Safety Science 134 (2021) 105067

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/safety

Strategies to exiting the COVID-19 lockdown for workplace and school: A scoping review

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ARTICLE INFO

Keywords:
Covid-19
Exit strategy
School
Work

ABSTRACT

In an attempt to curb the COVID-19 pandemic, several countries have implemented various social restrictions, such as closing schools and asking people to work from home. Nevertheless, after months of strict quarantine, a reopening of society is required. Many countries are planning exit strategies to progressively lift the lockdown without leading to an increase in the number of COVID-19 cases. Identifying exit strategies for a safe reopening of schools and places of work is critical in informing decision-makers on the management of the COVID-19 health crisis. This scoping review describes multiple population-wide strategies, including social distancing, testing, and contact tracing. It highlights how each strategy needs to be based on both the epidemiological situation and contextualize at local circumstances to anticipate the possibility of COVID-19 resurgence. However, the retrieved evidence lacks operational solutions and are mainly based on mathematical models and derived from grey literature. There is a need to report the impact of the implementation of country-tailored strategies and assess their effectiveness through high-quality experimental studies.

1. Introduction

The COVID-19 pandemic has impacted the world's health and socioeconomic systems, resulting in a global health emergency (De Sanctis et al., 2020). All people are susceptible to SARS-CoV-2, and in the absence of a vaccine or pharmaceutical treatments, several countries are implementing non-pharmaceutical interventions (NPIs) to control its spread (CDC, Accessed on August 18th, 2020; Ferguson, 2020). These strategies vary greatly across countries, ranging from the closures of schools and businesses to bans on mass gatherings and total lockdowns (Davies et al., 2020; Xu et al., 2020).

Since person-to person transmission is mostly driven by social interactions, closing schools and asking people to do their jobs from home were among the first decisions taken in many countries to stave off the impending pandemic (Christakis, 2020). These actions have had an unprecedented effect on the world's economy, education, and social life, and governments around the world had to triangulate the health and freedoms of their populations, as well as economic constraints (Kupferschmidt, 2020).

However, in order to smooth over the deep and long-lasting consequences of the lockdown and to keep transmissibility under control (avoiding another wave of infection), it is necessary to balance the clear benefits of restrictive measures in containing transmission against the negative socioeconomic effects on the community (Gibney, 2020). As some countries see a flattening or even a decline in deaths (Kupferschmidt, 2020; McKee, 2020), with the effective reproduction number (R_0) below 1 (Anderson et al., 2020a), it seems plausible that the reopening of society could be considered. In consideration that there is no quick

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† The views and opinions expressed in this article by this author do not necessarily reflect those of Bank of Italy.

https://doi.org/10.1016/j.ssci.2020.105067
Received 9 October 2020; Accepted 20 October 2020
Available online 31 October 2020

'exit strategy' to return to normal life, countries are planning a phase of gradual lifting of the containment measures(Anderson et al., 2020b; Fantini et al., 2020).

Great attention should be paid to safely managing and reorganising the reopening of schools and return to work, as the public health response to the COVID-19 pandemic has substantially changed working and school conditions through a social reorganisation of communities (Gilbert et al., 2020; Prem et al., 2020).

Furthermore, the need to get countries back to work is urgent, and of course, the risks posed by delaying school openings cannot be ignored, particularly for students from low-income families or in limited-income countries (Esposito and Principi, 2020; Xu et al., 2020). Clearly, without a vaccine or effective treatment, this pandemic can only be kept under control and policy makers have the task of balancing the pros and cons of each adopted strategy to figuring out which ones can be safely utilised, modified or deleted (Gibney, 2020; WHO, 2020).

Although there have been tremendous efforts in publishing clinical and mathematical models, as well as policy documents (WHO, 2020), there is still a lack of consensus on how to safely manage the pandemic beyond the lockdown (Gibney, 2020; Kupferschmidt, 2020; Sheikh et al., 2020).

The aim of this scoping review is to summarise the available literature on strategies for exiting lockdown during the COVID-19 pandemic or any other similar pandemic, focusing on reopening schools and returning to work. By identifying lockdown exit strategies, this review attempts to support government decision-making on strategies to handle this public health emergency.

2. Methods

2.1. Study design

The 5-stage framework proposed by Arksey and O'Malley (Arksey and O' Malley, 2005) and then further refined by Levac et al. (2010) and the Joanna Briggs Institute (Peters et al., 2017) for conducting a scoping review were followed. The framework comprises the following key phases: (1) identifying the research question; (2) identifying relevant studies; (3) study selection; (4) charting the data; and (5) collating, summarising, and reporting results. The optional consulting phase (6) has been excluded by this study due to time constraints.

The reporting method of this review follows the Preferred Reporting Item for Systematic Reviews and Meta-Analyses (PRISMA) Scoping Review (ScR) Checklist recently developed for scoping reviews (Tricco et al., 2018). The study selection process was summarised using a PRISMA flow diagram (Moher et al., 2009). The study protocol was registered on the medRxiv preprint server, and it is publicly available (https://doi.org/10.1101/2020.09.04.20187971).

2.1.1. Identified research questions

The following research question guided our review: Which lockdown exit strategies for workers and students during the COVID-19 pandemic or any other similar pandemic have been reported in the literature?

2.1.2. Identifying relevant studies

A preliminary search, run on 20 May 2020, was performed on MEDLINE to identify index terms and keywords. Then, this search strategy was translated and tailored for use in biomedical databases (EMBASE and SciSearch) through the STNext platform. The full search strategy is reported in Appendix Table 1. Online grey literature databases (Google Scholar) were also scanned. The mentioned databases were searched from inception until 25 May 2020. An initial scan of biomedical databases showed that the databases selected were not likely to identify results related to the focus of this scoping review. This was probably mainly due to the newness of the topic searched and to the potential delays in the indexing of databases. Thus, to ensure that the scoping review is comprehensive and up to date, the research team extensively hand-searched various reference lists of included studies and key journals.

Manual searches of the literature, until 1 July 2020 were undertaken using daily updated COVID-19 collections from the National Centre for Biotechnology Information (https://www.ncbi.nlm.nih.gov/research/coronavirus/docsum?filters=topics.Prevention) and both the medRxiv (https://www.medrxiv.org/) and bioRxiv (https://www.biorxiv.org/) preprint servers. We included all the relevant scientific publications written in English, Spanish, German, and Italian.

