School closure and management practices during coronavirus outbreaks including COVID-19: a rapid narrative systematic review

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School closure and management practices during coronavirus outbreaks

including COVID-19: a rapid narrative systematic review

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Abstract

Background
COVID-19 was declared a pandemic by the WHO on 12 March 2020 and UNESCO reported that day that 49 countries had implemented national or subnational school closures. Evidence for the effectiveness for school closures comes almost entirely from influenza outbreaks, where transmission tends to be driven by children. It is unknown whether school measures are effective in coronavirus outbreaks e.g. due to SARS, or MERS and COVID-19.

Methods
We undertook a rapid systematic review of 2 electronic databases and a preprint server to identify what is known about the effectiveness of school closure and other social school social distancing practices on infection during coronavirus outbreaks.

Results
We identified 498 articles, of which 13 are included in this review (9 published; 4 preprint articles considered sufficient quality to include). All published papers concerned the 2003 SARS outbreak and 3 preprints concerned COVID-19. School closures were deployed rapidly across China and Hong Kong for COVID-19, however there are no data on the relative contribution of school closure to control of transmission. Data from the SARS outbreak in China, Hong Kong and Singapore suggest that school transmission played no significant role in the outbreak and that school closures did not contribute to control of the epidemic. Modelling studies of SARS produced conflicting results.

Conclusions
Available evidence is consistent with a broad range of impacts of school closures, from little benefit for reducing transmission through to more substantial effects. Yet the economic costs and potential harms of school closure are very high. Data from influenza outbreaks suggests that school closures have low benefits in outbreaks with high transmissibility as with COVID-19. Policymakers need to be aware of the equivocal evidence when proposing or implementing school closures for COVID-19, and consideration should be given to other less disruptive social distancing interventions in schools.
Research in context

Evidence before this study

Four systematic reviews have examined the effects of school social distancing, particularly school closures on disease transmission during influenza outbreaks. School closures are likely to have the greatest effect if the virus has low transmissibility and attack rates are higher in children than adults.

The effects of school closure are reduced by continued child-child social contacts outside school and potentially increase child-adult contacts due to the need for unofficial and grandparent child-care. The economic harms of school closures are high. Costs have been estimated to be as high as 0.2-1% of UK national gross domestic product (GDP) for school closure for 12-13 weeks.

Forced work absenteeism of healthcare staff due to school closures can significantly reduce the benefits of school closures.

Added value of this study

We provide the first systematized summary of the evidence of benefit of school closure and other school social distancing interventions in coronavirus outbreaks i.e. SARS, MERS and COVID-19.

Data from the SARS epidemic do not support a role for school closures in the control of coronavirus infections. Emerging data from the COVID-19 pandemic do not yet allow an assessment of the value of school closures separately to other infection control measures.

Implications of all the available evidence

There is a lack of policy-relevant data on implementation of school social distancing during coronavirus outbreaks. However data from influenza outbreaks showing benefits of school closures cannot necessarily be applied to COVID-19. Indeed, systematic reviews suggest that school closures have only small effects in infections with a high reproductive number (R) and where children are not the main drivers of infection, such as in COVID-19. Policymakers need to be aware of the equivocal evidence when proposing or implementing national or regional school closures for COVID-19, given the very high costs of lengthy school closures during pandemics. Policymakers should also look to other school social distancing interventions that are likely to be much less disruptive.
Background

The World Health Organisation (WHO) declared the COVID-19 outbreak to be a pandemic on 12 March 2020. UNESCO reported the same day that 29 countries had implemented national school closures related to COVID-19, affecting 391 million children and young people, with a further 20 countries implementing localised school closures. School closures are based upon evidence and assumptions that they reduce social contacts between students and therefore interrupt transmission. Studies of UK children and young people report that mean numbers of daily social contacts during school holidays are approximately half that of school term days; however mixing between children and adults and between children at different schools increases during holidays.

