Reopening schools in the pandemic did not increase COVID-19 cases or deaths in São Paulo State, Brazi

Education Division

Guilherme Lichand
Carlos Alberto Dória
João Cossi
Onicio Leal Neto

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KEY POINTS:

Question: Does reopening schools in the pandemic increase COVID-19 incidence and mortality?

Findings: On average, there was no systematic association between school reopening and COVID-19 incidence or mortality in São Paulo State, up to 12 weeks after reopening. This was also the case for schools in most vulnerable conditions. Aggregate mobility was already high before the school reopening and did not significantly increase afterwards.

Meaning: Results imply that reopening schools under appropriate protocols in developing countries during the pandemic is unlikely to affect the aggregate number of cases or deaths when counterfactual mobility is already high.

ABSTRACT:

Importance: School closures due to COVID-19 have left 1.6 billion students around the world without in-person classes for a prolonged period of time. To date, no study has documented whether reopening schools in developing countries during the pandemic was associated with increased aggregate COVID-19 incidence and mortality with appropriate counterfactuals.

Objective: Testing whether reopening schools under appropriate protocols during the pandemic increased municipal-level COVID-19 cases and deaths in São Paulo State, Brazil.

Design: This is an observational study in São Paulo State to estimate the relationship between municipal decisions to reopen schools during the pandemic and municipal-level COVID-19 case and death rates between October and December 2020 using a differences-in-differences analysis.

Setting: Municipalities in São Paulo state, Brazil.

Participants: We compare 129 municipalities that reopened schools in 2020 with the remainder 514 that did not and drop data for 2 municipalities that reopened schools and closed then again.

Main outcomes and measures: COVID-19 new cases and deaths per 10,000 inhabitants, up to 12 weeks after school reopening, and municipal-level aggregate mobility for a subset of municipalities.

Results: There are 8,764 schools in the municipalities that reopened schools, relative to 9,997 in the control group. The municipalities that reopened schools had a cumulative COVID-19 incidence of 20 cases per thousand and mortality of 0.5 deaths per thousand in September 2020 (the baseline period), relative to an incidence of 18 cases per thousand and mortality of 0.45 deaths per thousand in the baseline period in the comparison group .We estimate no statistically significant difference between municipalities that authorized schools to reopen and those that did not, before and after October 2020, for (1) weekly new cases [DiD 95% CI, -0.087, 0.027], (2) weekly new deaths [DiD 95% CI, -0.011, 0.005]. Reopening schools was not associated with higher disease activity even in relatively vulnerable municipalities and neither affected aggregate mobility.

Conclusions and relevance: Our findings suggest that keeping schools open during the pandemic did not contribute to the aggregate disease activity.

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Introduction

Most countries around the world closed schools to reduce COVID-19 infections for a prolonged period of time[1-2]. Beyond learning outcomes, school closures have also been shown to adversely affect children's well-being,[1-4] and to increase dropouts.[5-6]

In-person classes might contribute to COVID-19 incidence and mortality. First, recent evidence suggests that the likelihood of infection among family members and school staff increases significantly when schools are open.[7-8] Second, non-pharmaceutical measures, have been shown to contribute to slowing down disease activity[9-15]. School closures were typically included in these interventions, as they concentrate more people than most other establishments.[16-19] Third, the mobility of primary caregivers is expected to increase when children are at school, potentially boosting transmission above and beyond the school setting.[20-21] The risks of in-person classes might be especially high in developing countries, where schools may lack resources for robust mitigation strategies that reduce transmission.[22-24]

Conversely, keeping schools open during the pandemic might not elevate risks of COVID-19 incidence and mortality. In fact, studies suggest that children, particularly those in primary school, are among the safest groups for whom social distancing could be gradually foregone due to their relatively low transmission risk.[18] No study to date has documented the aggregate consequences of keeping schools open in developing countries during the pandemic with appropriate counterfactuals. Few studies have examined the association between school reopening during the pandemic and COVID-19 disease activity in developed country settings[25-27]and their findings are mixed.

This paper takes advantage of a natural experiment in São Paulo State, Brazil. All State schools were closed by the end of March 2020, in response to increasing COVID-19 cases in the State. In-person school activities remained suspended in the State throughout September 2020. Between October and December 2020, 129 municipalities authorized schools to partially reopen for in-person activities. Using public data on the evolution of the pandemic across different municipalities, we test whether school reopening under appropriate protocols increased COVID-19 cases and deaths in São Paulo State, taking advantage of the staggered timing of municipal decrees that authorized schools to reopen in the State.

