GLOBAL BIOSECURITY

Chawla D, Trent MJ, Moa A, Stone H, MacIntyre CR. An analysis of COVID-19 outbreaks in schools in South and Southwestern United States using open-source data. *Global Biosecurity, 2020; 3(1).*

RESEARCH ARTICLES

An analysis of COVID-19 outbreaks in schools in South and Southwestern United States using open-source data

Deepti Chawla, Mallory Trent, Aye Moa, Haley Stone, C Raina MacIntyre

Biosecurity Program, The Kirby Institute, University of New South Wales, Sydney, Australia

Abstract

The reopening of schools for the 2020 fall academic session in the United States was linked to many cases of COVID-19 infection. This analysis utilized a dataset of school-related outbreaks created by National Education Association (NEA) to study attack rates and COVID-19 trends in schools located in the south and southwestern regions of the United States. The highest attack rate was observed in Mississippi for both students (AR= 0.74%) and teachers (AR= 3.68%). In most states, the percentage of cases was higher for students in high schools than elementary schools, whereas the reverse was true for teachers. Most outbreaks had fewer than five cases, with only a small number of outbreaks that involved more than 10 cases in the duration under study. Outbreak size was found to be the highest in the state of Texas. Epidemic curves of new cases in most of these states showed features of a propagated outbreak. Findings related to size and pattern of school outbreaks may have significant implications for defining public health policies related to school functioning during infectious disease outbreaks.

Keywords: COVID-19, School outbreaks, United States

Introduction

The impact of SARS-CoV-2 on educational settings has been felt across the globe. By March 18th 2020, within days of the declaration of the pandemic by the World Health Organization, 107 countries had enforced nationwide school closures (1). Historical evidence from influenza epidemics contributed to the rationale behind enforcing mandatory school closures (2, 3). However, the impact of transmission of COVID-19 in educational settings on overall disease incidence in the community has become a hotly contested issue (3-5). If the validity of school closure policies was debatable, reopening educational institutions became equally contentious. Some modelling studies predicted that reopening schools would result in an increase in case numbers unless backed up by stringent testing and contact tracing efforts (6), while other studies found no association between the two (7).

The United States of America has registered the highest number of cases of SARS-CoV-2 in the world (8). COVID-19 has caused mass disruption of education activity in the country. The historic closure of schools affected at least 50.8 million public school students (9). There has been significant concern over reopening of schools around the world including America (10). The inability of school authorities to effectively enforce physical distancing and mask use has been noted (11). Poor ventilation in rooms, overcrowding, and class size (number of students per class) have also been considered as potential factors for viral transmission. This, coupled with the fact that many children do not display the classic symptoms of COVID-19 or otherwise remain asymptomatic (12) has led to debate whether teachers, staff members and indeed the community will be at a heightened risk if and when schools become fully functional (13).

Systematic tracking of school-related outbreaks is important for assessing the magnitude and the nature of impact of transmission in schools. It may provide valuable insights for investigating whether school-related outbreaks impact the epidemic curve in the community and can help define best practice in infection control and prevention. However, this task is rendered nearly impossible in the absence of a centralised and standardised official national database.

In August 2020, an educator from Kansas, began creating a Google spreadsheet by tracking news stories reported on the internet related to COVID-19 school outbreaks across the United States. Later the project was taken over by National Education Association which hosted the project on its own website (14). The dataset aggregates state-wise information of school and college campus outbreaks, linking each report to a published news story or the school's social media account to ensure credibility and traceability of the information (15).

This study aimed to analyze open-source data to estimate attack rates and study trends of COVID-19 transmission among school students and teachers in the South and Southwestern regions of the United States from the time of reopening of schools in fall to October 11th2020, prior to vaccine rollout.

Methods

In this analysis 'outbreak' refers to an "occurrence of cases of disease in excess of what would normally be expected in a defined community, geographical area or season," where the occurrence of these cases is maintained by an infectious agent that can spread directly from person to person (16).