2.1.3. Study selection

The inclusion criteria were: (1) studies must refer to workers (working age population) or students of all ages facing an epidemic/pandemic crisis; (2) studies that measure or discuss strategies to exit lockdown during an epidemic/pandemic crisis, (3) quantitative studies of any study design can be included (i.e., systematic review, randomised controlled trials, cohort, case-control, quasi-experimental, cross-sectional, or mathematical model), as well as editorials, letters, and commentaries. Studies were excluded if they dealt with an epidemic/pandemic crisis in the presence of a vaccine or herd immunity. Considering the specific contribution that health care workers have during a pandemic crisis, articles focusing on such workers were excluded.

The first stage of screening was the review of titles and abstracts against the inclusion/exclusion criteria by two blinded reviewers (DD and AS). Selected papers from the first screening were then assessed by full-text reviews in a second stage.

Any discrepancies were discussed between the two reviewers until a consensus was reached. In the event of any disagreement, this was discussed in detail with a third reviewer (DC). Reasons for excluding studies after a full-text review (second stage) were documented.

2.1.4. Charting the data

Data were collected using a standardised charting form such as that modified by the Joanna Briggs Institute (JBI) (Peters et al., 2017), which is intended to facilitate the synthesis of information and quality of recommendations. In order to ensure that the coding was reliably applied, two reviewers (DD and AS) independently piloted at least five papers through full-text reviews and charting. Subsequently, a preliminary analysis was also performed to pilot the data summary process.

2.1.5. Summarising results

Data analysis included descriptive measures (e.g., counts and frequencies) of the characteristics of the included literature. Subsequently, we categorised the literature findings by setting (workplace and school) and by study methodology (observational studies, mathematical models, editorials/commentaries, and reviews). Table 1 shows the summarised characteristics of the included articles.

2.1.6. Assessment of methodological quality

Although the scoping review according to the framework of Arksey and O' Malley (2005) does not aim at critically appraising individual studies, a quality assessment of the retrieved studies was performed due to the newness of the topic and to gauge the credibility of avoiding inconclusive and/or biased results.

3. Results

The search yielded 7523 records. Of the 82 potentially relevant articles, 39 articles were excluded after a full-text reading. Therefore, 43 articles were included in this review (Fig. 1).

3.1. Characteristics of the included studies

Among the 43 research articles included in the analysis, most came

Table 1
Summarised characteristics of included articles.

Characteristics	Categories	N (%)
Publication or posted date (year/month)	Before 2020	5 (11)
	From 2020	
	Jan–March	5 (11)
	April–June	33 (77)
Geographical distribution	Europe	28 (65)
	America	10 (23)
	Asia	4 (9)
	Australia	1 (2)
Study design	Mathematical models	23 (53)
	Editorials/commentaries	11 (25)
	Observational studies	7 (17)
	Narrative reviews	2 (4)
Settings	Workplace	21 (48)
	School	17 (39)
	Both settings	4 (9)
Target population	General population	23 (53)
	Students	3 (7)
	Workers	2 (4)
	43 positive samples/40 control subjects	1 (2)
	Not specified	14 (32)
Outcomes*	Transmission ($R_{0,\ t}$)	13 (30)
	Infected people (rate/number)	14 (32)
	Severity (mortality, ICU admission,	11 (25)
	hospitalisation, and length of stay)	1 (9)
	Educational loss	1 (9)
	Other	15 (34)
	Unreported	
Articles' data derived from	UK	6 (13)
	USA	3 (7)
	Italy	3 (7)
	French	3 (7)
	Greek	2 (4)
	Spain	1 (2)
	German	1 (2)
	China	1 (2)
	Korea	1 (2)
	Not specified	8 (18)
	Not applicable	11 (25)

* Some articles addressed more outcomes at the same time.

from European countries (65%) and the USA (22%) (Fig. 2) and were published after April 2020.

Most of the articles were based on mathematical models (n = 23, 53%), followed by editorials/commentaries (n = 11, 25%), observational studies (n = 7, 16%), and narrative reviews (n = 2, 4%). Fifteen (65%) out of the 23 mathematical models were published as preprints, whereas eight (72%) out of 11 editorials and six (85%) out of seven observational studies were published in indexed journals. A total of 21 and 17 articles focused on lockdown exit strategies in the workplace and school settings, respectively, while four articles focused both on workplace and school strategies.

The most studied outcomes were the COVID-19 infection transmission (n = 12, 27%), number of people infected (n = 10, 23%), and severity subdivided into mortality (n = 10, 20%), ICU admissions (n = 5, 10%) and hospitalisations (n = 4, 8%). The characteristics of the included articles are summarised in Table 1, while further study details are shown in Appendix Table 2.

The breakdown of study designs by setting and country is shown in Table 2. The findings related to the different lockdown exit strategies for the workplace and school are narratively explained and summarised in Table 3.

3.2. Quality assessment

Overall, 23 mathematical models were assessed using the 'QUAntitative-Deterministic models Risk of Infeasibility Assessment Checklist' (QUADRIAC) (Porgo et al., 2019). The risk of unfeasibility was low for 11 models (Araz et al., 2013; Brethouwer, 2020; Giordano et al., 2020; Hoertel et al., 2020; Kim et al., 2020; Lee et al., 2020; Panovska-Griffiths et al., 2020; Potter et al., 2012; Prem et al., 2020; Rawson et al., 2020; Scala, 2020), medium for 10 models (Aleta et al., 2020; D'Orazio, 2020; Davey and Glass, 2008; Di Domenico et al., 2020a, 2020b; Fokas et al., 2020; German et al., 2020; Karin et al., 2020; Keeling et al., 2020; Kraay et al., 2020), and high for two models (Goscé et al., 2020; McBryde et al., 2020) (Appendix Table 3). It was not possible to assess the quality of the seven observational studies, as they were substantially heterogenous in terms of study design, methodology and results reported.