Methods

Data sources

We combine several data sources to study this question. First, we use data on the timing of municipal decrees that authorized schools to partially reopen for in-person activities in the State, collected by the São Paulo State Secretariat of Education. Second, we use publicly available data on COVID-19 cases and deaths from municipal Health Secretariats and the Brazil.io repository[28]. We focus on the period ranging from August to December 2020, so that we can examine trends for COVID-19 cases and deaths both before and (up to twelve weeks) after school reopening in the State. Third, we collect data for aggregate mobility from Google reports, which is available only for a subset of all municipalities. Fourth, we collect municipality characteristics (e.g., per capita income and population) from Brazilian Census data. Last, we collect school characteristics from the Brazilian school census. In the supplementary materials, we provide more details about data sources and variable construction.

Outcomes

We focus on two main outcomes of interest: weekly per capita new COVID-19 cases and deaths (both in logs). The log transformation allows us to interpret our estimates as percentual differences in the outcomes of interest. We add 1 to all values to prevent dropping weekly observations for which we do not observe any new cases or deaths. As such, we have values for both outcomes across all municipalities and periods in our sample.

Exposure

We have data on the existence and the timing of all municipal decrees that allowed schools to partially reopen in São Paulo State since October 2020. 131 out of the 645 municipalities in the State eventually reopened schools in 2020, as Figure E2 shows. Out of those, we drop from the analyses 2 municipalities that authorized schools to reopen at first but reversed that decision shortly after. Schools that reopened had to follow safety protocols; in particular, all school staff had to wear personal protective equipment, alcohol had to be made available at the school gate, and in-person attendance was limited (e.g., at 35% capacity in regions where the severity of the pandemic was high).

In our empirical strategy, we compare the trends of the outcomes of interest within municipalities that authorized schools to reopen to those that did not, before and after authorization decrees. We do not have data on how many students actually attended in-person classes during that period; as such, we are only able to estimate intention-to-treat (ITT) effects of school reopening. The São Paulo Secretariat of Education estimates that approximately two million students (out of the 3.5 million public school students in the State) attended in-person school activities between October and December 2020.

Statistical analyses

Since decisions to reopen schools or not for in-person activities in 2020 were not random, merely comparing trends of COVID-19 cases and deaths across different municipalities after in-person activities were allowed to resume would mistakenly associate school reopening to disease activity, especially in the presence of mean reversion.

To deal with this challenge, we implement a differences-in-differences strategy, which parses out any baseline differences across municipalities, as long as those that eventually authorized schools to reopen and those that did would not have exhibited systematic differences in trends for the outcomes of interest *in the absence of school reopening*. For each cohort of municipalities that reopened schools (defined by the week at which their authorization decree was made effective), we formally estimate the relationship between school reopening and disease activity using the differences-in-differences estimator of Callaway and Sant'Anna[29]. Since this estimator includes a matching procedure in the first step (see Appendix B in the supplementary materials), the parallel trends assumption has to hold only conditionally for its differences-in-differences estimates to be valid. Concretely, what this means is that, in the absence of school reopening, the growth rates of COVID-19 cases and deaths should have been the same across municipalities that did or did not authorize schools to reopen in 2020. While this is an assumption of the method, we can validate it implicitly by testing whether, conditional on baseline characteristics, the outcomes of interest exhibited differential trends across the two groups prior to October 2020 (when no municipalities had yet authorized in-person activities to resume; see supplementary materials).

Because in-person activities returned at different weeks across cohorts, we first estimate cohort-specific differences-in-differences coefficients through Ordinary Least Squares (OLS), and then combine them by weighting each estimate by its relative group size when computing the aggregate relationship for the whole sample.[29]

In all regressions, we control for municipal characteristics (income, population, number of schools, number of students per 1,000 inhabitants, and average quality of school infrastructure) from the 2010 Brazilian population census, and their baseline per capita COVID-19 cases and deaths (cumulative between January and September, immediately before school reopening). School infrastructure is the first principal component from a vector of school characteristics from the 2019 Brazilian school census (whether the school had a working kitchen, working bathrooms, trash collection, adequate sanitation infrastructure and access to drinking water, and its average class size).

We also estimate heterogeneous relationships between school reopening and COVID-19 disease activity with respect to the following municipality characteristics: (a) baseline COVID-19 deaths; (b) average quality of school infrastructure; (c) per capita income; and (d) 65+ year-old population share. In each case, we split municipalities according to the sample median, and focus on whether effects are statistically different from zero within the highest risk / most vulnerable sub-sample.

Last, we estimate the relationship between school reopening and municipality's average mobility index in that week, using the same differences-in-differences strategy. This outcome is publicly available from Google mobility reports[31], based on cell phone location. The outcome we have access to is an index, capturing changes in mobility relative to the municipal average in the week of February 15, 2020, measured in percentage points (see supplementary materials). The index is only available for 412 municipalities in São Paulo State. While these mobility data are not tagged to the school-relevant population, the interest lies on whether authorizing schools to reopen borne a relationship with overall mobility in each municipality, above and beyond that of children and their caregivers – in tandem with the main analyses, which concern municipal-level COVID-19 cases and deaths.

