insight from real-world practice into six overarching key learnings and corresponding priority areas for organizations and societies to consider (Tables 1 and 2). Recognizing that this is not the last pandemic the world will face and that existing approaches in the places we work, learn, and travel helped to create conditions that led to this pandemic, we also include recommendations for fundamental shifts within each priority area.

TABLE 1. Key learnings that informed the six priority areas for safe work, safe school, and safe travel.

Key Learnings	**Six Priority Areas for Safe Work, Safe School, and Safe Travel**
Delayed action on available science cost lives and livelihoods	Evaluate exposures and reduce infection risks using the 'anticipate, recognize, evaluate, control, and confirm' framework
Indoor environments are higher risk for respiratory disease transmission	Layer defenses with the Hierarchy of Controls framework
Risks are unevenly distributed	Increase protections for workers in essential industries
Costs of school closures are severe	Prioritize keeping schools open
The economic crisis is a public health crisis	Close and reopen businesses strategically
Air travel hastens the spread of disease internationally and domestically	Minimize risk of spread through air travel

TABLE 2. Summary of key learnings, corresponding priority areas, evidence, and select supporting literature that inform the six priority areas.

Key Learning Priority Area	Evidence	Select Citations
1. Delayed action on available science cost lives and livelihoods: Use the 'anticipate, recognize, evaluate, control, and confirm' framework		
	Ad-hoc approaches led to competition for health resources.	Lagu et al., 2020; Ranney et al., 2020; Steere, 2020; Whalen, 2020
	Earlier public health interventions (e.g., mandatory mask wearing, stay-at-home orders) could have saved thousands of lives in the U.S. alone.	Chernozhukov et al., 2020
	Airborne transmission is happening.	Allen & Marr, 2020; Morawska & Milton, 2020; Ong et al., 2020
2. Indoor environments are higher risk for respiratory disease transmission: Layer defenses with the Hierarchy of Controls Framework		
	Nearly all outbreaks of three or more people occur indoors.	Qian et al., 2020
	High-profile case studies show common underlying risk factors: time indoors, no masks, low or no ventilation.	Atrubin et al., 2020; Azimi et al., 2020; Hamner et al., 2020; Li et al., 2020; Miller et al., 2020; Newton & Asmelash, 2020; Stein-Zamir et al., 2020; Szablewski et al., 2020
	Building-related factors, like ventilation and filtration, influence disease transmission.	Brundage et al., 1988; Drinka et al., 1996; Gao et al., 2016; Hoge et al., 1994; Knibbs et al., 2011; Milton et al., 2000; Morawska et al., 2020; Stenberg et al., 1994; Wolkoff, 2018; Zhu et al., 2020
	Super-spreading events are best explained by far-field aerosol transmission as opposed to close contact or fomite transmission.	Allen & Marr, 2020; Miller et al., 2020
	Insufficient control measures such as unlayered, single-method risk reduction strategies fail.	Dyal, 2020; Rubin, 2020
3. Risks are unevenly distributed: Increase protections for workers in essential industries		
	Food workers and healthcare workers are at elevated risk of COVID-19 infection.	Chou et al., 2020;Middleton et al., 2020; Shrivastava & Shrivastava, 2020
	Higher risks from COVID-19 exist in communities of color and lower income communities, and among those living in crowded housing.	CDC, 2020a; Dasgupta et al., 2020; Fortuna et al., 2020; Gold et al., 2020; Hooper et al., 2020; Yancy 2020

