Coronavirus Disease Spread during Summer Vacation, Israel, 2020

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The relative increase in coronavirus disease incidence during summer 2020 in Israel was most prominent in young children. This finding contrasts with the lower increase in incidence observed in children than in adults during the school attendance period. School closure without lockdown conditions might not be independently effective at reducing spread.

During July 1–August 31, 2020, the period of school vacation in Israel, coronavirus disease (COVID-19) cases surged and reached one of the highest rates in the world. We examined the nationwide involvement of children in this resurgence by comparing severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections by age dynamics during the period of school vacation with that during the school attendance period.

The Study

We obtained data from public national data sources (*1*,*2*) (Appendix, https://wwwnc.cdc.gov/EID/article/28/1/21-0177-App1.pdf). To determine adjusted SARS-CoV-2 incidence rate ratios (IRRs), we adjusted age-specific SARS-CoV-2 weekly incidence rates for the number of PCR tests performed (Appendix, part B). For the period of regular school attendance (May–June), we compared weekly incidence rates during this time period with those of the week before school reopening (April 26–May 2). For summer vacation (July–August), we compared weekly incidence rates during this time period with those of the last week of school (June 21–27).

To determine positivity rate ratios (RRs) of SARS-CoV-2 tests, we calculated weekly average positivity RRs of SARS-CoV-2 PCR samples during school attendance and compared them with those of the week before school reopening (Appendix part B). We calculated weekly average positivity RRs for summer vacation and compared them with those of the last week of school.

Because some children 3–9 years of age attended summer school during July, we compared the average weekly IRRs and positivity RRs of children 0–9 years of age and of children ≥10 years of age during August 2020 to those ratios from July. We reviewed time periods related to school closure and openings and mitigation measures used in schools (Appendix parts A, C).

We studied the dynamics of slopes of the different variables across time periods as another approach for examining the involvement of children in COVID-19 spread during school attendance and summer vacation. We used linear regression analyses to compare the slopes of the adjusted weekly incidence of new cases in July–August (summer vacation) to those in May–June (school weeks) for each of the age groups. Because schools were reopened gradually in May 2020, we performed a separate analysis comparing the time period when all children attended schools (May 17–June 20, 2020) to slopes during summer vacation months (July–August 2020). We analyzed differences using 2-proportion z-tests and χ^2 tests and used linear regression to generate the slopes. We used propagation of error statistics for measurements of uncertainties of slope RRs and slope arithmetic differences.

We observed higher IRRs in adults than in children during school attendance (May–June); the lowest increases were in the 0–9-year group (Figure 1, panel A). Mean positivity rates of tests performed in children 0–9 years of age during May–June was 0.012, compared with 0.04 in the week before school opening (positivity RR 0.3 [95% CI 0.24–0.36]). Mean corresponding positivity rate for those >10 years was 0.015 during

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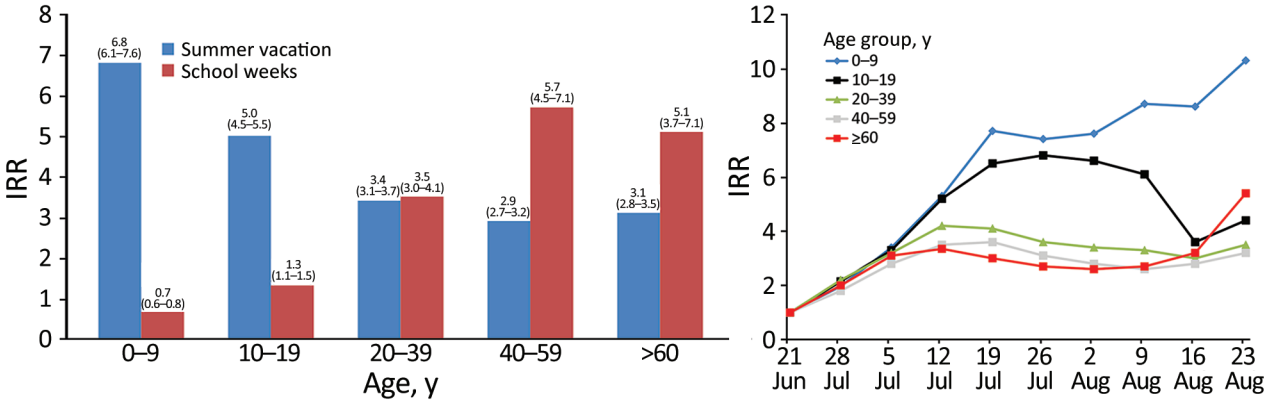

