Evaluating Scenarios for School Reopening Under COVID19

Arden Baxter
Georgia Institute of Technology College of Engineering
Buse Eylul Oruc
Georgia Institute of Technology College of Engineering
Pinar Keskinocak (pinar@isye.gatech.edu)
Georgia Institute of Technology College of Engineering https://orcid.org/0000-0003-2686-546X
John Asplund
Georgia Institute of Technology College of Engineering
Nicoleta Serban
Georgia Institute of Technology College of Engineering

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Abstract

Background: Thousands of school systems have been struggling with the decisions about how to safely and effectively deliver education during the fall semester of 2020, amid the COVID19 pandemic. This study evaluates the public health impact of various school reopening scenarios (when, and how to return in-person instruction) on the spread of COVID19.

Methods: An agent-based simulation model was adapted and used to project the number of infections and deaths under multiple school reopening dates and scenarios, including different cohorts receiving in-person instruction on alternating days, only younger children returning to in-person instruction, regular schedule (all students receiving in-person instruction), and school closure (all students receiving online instruction). The study period was February 18th-November 24th, 2020 and the state of Georgia was used as a case study.

Results: Across all scenarios, the number of COVID19-related deaths ranged from approximately 17 to 22 thousand during the study period, and on the peak day, the number of new infections ranged from 43 to 68 thousand. An alternating school day schedule performed: (i) almost as well as keeping schools closed, with the infection attack rate ranging from 38.5% to 39.8% compared to that of 37.7% under school closure; (ii) slightly better than only allowing children 10 years or younger to return to in-person instruction. Delaying the reopening of schools had a minimal impact on reducing infections and deaths under most scenarios.

Conclusions: Reopening schools following a regular schedule, i.e., all children returning to school without strict public health measures, would have serious negative public health consequences. The alternating school day schedule, especially if offered as an option to families and teachers who prefer to opt in, provides a good balance in reducing the infection spread compared to the regular schedule, while ensuring access to in-person education.

Background

School systems have been developing plans for safely reopening during the fall semester of 2020 while considering the potential impact of in-person interactions on students, staff, families, and public health during the COVID19 pandemic [1–3]. Recent studies have shown the potential benefits of non-pharmaceutical interventions, such as school closures [4–6], in slowing down infection spread and reducing the severe health outcomes, but also highlighted their negative impact on the economy, unemployment, mobility, mental health, education, caregiving, etc. [7–9]. Widespread school closures during spring 2020 not only impacted the education of children and youth but also had economic consequences due to increased childcare responsibilities of working parents [10–18].

To evaluate the tradeoffs between the potential public health benefits of various school reopening scenarios versus their impact on the educational development of children and the economy, in this study, we considered intervention metrics, namely, the projected number of infections and deaths due to

COVID19, and the following school reopening scenarios during the fall semester of 2020: (a) *schools closed* schedule: all students receive online instruction; (b) *alternating school day for younger children* schedule: only children 10 years old or younger return to in-person instruction while following an alternating school day schedule; (c) *alternating school day* schedule: half of the students receive in-person instruction on Mondays and Wednesdays and the other half on Tuesdays and Thursdays; (d) *younger children only* schedule: only children 10 years old or younger return to in-person instruction; (e) *regular* schedule: all students return to in-person instruction.

Quantifying the public health benefits of school reopening scenarios aim to provide much needed insights for school system decision-makers.

Methods

The study population consisted of children, youth, adults, and elderly stratified by age groups: 0-9, 10-19, 20-64, and 65+ in the state of Georgia.

The results were obtained by adapting and utilizing an agent-based simulation model to predict the spread of COVID19 geographically and over time [19-22]. The model captured the progression of the disease in an individual and interactions within households, workplaces, schools, and communities. It enabled the testing of scenarios incorporating various types and durations of physical distancing interventions, namely school closures, shelter-in-place, and voluntary quarantine of households (i.e., the entire household remains home if there is a person in the household with cold/flu-like symptoms) as well as the public's compliance levels. The model was populated using data from the Census Bureau [23-25] for the demographic and workflow information at the census tract level in Georgia and initialized with infection "seeds" following the distribution of the total number of confirmed COVID19 cases in Georgia (as of May 15th) at the county level [26] using the Huntington-Hill method of apportionment [27]. Additional information about the model and the data sources can be found in [19].