4. Costs of school closures are severe: Prioritize keeping schools open		
	Students at home face higher risks of abuse, neglect, exploitation, and violence.	Baron et al., 2020; UNICEF, 2020
	When not in school, children miss out on essential social-emotional learning, formative relationships with peers and adults, and other developmental necessities.	Levinson et al., 2020
	When not in school, children may not receive adequate nutrition.	Levinson et al., 2020; Rundle et al., 2020; The Forum, 2020
	Closing schools for in-person learning has led to widespread and unprecedented decreases in student enrollment and participation.	Belsha, LeMee, Willingham, & Fenn, 2020; CBS News, 2020
	School closures could have significant, long-term, global effects on childhood education.	Azevedo et al., 2020
	Closing schools for in-person learning exacerbates existing racial, socioeconomic, and gender inequalities.	Alon et al., 2020; Psacharopoulos et al., 2020
5. The economic crisis is a public health crisis: Close and reopen businesses strategically		
	The pandemic has deeply affected every sector of the economy; an estimated 345 million full time jobs were lost globally in the third quarter of 2020, relative to baseline.	International Labour Organization, 2020; Nicola et al., 2020
	Over 100 million people globally are estimated to enter extreme poverty as a result of the economic impacts of the pandemic.	Jackson et al., 2020
	Around the world, decisions to restrict economic activities have not always accounted for actual risks of SARS-CoV-2 transmission or non-COVID-19-related social, economic, and/or psychological externalities.	Dhillon & Karan, 2020
6. Air travel hastens the spread of disease both internationally and domestically: Minimize risk of spread through air travel		
	Airplanes can act as vectors of disease, transporting infected people around the globe and within countries.	Christidis & Christodoulou, 2020; Poletto et al., 2016; Wong et al., 2015
	Transmission can occur on airplanes, but airplanes are generally lower risk due to environmental controls.	Barnett, 2020; Harries et al., 2020; National Preparedness Leadership Initiative, 2020
	Airports have areas that require attention to reduce transmission, like boarding, security, and restaurant spaces.	National Academies of Sciences, Engineering, and Medicine, 2013

PRIORITY AREA 1:
Evaluate Exposures and Reduce Infection Risks Using the 'Anticipate, Recognize, Evaluate, Control, and Confirm' Framework

The urgency in mitigating infection transmission risk during a pandemic often means that decisions must be made quickly, even with incomplete or uncertain information. During these times, it is critical to rely on existing knowledge and frameworks. One relevant overarching framework comes from the field of industrial hygiene and focuses on five aspects of minimizing risk from hazards in the workplace: anticipate, recognize, evaluate, control, and confirm (ARECC).

Anticipating the hazard in the context of COVID-19 would have required the recognition that a pandemic was never a question of if, but rather when. Three recent disease outbreaks – severe acute respiratory syndrome coronavirus 1 (SARS-CoV-1), Middle East respiratory syndrome (MERS), and H1N1 influenza – were warning signs that the world needed to be prepared for a pandemic. Despite this, many organizations globally did not have pandemic preparedness plans in place at the start of 2020. Organizations were also slow to recognize the salient features of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that indicated this would be a difficult virus to contain: high population susceptibility, asymptomatic and pre-symptomatic spread, airborne transmission, and a high reproductive number. Countries that activated their response plans early suffered fewer deaths and less economic disruption.[2]

Proper evaluation of the threat was hindered by a substantial delay in recognition of the routes of SARS-CoV-2 transmission, as public health researchers, medical doctors, and environmental engineers had to overcome different disciplinary jargon and theoretical frameworks before beginning to come to some agreement. Early guidance from World Health Organization (WHO) and the United States (U.S.) Centers for Disease Control and Prevention (CDC) emphasized the importance of droplet and fomite transmission for COVID-19, but failed to recognize (or sufficiently prioritize) that respiratory aerosols in the size range relevant for airborne transmission – one to ten microns – can travel beyond two meters at typical indoor air velocities.[3,4,5,6] They will also stay aloft for 30 minutes or more,[7] which means that the concentration of these aerosols can increase over time indoors and infect people beyond two meters of distance. Additionally, the airborne transmission route dominates in short-range exposures in close contact range (1.5-2m range); this fact was disregarded by many who assumed large droplet transmission to dominate over short distances.[8,9] The reluctance to acknowledge airborne transmission of COVID-19 persisted even as additional evidence accumulated, including air sampling data and evidence from outbreak investigations.[10,11,12] It was only by October 2020, ten months into the pandemic, that health authorities such as the US CDC and WHO finally recognized the role of airborne transmission.[13,14]