3.3. Return to work

The social distancing measures were the exit strategy most analysed (Aleta et al., 2020; Castaldi et al., 2020; D'Orazio, 2020; Di Domenico et al., 2020b; German et al., 2020; Gilbert et al., 2020; Giordano et al., 2020; Hoertel et al., 2020; Ichino, 2020; Lee et al., 2020; McBryde et al., 2020; Petersen et al., 2020; Prem et al., 2020), which were associated with better outcomes (lower infections/transmission/severity). Social distancing was often associated with testing, contact tracing and the possibility to use a smartphone app to track contagion, quarantine and isolation, and other non-pharmacological interventions, such as wearing a mask. Several studies outlined a gradual return (Dewatripont, 2020; Ichino, 2020; Petersen et al., 2020; Sheikh et al., 2020) based on age-specific strategies (Di Domenico et al., 2020b; Fokas et al., 2020; Rawson et al., 2020; Scala, 2020), while shielding the most vulnerable (Gilbert et al., 2020; Hoertel et al., 2020) and reducing the age-mixing patterns (McBryde et al., 2020) had a significant impact on transmission. Specifically, Brethouwer (2020) reported the importance of reopening local connections before connecting cities further apart, while Karin et al. (2020) suggested providing part-time employment on a cyclic schedule of a 4-day work and a 10-day lockdown.

The need for low daily confirmed cases was proposed as a safe measure to ease the lockdown (Anderson et al., 2020a; Petersen et al., 2020; Prem et al., 2020; Rawson et al., 2020), while serological testing was considered important to support the progressive de-confinement of immune workers (Dewatripont, 2020; German et al., 2020; Gilbert et al., 2020; Ichino, 2020; Kraay et al., 2020). In this regard, a review (Sarwal, 2020) proposed a so-called 'localisation' strategy, suggesting that, if no new cases are identified in a geographical territory within 14 days of lockdown, the territory can be treated as free of COVID-19.

Several studies have developed different indexes to determine which workers need to be tested (Alhaery and Suh, 2020b) and to decide which workers may return to work (Hierro et al., 2020). According to Suh et al. (Alhaery and Suh, 2020a), the key to opening up the economy was a comprehensive, reliable and simple-to-use index to assess the level of containment in any state and to determine the level of risk in further opening. Finally, Stedman et al. (2020) suggested reopening those areas with significant COVID-19 cases, as such areas may have achieved high immunity (herd immunity).

3.4. Reopening school

With regards to schools, most articles (Davey and Glass, 2008; Di Domenico et al., 2020a; Fantini et al., 2020; Keeling et al., 2020; Long

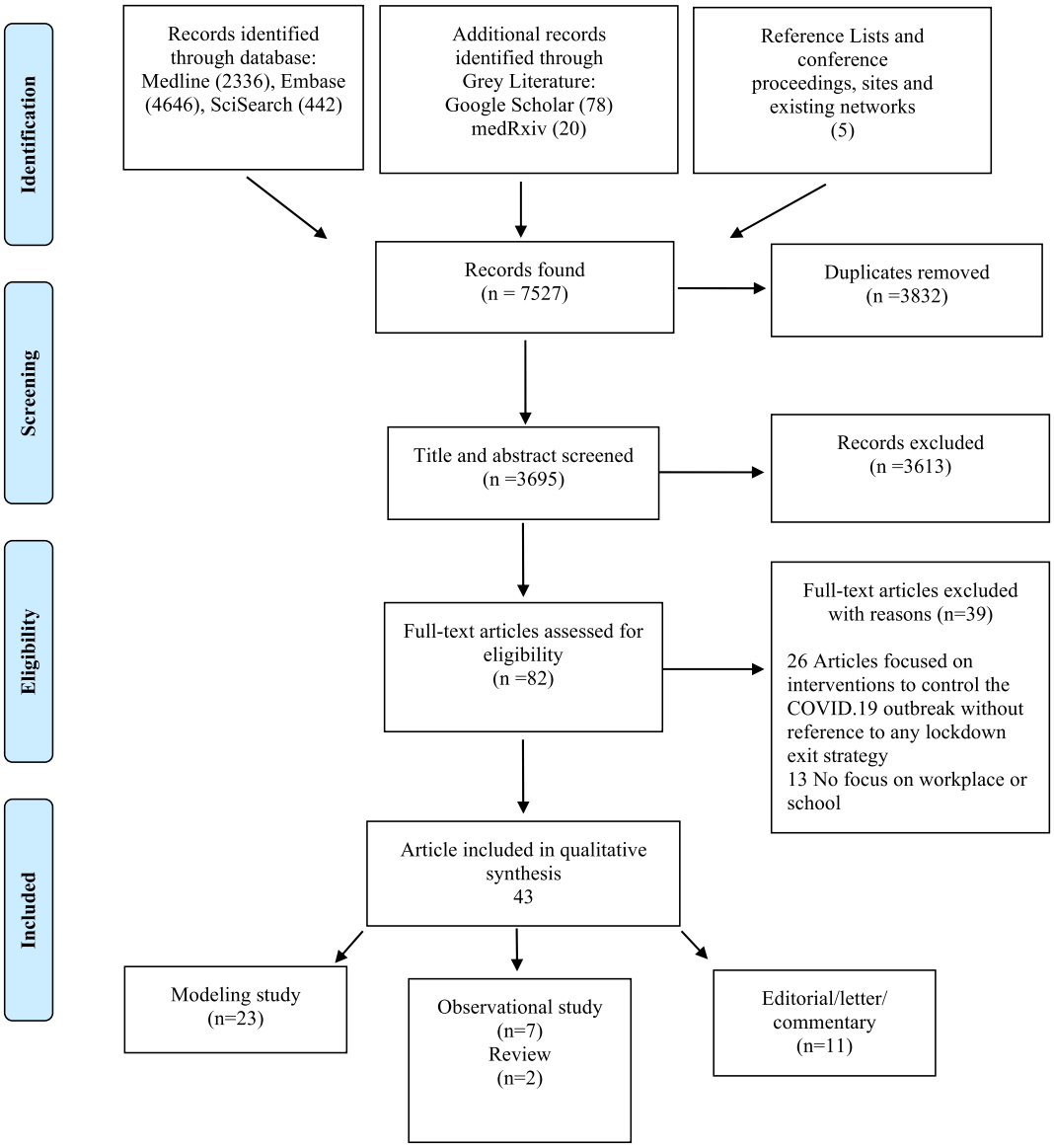

Fig. 1. Flow diagram of study selection process.