The evidence for the effectiveness for school closures and other school social distancing measures comes almost entirely from influenza outbreaks for which transmission and spread of the virus tends to be driven by children. It is unclear whether school measures are effective in coronavirus outbreaks e.g. due to SARS, or MERS and most specifically, COVID-19, for which transmission dynamics appear to be different.

School closures and influenza outbreaks

Four systematic reviews of the effects of school closure on influenza outbreaks or pandemics suggest that school closure can be a useful control measure although the effectiveness of mass school closures is often low. School closure strategies may be national, regional, local or based upon closure of individual schools dependent on a trigger such as student infection rates. A systematic review commissioned by the UK Department of Health in 2014, to inform Influenza Pandemic Preparations, included 100 epidemiological and 45 modelling studies and concluded that: 1) school closures can reduce transmission of pandemic influenza if instituted early in outbreaks; 2) school closure results in greater reductions in peak than in cumulative attack rates; and 3) modelling studies suggest that school closures are likely to have the greatest effect if the virus has low transmissibility and attack rates are higher in children than adults. A second review of modelling studies by the same authors made similar conclusions.

A 2018 review of 31 studies that addressed whether school closure had a quantifiable effect on influenza transmission reported that school closure reduced the peak of the related outbreak by a mean of 29.7% and delayed the peak by a median of 11 days. They also reported that earlier school closure predicted greater reduction in the outbreak peak. These latter estimates did not come from formal meta-analyses. A 2015 systematized review of social distancing practices including school closures for influenza pandemics reported a wide variation in reduction of transmission (range 1-50%) but noted that there is evidence that up to 70% of students may shift social contacts to other non-school sites during closures, reducing the impact of closures.

Reviews have noted the adverse effects of school closure, including broader economic harms to working parents, healthcare workers being forced from critical work to childcare, and to society due to loss of parental productivity, transmission from children to vulnerable grandparents, loss of education, issues due to children being left to self-care or in the care of siblings and nutritional issues where free school meals are an important source of nutrition. Social isolation itself brings a range of psychological harms.

The economic harms of school closures are high. A UK study from 2005 suggested that approximately 16% of the workforce are the main caregivers for dependent children and at very high risk of absenteeism if schools are closed, a proportion that rises to 30% in the health and social care sectors. A 2010 economic modelling analysis of school closures as mitigating interventions during
influenza outbreaks suggested that 4 or 13 week closures reduced the clinical attack rate minimally but markedly increased the economic cost to the nation, in particular through forced absenteeism by working parents. Costs have been estimated to be as high as 0.2-1% of UK national gross domestic product (GDP) for school closure for 12-13 weeks or up to 3% of GDP for an 8 week closure in US studies. Reviews have not summarized economic harms from school closure in detail, but economic modelling from an influenza outbreak in Hong Kong suggested that the most cost-effective models were selective local closures rather than national closures.

Note that regardless of official school closure or other distancing policies, unofficial student and staff absenteeism (whether due to illness or precautionary) can be very high during epidemics. Staff absenteeism can lead to forced local school closures.

Other school management practices

There are many other potential social distancing actions available for schools that are less drastic than full closure, although these receive little attention. A 2018 systematic review of such strategies noted that potential practices include suspending affected classes or grades, or changing school organisation to reduce student mixing, e.g. by closing playgrounds and cancelling non-essential activities and meetings, keeping students in constant class groups/classrooms, increasing spacing between students in classes, reducing the school week (to 3 or 4 days) and staggering school start and lunch/break times across years or classes. The review concluded that the literature was very limited but that a small number of modelling studies supported use of alternative strategies during influenza outbreaks. There were no UK studies included in this review. In the 2009 H1N1 influenza pandemic, Taiwan instituted class suspensions rather than school closures, as in Taiwan students remain in a home-room with a core teacher and other teachers routinely move between classes. Studies suggest this was an effective social distancing measure in this outbreak whilst reducing social disruption.