On each day, the school status ("attending in-person or "attending online") of younger children (0-9) and older children (10-19) was tracked and updated in the simulation depending on the reopening scenario. Children "attending online" did not engage in school-based peer interactions.

In the tables and figures that follow, scenarios were labeled by their names, as well as numbers 1 through 6 which refer to reopening schools on August 10, August 17, August 24, August 31, September 7, and September 14, respectively. For example, *Alternating School Day 3* refers to the scenario in which schools are reopened on August 24 and children adhere to an *alternating school day* schedule as defined in the Introduction section. All scenarios tested were built upon the base scenario, described in *Figure 1*.

The results presented were for the time period of February 18, 2020 to November 24, 2020. The simulation incorporated school closures during March 16- August 10 [28] and the following physical distancing practices with varying levels of compliance:

- Shelter-in-place: Staying home and refraining from interactions outside of the household. In Georgia, shelter-in-place order was in place during April 3-30, 2020. Shelter-in-place compliance of 80% was assumed for that time period.
- Voluntary quarantine: An entire household stays home if there is a person in the household with cold/flu-like symptoms, until the entire household is symptom-free. Voluntary quarantine compliance was 30% in mid-February, increased by 10% weekly until mid-March, and remained at 60% until the end of April. After the end of shelter-in-place, voluntary quarantine compliance was 70% and decreased by 10% weekly until stabilizing at 20%.
- Voluntary shelter-in-place: An entire household chooses to remain home, regardless of whether they have symptoms or not. During the week after the end of shelter-in-place, voluntary shelter-in-place compliance was 60% and decreased to 40%, 20%, and 5%, in consecutive weeks, until stabilizing at 5%.
- Voluntary shelter-in-place and voluntary quarantine compliance levels in the model were chosen to be in line with social mobility indicators [29].

Outcome Measures

The infection spread outcome measures over the time horizon of the study included:

- Cumulative deaths: cumulative number of people who died due to COVID19 over the time horizon of the study.
- Cumulative infections: cumulative number of people infected (including asymptomatic infections).
- Infection attack rate (IAR): cumulative percentage of the population infected.
- Peak day: the day when the number of new infections was highest.
- Peak infection: the number of the population infected on the peak day.

Results

All the results presented utilized data from the state of Georgia, which has a total population of approximately 10.8 million where 1.3 million children are of age 0–9 and 1.4 million children are of age 10–19 [24]. Kindergarten through 12th grade (K-12) schools typically open during the first or second week of August in Georgia; hence, the following reopening dates were considered: August 10, August 17, August 24, August 31, September 7, and September 14. Figure 1 depicts the base scenario.

Depending on the school reopening date, scenario, and the public's participation in physical distancing, the number of COVID19-related deaths by November 24 could range from approximately 17.4 to 22 thousand in the state of Georgia. On the peak day, the number of daily new infections could range from 19.4 to 47.6 thousand for adults and 10.6 to 22.2 thousand for children.

For the reopening date of August 10, in scenarios (a) through (e), respectively:

- The cumulative number of infections was (approximately, in thousands) 3,037; 3,098; 3,166; 3,242; 3,600 for adults and 1,037; 1,072; 1,134; 1,183; 1,491 for children.
- The cumulative number of deaths was 17,417; 18,075; 18,385; 18,977; 21,980.
- The peak number of infections was 43,360; 45,466; 46,609; 48,836; 67,896.
- The peak day was August 19; August 18; August 23; August 24; August 30.

Results for all other metrics (IAR, peak infections for adults and children and peak day) for other reopening dates can be found in Table 1. The relative ordering of the scenarios remains as (a) through (e) for each reopening date, with (a) being lowest and (e) being highest regarding infections and deaths. Figures 2 and 3 present a comparison of the daily number of new infections under different school reopening scenarios.

Table 1
Outcome measures across scenarios.