et al., 2020; Petersen et al., 2020; Potter et al., 2012; Sheikh et al., 2020; Stedman et al., 2020) pointed out how safe measures for reopening should be based on low COVID-19 infection rates and strict thresholds to immediately react to any new COVID cases or clusters. The maintenance of social distancing (D'Orazio, 2020; Keeling et al., 2020; Petersen et al., 2020; Prem et al., 2020) implemented through the reducing of class sizes, differentiating shifts, avoidance of mixing among children, and a partial school reopening with gradual increases (Castaldi et al., 2020; Di Domenico et al., 2020a; Fantini et al., 2020; Huang et al., 2014; McBryde et al., 2020; Sheikh et al., 2020; Wise, 2020) emerged as effective strategies. Additionally, large-scale testing, contact tracing and isolation measures (D'Orazio, 2020; Di Domenico et al., 2020a; Keeling et al., 2020; Panovska-Griffiths et al., 2020; Pollock, 2020; Wise, 2020), along with the above-mentioned strategies, were considered relevant to limiting the spread. The local implementation of careful risk assessment (i.e., daily temperature checks) and information systems consisting of the proper education of teachers and parents were also proposed as successful strategies to be implemented (Fantini et al., 2020). Before starting some relaxation measures, the duration of school closures (from 2 to 8 months) seemed to have a profound impact on reducing the number of cases at schools once reopened (Araz et al., 2013; Kim et al., 2020; Potter et al., 2012).

Three studies reminded us of the importance of wearing a face mask to reduce the amount of potentially infectious particles (Del Valle et al., 2010; Fantini et al., 2020; Sheikh et al., 2020), highlighting how their effectiveness is highly dependent on compliance (i.e., the proper wearing of masks in appropriate situations). Furthermore, they underlined how any relaxation measures need to be considered alongside provision of hygienic measures (i.e., hand washing, avoidance of sharing materials, and ventilation of rooms) (Fantini et al., 2020; Sheikh et al., 2020).

4. Discussion

This review collates the available literature on different strategies for exiting COVID-19 lockdown in the workplace and school.

Mathematical studies constituted 53% of all the analysed studies, with an overall low risk of infeasibility. The second most included articles were editorials/commentaries, followed by observational studies and narrative reviews. These results highlighted a gap in the literature, as the study designs are predominantly mathematical models, editorials, and observational studies over other designs, resulting in an extremely limited production of new clinical data to be implemented. A possible

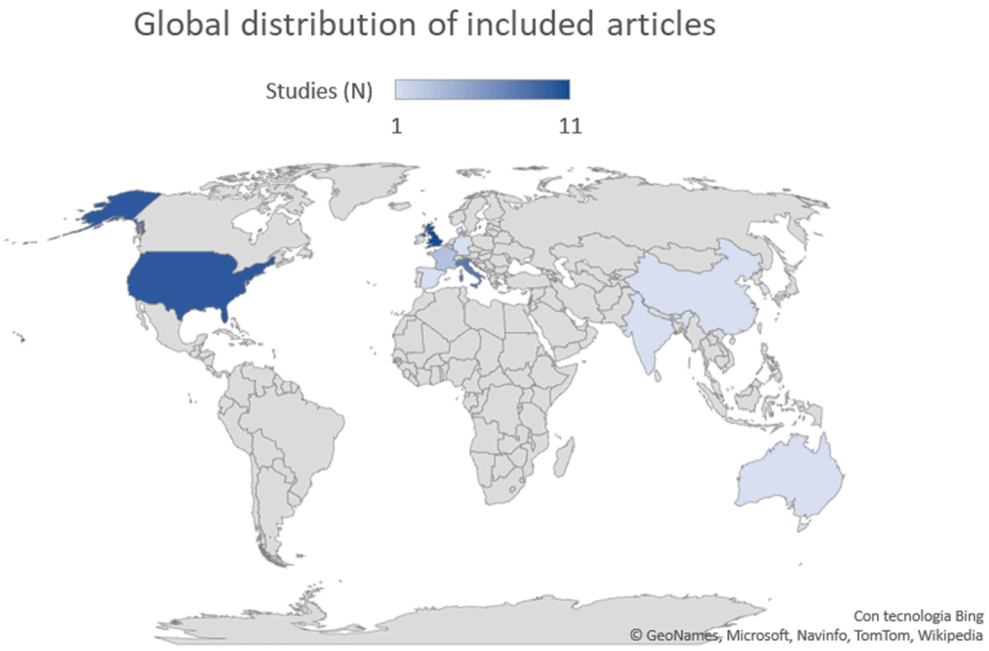

Fig. 2. Global distribution of the included articles.

Table 2
Breakdown of study designs by setting and country.

	Editorials/commentaries		Mathematical models		Observational studies		Narrative reviews	
	School	Workplace	School	Workplace	School	Workplace	School	Workplace
Country								
USA	2		3	2	1	2		
China					1			
Italy	2	2	1	4		1		
UK	4		3	5		1		
Germany				1				
Denmark							1	1
France			1	2				
Spain						1		
Belgium		1						
Netherlands				1				
Korea			1					
Australia			1	1				
India								1
Israel				1				
Total* N (%)	8 (16)	3 (6)	10 (20)	17 (34)	2 (4)	5 (11)		2 (4)

* Total exceeds the included studies, because some articles focused on two settings at the same time.

reason for the prevalence of such designs could be that experimental/cohort studies are more complex and take a longer time to complete. Therefore, when facing a public health crisis, to fill the lack of knowledge and share research as quickly as possible, researchers tend to use other forms of evidence (i.e., indirect evidence, reporting of cases, and sharing of clinical experiences) and post them on preprint servers (La Rosa et al., 2020).

Our review revealed the literature on school/workplace exit strategies were mainly based on general criteria that act like guiding principles, but it was lacking operational solutions. Furthermore, the attempt to differentiate by workplace and school revealed that, although derived from different articles, almost all the included studies dealt with the same strategies with marginal contextual differences.

From the selected articles clearly emerged that the epidemiological conditions and surveillance actions should be closely monitored and enforced. Indeed, before considering the implementation of any COVID-19 exit strategy, the epidemiological situation (i.e., R_0 and infection rate) must be under control to prevent reverting back to lockdown. Large-scale testing contact tracing and isolation strategies emerged as essential components that allowed easing of the lockdown. In particular, serological testing that detects immunoglobulins (IgM and IgG) specific for SARS CoV-2 emerged as an effective way to estimate the population exposure and to release workers with resulting immunity, even though it is not possible to quantify for how long the protection may last.