COVID-19 and school closures

As noted above, by March 2020 many countries have instituted large scale or national closure of schools aimed at reducing transmission of COVID-19. These actions appear largely based upon assumptions that the benefits apparent in influenza outbreaks are also likely for COVID-19.

There are a number of theoretical reasons why school closures may be less effective in COVID-19 than in influenza outbreaks. Children contribute more to influenza transmission than do adults, with higher levels of transmission due to symptomatic disease. However in the COVID-19 epidemic thus far, children appear to form a much lower proportion of cases than expected from their population, although the most recent data suggests that children may be as likely to be infected as adults but largely have asymptomatic or mild disease. It remains unclear whether the low proportion of confirmed COVID-19 cases amongst children in China relate to reduced risk of infection, to having subclinical or milder infections or relate to specific aspects of the population in China (e.g. one child policy). Evidence of COVID-19 transmission through child-child contact or through schools is not yet available, although family transmission is central.

In some previous coronavirus outbreaks, evidence suggested that transmission in schools was very low or absent. As modelling studies of school closures for influenza outbreaks rely on assumptions about the proportion of cases transmitted in schools being relatively high, these models cannot be assumed to be informative regarding effectiveness for COVID-19. Emerging epidemiological data suggest there has been little evidence of transmission through schools in China, although this may reflect closure of schools during most of the outbreak. At the time of writing, Taiwan has been recognised to have effectively minimised spread of COVID-19; national policies have avoided
proactive widespread school closures and have mandated initially local class closures then local temporary school closures based upon low thresholds for infected cases within individual schools.26

In view of the lack of information and pressure on countries to consider school closures to deal with the COVID-19 pandemic, we performed a rapid systematic review of the literature on the effects of school closure or alternative school social distancing practices in coronavirus outbreaks.

Methods

We undertook a systematic review to answer the question “What is known about the use of and effectiveness of school closure and other school social distancing practices on infection during coronavirus outbreaks?” We undertook searches of electronic databases as follows:

1. Search of PubMed
We searched PubMed on the 9th March 2020 using the following search terms:


Our search was designed to be inclusive of any studies providing data on schools or nurseries in relation to the viruses specified. We focused the search on closure and social distancing practices at the full text stage.

The search identified 116 articles. All articles were triple screened (SR, HC, JP) on title and abstract. We excluded opinion pieces, systematic reviews, studies addressing other viruses, university-specific settings, epidemiological studies (e.g. of prevalence of infection in schools) and studies in Chinese with no translation. This resulted in 22 potentially eligible studies for which full texts were obtained. Full text review was conducted by one author (RV) and 8 articles were included in the review.

2. Search of the WHO Global Research Database on COVID-19. As a search using the term ‘school’ only retrieved 1 article (excluded as it did not contain research), we undertook a 2-stage search. We initially used the search terms child, children, childhood, infant, baby, babies, pediatric, paediatric and identified 15 papers, of which 7 were excluded as lacking English translations. Secondly, we retrieved the full text of the remaining 8 studies to identify any relevant to the search question. No articles were included.

3. Search of the preprint server medRxiv on 10 Feb 2020 for all papers related to the search terms ‘SARS or MERS or coronavirus or COVID-19’. It was not judged useful to include search terms relating to schools as the search facilities were not sophisticated. The search yielded 373 articles, which were double screened by SR, HC, JP, using exclusion criteria consistent with the PubMed searches. 30 articles were considered potentially relevant on title and abstract review. After full text review, 4 were included.

4. Hand and citation searching

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=3556648
For each retrieved full text article, we hand searched included references and examined the citation chain for additional studies. 1 additional article was identified.

Quality: We made no attempt to rate the quality of included studies in this rapid review. We considered preprint articles separately to published peer-reviewed articles.

Findings

Thirteen studies (9 published papers and 4 preprint papers) were included in the review (see Figure 1).

Organism: All published papers concerned the 2003 SARS outbreak. One unpublished paper concerned the impact of school closures on transmission of other (endemic) coronaviruses (229E, NL63, OC43, HKU1) and three preprints concerned the COVID-19 pandemic.