Controlling the hazard requires an evaluation of the three factors that determine exposure: intensity, frequency, and duration. It involves first identifying highest risk locations and activities, and then implementing corresponding control strategies. The failure to account for these three factors led to an over-emphasis on low-risk environments in the work setting (e.g., elevators, which are low-risk due to low duration and frequency)[15] and a disregard for high-risk settings (e.g., meat packing plants). Last, the efficacy of controls must be continually confirmed through a process of verification and audit.[16]

RECOMMENDATIONS

A paradigm-shift toward using the ARECC framework is needed. This includes a focus on the upstream anticipation and early recognition of biological hazards as well as preparation to evaluate the exposure route and risk across micro-environments for any new hazard. Following the ARECC framework will allow targeted and layered control strategies to be applied and continually confirmed. The initial and substantial lack of recognition of airborne transmission of SARS-CoV-2 and the disproportionate burdens of proof expected for the different routes of transmission and corresponding mitigation strategies led to considerable delays in the communication of risk and the implementation of recommended controls.[17,18,19] The fields of building science, aerosol science, industrial hygiene, environmental health and safety, behavioral science, and exposure and risk science need closer alignment and integration with the public health, medical, and infectious disease communities.

PRIORITY AREA 2: Layer Defenses with the Hierarchy of Controls Framework

SARS-CoV-2 transmission can occur via three routes: droplet transmission (when larger aerosols emitted by an infectious person land on someone else's mucous membranes), airborne transmission (when smaller aerosols emitted by an infectious person travel short or long distances and are inhaled by someone else), and limited fomite transmission may also be possible (when someone touches an object on which an infectious person deposited virus and then transfers the virus to their own mucous membranes). As such, a holistic risk reduction strategy is warranted to simultaneously address each of these routes. In some cases, when organizations have relied on single or limited control strategies, high-profile outbreaks have occurred.[20,21,22,23]

Controlling the hazard requires a recognition that no one control measure in and of itself is sufficient during a pandemic. The hierarchy of controls, an integral component of the ARECC framework, lists five ways to manage risk, from most to least effective. Elimination of the hazard is at the top of the hierarchy, followed by substitution, engineering controls, administrative controls, and personal protective equipment (PPE). The hierarchy of controls framework has been applied to COVID-19.[24,25] Control strategies should be layered and paired with frequent handwashing to address multiple modes of transmission.

In a workplace, eliminating the hazard could involve prioritizing work from home, where possible. Substituting the hazard could be achieved by swapping higher risk activities with lower risk activities, such as identifying the core minimum number of people that have to be physically present for work to continue and allowing all other workers to work from home. However, we must recognize that these two options are not available for workers in essential industries, such as schools, healthcare, manufacturing, food production, delivery, transportation, construction, and childcare. The unavailability of such options is a contributing factor to the disproportionate COVID-19 burden that members of historically marginalized groups and those of low socioeconomic status carry, as they are more likely to hold employment in these public-facing job positions.[26]

Engineering controls are efforts to reduce the intensity of exposure in the environment. Concentrations of exhaled infectious aerosols can increase over time indoors unless they are removed through deposition, ventilation, or filtration. Ventilation standards for many space types including commercial, industrial, retail, and school buildings are set by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), and are adopted in many countries. ASHRAE standards are consensus-based minimum ventilation rates based on experimental or epidemiological data for odor control and perceived indoor air quality, and are not designed to address transmission of infectious diseases. However, many studies have shown that higher ventilation rates above these minimums are associated with reductions in risk of respiratory infections.[27,28,29]

Most buildings with mechanical ventilation recirculate a portion of the indoor air. The extent to which the recirculated air is free of infectious aerosols depends on the particle-size dependent efficiency of the filtration on the recirculated air. Most buildings use filters with a low particle capture efficiency for the size range of interest for infectious disease transmission, such as a minimum efficiency reporting value (MERV) 8 filter. Higher efficiency filters, such as MERV 13 filters, can capture approximately 80% of particles in the 1-10 micron size range, thereby increasing the overall volume of virus-free air delivered to a space, even if outdoor air ventilation rates are low.[30] In buildings without mechanical ventilation systems, opening windows can increase outdoor air ventilation rates. Portable air cleaners with HEPA filters, when sized correctly for the room, can also be used as a supplemental control strategy.