Results

This study includes 643 municipalities in São Paulo State, 129 that authorized schools to reopen in 2020 (comprising 8,764 schools), and 514 (9,997 schools) that did not. Municipalities that reopened schools had cumulative COVID-19 incidence of 20 cases per thousand and mortality of 0.5 deaths per thousand in the baseline period. Municipalities that did not authorize schools to reopen had a cumulative COVID-19 incidence of 18 cases per thousand and mortality of 0.45 deaths per thousand over the same period. Table 1 shows descriptive statistics for municipalities that authorized schools to reopen in 2020 and those that did not. On average, municipalities that reopened schools were larger, richer, and had less new COVID-19 cases and deaths before October 2020 than those that did not.

Figure 1 shows trends in the log of COVID-19 cases and deaths per 10,000 inhabitants, separately for each group of municipalities. We observe no clear acceleration trend in either new cases or deaths for the municipalities that reopened schools. In Figure 2, we show trends for those outcomes restricting attention to the sub-sample that most closely matches the characteristics of municipalities that reopened schools in the control group. For this matched sample, trends are even more similar across groups.

Next, Figure 3 estimates dynamic effects of school reopening non-parametrically, showcasing differences-in-differences coefficients by week after school reopening for the log of new cases per 10,000 inhabitants (Panel A) and the log of new deaths per 10,000 inhabitants (Panel B). We estimate no statistically significant difference between the two groups either before (falsification tests) or after school reopening, up to twelve weeks after in-person activities were allowed to resume.

In Table 2, we compile cohort-specific estimates of school reopening on the log of new cases per 10,000 inhabitants (Column 1), the log of new deaths per 10,000 inhabitants (Column 2), and the aggregate mobility index (Column 3), estimated through differences-in-differences. We find no association between school reopening and COVID-19 cases up to twelve weeks after reopening [-0.03, 95% CI: -0.086, 0.026] for log of weekly cases. Similarly, we find no association between school reopening and COVID-19 deaths [-0.003, 95% CI: -0.011,0.004] for log of weekly deaths. If anything, the average effect on cases and deaths is actually negative. The table also showcases the value of our estimation technique, as there is substantial variation in cohort-specific estimates. Last, school reopening is associated with a [1.465 , 95% CI: -0.062, 2.993] increase in local mobility, a small effect that is not statistically different from zero at conventional significance levels.

In supplementary materials, Table E3 documents no significant association between school reopening and disease activity within municipalities most at risk: those with below-median quality school infrastructure, below-median per capita income, above-median senior population share, and above-median baseline disease activity. Also, using additional COVID-19 testing data, which allows studying whether the association between school reopening and COVID-19 cases varies significantly by age, Table E4 finds no statistical difference in cases between school-aged children and young adults across municipalities that authorized schools to reopen and those that did not, before and after October 2020, and Table E5 finds no difference between 28-48 year-olds (within the typical age range of primary and secondary school parents) and 49-65 year-olds using the same strategy. Supplementary materials also show that results are robust to matching municipalities across groups based on characteristics (in Table E6), and to allowing COVID-19 cases and deaths to be influenced by reopening decisions in neighboring municipalities (in Table E7). In Figure E2, we show that our conclusions remain unchanged if we use alternative measures of the outcome variables, such as excluding municipalities with zero Covid-19 cases or deaths or using these variables in levels, instead of in logs.

Figure 4 then turns to Google mobility data, showing the index separately for each group of municipalities. For both groups, mobility was approximately 13 p.p. lower than pre-pandemic levels twelve weeks before school reopening. Mobility evolved similarly over time across all municipalities, increasing sharply even before schools were allowed to reopen, and ultimately reaching pre-pandemic levels by late November even within municipalities that did not reopen schools in 2020.

Discussion

In this study of 643 municipalities in São Paulo State, results suggest that reopening schools during the pandemic was not systematically associated with higher COVID-19 cases or deaths. Average differences in disease activity after October 2020 across municipalities that authorized schools to reopen and those that did not were small and not statistically significant at any week after reopening when it comes to COVID-19 new or cumulative cases or deaths. This is not because the study design lacks statistical precision: effect sizes on cases are nearly zero in most weeks and, if anything, average COVID-19 incidence and mortality was actually higher within municipalities that did not reopen schools in 2020. We show that school reopening was not significantly associated with disease activity even in municipalities with lower-quality school infrastructure, lower per capita income, higher senior population share, or most severely affected by the pandemic. Evidence from the studies conducted in developed countries about the association of school reopening and COVID-19 disease activity is mixed[25-27], and their empirical strategy can only estimate short-term effects of school reopening on disease activity (2-3 weeks after in-person classes returned).