Study type: Six papers described and/or evaluated school actions as part of control measures undertaken in response to the SARS outbreak in Taiwan,20 Singapore27-29 and Beijing, China.30 31 Two papers were modelling studies that estimated SARS transmission in schools32 or the impact of school closure33 on transmission in SARS outbreaks. One paper reported qualitative research with healthcare workers post SARS.34 Three preprint papers reported on school closures during the COVID-19 outbreak in China35 36 and Hong Kong.37 One preprint paper described the impact of school closure on winter transmission of other human coronaviruses.38

Effectiveness of School social distancing measures

COVID-19

Preprint studies report that school closures were initiated nationally across China in late January 2020 (manifesting as delaying the restarting of schools after Chinese New Year holidays) as part of a broader series of control measures during the COVID-19 epidemic. No data are available on the effectiveness of school closure, as 1) there was little variation in timing of closures (closures were reportedly applied in all Chinese cities uniformly and without delay); and 2) school closures were part of a broad range of quarantine and social distancing measures. Both studies concluded that the overall package of quarantine and social distancing was effective in reducing the epidemic in China,35 36 although the relative contribution of school closures was not assessed.

A preprint review of actions in Hong Kong related to COVID-19 noted that a 4-week school closure was initiated across Hong Kong on 31 January 2020, approximately 1 week after the first cases were identified in Hong Kong. School closures were then extended to 16 March 2020. As with China, no data were available on the impact of school closures.37

SARS

School closures were initiated during the SARS epidemic in Beijing on 24 April 2003, approximately 6 weeks after the beginning of the outbreak, remaining closed in many cases for over 2 months. The authors concluded that school closures made very little difference to the prevention of SARS in Beijing, given the very low attack rate in schools before closure and the low prevalence of disease in children during the SARS.30 A second study estimated the effective reproductive number (R) for each day of the Beijing SARS outbreak, noting that school closures occurred after the R had dropped below 1, and also concluded that school closures in this case added little to control of the outbreak.31 Class cancellation strategies, in which upper high-school and college students remained on college campuses but did not attend classes, were also widely used during the SARS outbreak in China.39 There was no recorded transmission of SARS in schools during the outbreak in China.40
A review of the 2003 SARS outbreak in Singapore noted that twice-daily mandatory temperature screening of all children 6-16 years in schools was part of the containment measures instituted. Pupils were excluded from school if their temperature was >37.8°C for students ≤12 years old or >37.5°C for students >12 years old. Whilst there were school children diagnosed with SARS in Singapore, none were identified through temperature screening. All educational facilities in Singapore were closed for 3 weeks from 27 March 2003 (the SARS outbreak ran from late February to May 2003) together with suspension of other activities to prevent the congregation of large groups of children.

A review of responses in Taiwan to the SARS and 2009 H1N1 influenza pandemics noted that schools were designated as alternative health care sites in case the health system was overwhelmed during the SARS outbreak, but that there were no school social distancing measures introduced during the SARS outbreak. This is in contrast to the use of class suspensions during the H1N1 pandemic in Taiwan.

Schools were also closed in Hong Kong during the SARS epidemic; however the extent to which this was national or local is unclear. There was no evidence of spread of infection in schools, with spread amongst children almost entirely through family settings and apartments.

Endemic coronaviruses
An unpublished study by Jackson et al. examined the effects of a 5-day closure of nearly all schools in the greater Seattle metropolitan area in February 2019 due to extreme weather on transmission of endemic human coronaviruses (229E, NL63, OC43, HKU1) and other viruses using routine viral surveillance. They estimated that the school closure resulted in a 5.6% (95% CI: 4.1, 6.9) reduction in coronavirus infections, similar to influenza H1N1 (7.6%) but higher than influenza H3N2 (3.1%) which all were prevalent at the time.