An important challenge in applying these strategies is that the ability to identify cases early may be hampered by a scarcity of reagents and other materials and to trace and isolate their contacts is also laborious and time-consuming. Specifically, performing an insufficient number of tests underestimates the transmission rate and overestimates the mortality (Giordano et al., 2020). Thus, in order to implement the test-trace-isolate strategy, logistical constraints need to be envisioned, and the success or failure of such strategies will depend on testing capacity and surveillance systems. It is reasonable to think that optimal exit strategies in countries with good diagnostic capacities and surveillance infrastructure are substantially different from those of developing countries.

The most analysed mitigation strategies are based on the general

Table 3
Mapping of exit strategies by setting and study methodology.

Return to work	Reopening school
Models	
Social distancing (Aleta et al., 2020; D'Orazio, 2020; Di Domenico et al., 2020b; German et al., 2020; Giordano et al., 2020; Hoertel et al., 2020; Lee et al., 2020; McBryde et al., 2020; Prem et al., 2020)	Low level of reproductive number (R0)/ monitoring epidemiological situation (Davey and Glass, 2008; Di Domenico et al., 2020a; Keeling et al., 2020; Potter et al., 2012)
Test and contact tracing (Aleta et al., 2020; Di Domenico et al., 2020b; Giordano et al., 2020; Goscé et al., 2020; Panovska-Griffiths et al., 2020)	Social distancing (D'Orazio, 2020; Keeling et al., 2020; Prem et al., 2020)
Quarantine and isolation (Aleta et al., 2020; Di Domenico et al., 2020b; German et al., 2020; Panovska-Griffiths et al., 2020)	Test and contact tracing (D'Orazio, 2020; Di Domenico et al., 2020a; Panovska-Griffiths et al., 2020)
Gradual returning (young, under 40 years, first) (Di Domenico et al., 2020b; Fokas et al., 2020; Rawson et al., 2020; Scala, 2020)	Isolation and quarantine (Di Domenico et al., 2020a; Panovska-Griffiths et al., 2020)
Shielding of vulnerable people(Di Domenico et al., 2020b; Goscé et al., 2020; Hoertel et al., 2020; Scala, 2020)	Duration of school closures (from 2 to 8 months) (Araz et al., 2013; Kim et al., 2020; Potter et al., 2012)
Wearing face masks (D'Orazio, 2020; Goscé et al., 2020; Hoertel et al., 2020)	Reopening primary school first with small size classes(Di Domenico et al., 2020a; Keeling et al., 2020)
Low infection rate/R_0 (Prem et al., 2020; Rawson et al., 2020)	Decrease age-assortative mixing(McBryde et al., 2020)
Serological testing to release positive workers from social distancing(German et al., 2020; Kraay et al., 2020)	
Decrease age-assortative mixing(McBryde et al., 2020)	
Reopening local connection before connecting cities further apart (Brethouwer, 2020)	
Cyclic schedules (i.e., short work weeks) (Karin et al., 2020)	
Editorials/commentaries	
Gradual returning (i.e., relevant sectors, young workers, no smart working) (Dewatripont, 2020; Ichino, 2020; Sheikh et al., 2020)	Reducing the class sizes/differentiated shifts (Castaldi et al., 2020; Fantini et al., 2020; Sheikh et al., 2020; Wise, 2020)
Incentives (i.e. interest-free loans, cut of the tax wedge) (Anderson et al., 2020a; Ichino, 2020)	Testing and contact tracing procedures (Fantini et al., 2020; Wise, 2020)
Serological testing for specific antibodies and RNA diagnostics (Dewatripont, 2020; Gilbert et al., 2020; Ichino, 2020)	Low infection rates (Fantini et al., 2020; Sheikh et al., 2020; Wise, 2020)
Social distancing measures (Castaldi et al., 2020; Gilbert et al., 2020; Ichino, 2020)	Wearing face masks(Del Valle et al., 2010; Fantini et al., 2020; Sheikh et al., 2020)
Quarantine/isolation (Gilbert et al., 2020; Ichino, 2020)	Avoidance the sharing of materials, frequent hand washing, ventilation of rooms and sanitisation of environments (Fantini et al., 2020; Sheikh et al., 2020)
Exempting from work vulnerable/high-risk(Gilbert et al., 2020; Ichino, 2020) workers	
Testing workers providing essential services with their progressive deconfinement (Gilbert et al., 2020)	
Smartphone app to track contagion (Ichino, 2020)	
Low infection rate (R_0) (Anderson et al., 2020a)	
Personal protective equipment (PPE) for those most at risk (Sheikh et al., 2020)	
Observational studies	
Serological tests/quarantine (Nuccetelli et al., 2020)	Low level of reproductive number (R_0) (Long et al., 2020)
Readiness index for returning (Alhaery and Suh, 2020a)	Risk level-based policies (Long et al., 2020)
Reopening first those areas with higher historic caseloads (Stedman et al., 2020)	Decrease mixing among children (Huang et al., 2014)
Determining who need to be tested by predicting the propensity of infection (Alhaery and Suh, 2020b)	
Applying a risk evaluation to decide the number of workers who can return to work(Hierro et al., 2020)	
Narrative Reviews	
Free of cases after 14 days of lockdown to create a 'COVID-19-free' area (Sarwal, 2020)	
Low infection rate (R_0), wearing non-medical face masks, social distancing, gradual returning, testing and contact tracing, and serological tests/ quarantine(Petersen et al., 2020)	Low infection rate (R_0), wearing non-medical face masks, social distancing, gradual returning, testing and contact tracing, and serological tests/quarantine (Petersen et al., 2020)

principle of the more a person interacts with several people and the longer and closer the contact, the higher the risk of COVID-19 spread (CDC). Thus, the maintenance of social distancing measures emerged as an overarching strategy to ease the lockdown.

The benefit gained from the practical implementation of social distancing (i.e., limiting classes to small cohorts of students, school shifts, avoidance of pattern mixing, gradual returning, and teleworking) was also well described (Di Domenico et al., b, 2020a; Huang et al., 2014; Ichino, 2020; McBryde et al., 2020). When social distancing is unfeasible (i.e., pre-school age children), measures such as use of class bubbles and hygiene measures were stressed (Sheikh et al., 2020).

Nevertheless, the guarantee of social distancing requires substantial reconfiguring of spaces, which may lead to considerable financial costs. In addition, there could be problems for equitable implementation of the strategies, as students from low-income families often attend schools with poor quality facilities. As a result, a gradual return may result in actual or perceived inequity.