Administrative controls address the occupant behavior aspects of viral transmission, focusing on minimizing the intensity, frequency, and duration of the exposure to SARS-CoV-2 through modifications to work schedules and routines. These controls address known risk factors for SARS-CoV-2 and other infectious agents, such as higher occupant density, close contact, and long duration of exposure.[31]

Lastly, the first four controls may be insufficient to fully remove the hazard due to a variety of challenges, including in the implementation of controls, maintaining personal compliance, and protecting against multiple modes of SARS-CoV-2 transmission. Therefore, the use of PPE is warranted in the case of SARS-CoV-2. Masks can reduce the concentration of particles emitted ("source control"), minimizing the short-range transmission by blocking the expired jets or puffs. They can also reduce the concentration breathed in by the wearer, with the level of removal efficiency dependent on the materials used in the mask.[32] While cloth and surgical masks only partially filter respiratory aerosols, higher efficiency masks (e.g., N95s, KF94s, KN95s, FFP2s, or simple modifications to cloth and surgical masks) can reduce the wearer's exposure by 90-95%, offering the best protection against the spread of COVID-19.[33,34,35,36] In addition to particle capture efficiencies through the fabric, mask fit also influences mask effectiveness. Instances of unclear and inconsistent communication on the proper methods and the benefits of mask wearing have resulted in poor compliance with masking guidelines. Nonetheless, even without full compliance, masking has been shown to reduce community transmission of COVID-19.[37]

RECOMMENDATIONS

There are opportunities to increase protections for work, school, and travel at each level of the hierarchy of controls. We highlight three areas in particular. First, frequent testing using low-cost tests with good performance and a rapid turnaround time should be deployed in order to identify those who should remain home.[38] Frequent testing must be paired with policies that support sick workers, such as paid sick-leave, especially for those workers in essential industries. Second, relevant professional bodies need to develop standards for deploying engineering controls that are designed for reducing infectious disease transmission, rather than minimal acceptable targets. This includes higher outdoor air ventilation rates and the use of MERV 13 or higher filters. Looking beyond COVID-19, holistic healthy building approaches are needed that not only address disease avoidance, but also well-being, comfort, and productivity, with a focus on buildings as tools for equitable health promotion.[39,40] Third, additional research support is needed related to the ideal design and composition of cloth masks used by the general public to support standards and certifications for non-medical grade masks.[41]

PRIORITY AREA 3:
Increase Protections for Workers in Essential Industries

Workplaces are one of the primary locations where transmission of SARS-CoV-2 occurs. The risks of exposure and infection, however, are unevenly distributed across workplaces and industries, and are concentrated in communities of color and low income communities.[42,43] Some workers have the ability to work from home with full technology and internet access, while maintaining their full income.[44] Others are at greater risk of exposure because they are employed in settings that preclude social distancing and have essential job functions that require close contact with other workers, customers, students, or the public. Since the beginning of the pandemic, workers in industries essential to maintaining societal function have been placed at increased risk in their workplaces to ensure that patients are cared for, food is available, and the public transportation and utility systems continue to function.

Many of the workers in these higher-risk essential industries are low-wage and, depending on the industry and location, are members of communities of color. Black people, for example, make up 13% of the total U.S. population, but account for 34% of confirmed COVID-19 cases.[45] As of November 30, 2020, deaths among African American and Hispanic communities were occurring at 2.8 times the rate of deaths in white communities.[46] Low wages and socioeconomic status drive factors that increase risks of personal exposure and of exposing others, contributing to community spread. These factors include inequity in health care access (unequal distribution of resources such as testing sites and hospitals), health care disparities (poorer quality of care), overrepresentation in correctional and immigration detention facilities, living in multi-generational housing (increased exposure risk due to crowding), and reliance on public and semi-public transportation.[47,48,49,50] In addition, low wages are associated with poor health and a lack of sick leave and health insurance benefits.