Modelling studies
SARS
An early modelling study of a SARS-like illness in school children concluded that a school closure policy would reduce the effective $R$ by 12-41% depending on the proportion of between-household mixing that occurred during school hours. The study noted that modelling was based upon ‘plausible assumptions’ regarding SARS behaviour, noting that obtaining good quality estimates of epidemiological parameters for SARS was difficult as the outbreak was contained rapidly.

A modelling study of the transmission of SARS in hospitals and in elementary school classrooms in Taiwan using data from the 2003 SARS outbreak concluded that a single case of SARS would infect 2.6 secondary cases on average in a population from hospital transmission, whereas less than 1 secondary infection was generated per case in a school classroom.

Broader societal issues
Conflict between the work and family requirements of healthcare professionals during the SARS epidemic was explored in qualitative research with 100 Canadian emergency and critical care nurses, many of whom had been involved with the SARS outbreak. The study found that healthcare workers experience substantial personal dilemmas in balancing work and family commitments, particularly relating to child-care needs if schools or child-care are closed. The study concluded there was a need for provision of adequate resources to protect the families of healthcare workers during outbreaks to maintain maximal staffing.
Discussion

This rapid review provides the first summary of data on school closures and other social distancing practices during coronavirus outbreaks. We were able to include only 9 published studies and 5 as yet unpublished studies. We decided to include unpublished studies as data would not otherwise be available on COVID-19, although findings were interpreted with caution. None of the included studies were designed to specifically examine the effectiveness of school distancing measures. Thus data provided on the impact of school measures were of relatively low quality.

We identified a remarkable lack of policy-relevant data on implementation of school social distancing during coronavirus outbreaks. This is perhaps not surprising for the rapidly emerging COVID-19 pandemic, but previous coronavirus outbreaks such as SARS and MERS provide limited information about the effectiveness of school closures and no data on cost-effectiveness. We identified no data on other school social distancing practices during coronavirus outbreaks.

School closures were rapidly deployed across China and Hong Kong in early 2020 as part of a wider set of control measures for COVID-19, with the result that no data were available on the comparative effectiveness of school closure interventions in isolation. Authors of unpublished studies concluded that school closures likely contributed to the control of COVID-19 as part of a package of very broad quarantine measures; however they provide no data to back up this assertion and indeed it may be very difficult to disentangle the relative contribution of school closures.

Data from the SARS outbreak in China, Hong Kong and Singapore suggest that school transmission played no significant role in the outbreak and that school closures and other activities such as school temperature monitoring did not contribute to control of infection transmission. It is possible that these reflect an effect of school closures in rapidly stopping transmission; however this is unlikely as schools remained open for significant periods during the early part of the outbreak in each country. Modelling studies from the SARS outbreak produced differing results. Whilst Becker et al. 2005 estimated that school closure resulted in potentially important reductions in transmission, Liao et al. 2005 estimated that transmission in school classrooms was low.

Conclusions and policy implications

There are few data available from the literature on coronavirus outbreaks to guide countries on the use of school closures or other school social distancing practices during COVID-19. Available evidence is consistent with a broad range of impacts of school closures, from little benefit for reducing transmission through to more substantial effects. Yet the economic costs and potential harms of school closure are undoubtedly very high.

