Systematic review.

Violations of stated methodology and misreported results in Viner and colleagues' School Closures Review

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Summary

A heavily media-amplified 6 April systematic review on school closures by Viner and colleagues in the *Lancet Child & Adolescent Health*[1] could have far-reaching consequences for policy and community behaviour. It includes a valuable discussion of the importance of schooling to psycho-social needs of children, but its systematic search itself purports to analyse impact of school closures on COVID-19 spread.

In a comprehensive evaluation of this Review, its bibliography, and articles available at the time of the Review's systematic search, we find pervasive violations of their stated methodology, omissions of articles that met selection criteria, and misreporting of results, including altered data. A more exhaustive analysis in our appendix shows almost no aspect of the Review's literature search and report provides accurately-reported information relevant to the COVID-19 spread questions the Review purports to address.

Introduction

Whereas some systematic reviews are more narrative in nature, Viner and colleagues provide a one-page flow chart for 616 articles, an over 350-word treatise on search terms and screening protocols, plus an additional 83 words of search objectives and exclusion criteria, with only 16 of the bibliography's 50 articles designated as "included." The myriad media amplifications of this Review have accordingly treated it as an exhaustive, objective analysis of the evidence to date on impact of school closures on COVID-19 spread.

In the following, we show that on the contrary, Viner and colleagues' Review

1 includes many SARS-related articles that overwhelmingly fail selection criteria, and for which no data used by the Review have any bearing on the spread of SARS;

2 excludes COVID-19 articles which meet selection criteria, and which provide the primary category of COVID-19 data the Summary claims to have sought but been unable to obtain (thereby providing the rationale for examining SARS); the results of these articles supported early school closure;

3 uses exclusion of certain cited SARS-related articles as a license to alter data and omit statements supporting school closure, for articles matching selection criteria better than some included articles do;

4 makes deceptive or false statements about articles in contexts that could not occur by accident;

5 withholds information from included SARS-related articles that would have broadcast the inappropriateness of extrapolating COVID-19 school transmission patterns from those of SARS;

6 categorically misreports COVID-19 article results: the Summary fails to allude to the main results of any of the 6 included COVID-19 studies, all 6 of which supported early school closure; and the entire Review omits the main result of the included COVID-19 study with the strongest evidence for the individual contribution of school closure to controlling COVID-19 infection spread.

The above points are addressed by number in the Results section. Appendix 1 analyses a de facto auxiliary systematic review of influenza-based evidence, apparently inserted into the Review's Discussion section. Appendix 2 systematically evaluates *all* of the Review's non-COVID-19 coronavirus articles, to demonstrate how categorically the Review fails to carry out its stated scientific objectives.

Methods

My search included the Review, its cited articles, and coronavirus-related articles from medRxiv and PubMed, with occasional reference to non-scientific literature for contextual data. I excluded non-English articles and literature unavailable at the time the Review's search was conducted. I selected articles according to their perceived relevance to the evaluation of this Review.

[1]This draft has been updated to reflect my later discovery regarding dates of temperature-screening in Singapore relative to dates of Singapore's SARS epidemic. The introduction has been accordingly edited and shortened, in part to compensate for the additional word count this discussion of temperature-screening dates required.

Results

1 Including SARS-related articles that violate search objectives and exclusion criteria

Viner and colleagues spell out a standard of evidence for articles measuring the effectiveness of school closure and other school social distancing measures for controlling coronavirus (especially COVID-19) infection spread. Here is the Methods section's description of these evidence standards.

Stated search objectives (also echoed in Summary):

> We sought to include quantitative studies using diverse designs to model or empirically evaluate the effects of school closure and other school social distancing practices on infection rates and transmission during coronavirus outbreaks. Our search was designed to be inclusive of any studies providing data on schools or nurseries.

Stated exclusion criteria:

> We excluded opinion pieces, systematic reviews, studies addressing other viruses, university-specific settings, epidemiological studies not examining intervention effects (eg, of prevalence of infection in schools), and studies in other languages with no English translation.[1]

The question is not whether an article should be cited at all, but whether it should be included as part of their systematic study. For example, in addition to the Review's 16 "included" articles, the Review cites 34 non-included articles, including

- 2 non-included SARS-related articles expressing support for school closure or class cancellation,[27,45]
- 7 analysing the impact of school closures on influenza spread,[8,9,10,11,20,28,48]
- 4 studying the impact of other school social distancing measures on influenza spread,[20,21,22,23] and
- 10 addressing the psychological and/or socioeconomic impact of school closures.[2,13,14,15,16,17,18,22,28,50]

(Above and throughout, articles from the Review are referred to by the number used in the Review.)

Of the Review's 9 included SARS 2003-related articles, one was from Canada and two were from Taiwan. Here are two of these articles:

[40].[2] A qualitative report on a 2008 open-ended discussion-based survey of 100 nurses from 4 Canadian cities about potential sources of nurse stress during future disease outbreaks, drawing partly on experiences from the 2003 SARS epidemic, a 2003 hurricane, and a 2004 blizzard. 58 nurses were from Halifax and Ottawa with no record of SARS infection, 27 were from Vancouver with 4 prior SARS cases, and 15 were from Toronto with 225 prior SARS cases.[2–4] Only one paragraph of this 5-page article mentions schools, and the only prior school-related incident discussed is a 1998 event in which Hurricane Mitch destroyed local schools. There is no discussion of past outbreak-related school closures, no reference to SARS in the section mentioning schools, and no discussion of efficacy of measures for controlling disease spread.

[24].[5] A systematic review (note exclusion criterion) on planning for future pandemics, based on Taiwan's response to the 2003 SARS and 2009 H1N1 influenza pandemics. Schools are only ever mentioned in the context of H1N1 (note exclusion criterion re other viruses), and of post-SARS planning to designate hospital overflow sites. No comment is made about whether Taiwan employed SARS interventions outside of healthcare settings, nor is this information available from other articles cited in the Review. All SARS-related statements of the Review about [24] are false; see 4.

Next are the three cited SARS-related articles from Singapore, all "included." They collectively meet at most one article's worth of stated selection criteria.

[34].[6] A commentary article cataloging Singapore's SARS intervention measures. It offers no outbreak timeline data beyond the date of first infection, the date Singapore was removed from the WHO's list of infected countries, and the start dates (24 March and 8 April) of two hospital superspreader events (nor was outbreak timeline data available from any of the Review's other cited Singapore articles). Other than a remark that data management and communication were suboptimal, it offers no analysis of nor comment on the impact or effectiveness of any intervention. Viner and colleagues' only reference to [34] is to say that schools and activities were halted "for 3 weeks from 27 March [out of an outbreak] from late February to May 2003." The Review does not convey that that schools closures were ordered at the height of the

epidemic, that only 3 SARS cases occurred in February and only 1 in May, and that case-count timeline data were consistent with school closure being effective (see Appendix 2).

