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Review article

Re-opening schools during COVID-19 pandemic: A "Good from the Bad" review for decision makers

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Abbreviations:
COVID-19: Coronavirus disease 2019
SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2
ARDS: Acute Respiratory Distress Syndrome
ACE2: Angiotensin-Converting Enzyme 2 receptors
WHO: World Health Organization;
PHEIC: Public Health Emergency of International Concern
CDC: Centre for Disease Control and Prevention

ABSTRACT

Background: The decision to re-open schools during the corona virus disease 2019 (COVID-19) pandemic isn't easy, and a lot of factors are contributing to direct such a decision. Authorities have responsibilities to both organize the education process and to keep the children, teachers, families and communities safe during such process. To produce the good from the bad out of such a critical issue needs a lot of creativity, dedication and responsibility. **Methods:** We searched PubMed, JAMA network, New England Journal of Medicine (NEJM) and other journals for studies published from January 1, 2020, to October 15, 2020. We searched in 45 references. We selected articles relevant to a general medicine readership, systematic reviews, letters to the editors and clinical practice guidelines. Other sources included publications from international organizations like World Health Organizations (WHO). **Results:** Strategies to protect children during the COVID-19 pandemic include prevention of collapse of various healthcare services, up-scaling of COVID-19 testing, maintaining vital access to social, economic and health care and using research for better understanding of COVID-19. Elements necessary for standing in face of COVID-19 include choosing science, the rule of law, equity in delivering healthcare services, resilient healthcare systems with entrusted leaderships, investment in scientific research and the global support of international organizations. **Conclusion:** We conclude that societies need to keep the necessary education systems working efficiently, during these bad times that are enforcing the globe to live symbiotically with the third and most dangerous zoonotic coronavirus that has crossed the species barrier from wild animals to humans.

Introduction

Coronavirus disease 2019 pandemic is causing substantial morbidity and mortality, pressuring on health care systems, attacking economies, and closing schools and educational facilities. In response to the COVID-19 pandemic, most countries had implemented national school closures in spring 2020. It is still unknown whether school measures are effective in such an outbreak [1].

As many countries are heading to re-opening schools for autumn 2020, many elements should be monitored including the effectiveness of symptoms reporting, rapid testing and tracing of suspected cases, the implications on educational objectives and learning outcomes, the effects on

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health and well-being of children, number of cases in children and staff in the school and the assessment of impact of remote teaching on learning outcomes. Deciding to close, partially close or reopen schools should be guided by a risk-based approach, to maximize the educational, well-being and health benefit for students, teachers, staff, and the community. Based on what is learned, further modifications should be made to continue to provide children, staff and the wider communities with the safest environment possible [1].

Importance

This review presents some of the current evidence regarding the natural history of SARS-CoV-2; its epidemiology, transmission, patho-physiology, and interaction with host immunity. It briefly summarizes clinical presentations and diagnostic methods. Our review covers SARS-CoV-2 incidence in children, role of children in viral transmission and its impact on pediatric health and education systems. We discuss various strategies from different countries regarding schools' closure, re-opening and continuing of educational process under the pandemic exceptional circumstances.