In developing country settings, most studies only analyze risks within the school community, rather than at the aggregate[30], and none of them estimates effects under appropriate counterfactuals. Studies that estimate the effects of school reopening by simply comparing cases within municipalities, before and after in-person activities returned, are likely to detect false positives. The reason is mean reversion – the statistical tendency for negative (positive) shocks to be followed by positive (negative) ones[31] –; concretely, locations that allow schools to re-open are statistically more likely to have experienced unusually low COVID-19 cases before in-person classes returned. Analogously, merely comparing average COVID-19 incidence and mortality across locations that authorized schools to reopen to those that did not would tend to over-estimate the effects of reopening during the pandemic; such locations typically differ in many dimensions, particularly when it comes to their previous trends for COVID-19 cases, hospitalizations and deaths. Analyzing a comparison group with similar pre-trends for COVID-19 case-rate and deaths is a critical element of study design to assign a clearer interpretation to empirical findings.

Resuming in-person school activities might affect the aggregate evolution of the pandemic through two mechanisms. First, students and school staff might get infected at school, and subsequently infect their families. Second, school reopening might increase the mobility of children and their caregivers, leading to infections above and beyond the school setting. When it comes to the first mechanism, schools were authorized to reopen in São Paulo State during the study period only under appropriate protocols, including strict limits to in-person attendance. When it comes to the second mechanism, the analysis of mobility data shows that school reopening was not significantly associated with higher aggregate mobility in a context where counterfactual mobility was already very high: the mobility index in São Paulo State reached pre-pandemic levels at the beginning of November, which indicates that families were *not* safe from contagion in the absence of in-person school activities.

All in all, the findings in this study suggest that reopening schools in developing countries during the pandemic is unlikely to contribute to aggregate risk in the presence of safe reopening protocols, especially where mobility is already high. As such, results suggest that the aggregate benefits of keeping schools closed is low. Together with recent evidence about the large educational costs of school closures across countries of all income levels[6,32], results suggest that the policy debate in developing countries must urgently focus on how to safely keep schools open amidst the pandemic, rather than whether or not to do so.

There are three important limitations to the analyses in this study. First, data limitations only allow documenting the association between school reopening and *aggregate* disease activity. As such, the null results estimated in this study do not imply that school reopening in the pandemic poses no risks for school staff or students' families – especially in settings where robust protocols to prevent infections at the school setting are not in place. Additional research is needed to document the direct impacts of school reopening in developing countries on those populations with appropriate counterfactuals. That would require drawing on individual-level data on COVID-19 cases, hospitalizations and deaths for students, school staff, and their families, both for schools that reopened and for those that did not, parsing out any differences in previous trends in disease activity across them.

Second, we are only able to estimate intention-to-treat effects of school reopening on disease activity. This is the case because we do not have detailed information on which schools effectively reopened or on municipal-level school attendance. As such, this study's findings are not informative about the marginal effects of student attendance on municipal-level COVID-19 cases and deaths.

Third, these findings might not necessarily replicate in other settings. On the one hand, Brazil is dense and was hard-hit by the pandemic – likely a relevant benchmark for other developing countries. Moreover, the null results documented in this study hold across a wide range of local contexts – by income levels, school infrastructure, senior population share, and local disease activity. On the other hand, in other countries or periods where mobility has been more successfully restrained by non-pharmaceutical measures, the study cannot rule out that school reopening could increase overall mobility and contagion, contributing to aggregate disease activity, especially if safe reopening protocols are not in place. Complementary approaches, from seroprevalence surveys[33-34] to identifying which variants of the virus are circulating in these settings[35], are also needed to further inform risk assessments in each context.

Tables

Table 1: Descriptive statistics of municipalities by school opening decision in the baseline period (as of end of September)

	Did not reopen schools	Reopened schools
New cases per thousand	0.79	0.76
New deaths per thousand	0.03	0.02
Accumulated deaths per thousand	0.44	0.49
Income per capita	672.17	804.58

Population (thousands)	38.65	200.37
Population density (hab/km^2)	277.77	586.37
Number of schools	19.41	67.94
Number of students (thousands)	7.21	34.34
School infrastructure	-0.01	0.00
Municipalities	514	129

Note: This table presents averages for several variables, separately for municipalities that reopened schools at any point of 2020 and those that did not. Time-variant variables are measured at the baseline period (last week of September 2020).Data for Covid-19 cases and deaths (rows 1-3) comes from the Brasil.io. Municipal characteristics comes from the Brazilian census (rows 4-6). School characteristics comes from the Brazilian school census (rows 7-9).