[33].[7] A systematic review (again, note exclusion criterion) describing and commenting on various control measures, with one analysis of impact of contact tracing and telephone surveillance involving 25 probable cases. The only discussion of schools (and the only part of the article used by the Review) involves school temperature screenings, which unfortunately only started after the outbreak had ended; see below. The Review's usage of [33] is purely redundant, duplicating the article [35] cited for the data used.

[35].[8] A clinical study of causes of temperature elevation in otherwise-asymptomatic children, with SARS-infection among its stated exclusion criteria. The only information the Review uses from this study is from introductory remarks, namely (a) details on implementation protocols for a mandatory school temperature screening programme, and (b) the fact that this detected no SARS cases. This is also the only information the Review uses from the above systematic review [33], which cited [35] for this information. However, there is a good reason this temperature study was not about SARS: it stated that mandatory school temperature screening started on 30 April, but *Singapore's SARS outbreak was already over by then.* Other than a sporadic lab-related infection in September, the last 2 SARS cases ever recorded in Singapore were on 27 April and 5 May.[9,10]

Data from [24], [34], or [33] about *non*-school-related interventions could conceivably have warranted inclusion had the Review made any reference to this information, and particularly if it had identified sources providing outbreak data timelines for Taiwan or Singapore with which one could attempt to evaluate the relative impact of these control measures; but the Review did not.

Since [34] should merely have been 'cited' for its school/activity closure dates, since there is no usage of the systematic review [33] that is not duplicated in [35], and since neither [40] nor [24] have anything to say about coronavirus-related school actions, it appears the only motivation for including these first 4 articles was to pad the collection of included SARS-related articles. This padding artificially inflates both the scope of the study and the apparent volume of evidence against school closure.

2 Excluding COVID-19 studies supporting the individual contribution of school closure

The SARS-related articles invalidly included among the Review's 16 designated articles bring into sharper relief the exclusion of relevant COVID-19 articles, including three studies which attempt to assess the relative impact of COVID-19 interventions with and without school closures. These articles were posted to the medRxiv on 11 February,[11] 16 February,[12] and 12 March.[13] Thus, two were posted weeks before the Review's 9 March search, and the third was posted a week before the Review's 19 March search.

The first article[11] attempts to estimate the individual contribution of contact-tracing-plus-quarantine to COVID-19 interventions in mainland China, as compared to the impact of China's more comprehensive response incorporating school closures (see below). The authors first assembled "an expanded dataset of individual case reports based on our collection and direct translations of documents published daily from official health commissions across provinces and special municipalities in China," and integrated this with "high-resolution real-time domestic travel data in China." They next analysed these data sets using two distinct modelling approaches to compute basic reproduction number and daily exponential growth rate, obtaining consistent results between modelling approaches.

After computations based on their reproduction number results, they claim "Results show that if as low as 20% of infected persons are asymptomatic and can transmit the virus, then even 95% quarantine efficacy will not be able to contain the virus." On the other hand, they observe that "Fortunately we see evidence that [additional] control efforts have a measurable effect on the rate of spread," and they compute that "vigorous control measures" implemented from January 23 onward decreased the exponential growth rate to $0{\cdot}14$ per day since 30 January. They conclude that "If the value of R_0 is as high in other countries, our results suggest that active and strong population-wide social distancing efforts, such as *closing down* transportation system, *schools*, discouraging travel, etc., might be needed to reduce the overall contacts to contain the spread of the virus"[11] (emphasis added).

The next article[12] incorporates mobile phone data from mainland China into a predictive modelling study "to predict the trend under three possible scenarios: the current trend maintained, control efforts expanded, and person-to-person contact increased due to work/school resuming." In conclusion, they predict that (a) China should see a peak of new infections by February 21 if the current trend is maintained, (b) this peak can be pushed forward or backward one week by adjusting control efforts, and (c) "Cities in central and east of mainland China will face a challenge to prevent the growing of disease transmission" in the event of the third scenario of school and work resuming.[12]

The third article is from Japan.[13] In the introduction, the authors describe just two policies: school closures implemented since 3 March, and a policy they call voluntary event cancellation (VEC), implemented from 26 March until at 11 March, later extended on 10 March to at least 19 March (the article was posted on 12 March). For VEC, sports and entertainment events were cancelled, and a government advisory requested that small business and private meetings be cancelled voluntarily. The introduction expresses the need for the efficacies of VEC and school closure to be evaluated, and then focusses on VEC.

The study concludes that "VEC can reduce infectiousness of COVID-19 by 35%," but that VEC only reduces their calculated R_0 from 2·5 to 1·88. Observing that this is still above 1, they conclude that "VEC cannot contain the COVID-19 outbreak in Japan completely,"[13] presumably with the implication that stronger measures will be necessary, such as school closure—the only other intervention mentioned.

The only statement the Review's Summary makes about COVID-19 studies (besides an out-of-context reference to a UK hypothetical modelling result) is that school closures were "deployed [so] rapidly" that "there are no data on the relative contribution of school closures to [COVID-19] transmission control." This complaint is used as a justification for looking to SARS articles, which make up the majority of the 16 included papers. The above three papers provide precisely the comparative COVID-19 data the Summary claims to be missing.

It is possible these articles were missed by negligence rather than intent, but the Review had 9 authors, with 4 explicitly named as being involved in a search and selection process. The Review also makes a point of mentioning auxiliary manual searches. I found the above three articles working single-handedly in the span of under half an hour, with no automation beyond the search features offered by medRxiv and my browser's "find in page" feature.

3 Data suppression and alteration from excluded cited SARS-related articles

The exclusion of three cited SARS-related articles might appear to invalidate complaints about padding the collection of included SARS articles, but the title of [46][14] makes it too obvious a candidate for exclusion. More importantly, for the two excluded articles [45][15] and [27],[16] there seems to be strong evidence that exclusion was used to facilitate and/or obscure the practice of omitting favourable assessments of school closure, and in one case, of altering data.

The cited excluded article [45][15] is a modelling study about class cancellation (i.e. cancelling school without sending students home) in residential and college settings in order to control the spread of respiratory infections such as SARS. In addition to acquiring real bluetooth-signal data about mutual exposure of students during the school week and weekends, the study says it "also evaluated a variety of disease control strategies, with emphasis on class-cancelation strategy, which was widely applied in Chinese colleges during the SARS outbreak in 2003." The study concludes, "Remarkably, the class-cancelation strategy shows a significant mitigating power of reducing the ratio of population infected by approximately 70%."