Figure 1. Mean weekly incidence rate ratios for COVID-19 during school attendance and during summer vacation, by age group, Israel, 2020. A) Adjusted IRR, the incidence adjusted for the number of COVID-19 tests performed for the specific age group. Numbers above bars are specific IRRs with 95% CIs. B) Weekly adjusted IRR during summer vacation by age group, which we calculated by comparing the incidence of each week to the incidence in the reference week for each age group. We calculated IRRs during school attendance by comparing the mean weekly rates during the school period (May–June), with rates during the week before school opening (April 26–May 3). We calculated mean weekly IRRs during summer vacation (July–August) by comparing the mean weekly rates during July–August to those of the last week of school (June 21–27), the reference week. Dates represent day 1 of the studied week. COVID-19, coronavirus disease; IRR, incidence rate ratio.

May–June compared with 0.012 in the week before school opening (positivity RR 1.2 [95% CI 1.1–1.3]).

In contrast, the 0–9 age group had the greatest increases in IRRs (Figure 1, panels A, B; Figure 2) and in positivity RRs (4.1 [95% CI 3.5–4.6] vs. 2.7 [95% CI 2.3–3.1] for older age groups combined). For children 0–9 years of age, we observed greater increases during August, when no schools were open, than during July, when some children 3–9 years of age attended summer schools, in IRRs (1.9 [95% CI 1.4–2.5]) and in positivity RRs of samples (1.7 [95% CI 1.6–1.8]). In contrast, for the other age groups combined, minimal increases were observed in IRRs (1.1 [95% CI 1.0–1.2]) and in positivity RRs (1.02 [95% CI 1.01–1.03]) (Appendix Figure 1).

We calculated slopes following linear regression of curves (Tables 1, 2; Appendix Table 2). Children 0–9 years of age had the highest slope rate ratios and arithmetic differences when comparing SARS-CoV-2 adjusted incidence during summer vacation months with those of school weeks (May 3–June 29) (Table 1). Comparing the slopes from July–August to those obtained at the time when all children attended school (May 17–June 20) revealed that children 0–9 years of age had higher vacation/schools slopes rate ratio and higher arithmetic differences (Table 2).

Conclusions

The relative increase in SARS-CoV-2 cases and in positivity of samples during summer vacation was most prominent in young children 0–9 years of age, in sharp contrast to the period of school attendance, when it was relatively flat. Parallel trends among children