This contributes to these individuals continuing to work while ill and the delay in testing once symptoms begin.[51] Many of these workers have one or more co-morbid conditions, such as cardiovascular disease or diabetes, which depresses their baseline health, increasing their risk of serious illness or death from COVID-19.

In general, there are inadequate data on the distribution and determinants of COVID-19 infections and mortality among workers in different industries and occupations. Public attention has focused on outbreaks among workers in the healthcare sector and at meat packing or processing facilities. This is not surprising, in that very large numbers of workers in these sectors have been infected and many have died.[52] However, increased risk of infection and death have been seen in workers in many sectors of the economy, including farming, warehouse and distribution, retail, construction, transportation, and food service.[53,54,55,56,57]

The proportion of cases either directly or indirectly associated with workplace exposure undoubtedly varies by industry and region and has not been studied in depth. There are some studies that provide some estimates; in Singapore, for example, it is estimated that approximately one-third of all cases are the result of workplace transmission.[58] It also appears that work-related cases were of particular importance in seeding the epidemic in its early stages.[59,60]

RECOMMENDATIONS

One of the most important lessons that can be derived from the pandemic to date is that if provided with adequate protection, workers in high-risk settings can avoid infection. There are many healthcare facilities where few workers have been infected,[61] while in others, the infection rate was quite high.[62] It is also apparent that the environmental conditions of some facilities, like meat processing facilities where there is limited air flow, increase the risk of viral transmission.

Preventing workplace transmission requires the involvement of employers, workers and their representatives, and government agencies. The application of precautions following the hierarchy of controls has been uneven in many industries. Employers need to develop and implement comprehensive plans to reduce exposure. Some companies may consider creating new positions for chief public health officers to facilitate this process. Workers and their representatives must be involved in the planning process, since worker buy-in and participation is important for the success of exposure and risk reduction plans. It will be critical for companies to foster a culture of health, safety, and shared responsibility for risk reduction amongst all stakeholders.

Government agencies have required employers to implement precautionary measures in only some locations; universal requirements would increase compliance and reduce workplace transmission. In addition, it is of great importance to reduce the presence of potentially infectious individuals in the workplace. Workers need to be supported financially to enable them to quarantine or isolate as appropriate, which may be particularly burdensome for small employers. Masks with high filtration efficiencies (e.g., N95s, KF94s, KN95s, FFP2s) should be made readily available to workers in essential industries, as they are for healthcare workers. Government support for workplace testing and for payment of infected or exposed workers during necessary quarantine and isolation can be effective in reducing risks of workplace exposures.[63] Finally, addressing the uneven risks of exposure faced by workers in communities of color requires correcting the myriad of inequities these communities face, such as healthcare access and disparities, chronic illnesses, low wages, technology barriers to remote work and education, mass incarceration, and urban crowding.

PRIORITY AREA 4: Prioritize Keeping Schools Open

School closures due to the COVID-19 pandemic have had an enormous impact globally. School closures peaked in early April 2020, affecting an estimated 84.8% of learners enrolled in pre-primary through post-secondary education.[64] In November 2020, nine months after the first school closures in Mongolia and China, 23 country-wide closures remained in effect and schools were only partially open in many other countries, including the U.S., Colombia, and India.[65]

The effects of sustained school closures are far-reaching. Sustained school closures are detrimental to students' academic, social, psychological, and physical development.[66] When schools are closed, children suffer from increased food insecurity and hunger due to lack of access to free school breakfast and lunch,[67,68,69] increased depression and anxiety,[70,71,72] academic and social regression,[73] and increased risk of abuse.[74] Sustained school closures affect adults as well, with parents and guardians of school-aged children unable to engage fully in their own jobs while they oversee their children's remote education.