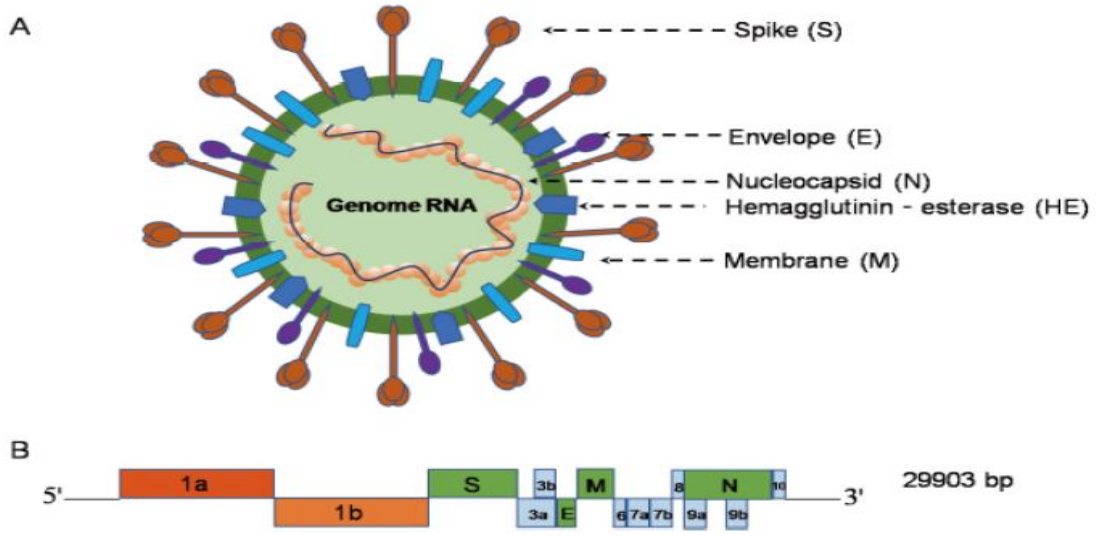
Our review also covers school practices to mitigate the effect of the disease and to reduce viral spread while organizing acceptable education process, providing some insights on children's protection.

Evolution and epidemiology of SARS-CoV-2

SARS-CoV-2 is the seventh member of the coronaviruses family that infect humans. Four viruses (229E, OC43, NL63, and HKU1) typically cause common cold symptoms in immuno-competent individuals, while the other two strains (severe acute respiratory syndrome coronavirus "SARS-CoV") and (Middle East respiratory syndrome coronavirus "MERS-CoV") are zoonotic in origin and have been linked to sometimes fatal illnesses [2].

The novel COVID-19 began in December 2019; with an outbreak caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) occurred in Hubei Province, China. On January 22nd, 2020, World Health Organization (WHO) supported human to human transmission, and later, on January 30th, declared COVID-19 a public health emergency of international concern (PHEIC) [3], and finally declared it as a pandemic on March 11th, 2020 [4]. Daily updates on COVID-19 epidemiology are provided by John Hopkins University web platform [5].

Figure 1. β-coronavirus particle and genome [6]: (A) β-coronavirus particle. (B) 5′ and 3′ terminal sequences of the SARS-CoV-2 genome.



Transmission of SARS-CoV-2

While the most common mode of transmission is by droplets expelled during face-to-face exposure (talking, coughing or sneezing), duration of exposure to symptomatic infected persons is associated with higher risk of transmission than briefer exposures to asymptomatic contacts [7].

Another possible mode is by contact spread with surfaces contaminated with the virus, where viral loads appears to persist at higher levels and longer durations (3-4 days) on impermeable

surfaces, such as plastics more than permeable surfaces such as, card board (2-3 days) [8].

Some studies suggest that children younger than 5 years are potential drivers for SARS-CoV-2 spread in the general population, as high amounts of SARS CoV- 2 viral RNA are detected by PCR in their nasopharynx, compared to older children and adults [9].

The behavioural habits of this population in schools and day-care centres raise concern of disease amplification while reopening schools [9]. Moreover, viral shedding has been detected in rectal swabs of children even beyond the recovery period, suggesting possibility of faecal-oral route transmission [10].

Incidence

Multiple parameters determine mortality rate between countries, including number of people tested, healthcare delivery, population demographics and factual reporting [11].

In a large case series in China, results showed that patients aged (10-19) years and (0-10) years represent only (1.2%) and (0.9%) of total patients, respectively [12].