The Review never alludes these results. Its only use of [45] is to insert a mention of SARS-related college class cancellation in a context that makes this practice look like a failure. To be fair, the Review's exclusion criteria do specifically exclude university settings, but this seems to have been a post-hoc addition intended to exclude this "70%" modelling result. If the Review's authors do not deem college class cancellation to be important enough to discussions of school interventions to merit inclusion, then why include class cancellation in their discussion of school intervention results from included articles?

The case of [27][16] is more serious, although some aspects of its treatment are merely puzzling. Article [27] is a report on pediatric aspects of the SARS outbreak in Hong Kong, primarily as witnessed by doctors at the Prince of Wales Hospital, which was central to Hong Kong's largest outbreaks and responsible for

the care of most pediatric cases. The article's generous provision of primary data includes information on pediatric infection level and modes and frequency of pediatric transmission. The report also discusses infected children in school and includes an assessment of the effectiveness of Hong Kong's school closures. The Review does not include [27] among its explicit list of 16 included articles. On the other hand, its serial analysis of included studies inserts a SARS-related paragraph on Hong Kong citing only [27], and the Summary states "We included 16 of 616 identified articles. [...] Data from the SARS outbreak in mainland China, Hong Kong, and Singapore suggest that school closures did not contribute to the control of the epidemic," despite the fact that no SARS-related article on Hong Kong is included among these 16 articles.

Similar to the case of [45], the Review omits [27]'s positive assessment of school interventions, even though this assessment sentence immediately follows a statement about school suspensions used by the Review. The sentence about school suspensions also mentions quarantine actions taken for a particular "apartment complex" discussed at length in the preceding paragraph and identified in other sources as Amoy Gardens. As discussed in [27] and verifiable elsewhere, public health investigations judged the Amoy Gardens outbreak most likely to have been caused by a known diarrhreal index patient who spread infection to 320 residents via bad plumbing spraying aerosolised infected fecal material into and between buildings. In particular, the outbreak was not believed to have been caused by ordinary family or community spread.[16]

The most serious instance of misreporting on [27] relates to the Review's reversal of what [27] says about family spread. Of [27], the Review reports,

> [...] no evidence of spread of the infection in schools, *with spread among children almost entirely through family settings and living in the same apartment blocks as infected cases.*[1]

Compare this to what [27] actually says about pediatric infection and family spread:

> schools were suspended for almost 4 weeks. All these measures probably helped to minimize the spread of infection to more children in the territory. Of the initial cohort of infected adults admitted to our hospital, *only 5% of close family contacts were infected.* This suggests that patients are noncontagious during the incubation period. Overall, only 6% of all SARS cases in Hong Kong were children or adolescents under 18 years of age. *The majority of them were a consequence of the outbreaks at the Prince of Wales Hospital or the apartment complex* [emphases added].[16]

The Review appears to have directly replaced the phrase "outbreaks at the Prince of Wales Hospital" with "family settings," even though [27] particularly discounts the role of family spread in the same paragraph, citing numerical data.

This alteration appears to have been a strategic change motivated by the desire to emphasise the threat of increased family exposure, which is a necessary consequence of school closures. The Review also takes the phrase "apartment complex" out of context, which seems unlikely to have occurred by accident, considering the emphasis [27] places on the role of this complex, including in the statement mentioning school suspensions.

4 Falsehood, deception, and alteration of data

There are various mechanisms by which the Review fails to communicate truthfully, including false statements, deceptive statements, deception by omission, and alteration of data. (I use the term "deception," here to mean causing the audience to believe something that is false, whether or not this is achieved by writing a false statement. A deceptive statement is one for which the intended interpretation is false, whether or not there exists a convoluted interpretation which is technically true.)

We have just now witnessed an "alteration of data" in the above discussion of [27],[16] where the Review replaces the statement

> The majority of [pediatric infections] were a consequence of the outbreaks at the Prince of Wales Hospital or the [Amoy Gardens] apartment complex.[16]

with

> [...] with spread among children almost entirely through family settings and living in the same apartment blocks as infected cases.[1]

This change also alters numerical data, as the relevant paragraph quoted above from [27] had just finished stating the statistic that "only 5% of close family contacts were infected." This alteration serves to amplify concern about increased family exposure due to school closures.

The Review provides a good example of "deceptive statement" in its characterisation of the Review's included article [40][2] on a 2008 Canadian nurse survey:

> One paper reported qualitative research with health-care workers after the SARS outbreak relating to the effect of school closures.[1]

Strictly speaking, any event from 2004 onward occurred "after the SARS outbreak," but the above statement seems clearly intended to be interpreted to mean that health-care workers reported on the effect of school closures that occurred *during* the SARS outbreak. However, that interpretation is false. Only one paragraph of this 5-page report mentions schools, and in it, the only discussion of prior school-related incidents is about a 1998 hurricane. The Review appears to count on reader assumption that [40]'s title was chosen as an indicator of topical focus, instead of as the catchiest representative of questions floated.

Of the four cities from which nurses were surveyed, Halifax, Ottawa, Vancouver, and Toronto respectively had 0, 0,[2] 4,[3] and 225[4] probable SARS cases. Of the 100 nurses surveyed, 15 were from Toronto. No SARS-related school closures were ordered in the first three cities, as far as I have been able to determine by extensive search. During the SARS outbreak in Toronto, 5 schools closed[17] out of over 550.[18] If by rare chance an interviewed nurse happened to have a child at one of these 5 schools, it is unlikely the survey discussion would have failed to draw attention to this fact. See Appendix 2 for a more involved misleading-statement example from [40].

The Review's treatment of [24][5] provides examples of "false statements," when it says:

> A review[24] of responses in Taiwan to the SARS outbreak and 2009 H1N1 influenza pandemic 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 (including closures) introduced during the SARS outbreak.[1]

The designation of schools as alternative health-care sites occurred *after* the SARS outbreak in Taiwan, but perhaps this fact was misunderstood during a casual reading of [24]. On the other hand, the statement that [24] "noted [...] that there were no school social distancing measures (including closures) introduced during the SARS outbreak" is simply false: the review [24] neither states nor implies such a thing. One cannot take the review's lack of mention of school-related interventions as evidence that they did not occur, when [24] does not discuss *any* SARS interventions outside the healthcare system. For instance, [24] also does not mention Taiwan's contact tracing, quarantine of arrivals from SARS-affected areas, or airport temperature screening.[19] In fact, Taiwan closed more schools than Canada did.[20] In total, none of the coronavirus-related information reported from [24] is true.

The context created by stated selection criteria can also result in deception. The Review refers to [38][21] as "estimating SARS transmission in schools," and says that whereas another study "estimated that school closure resulted in potentially important reductions in transmission, Liao and colleagues[38] estimated that transmission in school classrooms was low." These statements risk giving the impression that [38] was an epidemiological modelling study, as opposed to modelling airflow of infectious droplets in three types of airspace including a hospital floor and school room, distinguished only by ventilation and crowding levels.