This analysis utilized the dataset from the National Education Association (NEA) school and campus COVID-19 reporting site (15) to estimate the attack rates and investigate trends in COVID-19 transmission among students and staff members across schools in the south and southwestern regions of the United States. The dataset lists number of confirmed unique cases among students and staff members per school in each state.

This analysis focuses on the period of time spanning week 29 (beginning July 13th) to week 41 (beginning October 11th) of 2020. This duration was selected as schools in the United States had begun closing for the academic year at around the middle of March 2020. Data of cases reported prior to closing in March was unavailable for analysis.

The geographic regions of south and southwestern regions the United States as defined by the National Centres for Environmental Information (17) were studied in this analysis. These regions include the following 10 states:

South Region:

- Arkansas (AR)
- Kansas (KS)
- Louisiana (LA)
- Mississippi (MS)
- Oklahoma (OK)
- Texas (TX)

Southwestern Region:

- Arizona (AZ)
- Colorado (CO)
- New Mexico (NM)
- Utah (UT)

To analyse the distribution of school-related cases, each school was classified into high, middle or elementary schools based on the information in the source data, from the school website, or sites such as GreatSchools (https://www.greatschools.org/). Junior high schools and schools which catered to all age categories were labelled as undefined and excluded from the analysis to study trends in transmission across student age cohorts.

Data on student enrolment in each school was extracted from two websites: https://www.schooldigger.com/ (18) and https://www.greatschools.org/ (19). Data on student-teacher ratio from the same websites were used to derive an estimate of the number of teachers in each school.

Statistical Analysis

Attack rate for students in each state was calculated using the formula: (Number of confirmed cases in students in the state / Total number of students enrolled in the schools from which cases were reported) x 100%.

Similarly, attack rate in teachers was calculated as a percentage of total number of teachers that were reported as confirmed cases. Microsoft® Excel® 2016 MSO (Version 2109 Build 16.0.14430.20154) 32-bit (20) was used to calculate the Attack Rates for respective states.

An epidemic curve of new cases reported in the same duration in the general population of state was constructed using the data available on the website of the CDC (22). The data was also utilised to create a distribution of the size of the outbreak.

Schools that had reported single a case temporally over the weeks under consideration were eliminated from the analysis of attack rates. These isolated cases were however considered for drawing the school-related epidemic curve of new cases reported from respective states.

Results

A total of 3069 cases of school-related COVID-19 infection were analysed across nine states. The distribution of cases in these states has been depicted in Figure 1, with Texas leading in number of cases (n=1404, 45.75%). Analysis for New Mexico could not be undertaken due to insufficient data.

A total of 997 schools reported at least one case of COVID-19 across the nine states under consideration. The number of schools with at least 1 case in each state is depicted in Figure 1. Texas reported cases linked to 484 schools, whereas the dataset contained reports linked to only nine schools in Louisiana.

Epidemic Curves

Figures 2a-2g show epidemic curves of new cases reported in schools by state superimposed over epicurves of new cases state-wide from data published by CDC (22). The epidemic curves of school outbreaks of most of the states under consideration reflect a propagated outbreak characterised by successive irregular peaks separated by the incubation period. (Figures 2a-2i). Texas, Louisiana, Colorado, Kansas, Arkansas and Arizona show more than one irregular peak, whereas the epidemic curves of Oklahoma, Mississippi and Utah have a single peak.

COVID-19 attack rates among students and teachers

Table 1 summarizes the attack rates (AR) among students and teachers by state. Appendix i-ix contains detailed tables depicting the calculation of attack rates per school.

Mississippi was observed to have the highest attack rate among students (AR= 0.74%) as well as teachers (AR= 3.68%). Arizona reported the second highest attack rate among teachers (AR= 1.81%).