It should be underlined that the successful implementation of any mitigation strategy is contingent on several key factors. One of the major challenges to be faced in applying the above-mentioned mitigation strategies is the adherence at the individual- and population-level. Indeed, the impact of such strategies depends critically on how people respond to their introduction, which may vary between countries, communities, and age groups, as well as tends to decrease over time (Meltzer, 2008; Iannone et al., 2020).

When lifting restrictions, attention should be given to protect workers and students considered "clinically extremely vulnerable". Notably, from the literature, it emerged that the combination of mitigation strategies (i.e., social distancing and quarantine) and shielding extremely vulnerable people was associated with better outcomes (Hoertel et al., 2020).

5. Strength and limitation

This review applies a systematic rigorous and comprehensive search strategy to retrieve relevant articles according to the research objectives. Nevertheless, as only two studies represented lower income country settings, our findings may not be generalised to those countries. Furthermore, our review did not include articles published in Chinese, which could introduce a knowledge gap, as China was most heavily affected by the epidemic.

The types of retrieved studies lacked diversity, especially clinical studies, and our results are mainly based on mathematical models and editorials. In this regard, it is important to recognise that the findings of mathematical modelling studies are only as good as the data and

assumptions that inform them. However, modelling may be suitable and influential in situations where urgent action is asked for and may be more suitable in public health than in clinical decision-making.

6. Conclusion

The findings of this review represent guiding strategies based on general principles that should be respected when easing the lockdown in schools and workplaces. The evidence suggests that, as schools and workplaces are part of the communities in which they are situated, each strategy should be reliant on the situation of the outbreak and on several thresholds of safeguards to anticipate the possibility of resurgence. Furthermore, mitigation strategies should be combined with other interventions (i.e., face masks and hygiene) contextualised at local circumstances and scaled up or down depending on the changing local epidemiological situation. In addition, specific policies will need to be in place for the most vulnerable workers and students.

Our result outlines the need for reporting the impact of the implementation of exit strategies tailored to the situation of the specific country. It would help to address the practical problems that manifest and help administrators define which resources, individual and other, need to be working. Further studies are needed to assess the effectiveness of such operational solutions, so government agencies might incorporate the scientific findings into public policies at the community, regional, and national levels.

Funding

None.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssci.2020.105067.

References

Aleta, A., Martin-Corral, D., Pastore, Y.P.A., Ajelli, M., Litvinova, M., Chinazzi, M., Dean, N.E., Halloran, M.E., Longini, I.M., Merler, S., Pentland, A., Vespignani, A., Moro, E., Moreno, Y., 2020. Modeling the impact of social distancing, testing, contact tracing and household quarantine on second-wave scenarios of the COVID-19 epidemic. medRxiv.

Alhaery, M., Suh, E., 2020a. A COVID-19 Reopening Readiness Index: The Key to Opening up the Economy. 2020.2005.2022.20110577.

Alhaery, M., Suh, E., 2020b. Returning to Work: A COVID-19 Testing Need Indicator. Available from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3585449.

Anderson, M., Mckee, M., Mossialos, E., 2020a. Developing a sustainable exit strategy for COVID-19: health, economic and public policy implications. J. R. Soc. Med. 113 (5), 176–178.

Anderson, R.M., Heesterbeek, H., Klinkenberg, D., Hollingsworth, T.D., 2020b. How will country-based mitigation measures influence the course of the COVID-19 epidemic? The Lancet 395 (10228), 931–934.

Araz, O.M., Lant, T., Fowler, J.W., Jehn, M., 2013. Simulation modeling for pandemic decision making: a case study with bi-criteria analysis on school closures. Decision Support Syst. 55 (2), 564–575.

Arksey, H., O'Malley, L., 2005. Scoping studies: towards a methodological framework. Int. J. Soc. Res. Methodol. 8 (1), 19–32.

Brethouwer JT, v.d.R.A., Lindelauf R, Fokkink R., 2020. Stay Nearby or Get Checked": A Covid-19 Lockdown Exit Strategy. Available from: https://arxiv.org/abs/2004.06891.

Castaldi, S., Romano, L., Pariani, E., Garbelli, C., Biganzoli, E., 2020. COVID-19: the end of lockdown what next? Acta Biomed. 91, 236–238.

CDC, Accessed on August 18th 2020. Available from: https://www.cdc.gov/nonpharmaceutical-interventions/.

Christakis, Dimitri A., 2020. School reopening—the pandemic issue that is not getting its due. JAMA Pediatr. 174 (10), 928. https://doi.org/10.1001/jamapediatrics.2020.2068.

D'Orazio M, B.G., Quagliarini E., 2020. How to restart? An agent-based simulation model towards the definition of strategies for COVID-19 "second phase" in public buildings. . https://arxiv.org/ftp/arxiv/papers/2004/2004.12927.pdf.

Davey, V.J., Glass, R.J., 2008. Rescinding community mitigation strategies in an influenza pandemic. Emerg. Infect. Dis. 14, 365–372.

Davies, N.G., Kucharski, A.J., Eggo, R.M., Gimma, A., Edmunds, W.J., Centre for the Mathematical Modelling of Infectious Diseases, C.-w.g., 2020. Effects of non-pharmaceutical interventions on COVID-19 cases, deaths, and demand for hospital services in the UK: a modelling study. Lancet Public Health 5, e375–e385.

De Sanctis, V., Ruggiero, L., Soliman, A.T., Daar, S., Di Maio, S., Kattamis, C., 2020. Coronavirus Disease 2019 (COVID-19) in adolescents: an update on current clinical and diagnostic characteristics. Acta Biomed. 91, 184–194.

Del Valle, Sara Y., Tellier, Raymond, Settles, Gary S., Tang, Julian W., 2010. Can we reduce the spread of influenza in schools with face masks? Am. J. Infect. Control 38 (9), 676–677.

Dewatripont M.G.M., Muraille, E., Platteau, J.P., 2020. Rapidly identifying workers who are immune to COVID-19 and virus-free is a priority for restarting the economy. Available from: https://voxeu.org/article/rapidly-identifying-workers-who-are-immune-covid-19-and-virus-free-priority-restarting-economy.

Di Domenico, L., Pullano, G., Sabbatini, C.E., Boëlle, P.-Y., Colizza, V., 2020a. Expected impact of reopening schools after lockdown on COVID-19 epidemic in Île-de-France. 2020.2005.2008.20095521.