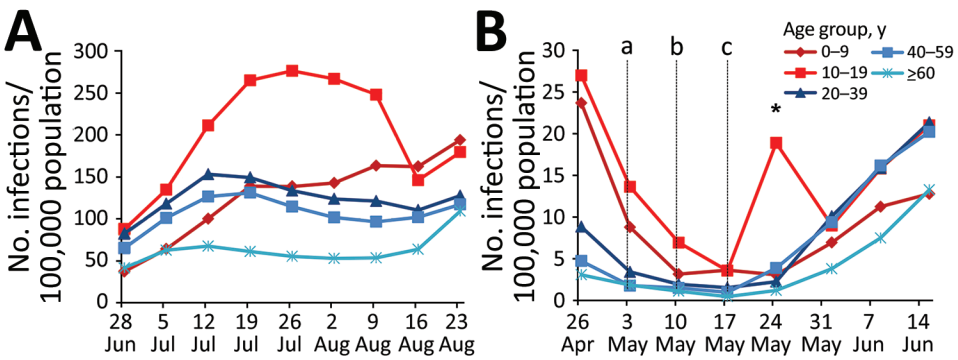

Figure 2. SARS-CoV-2 infection weekly adjusted incidence during school vacation (July 1– August 31) and attendance periods (May 3–June 19), Israel, 2020. Incidence was adjusted for the number of SARS-CoV-2 tests performed for the specific age group. Number of SARS-CoV-2 infections per 100,000 population for each age group are shown during summer vacation months (A) and during school weeks (B). Vertical lines represent partial reopening of schools (a), reopening of kindergartens and day care centers (b), and complete reopening of schools (c). Asterisk (*) indicates a single high school cluster. SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

Table 1. Comparison of slopes for adjusted incidence rates of SARS-CoV-2 infections during summer vacation and partial and full school attendance periods, Israel, 2020*

Age group, y	Adjusted incidence, %†		Slope rate ratio (95% CI)	Arithmetic difference (95% CI)
	Summer vacation ± SEM	School attendance ± SEM		
0–9	17.6 ± 2.1	1.8 ± 0.6	9.8 (5.3 to 34.2)	15.8 (10.9 to 21)
10–19	8 ± 8.8	3.4 ± 1.3	2.4 (–3.9 to 18.1)	4.7 (–15 to 24.4)
20–39	1.2 ± 2.9	4.5 ± 0.9	0.27 (–1.2 to 1.85)	–3.3 (–10.1 to 3.5)
40–59	2 ± 2.6	4.6 ± 1.8	0.43 (–8.9 to 3.6)	–2.6 (-8.9 to 3.6)
≥60	4 ± 2.1	2.5 ± 0.6	1.6 (–0.2 to 4.5)	1.5 (–3.4 to 6.4)

*Summer vacation was July 1–August 31, 2020. School attendance period was May 3–June 28, 2020. SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SEM, standard error of the mean.
†Incidence is no. cases/100,000 population; rates adjusted by numbers of SARS-CoV-2 tests.

aged 0–9 years during August compared with July indicate that the operation of summer schools during July did not significantly influence these results.

Analysis of curves of the adjusted incidence and comparisons of slopes of curves related to July–August to those for May–June revealed significantly higher rate ratios of slopes of adjusted incidence for children 0–9 years of age than any other age group. This analysis provides additional support to the finding that children in this age group are more likely to contract SARS-CoV-2 during vacation rather than during school attendance.

School closure has been shown to mitigate the spread of infection in conjunction with a lockdown (*3*). However, when schools are closed and a lockdown is not in effect, younger children tend to interact more intensively with adults than they do at school. Our findings suggest that school closure per se, without lockdown conditions, might not be sufficiently effective at reducing SARS-CoV-2 spread. We presume that because children may be less susceptible to COVID-19 infection and less infectious than adults, increased interaction with adults outside school may expose them more to SARS-CoV-2 infection (*4*–*6*). In addition, children may contract infection during regular and casual social encounters outside schools. The increased IRRs among adults during school period without a precedent or parallel increase in children suggest that SARS-CoV-2 transmission in children during school attendance does not necessarily lead to substantial increases in community transmission. In addition, in the described scenario, schools were closed because the academic year ended and not as a response to increased SARS-CoV-2 spread.

Our findings contrast with those seen in influenza epidemics, in which children play a leading role (*7*,*8*). A recent report suggests that contacts outside school were associated with SARS-CoV-2 infection, whereas attending school or child care was not associated with having positive SARS-CoV-2 test results (*9*). We also published a recent study that suggested that school reopening during May 2020 had a limited effect on COVID-19 spread in Israel (*10*). Those findings are in accordance with the results of this study and may be relevant regarding school reopening, which has been a challenge in many countries (*11*,*12*).

The main limitation of our study is its observational design. However, this study relies on a solid national database, and its findings are consistent when examined by several methods and several parameters. The highly consistent finding with different comparisons of regressions (slope rate ratios and arithmetic differences between slopes), as well as with different parameters (adjusted incidence and positivity rates of tests), when taken together, strengthen the reliability of the results.