Viral shedding

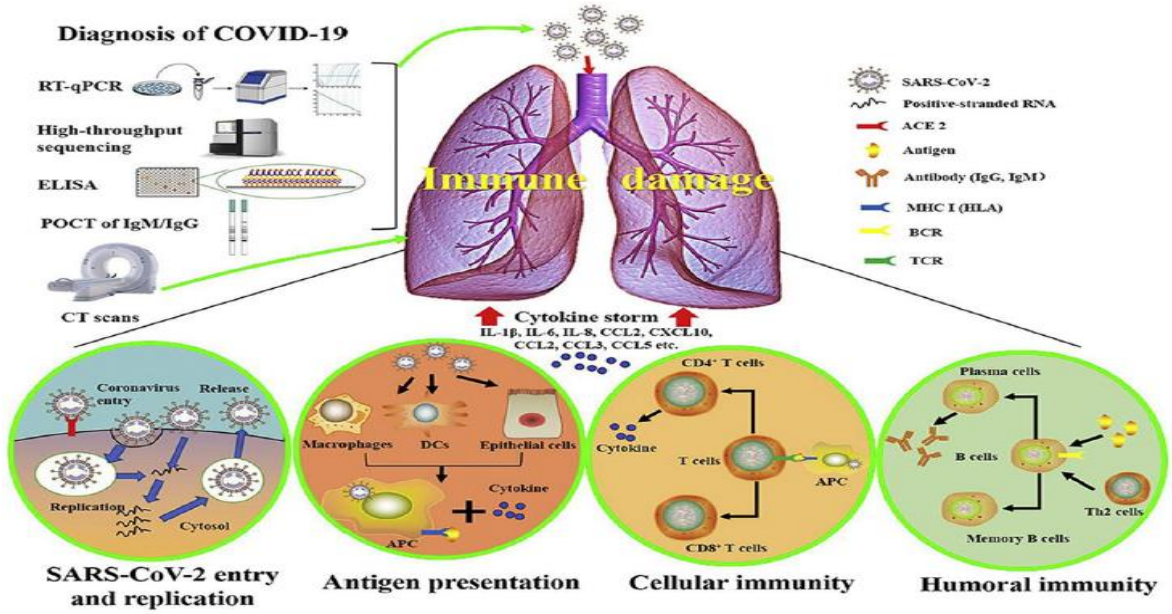
Mean incubation period has been established to be 6.4 days, ranging from 2.1 to 11.1 days [13]. Shedding of infectious virus occurred in both adults and paediatric patients, who have no fever and no signs or only minor signs of infection [14].

SARS-CoV-2 viral loads peak at around 5 to 6 days following the onset of symptoms as shown by RT-PCR, and it ranged from 10^4 to 10^7 copies / ml during this time [15].

Pathophysiology of SARS-CoV-2

Early in infection, SARS-CoV-2 targets nasal and bronchial epithelial cells and pneumocytes, through viral structural spike (S) protein that binds to the angiotensin-converting enzyme 2 receptors (ACE2), that is cleaved mediating viral entry into host cells [16]. Later, when viral replication accelerates, epithelial-endothelial barrier is compromised resulting in influx of monocytes and neutrophils, causing alveolar diffuse thickening, edema and infiltration of air spaces, which is shown as ground-glass opacities on computed tomographic imaging. SARS-CoV-2 - infected lungs also shows cellular fibromyxoid exudates, hyaline membrane formation, and desquamation of pneumocytes, indicative of acute respiratory distress syndrome (ARDS) [17].

Figure 2. Pathogenesis and diagnostic procedures for SARS-CoV-2 [18].



In critically ill patients microthrombi formation resulting from inflamed lung tissue may result in thrombotic complications like deep venous thrombosis, pulmonary embolism and thrombotic arterial complications; such as myocardial infarction or ischemic stroke [19]. In severe COVID-19, activation of coagulation and consumption of clotting factors results in fulminate diffuse intravascular coagulation [20].