As evidence from coronavirus outbreak control is limited, we must turn to evidence for the benefits of school closures from influenza epidemics and pandemics. School closures have been widespread in some countries during influenza pandemics, and many studies report important impacts on reducing transmission and the size of the pandemic. Yet there is considerable heterogeneity in the impact of school closures on transmission depending on characteristics of influenza serotype transmission. Systematic reviews of influenza outbreaks suggest that school closures are likely to have the greatest effect if the virus has low transmissibility ($R < 2$), particularly if attack rates and transmission are higher in children than adults.\footnote{Whilst our information on SARS-CoV-2 remains incomplete, this appears not to be the case with COVID-19. Reported $R$ for COVID-19 are high (2.5 or higher).} Whilst our information on SARS-CoV-2 remains incomplete, this appears not to be the case with COVID-19. Reported $R$ for COVID-19 are high (2.5 or higher).\footnote{Whilst children appear to contract infection at the same rate as adults, they largely have mild or asymptomatic disease and appear therefore to be less likely to spread the virus through coughing or sneezing, although information are lacking. It is notable that analyses using UK clinical data from the 1957 (Asian) influenza pandemic suggested that closure of schools would reduce the attack rates (2.5 or higher).} Whilst children appear to contract infection at the same rate as adults, they largely have mild or asymptomatic disease and appear therefore to be less likely to spread the virus through coughing or sneezing, although information are lacking. It is notable that analyses using UK clinical data from the 1957 (Asian) influenza pandemic suggested that closure of schools would reduce the
epidemic by less than 10% when the $R$ was similar to COVID-19 (i.e. 2.5-3.5). Reviews also note that the benefits of school closure may be less than assumed or modelled as social contacts between children and children and adults continue as part of informal child-care and non-school gatherings of children and young people. This is a particular concern for COVID-19, with its higher mortality amongst the elderly, as around 40% of the UK’s grandparents provide regular childcare for their grandchildren.

The WHO Director General noted on 12 March 2020 that “All countries must strike a fine balance between protecting health, preventing economic and social disruption, and respecting human rights.” Currently the evidence to support national closure of schools to combat COVID-19 is very weak and data from influenza outbreaks suggest school closures may have relatively small effects on a virus with COVID-19’s high transmissibility and apparent low impact upon school children. Yet these same data shows that school closures can have profound economic and social consequences.

More research is urgently needed on the effectiveness of school closures in COVID-19. However observational studies may be relatively uninformative if closures are national and implemented at the same time as other mitigation measures. Better learning may come from countries that have instituted later or subnational closures. Modelling studies, particularly those parameterised for COVID-19 in children, and that can consider interaction with other contextual factors (e.g. timing, parents working from home, additional social mixing as a consequence of school closures) or different strategies (national vs staged roll out) are likely to be more informative and are urgently needed.

These findings a dilemma for policy-makers seeking measures to protect populations. School closure presents an apparently logical method of dramatically reducing spread of disease and the evidence from previous influenza outbreaks appears compelling. Yet policymakers need to be aware of the equivocal evidence when proposing or implementing national or regional school closures for COVID-19, given the very high costs of lengthy school closures during pandemics. Decisions about closures involve a series of trade-offs between conflicting factors, and a substantial loss of healthcare staff to child-care duties during closures may substantially reduce any benefit to health systems and populations brought by closures of schools. We note that Taiwan did not initiate national school closures during COVID-19 but has been recognised to have effectively minimised spread of COVID-19. Policymakers should also look to other school social distancing interventions that are likely to be much less disruptive. Whilst evidence is also lacking for the effectiveness of these practices, they may be implementable with much less disruption, financial costs or harms.
Contributions

RV conceptualised the paper, undertook full text reviews and data extraction and wrote the paper. Searches and screening were undertaken by SR, HC and JP, advised by CS. JW and OW contributed to screening. RB and OM helped revise the paper and consider policy implications. All authors contributed to revision of the final paper.

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Conflicts of interest.
All authors declare they have no conflicts of interest.
PubMed
116 articles

Excluded
94 articles

Potential eligible
22 articles reviewed in
full text

WHO Global Research Database
on COVID-19
8 articles

Excluded
8 articles

Handsearching
1 article

Included
8 articles

Excluded
8 articles

medRxiv
preprint server
373 articles

Excluded
343 articles

30 potentially
eligible articles

Excluded
26 articles

Final inclusion
13 studies:
9 published articles & 4
preprint articles

Figure 1. Flow chart for search

This preprint research paper has not been peer reviewed. Electronic copy available at: https://ssrn.com/abstract=3556648


34. O'Sullivan TL, Amaratunga C, Phillips KP, et al. If schools are closed, who will watch our kids? Family caregiving and other sources of role conflict among nurses during large-scale


43. 5 million grandparents take on childcare responsibilities, 2017.