Di Domenico, L., Pullano, G., Sabbatini, C.E., Boëlle, P.-Y., Colizza, V., 2020b. Impact of lockdown on COVID-19 epidemic in Île-de-France and possible exit strategies. 2020.2004.2013.20063933.

Esposito, Susanna, Principi, Nicola, 2020. School closure during the coronavirus disease 2019 (COVID-19) pandemic: an effective intervention at the global level? JAMA Pediatr. 174 (10), 921. https://doi.org/10.1001/jamapediatrics.2020.1892.

Fantini, Maria Pia, Reno, Chiara, Biserni, Giovanni Battista, Savoia, Elena, Lanari, Marcello, 2020. COVID-19 and the re-opening of schools: a policy maker's dilemma. Ital. J. Pediatr. 46 (1) https://doi.org/10.1186/s13052-020-00844-1.

Ferguson, N.M., L. D., Nedjati-Gilani, G., Imai, N., Ainslie, K., Baguelin, M., Bhatia, S., Boonyasiri, A., Cucunubá, Z., Cuomo-Dannenburg, G., Dighe, A., Dorigatti, I., Fu, H., Gaythorpe, K., Green, W., Hamlet, A., Hinsley, W., Okell, L.C., van Elsland, S., Thompson, H., Verity, R., Volz, E., Wang, H., Wang, H., Walker, P., Walters, C., Winskill, P., Whittaker, C., Donnelly, C.A., Riley, S., Ghani, A.C., 2020. Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand. Available from: https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf.

Fokas, A.S., Cuevas-Maraver, J., Kevrekidis, P.G., 2020. Two alternative scenarios for easing COVID-19 lockdown measures: one reasonable and one catastrophic. 2020.2005.2008.20095380.

German, R., Djanatliev, A., Maile, L., Bazan, P., Hackstein, H., 2020. Modeling Exit Strategies from COVID-19 Lockdown with a Focus on Antibody Tests. 2020.2004.2014.20063750.

Gibney, Elizabeth, 2020. Whose coronavirus strategy worked best? Scientists hunt most effective policies. Nature 581 (7806), 15–16.

Gilbert, Marius, Dewatripont, Mathias, Muraille, Eric, Platteau, Jean-Philippe, Goldman, Michel, 2020. Preparing for a responsible lockdown exit strategy. Nat. Med. 26 (5), 643–644.

Giordano, Giulia, Blanchini, Franco, Bruno, Raffaele, Colaneri, Patrizio, Di Filippo, Alessandro, Di Matteo, Angela, Colaneri, Marta, 2020. Modelling the COVID-19 epidemic and implementation of population-wide interventions in Italy. Nat. Med. 26 (6), 855–860.

Goscé, Lara, Phillips, Professor Andrew, Spinola, P., Gupta, Dr Rishi K., Abubakar, Professor Ibrahim, 2020. Modelling SARS-COV2 spread in London: approaches to lift the lockdown. J. Infect. 81 (2), 260–265.

Hierro, L.A., Cantarero, D., Patiño, D., Rodríguez-Pérez de Arenaza, D., 2020. Who can go back to work when the COVID-19 pandemic remits? PloS one 15, e0238299–e0238299.

Hoertel, N., Blachier, M., Blanco, C., Olfson, M., Massetti, M., Rico, M.S., Limosin, F., Leleu, H., 2020. Lockdown exit strategies and risk of a second epidemic peak: a stochastic agent-based model of SARS-CoV-2 epidemic in France. 2020.2004.2030.20086264.

Huang, Karen E., Lipsitch, Marc, Shaman, Jeffrey, Goldstein, Edward, 2014. The US 2009 A(H1N1) influenza epidemic: quantifying the impact of school openings on the reproductive number. Epidemiology 25 (2), 203–206.

Ichino, A.C.G., Mattozzi, A., Rustichini, A., Zanella, A., Anelli, M., 2020. Transition steps to stop COVID-19 without killing the world economy. Available from: https://voxeu.org/article/transition-steps-stop-covid-19-without-killing-world-economy.

Iannone, P., Castellini, G., Coclite, D., Napoletano, A., Fauci, A.J., Iacorossi, L., D'Angelo, D., Renzi, C., La Torre, G., Mastroianni, C.M., Gianola, S., 2020. The need of health policy perspective to protect Healthcare Workers during COVID-19 pandemic. A GRADE rapid review on the N95 respirators effectiveness. PloS One 15, e0234025.

Karin, O., Bar-On, Y.M., Milo, T., Katzir, I., Mayo, A., Korem, Y., Dudovich, B., Yashiv, E., Zehavi, A.J., Davidovich, N., Milo, R., Alon, U., 2020. Adaptive cyclic exit strategies from lockdown to suppress COVID-19 and allow economic activity. 2020.2004.2004.20053579.

Keeling, M.J., Tildesley, M.J., Atkins, B.D., Penman, B., Southall, E., Guyver-Fletcher, G., Holmes, A., McKimm, H., Gorsich, E.E., Hill, E.M., Dyson, L., 2020. The impact of school reopening on the spread of COVID-19 in England. 2020.2006.2004.20121434.

Kim, S., Kim, Y.J., Peck, K.R., Jung, E., 2020. School opening delay effect on transmission dynamics of coronavirus disease 2019 in Korea: based on mathematical modeling and simulation study. J. Korean Med. Sci. 35, e143.

Kraay, A.N.M., Nelson, K., Zhao, C., Weitz, J.S., Lopman, B.A., 2020. Modeling serological testing to inform relaxation of social distancing for COVID-19 control. medRxiv.

Kupferschmidt, Kai, 2020. The lockdowns worked—but what comes next? Science 368 (6488), 218–219.

La Rosa, G., Mancini, P., Bonanno Ferraro, G., Veneri, C., Iaconelli, M., Bonadonna, L., Lucentini, L., Suffredini, E., 2020. SARS-CoV-2 has been circulating in northern Italy since December 2019: evidence from environmental monitoring. 2020.2006.2025.20140061.

Lee, S., Zabinsky, Z.B., Kofsky, S.M., Liu, S., 2020. COVID-19 Pandemic Response Simulation: Impact of Non-pharmaceutical Interventions on Ending Lockdowns. 2020.2004.2028.20080838.