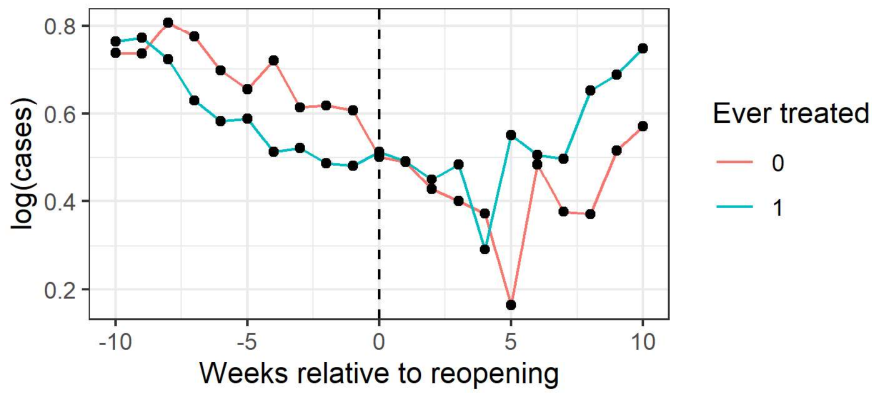
Table 2: difference-in-difference estimates aggregated by cohorts

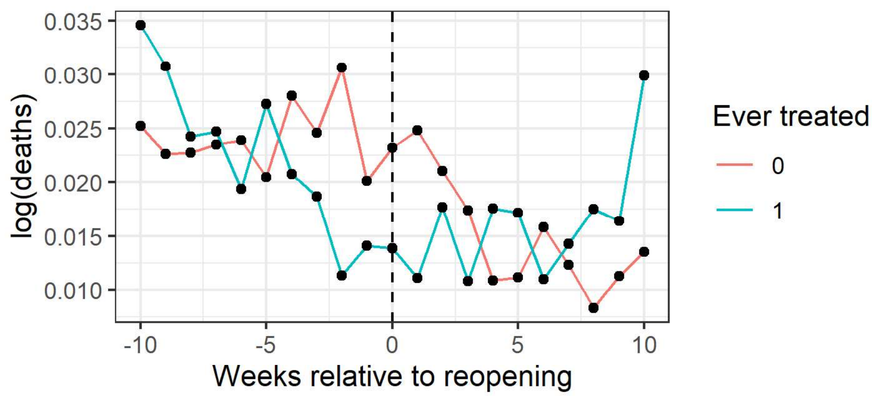
Cohort treatment	log(weekly cases)	log(weekly deaths)	mobility
	(1)	(3)	(5)
0	0.002	-0.009	1.855
	[-0.071, 0.076]	[-0.019, 0.001]	[-0.063, 3.773]
5	-0.084	0.015	-0.023
	[-0.273, 0.104]	[-0.024, 0.054]	[-3.989, 3.943]
6	-0.080	0.002	0.112
	[-0.207, 0.046]	[-0.005, 0.010]	[-2.878, 3.102]
8	-0.121	0.001	4.761***
	[-0.290, 0.048]	[-0.014, 0.013]	[1.985, 7.536]
9	0.046	-0.008	0.006
	[-0.195, 0.288]	[-0.022, 0.006]	[-5.061, 5.072]
Aggregate difference	-0.030	-0.003	1.465
	[-0.086, 0.026]	[-0.011, 0.004]	[-0.062, 2.993]

Notes: This table shows the estimated difference between municipalities that reopened schools and those that did not using the Calloway and Sant'anna estimator aggregated at the cohort level. We show point coefficients and 95% confidence intervals. *p<0.1, **p<0.05, ***p<0.01.

Figures

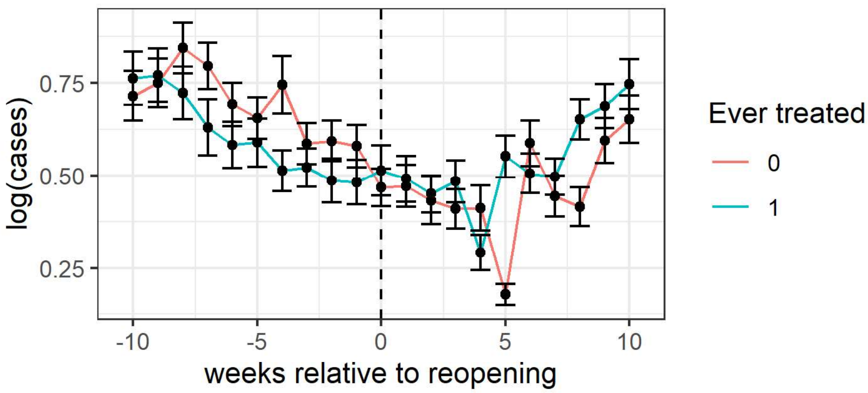
Figure 1 – Trends in the outcomes of interest for municipalities that reopened schools and those that did not