For remaining examples of deception, particularly by omission, I defer to the remaining two sections.

5 Withholding paradigm-altering data from SARS-related articles

The premise of the Review's SARS-related study is that, given a supposed dearth of data about COVID-19, one might hopefully be able to extrapolate an assessment of the effectiveness of school closures for COVID-19 from an analogous assessment for SARS.

Unfortunately, this premise is fatally flawed, in that unlike COVID-19,[22] SARS did not exibit asymptomatic, presymptomatic, or afebrile transmission, and even paucisymptomatic transmission was rare.[23] In

particular, outside of healthcare settings, where severely-ill SARS patients became very contagious, temperature screening was almost certainly an adequate control measure for anyone with no known contact with a SARS patient.

The Review appears keen to obscure this message.

The Review reports false statements about what its Taiwan systematic review [24][5] says, but it fails to mention [24]'s statement that 70% of Taiwan's SARS cases were nosocomial infections, or that as a consequence the review only spoke of healthcare-system control measures.

The Review includes two articles, [33][7] and [35],[8] merely to report on one set of data about Singapore's school temperature screening, but it fails to report [35]'s introductory statement that "SARS patients are infectious only when febrile," and it fails to mention from [33][7] that "As SARS was predominantly a nosocomial infection, the major part of containment efforts was concentrated on hospitals," or to mention that 78% of SARS infection in Singapore was nosocomial.[7]

The Review falsely cites [27][16] to claim most pediatric SARS infection in Hong Kong was due to family spread, but it does not share from the same paragraph in [27] that patients were likely "noncontagious during the incubation period" or that "only 5% of close family contacts were infected."

The Review reports that two studies from Beijing did not regard school closure to have been of much benefit, but it fails to mention that in the same breath, these studies collectively discounted the benefit of closure of public places, travel checkpoint screening, and quarantine of low-risk cases, placing nearly all emphasis instead on healthcare system interventions and contact tracing.[24,25]

It does not require nine SARS articles to show that school closure for SARS was unnecessary; it just takes one article, honestly reporting on the nature of SARS transmission.

6 Categorical misreporting of COVID-19 results

Although the results section quietly concedes that the 5 Asian COVID-19 studies demonstrated a powerful impact of control measures incorporating school closure, the Review's Summary—in many cases the only part read by journalists—does not allude to any of these 5 results.

Even more damagingly the Review fails to report on the main result of the COVID-19 modelling study by Imperial College [31],[26] which predicted that adding or subtracting school closure to a standard battery of social distancing measures made the difference between only reaching a small fraction of critical care bed capacity, versus exceding it by a factor of 2 (see the blue region of Figure 3B from page 10).[26]

Instead, the only result the Summary reports from COVID-19 studies is a result taken badly out of context from the Imperial College study. The Review quotes a 2-4% figure that comes from a side thought experiment motivated by influenza-type measures in which governments consider closing schools as an exclusive measure, sending everyone to work as usual with no non-school social distancing. As no modern government is implementing such a plan or has plans ever to implement such a plan for COVID-19, this statistic is merely misleading, and irrelevant to the question at hand.

Discussion/Conclusion

This Review, and particularly the widely-misinterpreted 2-4% figure, has seen global amplification, not just from major media outlets, but from the *Lancet Child & Adolescent Health*'s own editorial.[27] This has been further propelled by yet-more-misleading quotations from the Review's lead author in media interviews.

This Review's reckless message risks encouraging parents to allow large child gatherings and to pressure governments to open schools before we have enough pediatric transmission data to know if this is safe.

There is indeed a critical need to estimate the difference in human cost between school closures and school reopenings. This urgently calls for honest scientific research into pediatric COVID-19 transmission.

Appendix 1. Influenza based arguments

Instead of merely reviewing the Results section and resuming the Introduction's discussion of the health and socioeconomic impacts of school closures, the Discussion section is co-opted to provide a de-facto second systematic review, this time for influenza studies, but with no provision of search and selection criteria, and with misleading context.

This section fails ever to hint that the influenza studies in question all employed school closures as an exclusive measure, in the absence of any other intervention or social distancing measure. Unsurprisingly, studies indicate that school closure as an exclusive measure—with no interventions for adults—is most effective for illnesses with high transmission among children and low transmission among adults. Instead of admitting the absence of adult interventions in these studies, the Review reports,

> 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 in adults.[8] Although our information on SARS-CoV-2 remains incomplete, this appears not to be the case with COVID-19 outbreaks.[1]

With no pause to mention the absence of adult interventions, the Review proceeds to belabour the above point. It cites estimates for the R value for COVID-19, and it implies that the asymptomatic and mild presentation of COVID-19 in children should lead to lower transmission rates in children. (Admittedly, the authors craft the latter statement carefully, saying that children appear "less likely to spread the virus through coughing or sneezing."[1] As such, they only *imply*, given the immediately preceding context, that children transmit COVID-19 at an overall lower rate than adults.)

The Review further proceeds to mention a particular study[28] from the systematic review it just cited, for which the 1957 Asian influenza in question had a similar R range to COVID-19. The Review says "analyses using UK clinical data [from this 1957 Asian influenza pandemic] suggest that school closures would reduce the epidemic size by less than 10% when the R was similar to that of COVID-19." (To clarify, the study in question was a predictive modelling study for a hypothetical recreation of the pandemic employing school closures, rather than a retrospective study of a community that actually employed school closures.) The Review fails to mention that this model excludes all intervention measures beside school closures and in particular excludes all adult intervention measures. Under the circumstances, it is surprising that the Review bothers to advertise this 10% figure, since it is higher than the 2-4% figure cited in the Summary for precisely the same control measure scenario. On the other hand, when the control measure scenario is obscured, both figures benefit the Review's argument.

The Review then launches into a new discussion that "[r]eviews also note that the benefits of school closure might be less than what have been assumed" due to lack of accounting for increased community contact resulting from school closures. (The Review follows this with an elaboration on common sources of increased community contact, with emphasis on the role of grandparents in childcare). The Review states the above concern about underestimations of community contact even though (a) its only included COVID-19 modelling study assumes a relatively extreme increase in community contact, and (b) current lockdown procedures decrease rather than increase community contact.

It is unclear in general why the Review went to elaborate ends to describe a systematic search for 16 coronavirus-related studies, to the exclusion of influenza studies, but then cited 7 studies on the impact of school closures on influenza spread, plus 3 other studies on the impact of school social distancing measures on influenza spread, and then relegated the analysis of these studies to the Introduction and Discussion sections of the Review.