Immunity

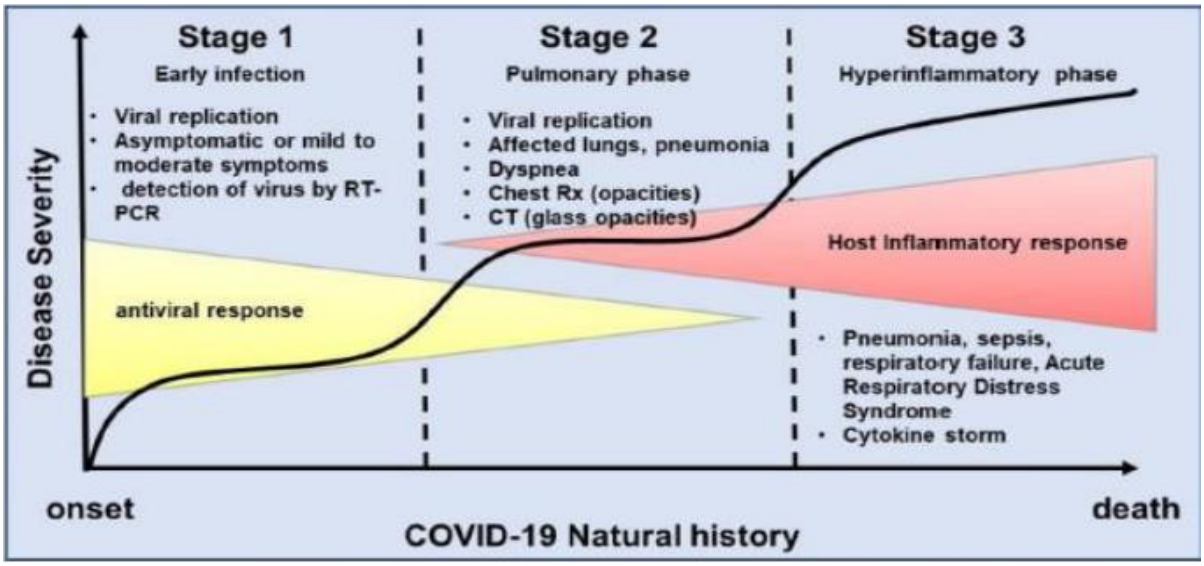
The two main theories for explanation of the protective effect of age that currently being perused are: (a) differences in pediatric immune responses as compared to adults, or (b) differences in airway epithelial cell make-up affecting the availability of viral binding sites [21].

Children with mild or asymptomatic infection might produce weaker responses, based on thoughts that the magnitude of antibody response is associated with severity [22].

Clinical manifestations in children

Severity of illness in children has been categorized into four categories. The mild form is presented with fever, sore throat, cough, and/or myalgia with no dyspnea. Moderate disease symptoms are fever, dyspnea, and/or chest imaging consistent with SARS-CoV-2 pneumonia. Severe disease shows fever, dyspnea, and/or chest imaging consistent with SARS-CoV- pneumonia, with new or increased supplemental oxygen requirement and/or ventilatory support requirement. Critical disease includes respiratory failure requiring mechanical ventilation, acute respiratory distress syndrome, shock or systemic inflammatory response syndrome, and/or multi-organ failure [23].

Figure 3. Schematic representation of the natural history of COVID-19 from the onset to recovery or death [24].



Clinical management

Corona virus disease 2019 management is still limited clinically to supportive care like supplemental oxygen and mechanical ventilation [25].

Therapeutic approaches for SARS-CoV-2 effective drug includes testing repurposed drugs like anti-viral agents or anti-inflammatory agents, using immuno-modulators to inhibit cytokines overproduction, and using epidemic-adopted strategies like convalescent plasma therapy [24].

Laboratory diagnosis of COVID-19 in children

Laboratory findings regarding lymphocytes for COVID-19 infected children, either symptomatic or not were variable, while CRP, pro-calcitonin, liver enzymes and D-Dimer all show slight elevation in some symptomatic children [26].

Real time RT-PCR is considered to be an effective method for confirming the diagnosis in clinical cases of COVID-19 [27].

Approaches to prevention and control measures

Corona virus disease 2019 pandemic has disrupted normal life, with more than 40 million cases and more than 1.1 million deaths worldwide as of mid-October 2020 [5].