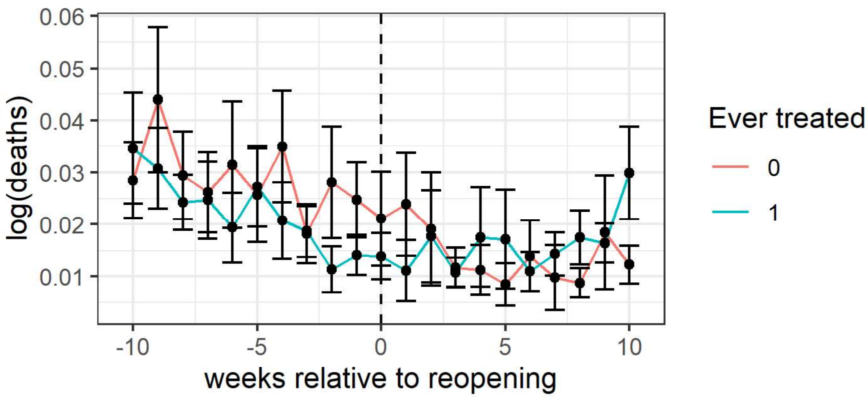




Notes: This figure shows trends for the outcomes of interest separately for municipalities that reopened schools and those that did not. Panel A showcases the log of cases and Panel B showcases the log of deaths. For the control group, the week of reopening is normalized to the last week of September 2020. The sample includes 129 municipalities for the treated group and 514 for the control group.

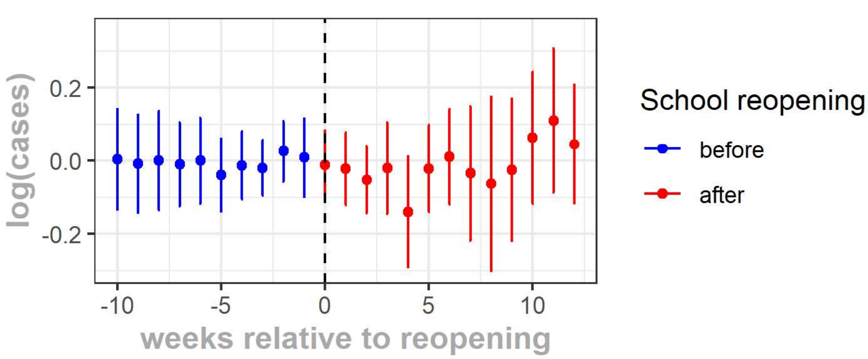
Figure 2 – Trends in the outcomes of interest for municipalities that reopened schools and those that did not with matched sample

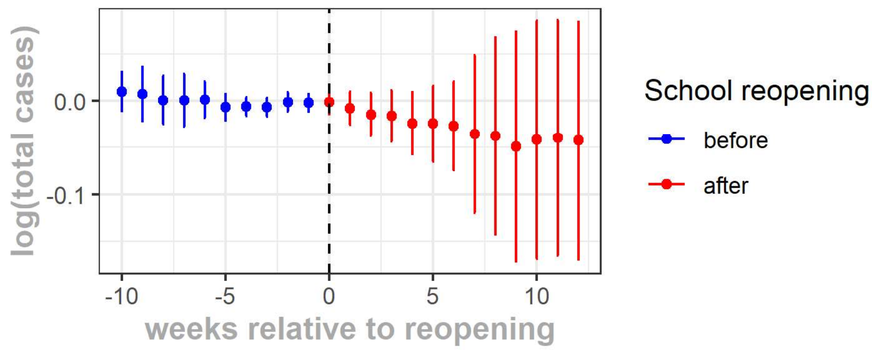




Notes: This figure shows trends for the outcomes of interest separately for municipalities that reopened schools and those that did not and were the closest matches for the municipalities that reopened. Panel A showcases the log of cases and Panel B showcases the log of deaths. For the control group, the week of reopening is normalized to the last week of September 2020 and we show 95% confidence intervals as vertical bars. The sample includes 129 municipalities both for the treatment and control groups.

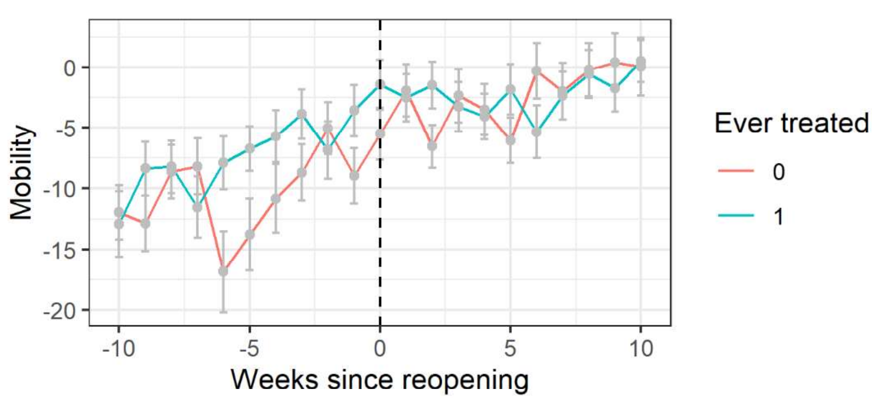
Figure 3: estimates of the difference between the groups using the difference-in-difference estimator





Notes: This figure shows the estimated difference between municipalities that reopened schools and those that did not using the Calloway and Sant'anna estimator. Vertical bars represent 95% confidence intervals.