Proportion of cases by age cohort

Table 2 contains the distribution of cases across elementary, middle and high schools. The proportion of cases reported from each age cohort was calculated as a percentage of total school-related cases reported from the state. High schools contributed to a majority of student cases in Arkansas (n=55, 40%), Arizona (n=38, 75%), Kansas (n=55, 37.7%), Mississippi (n=81, 41%), Texas (n=301, 47%) and Utah (n=31, 48%). However, the same was not observed for Colorado and Oklahoma, which reported a greater proportion of student cases in elementary schools at 39% and 32%, respectively.

A higher proportion of cases was observed among teachers working in elementary schools than in high schools in several states including Arkansas (n=18, 26%), Arizona (n=8, 26%), Colorado (n=23, 49%), Mississippi (n=30, 41%), and Texas (n=125, 16.2%)

However, a large number of cases remained undefined in this analysis as the school level could not be ascertained.

Analysis of size of school-related outbreaks

Table 3 and 4 contain the analysis of the size of outbreaks. Smaller outbreaks were more frequent than larger ones., 176 outbreaks involved 2 cases for both teachers and students. 17 outbreaks among students involved more than 10 cases spread across 6 states. Among teachers, a total of 10 outbreaks in 4 states involved more than 10 cases. Outbreak size was highest in Texas and lowest in Louisiana.

Table 1. COVID-19 attack rates among students and in south and southwestern USA from July to October 2020, by state.

State	**Attack Rate** (Students)	**Attack Rate** (Teachers)
Arizona	0.23%	1.81%
Arkansas	0.10%	0.60%
Colorado	0.12%	1.02%
Kansas	0.18%	1.03%
Louisiana	0.07%	1.39%
Mississippi	0.74%	3.68%
Oklahoma	0.18%	0.94%
Texas	0.16%	0.54%
Utah	0.30%	1.27%

Figure 1. State-wise total recorded cases amongst teachers and students and State-wise number of schools with at least one recorded case

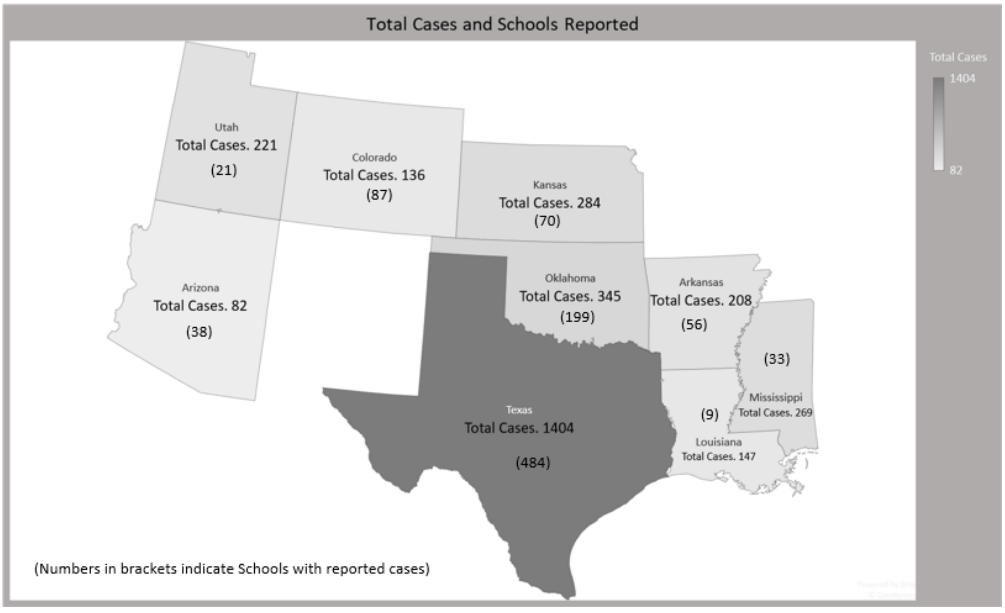
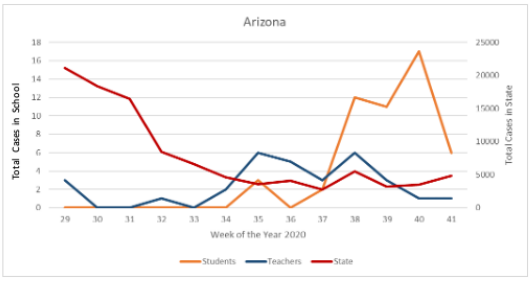
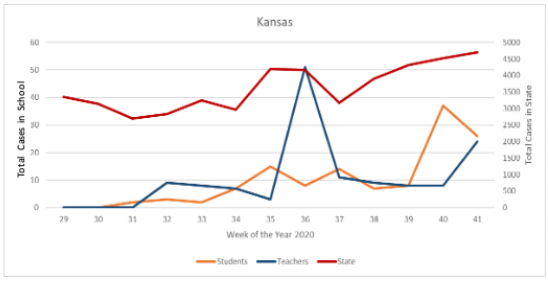
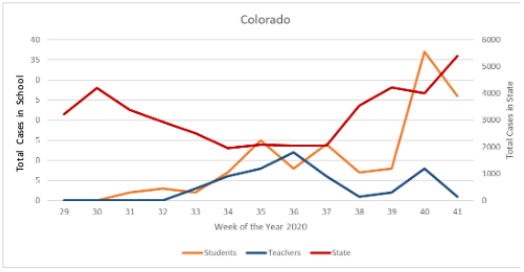
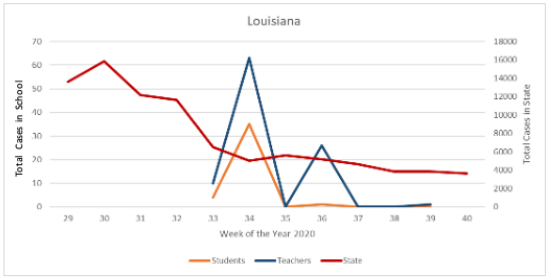