In conclusion, our results suggest that children, especially those <10 years of age, may contract SARS-CoV-2 infections mainly outside of school. The main implication of our findings is that that school closure without lockdown conditions might not be sufficiently effective in reducing SARS-CoV-2 spread.

Table 2. Comparison of slopes for adjusted incidence rates of SARS-CoV-2 infections during summer vacation weeks with those during full school attendance period, Israel, 2020*

Age, y	Adjusted incidence, %†		Slope rate ratio (95% CI)	Arithmetic difference (95% CI)
	Summer vacation ± SEM	School attendance ± SEM		
0–9	17.6 ± 2.1	2.6 ± 0.47	6.8 (4.3 to 11.7)	15 (8.7 to 21.3)
10–19	8 ± 8.8	3.2 ± 1.9	2.5 (–3.1 to 8.1)	4.8 (–14.2 to 20.8)
20–39	1.2 ± 2.9	5.3 ± 0.6	0.23 (–0.99 to 1.5)	–4.1 (–12.8 to 4.7)
40–59	2 ± 2.6	5.1 ± 0.34	0.4 (0.7 to 1.5)	–3.1 (–10.9 to 4.7)
≥60	4 ± 2.1	3.2 ± 0.55	1.25 (–0.2 to 3.5)	0.8 (–5.5 to 7.1)

*Summer vacation was July 1–August 31, 2020. Full school attendance period was May 17–June 19, 2020. SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SEM, standard error of the mean.
†Incidence rates adjusted by numbers of SARS-CoV-2 tests;

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Author contributions: I.S. and E.S. conceptualized the study; I.S., E.A.F.S., and E.S. analyzed the data and drafted the manuscript. All authors reviewed and approved the manuscript.

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Appendix

Part A: Time Periods Related to School Closure and Openings

Data on school closure and reopening were obtained from official publications of the Ministry of Health and public resources 1,2.

March 14–May 2, 2020: Complete school closure period. All schools closed during the initial stage of the COVID-19 pandemic.

May 3, 2020: Partial school reopening for children in grades 1–3 and 11–12.

May 10, 2020: Reopening of kindergartens and day care centers.

May 17–June 18, 2020: Complete open school period. Complete reopening of all schools.

June 19, 2020: End of the academic year for high schools (grades 7–12).

June 30, 2020: End of the academic year for elementary schools (grades 1–6).

June 19–August 31, 2020: High school summer vacation.

July 1, 2020: Start of summer school programs for some children 3–9 years of age.

August 1–August 31, 2020: Summer vacation continued, no activities of summer schools.

September 1: Start of new academic year.

Part B: Computation of Adjusted Incidence, Adjusted Incidence Rate Ratio (IRR), and Positivity Rate Ratio (RR)

We used the following definitions to analyze our data.

Adjusted Incidence

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) age-specific weekly incidence rates were calculated and adjusted for the number of tests performed for the following age groups: 0–9, 10–19, 20–39, 40–59 and ≥60 years. For each age group, incidence rate (weekly number of new cases /100,000 population of the specific age group) was multiplied by the proportion of this age group in the general population and divided by the proportion of the weekly number of samples taken from persons of this age group out of all samples.

IRR and RR for School Attendance Period

A: Mean weekly adjusted incidence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) or number of tests performed in each age group during the period of regular school attendance (May–June 2020).

A1: Mean weekly SARS-CoV-2 positivity rates of samples tested in each age group during the period of regular school attendance (May–June, 2020).

a: Weekly SARS-CoV-2 adjusted incidence in each age group during the week prior to school reopening (April 26–May 2, 2020).

a1: Weekly SARS-CoV-2 positivity rates of samples tested in each age group during the week prior to school (April 26–May 2, 2020).

IRR = A/a,

RR = A1/a1.