Figure 4 – Trends in mobility index for the matched sample



Notes: This figure shows trends for the Google mobility index separately for municipalities that reopened schools and those that did not and had similar characteristics as the former group. Details of the matching procedure are given in Appendix B of the Supplementary materials. The dependent variable represents weekly mobility relative to February 2020.

Contributors

GL takes responsibility for the integrity of the data and the accuracy of the data analysis. GL and OLN decided to publish the paper. CAB was responsible for compiling the data. GL, CAB and OLN drafted the manuscript. GL, CAB and OLN contributed to statistical analysis. CAB led data management. GL, CAB, JC and OLN critically revised the manuscript. All authors had full access to all the data in the study and had responsibility for the decision to submit for publication.

Declaration of interests

GL and OLN received fees from the Inter-American Development Bank (IADB) for the design of this study. JC is an IADB staff member. CAB declares no competing interests.

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REFERENCES

1. Auger KA, Shah SS, Richardson T, Hartley D, Hall M, Warniment A, et al. Association between statewide school closure and COVID-19 incidence and mortality in the US. JAMA. 2020;324(9):859–70.

2. Donohue JM, Miller E. COVID-19 and school closures. JAMA. 2020;324(9):845–7.

3. Azevedo JP, Hasan A, Goldemberg D, Iqbal SA, Geven K. Simulating the potential impacts of COVID-19 school closures on schooling and learning outcomes. World Bank. 2020 Jun; Policy Research Working Paper No. 9284. Available from: https://openknowledge.worldbank.org/bitstream/handle/10986/33945/Simulating-the-Potential-Impacts-of-COVID-19-School-Closures-on-Schooling-and-Learning-Outcomes-A-Set-of-Global-Estimates.pdf. Accessed March 25, 2021.

4. Alsan M, Braghieri L, Eichmeyer S, Kim MJ, Stantcheva S, Yang D. Civil liberties in times of crisis. [published online October 2020] National Bureau of Economic Research. 2020. doi: 10.3386/w27972.

5. Lichand G, Christen J. Using nudges to prevent student dropouts in the pandemic. [published online 4 Nov 2020]. SSRN Electron J. 2020; doi: http://dx.doi.org/10.2139/ssrn.3724386.

6. Lichand G, Belchior C, Neto OL, Cossi J. The Impacts of Remote Learning in Secondary Education: Evidence from Brazil during the Pandemic. [published online 10 May 2021] SSRN Electron J. 2021; doi: http://dx.doi.org/10.2139/ssrn.3841775.

7. Flasche S, Edmunds WJ. The role of schools and school-aged children in SARS-CoV-2 transmission. Lancet Infect Dis. 2021;21(3):298–9.

8. Lessler J, Grabowski MK, Grantz KH, Badillo-Goicoechea E, Metcalf CJE, Lupton-Smith C, et al. Household COVID-19 risk and in-person schooling [published online March 1, 2021]. doi: https://doi.org/10.1101/2021.02.27.21252597.

9. Lai S, Ruktanonchai NW, Zhou L, Prosper O, Luo W, Floyd JR, et al. Effect of non-pharmaceutical interventions to contain COVID-19 in China. Nature. 2020;585(7825):410–3.

10. Flaxman S, Mishra S, Gandy A, Unwin HJT, Mellan TA, Coupland H, et al. Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe. Nature. 2020;584(7820):257–61.

11. Sun J, Shi Z, Xu H. Non-pharmaceutical interventions used for COVID-19 had a major impact on reducing influenza in China in 2020. J Travel Med. 2020; 27(8).

12. Seale H, Dyer CEF, Abdi I, Rahman KM, Sun Y, Qureshi MO, et al. Improving the impact of non-pharmaceutical interventions during COVID-19: examining the factors that influence engagement and the impact on individuals. BMC Infect Dis. 2020;20(1):607.

13. Davies NG, Kucharski AJ, Eggo RM, Gimma A, Edmunds WJ, Centre for the Mathematical Modelling of Infectious Diseases COVID-19 working group. Effects of non-pharmaceutical interventions on COVID-19 cases, deaths, and demand for hospital services in the UK: a modelling study. Lancet Public Health. 2020;5(7):e375–85.

14. Regmi K, Lwin CM. Impact of non-pharmaceutical interventions for reducing transmission of COVID-19: a systematic review and meta-analysis protocol. BMJ Open. 2020;10(10):e041383.