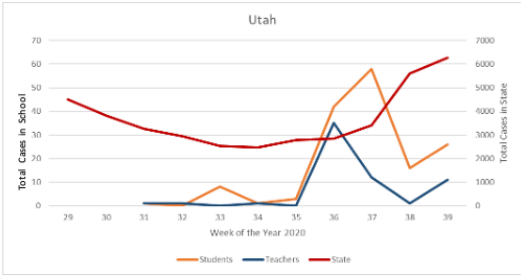
Figure 2a-i. Case numbers per week by state

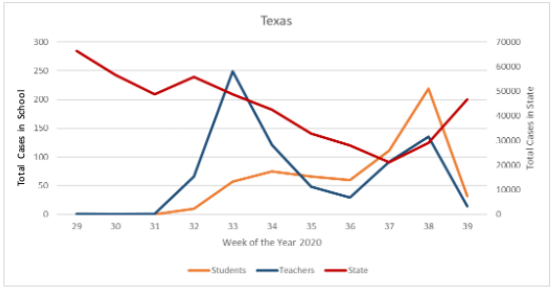


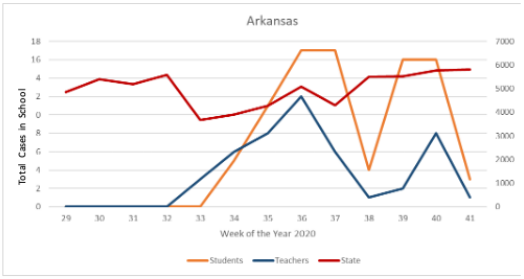


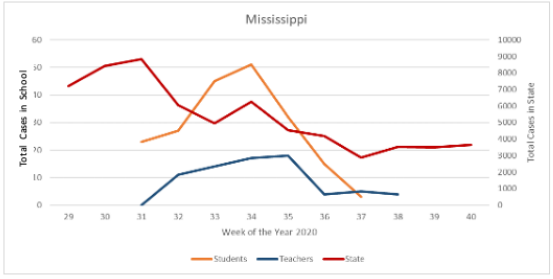












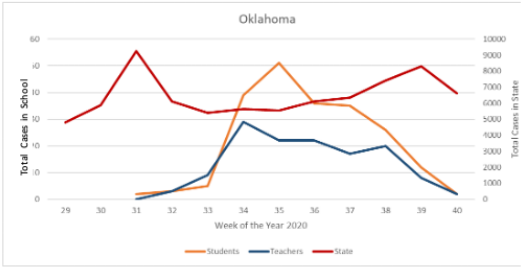


Table 2. School level-wise case distribution of COVID-19 in high schools, elementary and middle schools in south and southwestern USA from July to October 2020

States:	AR		AZ		CO		KS		LA		MS		OK		TX		UT		Totals	
Schools with at least one case	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Total	**56**	**100%**	**38**	**100%**	**87**	**100%**	**70**	**100%**	**9**	**100%**	**33**	**100%**	**199**	**100%**	**484**	**100%**	**21**	**100%**	**997**	**100%**
Elementary	16	29%	9	24%	45	52%	11	16%	0	0%	12	36.4%	73	36.7%	189	39%	3	14%	358	36%
Middle	9	16%	2	5%	13	15%	9	13%	0	0%	6	18.2%	33	16.6%	87	18%	0	0%	159	16%
High School	23	41%	17	45%	14	16%	33	47%	2	22%	11	33.3%	53	26.6%	140	29%	14	67%	307	31%
Undefined	8	14%	10	26%	15	17%	17	24%	7	78%	4	12.1%	40	20.1%	68	14%	4	19%	173	17%
Total Cases	**208**		**82**		**136**		**284**		**147**		**269**		**345**		**1404**		**221**		**3096**	
Students	138	**100%**	51	**100%**	89	**100%**	146	**100%**	40	**100%**	196	**100%**	133	**100%**	634	**100%**	64	**100%**	**1491**	**100%**
Elementary	15	11%	3	6%	35	39%	4	2.7%	0	0%	35	18%	43	32%	139	22%	1	2%	275	18%
Middle	10	7%	1	2%	14	16%	4	2.7%	0	0%	53	27%	7	5%	70	11%	0	0%	159	11%
High School	55	40%	38	75%	23	26%	55	37.7%	0	0%	81	41%	13	10%	301	47%	31	48%	597	40%
Undefined	58	42%	9	18%	17	19%	83	56.8%	40	100%	27	14%	70	53%	124	20%	32	50%	460	31%
Teachers	**70**	**100%**	**31**	**100%**	**47**	**100%**	**138**	**100%**	**107**	**100%**	**73**	**100%**	**212**	**100%**	**770**	**100%**	**157**	**100%**	**1605**	**100%**
Elementary	18	26%	8	26%	23	49%	16	12%	0	0%	30	41%	51	24%	125	16.2%	3	2%	274	17%
Middle	8	11%	1	3%	2	4%	6	4%	0	0%	14	19%	30	14%	88	11.4%	0	0%	149	9%
High School	11	16%	7	23%	7	15%	12	9%	2	2%	11	15%	64	30%	101	13.1%	73	46%	288	18%
Undefined	33	47%	15	48%	15	32%	104	75%	105	98%	18	25%	67	32%	456	59.2%	81	52%	894	56%

% depicts the distribution of cases across school types (elementary, middle, high school or undefined)

Table 3. Count of outbreaks among students by case numbers in south and southwestern USA from July to October 2020 (n=188)

Case Count	**AR**	**AZ**	**CO**	**KS**	**LA**	**MS**	**OK**	**TX**	**UT**
2 Cases (n=97)	7	5	10	6	1	4	5	59	0
3-5 Cases (n=51)	5	2	4	3	1	2	0	34	0
6-10 Case (n=23)	3	3	1	1	0	5	0	9	1
>10 Cases (n=17)	1	0	0	2	0	5	2	5	2