In any case, the Review's discussion of influenza-based arguments provides yet more examples of instances in which the Review misleads the reader about context in order to make arguments with no valid application to school closures as currently employed in intervention schemes against COVID-19.

Appendix 2. Global assessment of Review's overall analysis

My review of Viner and colleague's article addresses a large collection of individual problems with their Review, but it is important to take a global view of what they did.

All in all, their Summary claims to have systematically selected 16 articles, justifies extrapolating SARS-related results to predictions for COVID-19, reports exclusively anti-school-closure results from SARS restrospective studies, reports "conflicting" results from SARS-related modelling, makes no report on COVID-19 retrospective studies beyond the claim that "there are no data on the relative contribution of school closures to transmission control," and for COVID-19 modelling studies, exclusively reports that "[r]ecent modelling studies of COVID-19 predict that school closures alone would prevent only 2-4% of deaths, much less than other social distancing interventions"—a statement almost universally interpreted by media as referring to the individual contribution of school closures to transmission control, given that just two sentences prior, the Summary complained about lack of "data on the relative contribution of school closures to transmission control." The Summary concludes that "[p]olicy makers need to be aware of the equivocal evidence when considering school closures for COVID-19." The Review's Discussion echoes these remarks, then introduces a new (and highly misleading) collection of arguments against school closure based on influenza spread; see Appendix 1.

In the following, I compare the Review's overall analysis with the *actual* results of the articles in question. I have already mentioned that every single COVID-19 article they analysed is strongly in favour of school closures. In the following, I systematically assess all 10 *non*-COVID-19 articles included, in addition to two excluded SARS-related articles that the Review treats somewhat similarly to included articles. For each article, readers should pay particular attention to the line "Actual import of article on effectiveness of school interventions on COVID-19 spread." It turns out that, *contrary to the analysis of the Review, every one of these 12 articles either (a) has no bearing on COVID-19 school closures or (b) actively supports the significant benefit of school closures for COVID-19.*

Invalidity of extrapolating SARS school transmission results to COVID-19.

Since the appropriateness of extrapolating insights about the effectiveness of COVID-19-related school closures from those for SARS is a recurring theme for these articles, I address this issue up front, as follows.

SARS patients were not contagious while asymptomatic,[23] presymptomatic,[16] or afebrile,[8] and this transmission pattern extended to children.[16,29] Moreover, parents were instructed not to send sick or feverish children to school.[6,16] (Note that aside from the WHO report,[23] all articles cited in this paragraph are also cited by Viner and colleagues' Review.[1]) A random serological sampling performed in Hong Kong[30] found only 2 of 117 seropositive children were asymptomatic. Paucisymptomatic pediatric transmission was rare enough that although 46 of these SARS-infected children attended school while symptomatic, the authors found "[t]here was no spread of SARS in the school setting."[30]

By contrast, asymptomatic, presymptomatic, and afebrile COVID-19 transmission were known to occur[22] by the time the Review was written, and evidence of this has continued to accumulate.[31] We also now know that asymptomatic infection in children is common[32] and that pediatric transmission occurs.[33] Due to global lockdowns and school closures there is insufficient data on the extent to which children transmit asymptomatically, but so far there is no reason to believe this occurs less often for children than for adults.

Lastly, before commencing, we repeat the Review's search and selection criteria for reference.

Stated search objectives (also echoed in Summary):

> We sought to include quantitative studies using diverse designs to model or empirically evaluate the effects of school closure and other school social distancing practices on infection rates and transmission during coronavirus outbreaks. Our search was designed to be inclusive of any studies providing data on schools or nurseries.

Stated exclusion criteria:

> We excluded opinion pieces, systematic reviews, studies addressing other viruses, university-specific settings, epidemiological studies not examining intervention effects (eg, of prevalence of infection in schools), and studies in other languages with no English translation.[1]

[40].[2] Canada. Report on 2008 discussion-based survey (note search objective for "quantitative studies")

Open-ended survey of 100 nurses from 4 Canadian cities on potential sources of nurse stress during future disease outbreaks, drawing partly on experiences from the 2003 SARS epidemic, a 2003 hurricane, and a 2004 blizzard. 58 nurses came from Halifax and Ottawa with 0[2] probable SARS cases, and 27 nurses came from Vancouver, with 4[3] probable SARS cases. For these 85 nurses, none of their cities had SARS-related school closures (as far as I have been able to determine by extensive search). For the 15[2] nurses from Toronto, only 5[17] out of over 550[18] schools closed. The article makes no mention of prior outbreak-related school closures. Of this 5-page article, only one paragraph mentions schools. Here is the entire paragraph:

> In relation to challenges with child/elder/pet care during prolonged shifts and quarantine, the nurses expressed concern about organizational and social supports when institutions, such as schools, are closed during a pandemic or other type of disaster; "If schools are closed, who will watch our kids?" This situation was experienced during Hurricane Mitch in 1998, when many communities were destroyed. To address barriers such as child care (which affected hospital staffing), administrators brought in trained educational specialists to provide temporary day-cares for the children of hospital staff. For an outbreak situation in which the children would be at risk in a hospital, child care, and other dependent care supports, will require creativity and careful planning.[2]

(Note the usage of future tense.) SARS-related discussion in [40] is almost exclusively focussed on fears of exposing self/family to infection and on the demands/consequences of long shifts and nurse quarantine at hospital. Most discussion of care obligations and potential resulting absenteeism involves either long hours away from home or the impact of sick family members, particularly if exposed to the outbreak. The article has later discussion of elder care and of pet care in this context.

Use in Summary: Inflates 16-article count of implied sources of evidence against school closure.

Use in Results: Emphasises potential impact of school closures on health-care provision, writing,

> Conflict between the work and family requirements of health-care 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 health-care workers experience substantial personal dilemmas in balancing work and family commitments, *particularly relating to childcare needs if schools are closed and childcare services are unavailable.* The study concluded that there was a need for provision of adequate resources to protect the families of health-care workers during outbreaks to maintain maximal staffing.[1] [emphasis added]

The "particularly related to childcare needs if schools are closed" line appears to be modeled on the following quotation from [40]:

> The role conflict experienced by the nurses in the current study also was evident in a study by Hsu and Kemohan, in which family duty was reported as an important reason given by nurses who were intent on leaving their jobs. *Particular challenges include finding child care when a child is sick.*[2] [emphasis added]

The similarity in phrasing could merely be coincidental, but the comparison of messages is still important.

Actual import of article on effectiveness of school interventions on SARS spread: None.