IRR and RR for Summer Vacation Period

A: Mean weekly SARS-CoV-2 adjusted incidence (for number of tests performed) in each age group during the period of summer vacation (July–August, 2020).

A1: Mean weekly SARS-CoV-2 positivity rates of samples tested in each age group during the period of summer vacation (July–August, 2020).

a: Weekly SARS-CoV-2 adjusted incidence in each age group during the last week of school (June 21–27, 2020).

a1: Weekly SARS-CoV-2 positivity rates of samples tested in each age group during the last week of school (June 21–27, 2020).

IRR = A/a,

RR = A1/a1.

Part C: Mitigation Measures during School Attendance

The following are the guidelines provided to schools and parents regarding reopening, May–June 2020 (*1*).

Masks

Children >7 years of age were required to wear masks in classrooms and in public areas (*2,3*). However, between May 19–22 2020, restrictions on wearing masks in classrooms and open space were lifted due to a heat wave.

Daily Screening

Parents filled in and signed a daily report of their child's health including body temperature, as a prerequisite for school attendance. There were no recommendations for screening of teachers unless they were exposed to a confirmed SARS-CoV-2 case.

Social Distancing

According to national policies, the entrance of pupils to schools should be controlled to prevent crowding. It was recommended that activities during recess should be separated between classes. However, the degree of implementation of these measures was unclear.

During the first stage of school reopening (on May 3, 2020), the children were divided to separate "capsules" that were supposed to study in different times and different days, however these restrictions were lifted on May 17 and schools were completely reopened.

Taking Examinations

In addition, specific recommendations were provided for taking examinations (*4*).

Quarantine

Classmates and teachers of SARS-CoV-2 infected pupils or teachers were required to stay in quarantine and were also screened for SARS-CoV-2 infection regardless of whether they were symptomatic or asymptomatic.

School Closure

Temporary school closing was recommended if ≥3 cases of SARS-CoV-2 infection were identified in persons attending school.

Part D: Regression Analyses of Curves

Randomness

All analyzed data were based on Israeli Ministry of Health reports of new SARS-CoV-2 infections without selection or elimination. The Ministry of Health has operated a Coronavirus Surveillance Computerized Database including the results of RT-PCR tests and epidemiological investigations with mandatory reporting of laboratory-confirmed SARS-CoV-2 infections and associated hospitalizations.

Sample Size

We have provided samples from the specific age groups that were used for creating the curves and calculating regression analyses (Appendix Table 1) and linear regression parameters (Appendix Table 2).

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Appendix Table 1. Positive samples and total number of tests used for regression analysis in study of coronavirus disease incidence during school session and vacation, Israel, 2020*