Preventive interventions are required to continue until treatments or vaccinations become available for this potentially preventable disease. Measures consist of personal actions (including physical distancing), case and contact identification (including test-trace-track-isolate), regulatory actions (including pro-active school closure or restriction) and international border measures (like enforced quarantine). Variations in measures occur between countries based on resource limitations, geography, population, and political factors [28].

In a global effort, WHO initiated "Solidarity Trial" in March 2020 to test drugs and drug combinations including Remdesivir, Chloroquine and hydroxychloroquine combinations,

Ritonavir/lopinavir and Ritonavir/ lopinavir & interferon-beta, and other agents, trying to dramatically cut down the time needed to generate robust evidence about what drugs work [11].

COVAX is a global initiative aimed at engaging 172 countries with vaccine manufacturers to provide countries worldwide equitable access to safe and effective vaccines. These vaccines will be offered equally to all participating countries, initially prioritising healthcare workers [29].

Impact of COVID-19 on children's health and education

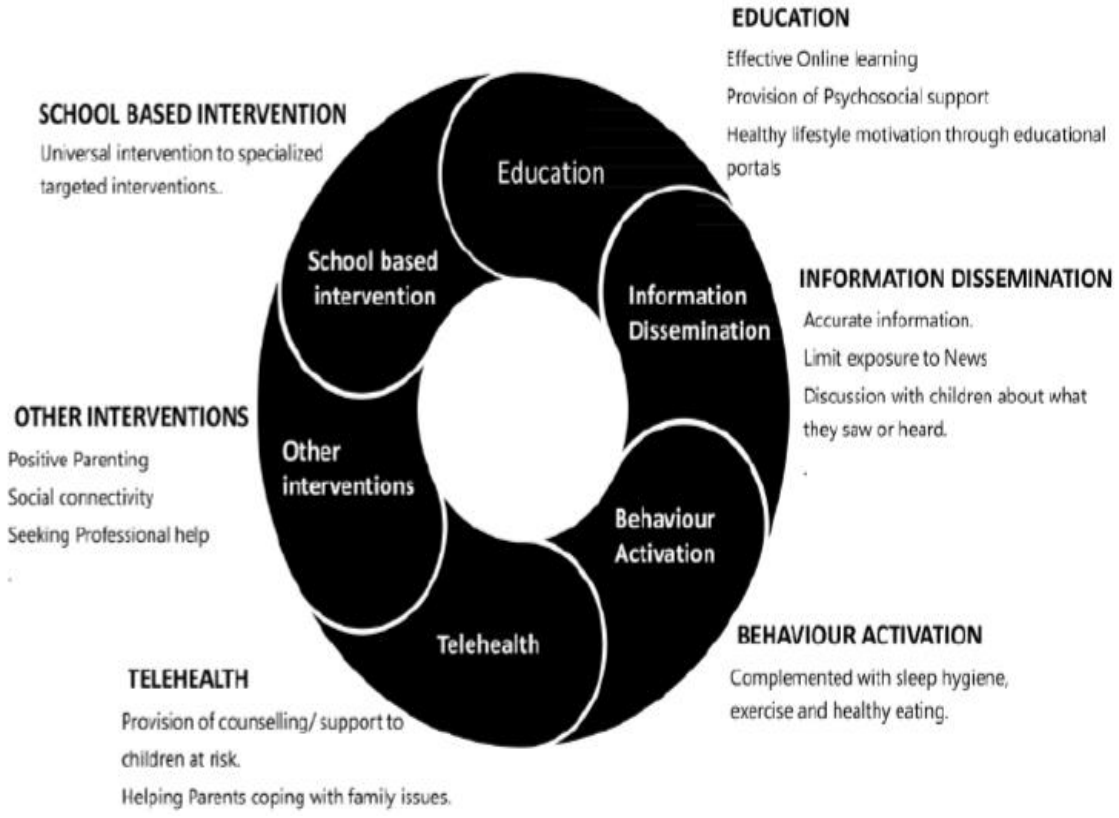
Despite the increasing numbers of confirmed COVID-19 cases, data on COVID-19 in children and adolescents remain scarce, originated mainly from China, which can't be extrapolated to children elsewhere. Other studies from Europe and North America contain very few data about clinical outcome or supportive measures required by children [30].