Actual import of article on effectiveness of school interventions on COVID-19 spread: Healthcare workers may be impacted by closure of "institutions such as schools" unless "creativity and careful planning" are employed to find childcare and dependent care solutions (for example, the current UK provision of schooling to children of key workers). On the other hand, [40] places much more emphasis on the risk of healthcare worker "[stress, role conflict, and] absenteeism due to illnesses of other family members" if their children or dependents are inadequately protected from exposure. The survey article hones in on priority vaccination of healthcare worker families as the solution to this problem, but in the absence of vaccines, the only available means of protection is through non-pharmaceutical interventions.

[24].[5] Taiwan. Systematic review (note exclusion criterion).

A review on planning for future pandemics, based on Taiwan's response to the 2003 SARS and 2009 H1N1 influenza pandemics. Schools are only ever mentioned in the context of H1N1 (note exclusion criterion re other viruses), and of post-SARS planning to designate hospital overflow sites. No comment is made about whether Taiwan employed SARS interventions outside of healthcare settings, nor is this information available from other articles cited in the Review.

Use in Summary: Inflates 16-article count of implied sources of evidence against school closure.

Use in Results: As discussed in Subsecton 4 of my Results, all SARS-related statements of the Review about [24] are false. The Review's statements about [24] seemed primarily aimed at justifying the article's inclusion in the Review. However, their false claim that [24] "noted [...] that there were no school social distancing measures (including closures) introduced during the SARS outbreak" is likely intended to demonstrate that Taiwan survived SARS without school closures.

Actual import of article on effectiveness of school interventions on SARS spread: Although the Review's claim that [24] noted lack of school interventions or closures was false, and although Taiwan had more SARS-related school closures than Canada did,[20] it is still the case that school closures in Taiwan were limited. This fact shows that it was possible to contain SARS without widespread school closures.

Actual import of article on effectiveness of school interventions on COVID-19 spread: Minimal.

[34].[6] Singapore. Commentary (note search objective for "quantitative studies")

A commentary article cataloging Singapore's SARS intervention measures. It offers no outbreak timeline data beyond start and end dates and a list of some hospital superspreader events (nor was such data available from the review's other Singapore articles). Other than a remark that data management and communication were suboptimal, it offers no analysis of nor comment on the impact or effectiveness of any intervention, nor does it provide any data that would make such analysis possible.

Use in Summary: Inflates count of 16 articles (since should have merely been "cited"). Counted as evidence towards the statement "Data from the SARS outbreak in mainland China, Hong Kong, and Singapore suggest that school closures did not contribute to the control of the epidemic."

Use in Results: The only part used is that schools and activities were halted for 3 weeks from 27 March, plus the fact that Singapore's SARS outbreak ran from "late February to May." The discussion concludes "Data from the SARS outbreak in mainland China, Hong Kong, and Singapore suggest that school transmission played no substantial role in the outbreak," but at least in the case of [34], this is an invalid conclusion. In the absence of outbreak timeline data for comparison (and in the absence of a discussion of the general transmission patterns of SARS), a priori these school closures could have been instrumental in controlling the spread of SARS. Indeed, if one actually examines Singapore's outbreak data,[9,10] one finds that only 4 SARS cases occurred outside of March and April; school closures were ordered just before the height of the outbreak; and other than a single sporadic case on 5 May, the outbreak completely ended by 11 days after the reopening of schools, with over 92% of cases occurring before this reopening. (Of course, this apparent success is more likely due to other control measures introduced at the same time.)

Actual import of article on effectiveness of school interventions on SARS spread: As a standalone article: minimal. Without data on how the timing of these school closures corresponded to the timeline of infection spread, very little can be deduced from merely the dates of school closure.

Actual import of article on effectiveness of school interventions on COVID-19 spread: Minimal.

[33].[7] Singapore. Systematic review (note exclusion criterion).

A review describing and commenting on various control measures, with one analysis of impact of contact tracing and telephone surveillance, involving 25 probable cases. Its only mention of schools is in the context of temperature screening, citing a result from [35].

Use in Summary: Inflates count of 16 articles (since usage is duplicated by [35]). Counted as evidence towards the statement "Data from the SARS outbreak in mainland China, Hong Kong, and Singapore suggest that school closures did not contribute to the control of the epidemic."

Use in Results: The only part used is the discussion of school temperature screenings. The part used is entirely duplicated by the included article [35], which is the study [33] cited for this information.

Actual import of article on effectiveness of school interventions on SARS spread: See comments on [35] for import of temperature screening results. As for the rest of [33] (none of which was used by the Review), the emphasis on prevalence of nosocomial infection helps demonstrate the unlikelihood of school transmission as a major driver for SARS spread.

Actual import of article on effectiveness of school interventions on COVID-19 spread: Minimal.

[35].[8] Singapore. Clinical/retrospective study.

A study of causes of temperature elevation in otherwise-asymptomatic children, with SARS-infection among its stated exclusion criteria.

Use in Summary: Counted as evidence towards the statement "Data from the SARS outbreak in mainland China, Hong Kong, and Singapore suggest that school closures did not contribute to the control of the epidemic."

Use in Results: The only information the Review uses from this study is from introductory remarks, namely (a) details on implementation protocols for mandatory school temperature screening during SARS 2003, and (b) the fact that this detected no SARS cases. This is also the only information the Review uses from the above systematic review [33], which cited [35] for this information.

Actual import of article on effectiveness of school interventions on SARS spread: As for import of the temperature screening programme: none. Article [35] states that mandatory temperature screening in schools began on 30 April. Other than a sporadic lab-related infection in September, the last 2 SARS cases ever recorded in Singapore were on 27 April and 5 May. In other words, the SARS outbreak in Singapore was already over by the time school temperature screening began. Thus, no new information about SARS is gleaned from the fact that no cases were detected by this mandatory temperature screening programme.

On the other hand, the (unused) statement from [35] that "SARS patients are infectious only when febrile"[8] has substantial import: it implies the unlikelihood of school-mediated SARS transmission, given the instruction of parents not to send children to school while feverish.[6]

Actual import of article on effectiveness of school interventions on COVID-19 spread: Minimal.

[36].[24] Beijing. Retrospective study.

A report on quantitative epidemiological data obtained from widespread surveys of inhabitants of Beijing, along with a summary of and commentary on primary intervention measures employed against SARS.

Use in Summary: Counted towards the statement "Data from the SARS outbreak in mainland China, Hong Kong, and Singapore suggest that school closures did not contribute to the control of the epidemic."[1]

Use in Results: According to the Review, [36] "concluded that school closures made very little difference to the prevention of SARS in Beijing, given the very low attack rate in schools before the closure and the low prevalence of disease in children."[24]

Actual import of article on effectiveness of school interventions on SARS spread:

In its analysis of less helpful measures, the study first raises doubts about the practice of quarantining contacts only exposed during the asymptomatic phase, next states that "screening at points of transportation" was likely to have had a "less direct impact in resolving the outbreak," and then states that "the closing of the public schools likely had a minimal effect on the prevention of SARS because of the low attack rate among schoolmates and the rarity of pediatric SARS in Beijing." However, it says "the closing of schools may have contributed to the widespread self-quarantine that occurred in Beijing in early May, when the streets were virtually empty." The study's concluding paragraph does not mention schools, but it says "Some interventions, in retrospect, such as quarantine of low-risk contacts and fever checks at transportation sites, seemed to have less direct impact in curbing the outbreak."