Table 4. Count of outbreaks among teachers by case numbers in south and southwestern USA from July to October 2020 (n=136)

Case Count	AR	AZ	CO	KS	LA	MS	OK	TX	UT
2 Cases (n=79)	7	1	5	9	0	5	11	40	1
3-5 Cases (n=42)	2	2	0	3	0	5	4	23	3
6-10 Case (n=5)	1	0	1	1	0	1	0	1	0
>10 Cases (n=10)	0	0	0	2	0	0	2	3	3

Discussion

While evidence suggests a strong correlation between higher incidence in the community and an increased risk of outbreak in schools (23), the role of children in impacting the course of the pandemic is yet to be fully understood (24, 25). As schools begin reopening in many countries the possibility that children could be potential sources of community transmission has become an important area of interest (3, 26-29). Indeed person-to-person transmission within and originating from educational settings could put lives of teachers, staff members and household contacts at risk, many of whom may potentially have the risk factors for developing serious illness due to COVID-19 infection (30).

In the current analysis we observed specific instances that highlight the role of school outbreaks in the larger picture of the pandemic and its management. For example, Mississippi had the highest attack rate among students (0.74%) as well as teachers (3.68%) in the two regions. An outbreak in one Mississippi school resulted in 15 students testing positive for SARS-CoV-2 by August 24th (31). According to the local health officials, contact tracing activities suggest that large social gatherings such as weekend parties, sleepovers and get togethers where social distancing was not followed were largely to blame for the outbreak in the school (32). This instance perhaps underscores the point that schools may act as accelerators of infection when community wide social distancing norms are not followed. Mississippi has been criticised for its response to the pandemic. In April 2020, a study ranked Mississippi 50th among all states in terms of strength of virus containment measures, including testing (33). According to a World Health Organisation report, the risk of outbreaks in schools rises when there is high level of transmission the community (24). Mississippi perhaps exemplifies this observation. Hence, it is imperative that community wide interventions are planned and implemented to protect educational settings (23).

Utah reported an attack rate of 1.27% among teachers. In particular, one school reported 9 cases among 30 staff members resulting in a high attack rate of (29.89%). However, no cases were reported among its 435 students during the period under study. The academy moved to online mode after this cluster was reported (34). The World Health Organisation has observed that in a majority of instances of outbreaks in schools the virus was introduced by an adult (24). Therefore, in this case prompt closure of the school may have averted a larger outbreak among students.

The high variability of attack rates in this study may be dependent upon multiple factors including class size, contact tracing, testing, social distancing, quarantine and school closure policy. However, heterogeneity in reporting standards make the interpretation of the data in this analysis difficult.

A higher proportion of student cases originating from high schools in some states aligns with the accumulating body of evidence from literature (24, 35) that points towards a more robust spread of infection in high schools as compared to elementary schools. Lower susceptibility of younger children to the virus as compared to adolescents, large class room sizes and failure of social distancing and mask use in school students are thought to be contributing factors.

Interestingly, a higher percentage distribution of cases was observed among teachers working in elementary schools than in high schools in several states. An in-depth analysis is required to understand whether this trend could indicate the increased vulnerability of adults coming in contact with young children.

Smaller outbreaks appear to be more common than larger outbreaks, however the possibility that secondary cases were simply not traced and tested cannot be ruled out as a vast majority of children infected with SARS CoV-2 either remain asymptomatic or present with mild or non-specific symptoms (36).