Children experiencing isolation and quarantine have shown an increased risk of developing post-traumatic stress disorder, anxiety, grief, and adjustment disorder [31].

Threats to the well-being of children due to COVID-19 response include widespread parental unemployment, disrupted education, food and housing insecurity and threats to vital preventive health programmes, like immunisation, antenatal care, infant feeding and mental health [32].

School closure also extends to affect both the emotional aspects of the children and the school mission. Social and emotional learning is important for young people to become conscious members of a solidarity-based community. Learning objectives can be achieved remotely but the core mission of any school system also comprises the promotion of students' wellbeing, which is closely related to school performance [33].

Figure 4. Interventions to reduce adverse psychosocial impact of quarantine in children and adolescents [34].



School closures impede learning inequities, disproportionately affecting children through increased dropouts, child labour, violence against children, and persisting socioeconomic and gender disparities. Also, access to distance learning through digital technologies is highly unequal, and subsidised meal programmes, vaccination clinics, and school nurses are essential to child health care, especially for marginalised communities [35].

Risk of re-opening schools

Countermeasures against the pandemic have been adopted by several countries with a full or

partial lockdown in place. Countries like Spain, Italy, Germany, USA and others have cautiously announced and put in place a lockdown lift measures seeking for a return to normal life. Nobody can predict when the virus will be defeated, but certainly, life after COVID-19 will be different [36].

Despite it's not known yet, but COVID-19, a viral pneumonia syndrome, may impact children in Lower-income and Middle- income countries more severely than what has been observed to date [32]. Children aged from 2 to 10 years may have a marginal role in spreading the disease. Re-opening of nursery and primary schools can be implemented at an early stage of recovery efforts with guarantees for safe conditions and an appropriate surveillance system [31].

Computer simulations from Europe have suggested that re-openings may further increase transmission risk in communities where transmission is already high. Meanwhile, with precautions, opening schools doesn't seem to cause significant jump in infections, when local rates are low [36].

Health and safety practices for re-opening schools

Some strategies are proposed to protect children during the COVID-19 pandemic. The first strategy is to prevent the collapse of vital acute care services (like antibiotics, personal protective equipment), preventive services (like immunisation, maternity care) and supply chains. The second is to up-scale COVID-19 testing. The third is to maintain vital access to social, economic and health care during lockdown. The fourth is to use research for better understanding of COVID-19 fundamentals on children [32].

Schools as "healthy places" should be viewed by communities and families through building public health–focused collaboratives capable of learning and rapidly implementing, as COVID-19 information evolves by the minute. As schools reopen, school-based health centers should be expanded to improve student health and educational outcomes and reduce healthcare disparities among vulnerable student populations [37].

Opening schools is possible if adults accompany this school year in a positive way. It is adults who must protect children from possible contamination, while maintaining quality interactions between adults and children as well as between the children themselves [38].

Keeping masks and face shields on or off

The need for universal use of cloth face coverings or surgical masks of smaller size suitable for children from 3 to 12 years old is supported by the hypothesis that face masks are effective in reducing the presence of viral particles in droplets and aerosol generated by symptomatic SARS-CoV-2–infected individuals [39].

Masks don't fit snugly on faces of toddlers and children of the first school years, with the risk that contaminated air can access or mask is poorly tolerated. Moreover, as generally children do not like to keep the mask on and will likely try to remove it, as well as touch their face more, the use of mask can favour infection development [40].

Wearing a mask in nurseries, kindergartens and primary schools for children is not necessary, desirable, or reasonable [38].