Schedules	Cumulative Deaths	Cumulative Infections		IAR	Peak Infections		Peak Day
		Adult	Children		Adults	Children	
Schools Closed	17417	3036819	1037471	37.73	32562	10798	19-Aug
Regular 1	21980	3600338	1490883	47.15	45750	22146	30-Aug
Regular 2	21405	3566364	1455359	46.51	40718	20099	2-Sep
Regular 3	20902	3516434	1412750	45.65	35376	17845	8-Sep
Regular 4	20318	3451780	1361897	44.58	29626	15141	10-Sep
Regular 5	19791	3375957	1302854	43.33	32834	10834	15-Aug
Regular 6	19346	3320594	1259850	42.42	32647	10774	18-Aug
Alternating School Day 1	18385	3165649	1133661	39.82	34229	12380	23-Aug
Alternating School Day 2	18466	3164226	1121944	39.69	33241	12159	22-Aug
Alternating School Day 3	18264	3154783	1116358	39.55	32000	14348	25-Aug
Alternating School Day 4	17912	3111939	1094476	38.95	32717	10651	19-Aug
Alternating School Day 5	18030	3115832	1089622	38.95	33427	11081	18-Aug
Alternating School Day 6	17739	3086135	1072150	38.51	32717	10769	19-Aug
Younger Children Only 1	18977	3242205	1183429	40.99	35232	13604	24-Aug
Younger Children Only 2	18813	3228035	1168330	40.71	33609	12958	25-Aug

Summary comparison of school reopening scenarios with respect to cumulative deaths, cumulative infections in adults and children, infection attack rate (IAR), peak infections in adults and children, and peak day.

Schedules	Cumulative Deaths	Cumulative Infections		IAR	Peak Infections		Peak Day
		Adult	Children		Adults	Children	
Younger Children Only 3	18652	3195697	1148196	40.23	32714	10663	18-Aug
Younger Children Only 4	18499	3164906	1129067	39.77	32659	10799	19-Aug
Younger Children Only 5	18333	3154983	1115030	39.54	33395	11048	18-Aug
Younger Children Only 6	18030	3126636	1097190	39.12	33036	10815	19-Aug
Alternating School Day for Younger Children 1	18075	3098238	1072097	38.62	33939	11527	18-Aug
Alternating School Day for Younger Children 2	17852	3081321	1062270	38.37	32608	11097	20-Aug
Alternating School Day for Younger Children 3	17707	3076859	1060334	38.31	32832	10759	17-Aug
Alternating School Day for Younger Children 4	17866	3078539	1057583	38.30	33093	10831	17-Aug
Alternating School Day for Younger Children 5	17736	3071110	1055003	38.21	33501	11018	17-Aug
Alternating School Day for Younger Children 6	17508	3057110	1048999	38.03	32513	10724	16-Aug

Summary comparison of school reopening scenarios with respect to cumulative deaths, cumulative infections in adults and children, infection attack rate (IAR), peak infections in adults and children, and peak day.

Discussion

Governments and school systems have been grappling with the decisions of how to prepare students for academic success while also trying to minimize the spread of COVID19. The negative impact of school closures has been disproportionately high on some students, e.g., those who do not have access to technology in the household, lack proper childcare, face an unsafe home environment, or have traditionally relied on the school system for meals, special education, counseling, and other forms of social or emotional support [9, 30]. While children seem to be less affected by COVID 19 than adults, they

could be transmitters of COVID19, potentially increasing community infection spread if schools were to return to in-person instruction [6, 18], particularly if the implementation of social distancing measures and recommendations remains financially or physically challenging for some schools (e.g., poor ventilation in buildings, short supply of disinfectant products, state budget shortfalls, etc.) [1, 9].

Guidelines for the state of Georgia recommend for districts with high case numbers to reopen schools with online instruction. However, online instruction poses numerous challenges. Several rural counties have limited internet connectivity; for example, Hancock County ranked number six for COVID19 cases per capita yet only 2% of the county has access to broadband internet [31]. Two-thirds of children in Georgia are not able to read proficiently by the end of third grade; limited or no access to in-person instruction in the fall could further increase this educational gap, with significant long-term consequences [9, 32]. Further, in Georgia, over half of the children are eligible for free and reduced fee school lunches and many families depend on these services [33].