(All in all, this is one of the most accurately reported studies of the Review.)

Actual import of article on effectiveness of school interventions on COVID-19 spread: Minimal, although the remark about increased self-quarantine due to school closures is potentially relevant.

[37].[25] Beijing. Quantitative study.

A study calculating effective reproduction number in Beijing as a function of time, relative to the timing of various interventions employed against SARS.

Use in Summary: Counted as evidence towards the statement "Data from the SARS outbreak in mainland China, Hong Kong, and Singapore suggest that school closures did not contribute to the control of the epidemic."

Use in Results: According to the Review, [37] "estimated the effective R for each day of the Beijing SARS outbreak, noting that school closures occurred after the R had dropped below 1 and that school closures in this case added little to control of the outbreak."[1]

Actual import of article on effectiveness of school interventions on SARS spread:

According to [37], "When the government finally announced on 20 April the scope of the ongoing SARS epidemic, the disease was already almost under control (R_t was just above 1). Our estimates of R_t call into question the necessity and utility of closing schools, universities and other public places, with its disruptive effects on society. Furthermore, R_t was $0{\cdot}5$ when the 1000-bed Xiao Tang Shan specialist SARS hospital was constructed, updated infection control guidelines were issued, and new fever clinics opened in early May." By 20 April, the only interventions that had been employed were contact-tracing-related quarantines, the opening of fever clinics, upgraded usage of PPE, and updated instructions for healthcare workers. Given the first sentence quoted above, the study calls into question the marginal effect of all other remaining interventions.

Since the Review purports to be comparing school closures to other interventions, it was at least somewhat remiss of the Review to fail to mention any other interventions "called into question" at the same time as school closures. Bringing these other failures to attention would have highlighted the discrepancy between SARS and COVID-19 transmission patterns.

Actual import of article on effectiveness of school interventions on COVID-19 spread: Minimal.

[39].[34] Australia. Epidemiological modelling study.

An abstract modelling study for a hypothetical SARS-like outbreak among an Australian demographic.

Use in Summary: Contributed to the one sentence "Modelling studies of SARS produced conflicting results." That is, although [39] supports SARS-related school closure, the Review regards its other SARS-related modelling study (see [38] below) as opposing the benefit of school closure.[1]

Use in Results: The Review accurately states the following of [39] "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."[1]

Actual import of article on effectiveness of school interventions on SARS spread: Although this modelling study predicts school closures would substantially lower infection in a SARS-like outbreak, the model employs a highly inaccurate description both of the basic transmission behaviour of SARS and of the extent to which SARS-contagious children would attend school, since in reality, SARS-infected children ill enough to be contagious would most likely never be sent to school.

Actual import of article on effectiveness of school interventions on COVID-19 spread: Since the modelled illness is a closer match to COVID-19 than to SARS (for example in terms of the likelihood that contagious children might attend school), it is possible this model's results are at least somewhat applicable to the case of COVID-19.

[38].[21] Taiwan. Airflow modelling study.

A study from the journal *Risk Analysis*, modelling airborne spread of infectious droplets "in the absence of interventions and control efforts" for 3 environments (a hospital floor, school room, and aircraft) distinguished only by crowding level, ventilation, and exposure time (not by any epidemiological factors). They compute the probability distribution for the number of secondary infections from a single infected person in each setting, using Wells-Riley infectivity parameters extracted from a 2-week timeline of infections at Taipei Municipal Ho-Ping Hospital. There is no mention of school closure or any other SARS intervention.

Use in Summary: Contributed to the one sentence "Modelling studies of SARS produced conflicting results."[1] (Without the Review's opinion on [38], the Review would have been forced to report that its only SARS-related modelling study supports school closure.)

Use in Results: Of [38], the Review states: "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 an average of 2·6 secondary cases in a population from transmission in hospital, whereas less than 1 secondary infection would be generated per case in a school classroom." The Discussion further says that whereas the Australian study predicted school closures to cause a reduction in infection, "Liao and colleagues[38] estimated that transmission in school classrooms was low."

Nowhere does the Review hint that [38] modelled the flow of airborne infectious droplets (and with no contribution from fomites) instead of modelling the spread of human infection among populations, or that the study's distinction between schools and hospitals was not based on any epidemiological parameters.

The Review also fails to convey that [38]'s aim was to provide a *probability distribution* of R_0 values. In particular, [38] concludes there is a "*50% probability that R_0 is greater than 2 during an outbreak of SARS in the elementary school*"[21] (emphasis added).

The Review also makes invalid inferences from the only data from [38] it does use, namely the "less than 1 secondary infection" generated per case in a school classroom. (The numerical value of this "less-than-1" figure is never stated in the study, but from figures, it looks to be $> 0{\cdot}95$.) The Review's characterisation of its two SARS modelling studies as having "conflicting results," and its claim that [38] "estimated that transmission in school classrooms was low," fail to take *total* reproduction number into account. Even excluding adult contributions, if the first infected child in any family infected an average of 0·06 school-aged family members at home, than the school-child subpopulation would have reproduction number

$$R_{child} \geq \frac{\cdot 95}{\cdot 95 + \cdot 06}(\cdot 95 + \cdot 06) + \frac{\cdot 06}{\cdot 95 + \cdot 06}(\cdot 95) \approx 1{\cdot}01 > 1{\cdot}$$

Actual import of article on effectiveness of school interventions on SARS spread: (a) This study of airborne droplet flow and inhalation fails to account for differences in PPE, walls, doors, and other barriers on a hospital floor versus a school room or airplane. (b) The study takes so few epidemiological factors into account that its methodology predicts substantially lower transmission rates in schools than hospitals for nearly *any* airborne virus, including influenza, which is likely why the study mysteriously omits its hospital-related influenza calculations and results. (c) Its schoolroom SARS prediction is a moot point, since SARS-infected children were non-contagious unless febrile and highly symptomatic,[8,16,30] making the transmission of SARS in schools effectively zero.

Actual import of article on effectiveness of school interventions on COVID-19 spread: Minimal.

Included coronavirus-related article (on endemic coronavirus):

[32].[35] Washington State, USA. Retrospective study.

A retrospective study of how influenza and common-cold infection levels varied after a series of snow-related school closures in two counties of Washington State.