The effects of sustained school closures are not distributed equitably either within or between countries. Children with special needs, those from low-income or marginalized backgrounds, and students who were already struggling in school are finding it harder to access and benefit from remote schooling than children in the same communities who were already academically thriving, or who have more robust family and social support systems.[75] With the notable exception of the U.S., countries in the global South – particularly India and Central and South America – are also somewhat more likely to have shuttered schools than those in the global North.[76] School closures threaten to widen education and earnings gaps globally, with children in low-income countries suffering the largest loss of future earnings.[77] School closures are also exacerbating within-family inequities, as women – including those who are (or were) employed full-time – are disproportionately shouldering childcare and remote schooling supervisory responsibilities resulting from in-person school closures.[78] These harmful effects of prolonged school closures have not always been adequately acknowledged by schools and leaders responding to COVID-19.

Throughout the progression of the COVID-19 pandemic, it has become increasingly clear that in-person schooling has not led to substantial increases in community transmission of SARS-CoV-2, especially when effective risk reduction measures are put in place.[79] In part, this is due to disease dynamics specific to COVID-19. Children, particularly primary school-aged children, seem to be less susceptible to becoming infected with COVID-19.[80] If they do become infected, children are much less likely than adults to suffer severe outcomes and they may be less likely to transmit the virus to other children and adults.[81,82] This evidence of reduced risks among children and of lower risk in primary vs. secondary school-aged children has not consistently been factored into risk-benefit discussions around in-person schooling. Older adults, on the other hand, are more susceptible to becoming infected with COVID-19 and are more likely to suffer severe outcomes.[83] Although there is no evidence that teachers and other adults who are working in schools that follow appropriate safety guidelines are at increased risk of contracting COVID-19, they are at higher risk on average than children are in school settings.

RECOMMENDATIONS

Given the profound, multisystemic, and likely long-term harms suffered by children when schools are kept closed for extended lengths of time, as well as the observational evidence of school openings around the world and epidemiologic evidence that children are less susceptible to COVID-19,[84,85] schools should be treated as essential institutions and should be provided with the necessary support to remain open throughout the COVID-19 pandemic. In this respect, schools should be categorized with hospitals, grocery stores, and public transportations systems rather than with restaurants, bars, or non-essential manufacturing facilities, particularly for younger children and those with special educational needs who are unlikely to succeed in remote-learning environments. School closures should only be used as a short-term measure and in as targeted a way as possible, avoiding broad closures where narrower closures are feasible (e.g., for a given grade or school, or a local area with very high community rates, as opposed to across entire provinces, states, or countries).

To minimize the potential risk of in-school transmission for both children and adults, schools should implement a suite of control measures that include universal masking, enhanced ventilation and filtration, maintaining one-meter distancing between students where possible, maintaining two-meter distancing between adults where possible, and other control measures.[86] Implementing these strategies may be complicated in school districts of varying sizes and with varying amounts of resources. Challenges that schools may encounter while trying to implement risk reduction measures include logistical challenges and challenges of coordinating across schools, older facilities and deferred maintenance, few school nurses, budget constraints, and low mutual trust between families and school administrators.

Supports provided to schools should include funding of facilities maintenance to verify and, if necessary, upgrade ventilation system performance; reliable provision of appropriate PPE to all adults and to children as needed; prompt testing for symptomatic students and staff and contact tracing for all confirmed cases, as well as surveillance testing (with priority placed on staff) as resources allow; funding of building construction and creation of temporary outdoor learning and play spaces to eliminate classroom crowding; funding for technology to facilitate and ensure student access to remote education when it is necessary; increased staffing, salary support, and training for teachers, school nurses, counselors, custodians, cafeteria workers, and other schools staff; and financial, logistical, and political support for school systems to partner with local workplaces, community organizations, faith communities, and other local organizations to expand school into non-traditional spaces. Because of the specifics of COVID-19 transmission, infectiousness, and clinical outcomes, secondary schools will likely need additional safeguards and support compared to primary schools. Non-essential work and indoor recreational spaces may also need to be closed in order to maintain transmission at a sufficiently low level to keep schools open. To ensure schools are more resilient to future crises, investments should be made in school buildings, systems, and personnel beyond the current pandemic.