There has been considerable debate about the benefits and risks of when and how to return to in-person instruction in schools during fall 2020. The American Academy of Pediatrics “strongly advocates that all policy considerations for the coming school year should start with a goal of having students physically present in school [34].” Some school systems delayed their opening dates or announced fully online instruction for the fall semester, while others considered hybrid models such as “groups of students to attend on alternating days or weeks, as well as allowing only younger students to attend while older students learn at home [35].”

According to our study results, delaying the reopening date would have a minimal impact on the peak day and peak number of new infections under the *alternating school day* schedule, the *younger children only* schedule, and the *alternating school day for younger children* schedule. However, under the *regular* schedule, delaying the reopening date from August 10 to September 17 could delay the peak day by 26 days and reduce the peak number of new infections from approximately 67.9 to 43.4 thousand.

The cumulative number of infections as well as the percentage of the population infected at the peak are similar under the *alternating school day* and the *schools closed schedules*, and significantly lower compared to the *regular schedule*. Hence, implementing an *alternating school day schedule* or limiting interactions between student cohorts during the in-person instruction could have a significant impact on slowing down the disease spread.

The *younger children only* schedule does not result in a significant reduction in cumulative infections compared to the *alternating school day* schedule. The *alternating school day for younger children* schedule reduces the number of infections compared to the *younger children only* schedule but not as much as the *schools closed* schedule.

COVID19 has had a significant impact on the society both in terms of public health and social and economic interactions. The health and well-being of the population are of the utmost importance, but

there is also a growing desire to return to in-person instruction to support the educational development of children.

As school systems continue to develop plans for reopening, it is critical to understand the impact of various reopening scenarios on public health as well as the children's development and the economy. Our results suggest that reopening schools following a *regular* schedule, i.e., all children returning to school without strict public health measures, would significantly increase the number of infections and deaths, i.e., have serious negative public health consequences. The *alternating school day* schedule, especially if offered as an option to families and teachers who prefer to opt in, provides a good balance in reducing the infection spread compared to the *regular* schedule, while ensuring access to in-person education.

This study did not consider the use of face masks or testing and tracing; if these measures were incorporated into the model, this would likely lead to a lower number of infections and deaths in all scenarios, due to the reduced transmission rate, but not change the relative ordering of the scenarios regarding infections and deaths. Regardless of how school instruction is formatted in the fall, it is important to continue promoting physical distancing measures and the usage of face masks as well as establishing testing and tracing practices to ensure prevention or early detection of outbreaks in schools.

Declarations

Ethics approval and consent to participate: Not applicable.

Consent for publication: Not applicable.

Availability of data and materials: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request. All data used was publicly available.

Competing interests: The authors declare that they have no competing interests.

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Figures

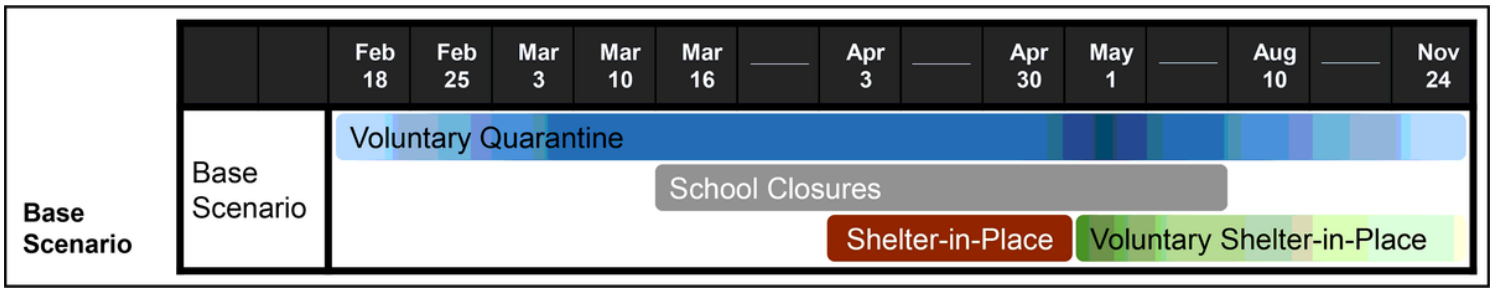

Figure 1

Base Scenario. All scenarios considered are built upon the base scenario along with the corresponding school reopening date. Compliance with shelter-in-place, voluntary quarantine, and voluntary shelter-in-place varies over time.