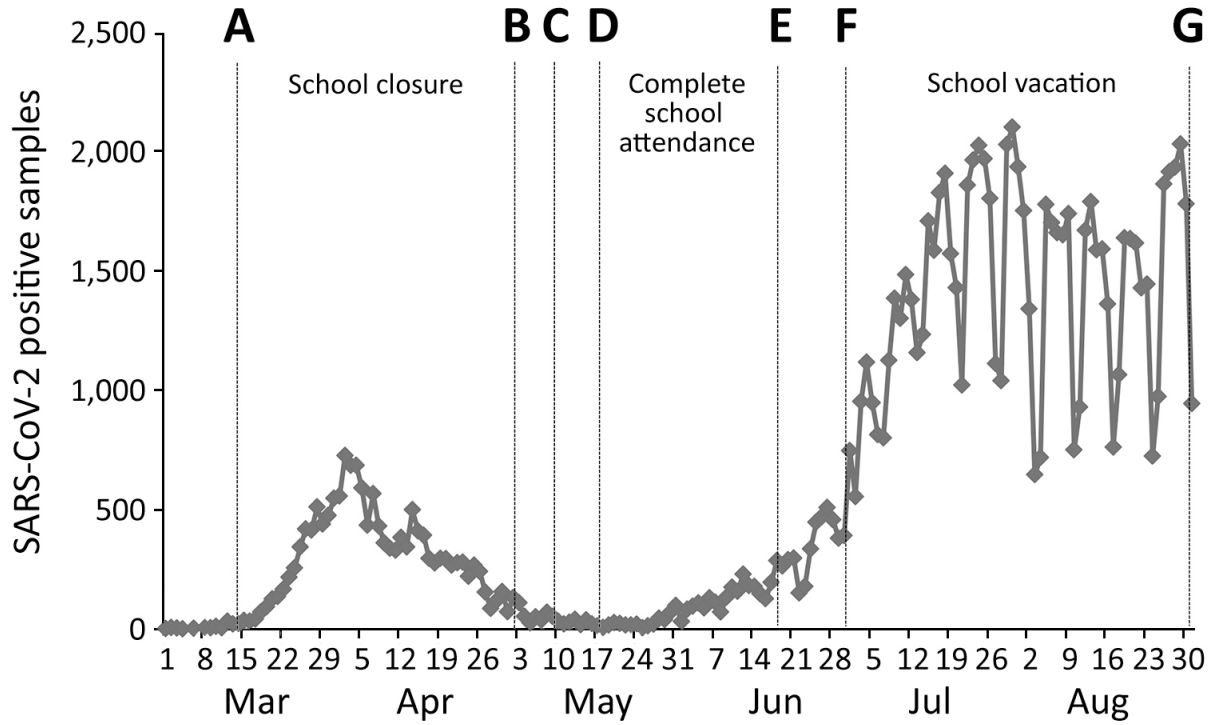
		Full school attendance period		Summer vacation	
Age group, y	No. in age group	No. tests	Positive tests	No. tests	Positive tests
0–9	1,719,000	37,735	395	141,592	9,777
10–19	1,428,000	50,585	807	158,510	16,859
20–39	2,380,000	109,437	2066	444,969	32,518
40–59	1,818,000	66,673	887	333,897	20,870
≥60	1,367,000	68,908	449	303,859	10,911

*Full school attendance period was May 17–June 19, 2020; summer vacation was July 1–August 31, 2020.

Appendix Table 2. Linear regression parameters for adjusted incidence curves in different time periods analysis in study of coronavirus disease incidence during school session and vacation, Israel, 2020*

Age group, y	Regression line equation	Regression coefficient	Regression coefficient error	Standard error	p value†	R^2	p value‡
School attendance period							
0–9	y = 15+ 2.6x ± 1.4	2.64	0.47	1.4	0.01	0.91	reference
10–19	y = 23 + 3.2x ± 6.02	3.17	1.9	6.02	0.19	0.48	0.49
20–39	y = 26 + 5.3x ± 1.9	5.32	0.6	1.9	0.0003	0.96	0.0080
40–59	y = 25 + 5.1x ± 1.13	5.1	0.35	1.13	0.00076	0.98	0.0034
≥60	y = 14.8 + 3.2x ± 1.7	3.2	0.54	1.7	0.01	0.92	0.11
Summer vacation							
0–9	y = 215 + 17.6x ± 14.5	17.6	2.1	14.5	0.0004	0.92	reference
10–19	y = 241 + 7.97x ± 61.2	7.97	8.9	61.2	0.29	0.10	0.05
20–39	y = 130.1 + 1.18x ± 14.3	1.18	2.89	14.3	0.11	0.10	0.0008
40–59	y = 116 + 2.05x ± 13.4	2.05	2.6	13.4	0.19	0.62	0.0004
≥60	y = 82.8 + 3.98x ± 17.7	3.98	2.14	17.7	0.13	0.33	0.0001

*Full school attendance period was May 17–June 19, 2020; summer vacation was July 1–August 31, 2020.
†p value of the specific regression.
‡p value of the regression coefficient of the specific age group compared to that of children 0–9 years of age.



Appendix Figure. SARS-CoV-2 daily incidence in the general population, Israel. Numbers of daily new SARS-CoV-2 cases during March 1–August 31, 2020 are shown. Time points related to school closure, school opening and summer vacation are indicated.