Use in Summary: None, beyond contributing to the count of 16 articles for which the Review gives the impression that the majority were against school closures.

Use in Results: The Review states that after a "5-day closure" due to extreme weather, "Their study 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%; 5·2-9·7) but higher than influenza H3N2 (3·1%; 2·5-3·2), all of which were prevalent at the time."[1]

Actual import of article on effectiveness of school interventions on coronavirus spread: The Review fails to mention that this "5-day closure" was actually one 2-day closure and one 3-day closure, separated by 6 days. (Unlike the briefer closures, a closure of 5 school-days plus 2 week-end days would be comparable to the average contagion period after exposure from a cold.) This makes the subsequent $5{\cdot}6\%$ decrease in infection appear all the more significant, especially considering that many children presumably still played with friends in the snow outside, and that no social distancing measures were implemented beyond the difficulty of travel imposed by snow.

Actual import of article on effectiveness of school interventions on COVID-19 spread: It is unclear how similar the transmission patterns of common colds are to COVID-19. They at least share the trait that many parents send children to school with cold symptoms, likely mimicking the behaviour of parents sending asymptomatic COVID-19-infected children to school.

Cited excluded SARS-related article (not among the designated 16):

[45].[15] Mainland China. Experimental plus modelling study.

A modelling study about class cancellation (i.e. cancelling school without sending students home) in residential and college settings in order to control the spread of respiratory infections such as SARS. In addition to acquiring real bluetooth-signal data about mutual exposure of students during the school week and weekends, the study says it "also evaluated a variety of disease control strategies, with emphasis on class-cancelation strategy, which was widely applied in Chinese colleges during the SARS outbreak in 2003." The study concludes, "Remarkably, the class-cancelation strategy shows a significant mitigating power of reducing the ratio of population infected by approximately 70% (Fig. 7G). This mitigating power is better than all the five network-based quarantine/vaccination strategies even when the quarantine/vaccination coverage is as high as 25%." The study's summary advertises, "Remarkably, class cancelation, though simple, shows a mitigating power equal to quarantine/vaccination applied on 25% of college students, which quantitatively explains its success in Chinese colleges during the SARS period."

Use in Summary: None. Since [45] is not among the Review's 16 included articles, the Summary does not allude to the study's prediction of 70% reduction of infection from class cancellation (nor to any other of the study's results). Although the Summary does remark that SARS-related modelling studies had "conflicting" results, the Review later indicates that this comment was purely in reference to [38] and [39].

Use in Results: The only aspect of [45] the Review uses is the fact that this class cancellation strategy was employed in mainland China during the SARS outbreak. The Review sandwiches this fact (see middle sentence) between two negative statements about school closures in China:

> [...] for each day of the Beijing SARS outbreak, noting that school closures occurred after the *R* had dropped below 1 and that school closures in this case added little to control of the outbreak. *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 mainland China.*[45] There was no recorded transmission of SARS in schools during the outbreak in mainland China[46] [emphasis added].[1]

No allusion is made to the prediction of a 70% reduction in infection from class cancellations.

Actual import of article on effectiveness of school interventions on SARS spread: Since lack of afebrile transmission for SARS is not taken into account, the predictions made by [45] are less applicable to SARS than to infections for which students would otherwise still attend class while contagious.

Actual import of article on effectiveness of school interventions on COVID-19 spread: Although differing reproduction numbers lead to differing predictions for *overall* infection, the prediction of 70% fewer infections with class cancellation than without is a result that is approximately uniform accross respiratory illnesses, *provided* the key assumption that without class cancellation, students would continue to attend classes early in their contagion period. Although this assumption is false for SARS, it is well-suited to COVID-19, keeping in mind that this result is specific to the subpopulation of residential students.

Cited excluded SARS-related article (not among the designated 16):
[27].[16] Hong Kong. Quantitative report.

A report on pediatric aspects of the SARS outbreak in Hong Kong, primarily as witnessed by doctors at the Prince of Wales Hospital, which was central to Hong Kong's largest outbreaks and responsible for the care of most pediatric cases. The article's generous provision of primary data includes information on pediatric infection level and modes and frequency of pediatric transmission. The report also discusses infected children in school and includes an assessment of the effectiveness of Hong Kong's school closures.

Use in Summary: Although [27] is not among the 16 included articles, it is the only SARS-related articles on Hong Kong. As such, it seems the only possible source of data to which the Summary might be referrring when it states that "Data from the SARS outbreak in [...] Hong Kong [...] suggest that school closures did not contribute to the control of the epidemic."[1]

Use in Results: Here is the full paragraph the Review devotes to [27] in its results section:

> Schools were also closed in Hong Kong during the SARS epidemic; however, the extent to which this was at a city-wide or local level is unclear. There was no evidence of spread of the infection in schools, *with spread among children almost entirely through family settings and living in the same apartment blocks as infected cases*[27] [emphasis added].[1]

Actual import of article on effectiveness of school interventions on SARS spread: The Review's statement about primary sources of pediatric infection is a direct alteration of text. Instead, [27] states:

> [...] schools were suspended for almost 4 weeks. All these measures probably helped to minimize the spread of infection to more children in the territory. Of the initial cohort of infected adults admitted to our hospital, only 5% of close family contacts were infected. This suggests that patients are noncontagious during the incubation period. Overall, only 6% of all SARS cases in Hong Kong were children or adolescents under 18 years of age. *The majority of them were a consequence of the outbreaks at the Prince of Wales Hospital or* the *apartment complex* [emphasis added].[16]

Referring the reader to sections 3 and 4 for a discussion of the plumbing-mediated Amoy Gardens apartment complex outbreak and about matters of data alteration, we now focus on other aspects of [27].

The lack of infection for close family contacts, the implication that "patients are noncontagious during the incubation period," and the article's earlier statements about multiple symptomatic children having attended school without having transmitted SARS, all point to the lack of a-/pre-symptomatic transmission and the infrequency of paucisymptomatic transmission, for SARS. This, in turn, simultaneously demonstrates both the unlikelihood of major impact of school closures on infection spread, and the invalidity of extrapolating COVID-19 school transmission results from SARS.

Although the Review does not report this, the authors of [27] propose above that the combination of school closures with other measures "probably helped to minimize the spread of infection to more children in the territory." The authors of [27] do not provide much rationale for this assessment, but it is possible they based this on observations of outbreak data. Although Review authors say merely that the geographic extent of Hong Kong's school closures was "unclear," schools were cancelled for all of Hong Kong, they were initiated on 27 March at the height of the epidemic, and the outbreak was mostly under control by the time schools reopened.[36–38]

Actual import of article on effectiveness of school interventions on COVID-19 spread: Minimal.

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