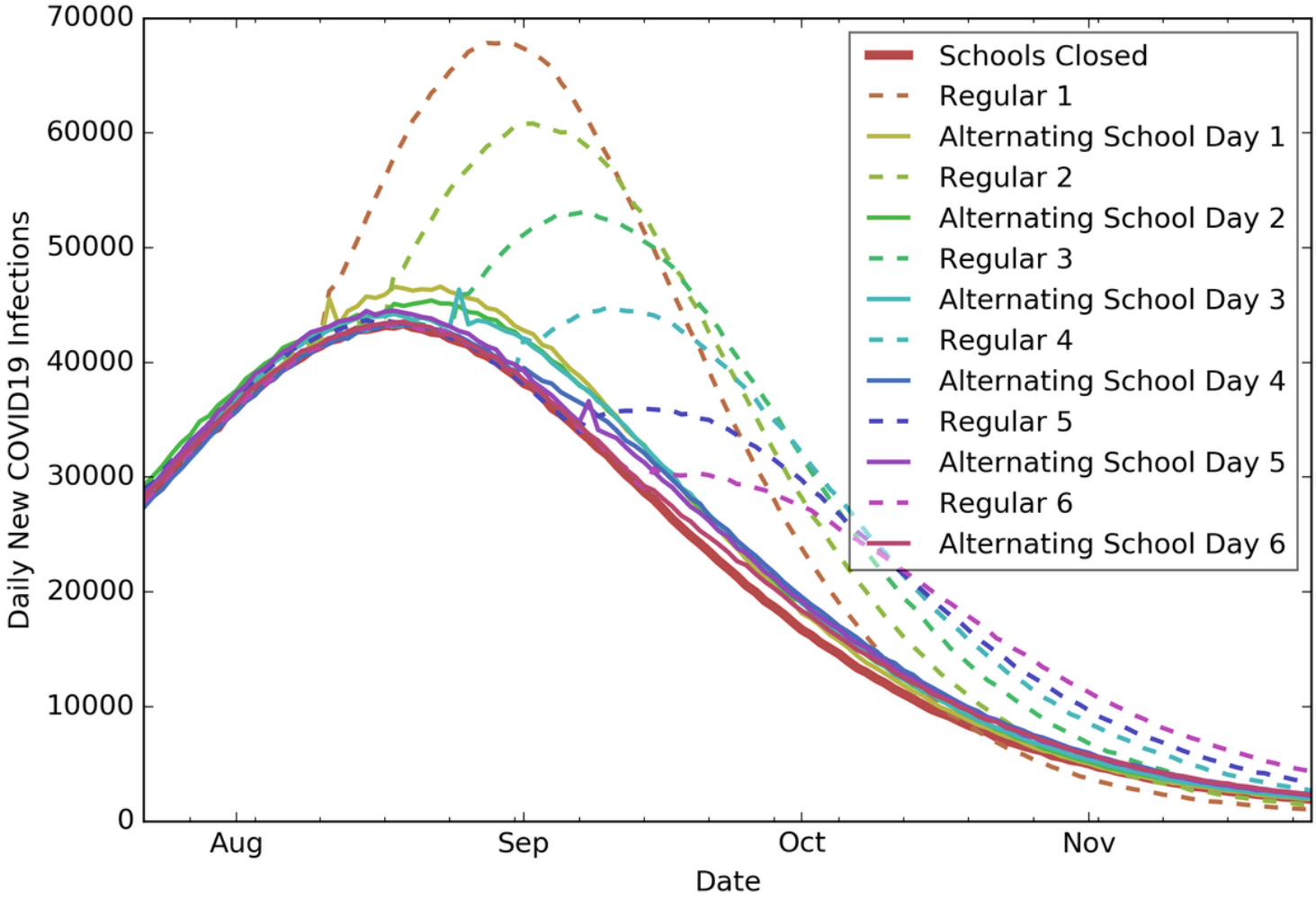

Figure 2

Schools closed schedule, regular schedule, and alternating school day schedule. Daily new COVID19 infections under the schools closed schedule, the regular schedule, and the alternating school day schedule.