It is also important to invest in centralized school leadership at all levels, to offer guidance, coordinate efficient and equitable deployment of resources and personnel, and coordinate information gathering and relevant research in times of crisis. In the case of COVID-19, centralized repositories of COVID-19 cases in schools should be created. Along with case counts, these repositories should include in-person attendance numbers and information about what risk reduction measures schools and their local communities are implementing. It may also be useful to implement seroprevalence studies or studies of widespread testing in different communities to further evaluate the community-level effects of opening schools with specific risk reduction measures. Care should be taken to design analyses that can distinguish how disease risks and intervention effectiveness vary between young children and adolescents. As new evidence about child- and school-specific COVID-19 dynamics and effective risk reduction strategies becomes available, it should be rapidly assimilated into practice so schools' COVID-19 responses can become more effective over time.

PRIORITY AREA 5: Close and Reopen Businesses Strategically

In the absence of widespread vaccination or reliable therapeutics, many countries have implemented closures of schools, workplaces, and restrictions on travel. Reducing person-to-person interaction and large gatherings slows the spread of the virus, reduces the burden on healthcare systems, and allows public health systems to maintain the ability to test, trace, and isolate a sufficient proportion of symptomatic and asymptomatic individuals.[87] However, widespread and universal shutdowns do not acknowledge differential risk by activity and location, nor spatial and temporal heterogeneity with regard to disease spread. During periods of elevated risk, there is a need for a strategic decision-making process to prioritize closures and restrictions within the greater context of society.

Shutdowns void of a selective approach or prioritization based on evidence for health risks and the societal costs of closures have led to excess economic damage, pandemic fatigue, and the loss of trust and adherence to public health measures over time.[88] For example, an estimated 5.6%, 17.3%, and 12.1% of global working hours were lost in the first, second, and third quarters of 2020, respectively, relative to the pre-pandemic baseline. In the third quarter of 2020, 345 million full time jobs were lost.[89] Targeted strategies should focus on restricting venues and scenarios that are known to most often lead to SARS-CoV-2 transmission,[90] rather than lower-risk activities or critical activities, like school. Yet, this strategic approach is not happening in many countries. As of mid-December 2020, 28 country-wide school closures were still in place.[91] In late 2020 in the U.S., forty-eight of fifty states were categorized as having 'uncontrolled spread,'[92] but many non-essential venues associated with higher-risk of spread such as bars, gyms, and indoor dining remained open,[93] even while schools remained closed or poorly attended. Other lower-risk locations like public parks and trails were closed across the world despite the public health benefits of these areas and the existing evidence for low transmission risk in outdoor settings when basic precautions are followed.[94] This was also observed in workplaces, where commercial office spaces were closed, and construction activities limited in places not experiencing high levels of community spread and/or where strict control measures were instituted in work buildings.

Strategic decisions are not only required to determine when to restrict activities, but also to determine when and how to reopen. Evidence-based criteria should be calculated and followed using a gradual phased approach to avoid a resurgence of infections and longer-term damage to the economy.[95] External and internal metrics, each with leading and lagging indicators, are required for organizations to assess moving between phases of reopening and closing. External factors include indicators of community spread, such as case counts (leading indicator) and hospitalizations and deaths (lagging indicators). Internal factors include building and organization readiness and controls (leading indicator) and building-related cases (lagging indicator).

RECOMMENDATIONS

Determining which activities are highest risk, and therefore should close first, should rely on epidemiological case studies as well as quantitative risk models. Several quantitative risk models have been developed that can be used to guide local and national decision-making related to closures and reopening.[96,97,98,99] These quantitative models vary in assumptions and require further advancements, particularly around the dose-response relationship (infection intensity) for SARS-CoV-2. Restrictions should be focused primarily around limiting the highest risk scenarios and venues that have been shown to lead to widespread transmission. Targeted restrictions should prioritize saving lives, ensuring equity, and preserving societal values such as education and essential services. To do this, a holistic assessment of the second-tier effects of closures should be brought forward by appropriate representatives during decision-making. Rather than widespread national closures that unnecessarily impact some schools, businesses, and travelers, more targeted closures based on local high-quality COVID-19 data are recommended. A strategic, contextualized approach to closures and reopening should also be based on current public health and medical resource availability. A successful reopening of schools, workplaces, and public travel also necessitates bridging the gap between differing perceptions of health risk. Shared input and close collaboration are required between the scientific community, key leadership, and the public to bridge this gap and promote informed decision-making.