15. Cowling BJ, Ali ST, Ng TWY, Tsang TK, Li JCM, Fong MW, et al. Impact assessment of non-pharmaceutical interventions against coronavirus disease 2019 and influenza in Hong Kong: an observational study. Lancet Public Health. 2020;5(5):e279–88.

16. Van Lancker W, Parolin Z. COVID-19, school closures, and child poverty: a social crisis in the making. Lancet Public Health. 2020;5(5):e243–4.

17. Fantini MP, Reno C, Biserni GB, Savoia E, Lanari M. COVID-19 and the re-opening of schools: a policy maker's dilemma. Ital J Pediatr. 2020;46(1):79.

18. Viner RM, Russell SJ, Croker H, Packer J, Ward J, Stansfield C, et al. School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review. Lancet Child Adolesc Health. 2020;4(5):397–404.

19. Stein-Zamir C, Abramson N, Shoob H, Libal E, Bitan M, Cardash T, et al. A large COVID-19 outbreak in a high school 10 days after schools' reopening, Israel, May 2020. Euro Surveill. 2020;25(29).

20. Kraemer MUG, Yang C-H, Gutierrez B, Wu C-H, Klein B, Pigott DM, et al. The effect of human mobility and control measures on the COVID-19 epidemic in China. Science. 2020;368(6490):493–7.

21. Alon TM, Kim M, Lagakos D and VanVuren M . How Should Policy Responses to the COVID-19 Pandemic Differ in the Developing World?, NBER Working Paper No. 27273, 2020.

22. Nugroho, Dita; Pasquini, Chiara; Reuge, Nicolas; Amaro, Diogo (2020). COVID-19: How are Countries Preparing to Mitigate the Learning Loss as Schools Reopen? Trends and emerging good practices to support the most vulnerable children, Innocenti Research Briefs no. 2020-20, UNICEF Office of Research - Innocenti, Florence

23. Gurdasani D, Alwan N A, Greenhalgh T, Hyde Z, Johnson L, McKee M ,Michie S, Prather K A, Rasmussen S A , Reicher S, Roderick P , Ziauddeen H. Reopening schools without strict COVID-19 mitigation measures risks accelerating the pandemic. OSF Preprints. 2021. [Published online March 6, 2021] doi: 10.31219/osf.io/qg4bj

24. Chang S, Pierson E, Koh PW, Gerardin J, Redbird B, Grusky D, et al. Mobility network models of COVID-19 explain inequities and inform reopening. Nature. 2021;589(7840):82–7.

25. School re-openings after summer breaks in Germany did not increase SARS-CoV-2 cases [Internet]. Iza.org. [cited 2021 Mar 19]. Available from: https://COVID-19.iza.org/publications/dp13790/.

26. Amodio, E, M Battisti, A Kourtellos, G Maggio and C M Maida, Schools opening and COVID-19 diffusion: evidence from geolocalized microdata, Covid Economics 65, 2020.

27. Bravata D, JH Cantor, N Sood and CM Whaley. Back to School: The Effect of School Visits During COVID-19 on COVID-19 Transmission. Available from: https://www.nber.org/papers/w28645.

28. COVID-19 - Datasets - Brasil.IO [Internet]. Brasil.io. [cited 2021 Mar 24]. Available from: https://brasil.io/dataset/covid19/caso_full/

29. Callaway B, Sant'Anna PHC. Difference-in-differences with multiple time periods [Internet]. arXiv [econ.EM]. 2018. Available from: http://arxiv.org/abs/1803.09015.

30. Ferrante, L., Steinmetz, W.A., Almeida, A.C.L, Leão, J, Vassão R. C., Tupinamba U, Fearnside PH, and Duczmal LH. Brazil's policies condemn Amazonia to a second wave of COVID-19. Nature Medicine 26, 1315, 2020.

31. Bland J M and Altman DG. Statistic Notes: Regression towards the mean. British Medical Journal, 308 (6942): 1499, 1994.

32. Engzell, P, A Frey, and M D Verhagen (2020). Learning inequality during the COVID-19 pandemic, SocArXiv.

33. Lachassinne, E., de Pontual, L., Caseris, M., Lorrot, M., Guilluy, C., Naud, A., … COVIDOCRECHE collaborators. SARS-CoV-2 transmission among children and staff in daycare centres during a nationwide lockdown in France: a cross-sectional, multicentre, seroprevalence study. The Lancet. Child & Adolescent Health, 5(4), 256–264, 2021.

34. Waterfield T, Watson C, Moore R, Ferris K, Tonry C, Watt A, et al. Seroprevalence of SARS-CoV-2 antibodies in children: a prospective multicentre cohort study. Arch Dis Child. 2020;archdischild-2020-320558.

35. Brookman, S., Cook, J., Zucherman, M., Broughton, S., Harman, K., & Gupta, A. . Effect of the new SARS-CoV-2 variant B.1.1.7 on children and young people. The Lancet. Child & Adolescent Health, 2021 5(4), e9–e10.