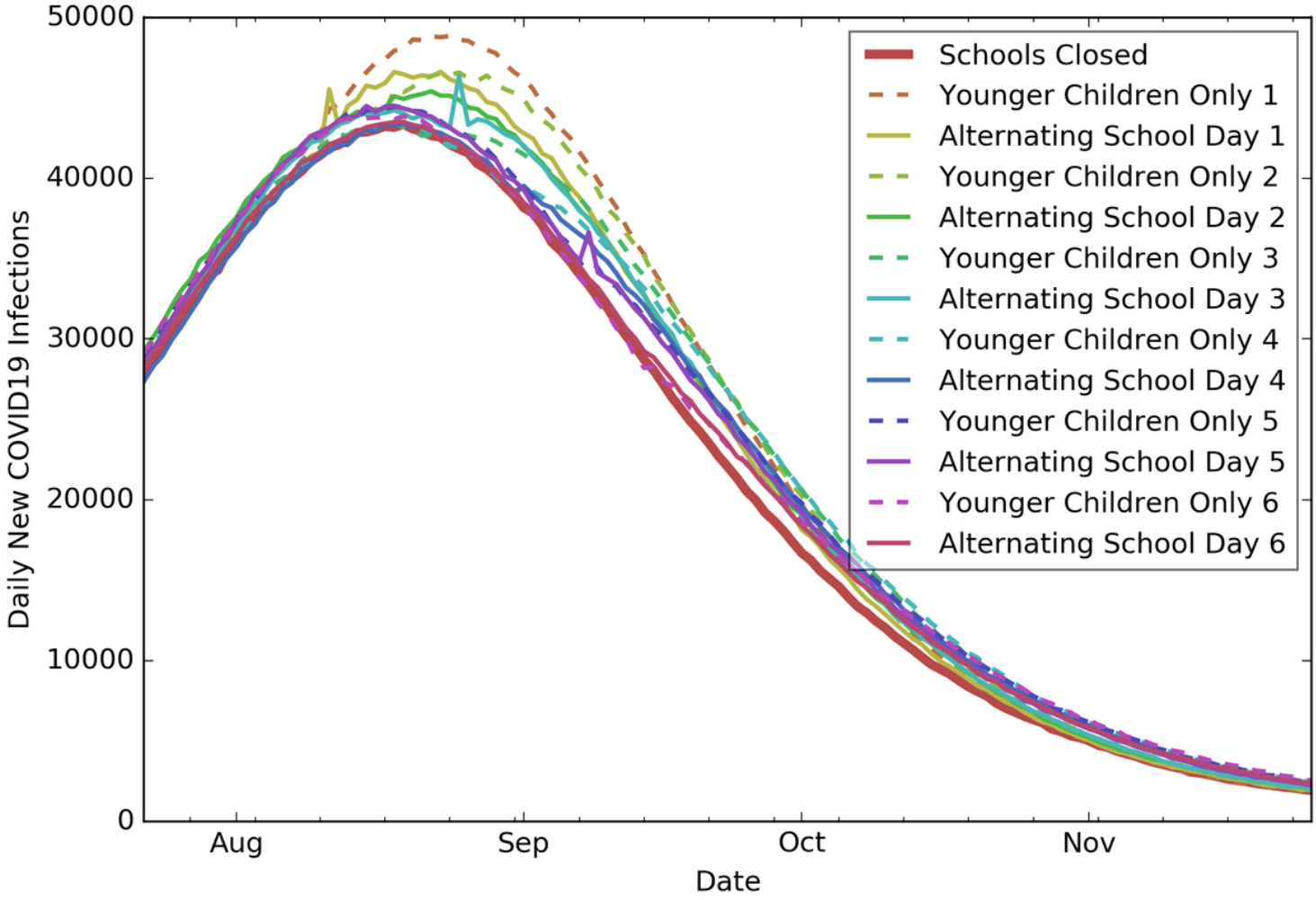

Figure 3

Schools closed schedule, younger children only schedule, and alternating school day schedule. Daily new COVID19 infections under the schools closed schedule, the younger children only schedule, and the alternating school day schedule. The alternating school day for younger children schedule is similar to the alternating school day schedule.