A better option may be offered by face shields, as they significantly reduce inhaled amount of another droplet-transmitted virus; influenza. They reduce immediate and after 30 minutes exposures to the inhaled virus, besides reducing the inhaled virus at the currently recommended physical distancing distance of 6 feet by 92%. Unlike medical masks, they can be used indefinitely, and can be easily cleaned with common household disinfectants. Their advantages include their ability to protect portals of viral entry and reducing autoinoculation, while allowing for visibility of facial expressions and lip movements [41].

Table 1. Different types of face masks and which could be good or not for children in the community [40].

	Type of Mask	Characteristics	Components of the pediatric population in the community
1	Cloth mask	Cloth face mask covering over nose and mouth in the community setting to reduce the possibility that someone with no symptoms could transmit the disease to others	Homemade or purchased cloth masks for the average person to wear. For a small child ensuring the right fit is important. Children younger than age 2 shouldn't wear masks.
2	Surgical mask	Loose-fitting disposable device that creates a physical barrier between the mouth and the nose of the wearer and potential contaminants in the immediate environment	Available for smaller size for children ≥ 3 years old.
3	N-95 respirator	Personal protective equipment that is used to protect the wearer from airborne particles and from liquid contaminating the face	Not recommended for the general population. Only children who are considered high-risk for severe complications or severely immuno-compromised are encouraged to wear an N-95 mask to best protect themselves.

Reasons for mask wearing without attempts of removing it must be clearly explained and the child must not be forced. If compliance is difficult, it is better that the child does not wear the mask, and other measures or reducing infection risk, including remaining at home, are practiced [40].

To get the good from the bad

Safe exit strategies must capitalise upon periods of relative suppression of COVID-19 to ensure those with highest clinical needs, such as health care workers, mentally ill patients and those who have experienced domestic violence, including children are identified and receive care [42].

Because fever and cough are the most commonly reported symptoms in children, staff should be provided with thermometers and instructed in their proper use. Also, school staff will need to be trained in screening for symptoms of COVID-19 [43]. Also, high coverage of Children's immunisation programmes must be achieved [44].

As policy makers, health care professionals, and parents prepare for the fall semester, a better understanding of virtual learning options and outcomes may facilitate those difficult decisions [45].

School districts should engage key stakeholders to establish a COVID-19 task force. This task force can provide educational materials and training for students, parents, and school staff on the basics of COVID-19 prevention, applicable to both when children are in school and when they are not in school. It's recommended that schools implement multilevel screening for students and staff. Each morning, parents should report (via an online interface or by an automated telephone-based program) any fever or symptoms concerning for COVID-19 to the school. When students arrive at school each day, school staff should also record their temperatures and any alarming symptoms [43].

For this exceptional time, a COVID-19 task force is required to develop creative and pragmatic solutions through action plans that support safe return activities from safety, operational and risk assessment perspectives [36].

In terms of protective equipment, schools will need to have a steady supply of hand sanitizer for students and staff each day. Disposable masks can be used over the course of a day. Transparent barriers placed on the sides of students' desks can further limit the spread of respiratory droplets. It's recommended to create fixed cohorts of students and teachers to limit exposure of students to teachers and students to each other. Even with all the precautions in place, schools will need to remain flexible and consider temporary closures if there is an outbreak involving multiple students and/or staff and be ready to transition to online education [43].

Sharing common methods consistent with national and international health guidelines, taking into account characteristics of different contexts will foster the dissemination of good practices [36].

In an article by **Gostin**, he determined seven essential elements for institutions, governments and international society to stand in face of COVID-19, including choosing science, the rule of law, and equity as core values. Also, it's mandatory to build resilient health systems with entrusted leaderships and investment in scientific research with the global support of international organizations [46].

A second wave of the pandemic is expected in northern hemisphere countries, which requires that all governments to be called to meet this more challenging phase of the disease. We should 'hope for the best, but plan for the worst' [44].

Limitations

The information is based on current knowledge. As the situation of the novel coronavirus is currently evolving, more information will be continuously emerging.

Authors' contributions

Authors co-wrote the manuscript and approved the text.

Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent: Not applicable.

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