Limitations

This analysis has a number of limitations. Since the source data has been contributed by volunteers, data completeness cannot be assured. The analysis does not account for each and every case of school-related COVID-19 infection. Hence, the attack rates and epidemic curves can at best be interpreted as estimates of the true burden of disease. The number of teachers in each school has been derived using the student number and student teacher ratio. No data source containing total staff strength in various schools was found. Teacher attack rate has been derived as a percentage of total staff strength that were reported to have confirmed COVID-19 infection with the total number of teachers as the denominator. This could have resulted in a marginal over estimation of the teacher attack rates. Interpretation of week of the year

is based on the source date of the newspaper report. In some cases, cumulative new cases have been reported by school districts. These were excluded from the analysis as the total number of people exposed could not be estimated. A time lag between the event date and date of report may have a minor impact on the distribution of cases in the epidemic curve of school outbreak. New Mexico was excluded from the analysis of the two regions because of non-availability of sufficient data.

Conclusions

Lack of a centralised tracking of school-related outbreaks by any federal agency can pose a serious challenge to planning and delivering public health interventions for containment of an outbreak (37). Unofficial data sources can provide some indications of the trends in an outbreak however such analyses have several limitations notably data validity and completeness. A national level tracking mechanism for outbreaks in educational settings, including schools is necessary first step in attempting to understand the true impact of these outbreaks and inform policies for containment of the pandemic. This analysis found evidence of higher attack rate among students in high schools and teachers in elementary schools. An in-depth study of attack rates and distribution of outbreaks across age cohorts could have implications for public health policies that define school functioning.

References

1. 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. The Lancet Child & Adolescent Health. 2020;4(5):397-404.
2. Bayham J, Fenichel EP. Impact of school closures for COVID-19 on the US health-care workforce and net mortality: a modelling study. The Lancet Public Health. 2020;5(5):e271-e8.
3. Silverman M, Sibbald R, Stranges S. Ethics of COVID-19-related school closures. Canadian Journal of Public Health. 2020;111(4):462-5.
4. Heavey L, Casey G, Kelly C, Kelly D, McDarby G. No evidence of secondary transmission of COVID-19 from children attending school in Ireland, 2020. Eurosurveillance. 2020;25(21):2000903.
5. Courtemanche C, Garuccio J, Le A, Pinkston J, Yelowitz A. Strong Social Distancing Measures In The United States Reduced The COVID-19 Growth Rate. Health Affairs. 2020;39(7):1237-46.
6. Panovska-Griffiths J, Kerr CC, Stuart RM, Mistry D, Klein DJ, Viner RM, et al. Determining the optimal strategy for reopening schools, the impact of test and trace interventions, and the risk of occurrence of a second COVID-19 epidemic wave in the UK: a modelling study. Lancet Child Adolesc Health. 2020;4(11):817-27.
7. Català Sabaté M, Cardona Iglesias PJ, Prats Soler C, Alonso Muñoz S, Álvarez Lacalle E, Marchena Angos M, et al. Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries: short version. Daily report; 127. 2020.
8. John Hopkins University & Medicine. COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU)
9. John Hopkins University & Medicine,; 2020 [Available from: https://coronavirus.jhu.edu/map.html.
10. Education Week. The Coronavirus Spring: The Historic Closing of U.S. Schools 2020 [updated 01.07.2020. Available from: https://www.edweek.org/ew/section/multimedia/the-coronavirus-spring-the-historic-closing-of.html.
11. Wingham N. 'This is not ok': US schools crowded on first day back amid coronavirus crisis. Yahoo News. 2020.
12. Strauss V. The face mask problem: Experts say they're essential, but some schools and colleges aren't requiring students wear them this fall. 2020.
13. American Academy of Pediatrics. Research Highlights: COVID-19 and Pediatric Populations 2020 [cited 2021. Available from: https://www.aappublications.org/sites/default/files/additional_assets/aap_files/COVID-19-Pediatric-Research-Highlights.pdf.
14. Mallapaty S. How schools can reopen safely during the pandemic. Nature. 2020.
15. Walker T. Teacher Creates National Database Tracking COVID-19 Outbreaks in Schools: nea Today; 2020 [Available from: https://www.nea.org/advocating-for-change/new-from-nea/teacher-creates-national-database-tracking-covid-19-outbreaks.
16. National Education Association. nea school and campus covid-19 reporting site 2020 [Available from: https://app.smartsheet.com/b/publish?EQBCT=00a2d3fbe4184e75b06f392fc66dca13.
17. World Health Organization. Disease outbreaks 2021 [Available from: http://www.emro.who.int/health-topics/disease-outbreaks/index.html.
18. National Centers for Environmental Information U.S. Climate Regions 2020 [Available from: https://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-regions.php.