Levac, Danielle, Colquhoun, Heather, O'Brien, Kelly K, 2010. Scoping studies: advancing the methodology. Implementation Sci. 5 (1) https://doi.org/10.1186/1748-5908-5-69.

Long, C., Zeng, T., Fu, X., 2020. Little Risk of the COVID-19 Resurgence on Students in China (outside Hubei) Caused by School Reopening. 2020.2004.2004.20053645.

McBryde, E.S., Trauer, J.M., Adekunle, A., Ragonnet, R., Meehan, M.T., 2020. Stepping out of lockdown should start with school re-openings while maintaining distancing measures. Insights from mixing matrices and mathematical models. 2020.2005.2012.20099036.

McKee, M., 2020. A European roadmap out of the covid-19 pandemic. BMJ 369, m1556.

Meltzer, M.I., 2008. Pandemic influenza, reopening schools, and returning to work. Emerg. Infect. Dis. 14, 509–510.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., Group, P., 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 6, e1000097.

Nuccetelli, Marzia, Pieri, Massimo, Grelli, Sandro, Ciotti, Marco, Miano, Roberto, Andreoni, Massimo, Bernardini, Sergio, 2020. SARS-CoV-2 infection serology: a useful tool to overcome lockdown? Cell Death Discov. 6 (1) https://doi.org/10.1038/s41420-020-0275-2.

Panovska-Griffiths, J., Kerr, C., Stuart, R.M., Mistry, D., Klein, D., Viner, R.M., Bonell, C., 2020. Determining the optimal strategy for reopening schools, work and society in the UK: balancing earlier opening and the impact of test and trace strategies with the risk of occurrence of a secondary COVID-19 pandemic wave. 2020.2006.2001.20100461.

Peters M.D.J., Godfrey, C., McInerney, P., Baldini Soares, C., Khalil, H.D.P., 2017. Chapter 11: Scoping Reviews In: Aromataris E, Munn Z (Editors). Joanna Briggs Institute Reviewer's Manual. The Joanna Briggs Institute. Available from https://reviewersmanual.joannabriggs.org/.

Petersen, Eskild, Wasserman, Sean, Lee, Shui-Shan, Go, Unyeong, Holmes, Allison H., Al-Abri, Seif, McLellan, Susan, Blumberg, Lucille, Tambyah, Paul, 2020. COVID-19–We urgently need to start developing an exit strategy. Int. J. Infect. Dis. 96, 233–239.

Pollock, A.M., 2020. Covid-19: local implementation of tracing and testing programmes could enable some schools to reopen. BMJ 368, m1187.

Porgo, Teegwendé V., Norris, Susan L., Salanti, Georgia, Johnson, Leigh F., Simpson, Julie A., Low, Nicola, Egger, Matthias, Althaus, Christian L., 2019. The use of mathematical modeling studies for evidence synthesis and guideline development: a glossary. Res. Syn. Meth. 10 (1), 125–133.

Potter, M.A., Brown, S.T., Cooley, P.C., Sweeney, P.M., Hershey, T.B., Gleason, S.M., Lee, B.Y., Keane, C.R., Grefenstette, J., Burke, D.S., 2012. School closure as an influenza mitigation strategy: how variations in legal authority and plan criteria can alter the impact. BMC Public Health 12, 977.

Prem, K., Liu, Y., Russell, T.W., Kucharski, A.J., Eggo, R.M., Davies, N., Centre for the Mathematical Modelling of Infectious Diseases, C.-W.G., Jit, M., Klepac, P., 2020. The effect of control strategies to reduce social mixing on outcomes of the COVID-19 epidemic in Wuhan, China: a modelling study. Lancet Public Health 5, e261–e270.

Rawson, T., Brewer, T., Veltcheva, D., Huntingford, C., Bonsall, M.B., 2020. How and when to end the COVID-19 lockdown: an optimization approach. Front Public Health 8, 262.

Sarwal R, S.T., 2020. Mitigating COVID-19 With Lockdowns: A Possible Exit Strategy. Available at SSRN: https://ssrn.com/abstract=3563538.

Scala, Antonio, Flori, Andrea, Spelta, Alessandro, Brugnoli, Emanuele, Cinelli, Matteo, Quattrociocchi, Walter, Pammolli, Fabio, 2020. Time, space and social interactions: exit mechanisms for the Covid-19 epidemics. Sci. Rep. 10 (1) https://doi.org/10.1038/s41598-020-70631-9.

Sheikh, A., Sheikh, A., Sheikh, Z., Dhami, S., Sridhar, D., 2020. What's the way out? Potential exit strategies from the COVID-19 lockdown. J. Glob. Health 10, 010370.

Stedman, M., Davies, M., Lunt, M., Verma, A., Anderson, S.G., Heald, A.H., 2020. A phased approach to unlocking during the COVID-19 pandemic-Lessons from trend analysis. Int. J. Clin. Pract. e13528.

Tricco, Andrea C., Lillie, Erin, Zarin, Wasifa, O'Brien, Kelly K., Colquhoun, Heather, Levac, Danielle, Moher, David, Peters, Micah D.J., Horsley, Tanya, Weeks, Laura, Hempel, Susanne, Akl, Elie A., Chang, Christine, McGowan, Jessie, Stewart, Lesley, Hartling, Lisa, Aldcroft, Adrian, Wilson, Michael G., Garritty, Chantelle, Lewin, Simon, Godfrey, Christina M., Macdonald, Marilyn T., Langlois, Etienne V., Soares-Weiser, Karla, Moriarty, Jo, Clifford, Tammy, Tunçalp, Özge, Straus, Sharon E., 2018. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann. Intern. Med. 169 (7), 467. https://doi.org/10.7326/M18-0850.

WHO, 2020. WHO/Europe advice for gradual easing of COVID-19 measures. Available from: https://www.who.int/news-room/feature-stories/detail/who-europe-advice-for-gradual-easing-of-covid-19-measures.

Wise, J., 2020. Covid-19: Delaying school reopening by two weeks would halve risks to children, says iSAGE. BMJ 369, m2079.

Xu, C.L.H., Raval, M., Schnall, J.A., Kwong, J.C., Holmes, N.E., 2020. Duration of respiratory and gastrointestinal viral shedding in children with SARS-CoV-2: a systematic review and synthesis of data. Pediatr. Infect. Dis. J. 39, e249–e256.