PRIORITY AREA 6: Minimize Risk of Spread Through Air Travel

Air travel has been the main vector of global SARS-CoV-2 transmission via the rapid movement of infected individuals across large geographic areas.[100,101,102] The outbreak in China, detected in early January, quickly became a global crisis. Within the first month of the outbreak in Wuhan, China, COVID-19 spread to the U.S., India, countries in East and Southeast Asia including Japan, South Korea, and Singapore, and European countries including France, Italy, and the United Kingdom.[103] Within two months, cases were reported in 75 countries.[104]

In response to the crisis, most countries immediately adopted air travel restrictions, and consumer confidence in airlines fell, leading to a sharp decline of global passenger traffic.[105] Worldwide flights have been reduced by 43% compared to 2019 levels.[106] In countries that have reached a point where community spread is effectively controlled, limiting the introduction of new cases from other countries remains a top priority. China, Australia, South Korea, and Iceland, for example, are testing all arriving passengers for SARS-CoV-2 and requiring strict 14-day quarantines.

Disease transmission can occur on airplanes, and several instances of SARS-CoV-2 transmission on airplanes have been reported to demonstrate this.[107,108,109] However, the overall number of COVID-19 cases attributed to air travel is small relative to the number of travelers. Within the airplane, disease spread is very limited due to the environmental control systems onboard airplanes. Airplanes have very high air exchange rates, and all recirculated air is passed through high-efficiency particulate air (HEPA) filters. Additionally, airflow around the plane is limited. As a result, when SARS-CoV-2 transmission occurs, it is generally limited to within one or two rows of an infectious person. However, airplane environmental controls only help reduce disease transmission risk when they are operating; risk may be higher on airplanes when environmental control systems are not operating, such as during boarding.[110,111]

Air travel always includes time spent in other environments beyond the airplane cabin, some of which may be higher risk than the airplane. This includes time spent on public transportation, in security and check-in queues, in airport restaurants, at the gate, and during the boarding and disembarkation processes. The entire door-to-door travel process should be evaluated for opportunities to reduce transmission risk.

RECOMMENDATIONS

To slow the spread of disease globally, countries should implement early and effective pre-flight screening and testing, and post-flight quarantine and isolation. Masking should be required in airports and on airplanes during disease outbreaks. Gate-based ventilation should be mandatory. Within the airport, enhanced risk reduction procedures should be implemented, in accordance with recommendations from the Airport Cooperative Research Program.[112] This includes having, and activating, a pandemic response plan. Last, our understanding of disease transmission on airplanes has depended on case reports, limiting our ability to evaluate the number of flights with infected people where transmission did not occur. Several countries are currently screening, testing, and quarantining passengers on every arriving flight. The data from these testing programs provide a critical opportunity to quantitatively estimate baseline incidence of SARS-CoV-2 transmission during air travel.

CONCLUSION

The COVID-19 pandemic has elevated long-standing issues related to public health and the protection against respiratory infection transmission in work, school, and travel environments. The failures are many. Failure to fully anticipate the pandemic, act early, and follow the precautionary principle to mitigate risk in our actions; failure to address inequities around race, gender, and wealth; failure to protect the most vulnerable workers and community members; failure to incorporate existing scientific knowledge and learn from our past; failure to create sustainable and healthy buildings in the places we live, work, learn, and travel. We have an obligation to do better moving forward. The lessons from this pandemic can, and should, guide us to solutions for the current crisis and the future crises which will undoubtedly come. With this report, we have attempted to highlight a few of the many key lessons from the COVID-19 pandemic, and have provided recommendations for how each can be addressed moving forward.

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