19. SchoolDigger K-12 school performance data at your fingertips. [Internet]. 2020 [cited November 10th 2020]. Available from: https://www.schooldigger.com/.
20. Find a great school for your child. [Internet]. 2020 [cited November 10th 2020].
21. Microsoft Corporation. Microsoft® Excel® 2016 MSO (Version 2109 Build 16.0.14430.20154) 32-bit 2016.
22. StataCorp LLC. Stata/IC 16.1 StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC. 2019.
23. Centers for Disease Control and Prevention. Trends in Number of COVID-19 Cases and Deaths in the US Reported to CDC, by State/Territory 2020 [Available from: https://covid.cdc.gov/covid-data-tracker/#trends_dailytrendscases.
24. Ismail SA, Saliba V, Bernal JL, Ramsay ME, Ladhani S. SARS-CoV-2 infection and transmission in educational settings: cross-sectional analysis of clusters and outbreaks in England. 2020.
25. World Health Organization. What we know about COVID-19 transmission in schools. World Health Organization; 2020.
26. Hildenwall H, Luthander J, Rhedin S, Hertting O, Olsson-Åkefeldt S, Melén E, et al. Paediatric COVID-19 admissions in a region with open schools during the two first months of the pandemic. Acta Paediatrica. 2020;109(10):2152-4.
27. Rajmil L. Role of children in the transmission of the COVID-19 pandemic: a rapid scoping review. BMJ Paediatrics Open. 2020;4(1):e000722.
28. Queensland Government. Are children 'super-spreaders' of the coronavirus? 2020 [Available from: https://www.childrens.health.qld.gov.au/blog-covid-19-and-kids-what-you-need-to-know/.
29. Mallapaty S. How do children spread the coronavirus? The science still isn't clear. Nature. 2020.
30. Centers for Disease Control and Prevention. Operating schools during COVID-19: CDC's Considerations 2020 [Available from: https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/schools.html.
31. Gaffney AW, Himmelstein D, Woolhandler S. Risk for Severe COVID-19 Illness Among Teachers and Adults Living With School-Aged Children. Annals of Internal Medicine. 2020;173(9):765-7.
32. Staff W. Biloxi High School temporarily moving all students to virtual learning. WLOX. 2020.
33. Pittman A. Biloxi High Suspends In-Person Classes After 324 Quarantined Amid COVID-19 Outbreak. Mississippi Free Press. 2020.
34. Kulo W. Report: Mississippi ranks 50th in COVID-19 testing. Gulflive. 2020 April 7th 2020.
35. Cortez M. Utah Military Academy campus moves to online learning after 9 COVID-19 cases among adults. Deseret News. 2020 September 2nd 2020.
36. Goldstein E, Lipsitch M, Cevik M. On the effect of age on the transmission of SARS-CoV-2 in households, schools and the community. medRxiv. 2020:2020.07.19.20157362.
37. Centers for Disease Control and Prevention. Symptoms and Severity of COVID-19 in Children 2020 [Available from: https://www.cdc.gov/coronavirus/2019-ncov/hcp/pediatric-hcp.html.
38. Grayer A. Schools are 2 months into reopening under Covid-19 and no one's officially keeping track of how it's going. CNN. 2020 October 12th 2020.

How to cite this article: Chawla D, Trent MJ, Moa A, Stone H, MacIntyre CR. An analysis of COVID-19 outbreaks in schools in South and Southwestern United States using open-source data. *Global Biosecurity, 2020; 3(1).*

Published: December 2021

Global Biosecurity is a peer-reviewed open access journal published by University of New South Wales.