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Impact of COVID-19 School Learning Model on STI Testing, Diagnosis Rates, and Related Behaviors

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Abstract

Background: The COVID-19 pandemic and associated changes in school learning model reshaped students' lives and may have impacted sexual behaviors and healthcare access.

Methods: We used a difference-in-differences (DID) approach to compare changes in sexual behaviors, human immunodeficiency virus (HIV)/sexually transmitted infection (STI) testing, and STI diagnosis rates from 2019–2021 between jurisdictions where high school was primarily virtual versus in-person for the 2020–2021 school year. We used behavioral data from local jurisdictions administering Youth Risk Behavior Survey and reported chlamydia and gonorrhea diagnosis rates for 15- to 19-year-olds in corresponding counties from AtlasPlus. Learning model was defined using the COVID-19 School Data Hub, school/governmental policies, news, or other documentation. We used survey-weighted logistic regression for behavioral outcomes and Poisson regression for diagnosis rates. The DID estimates were parameterized as the interaction between year and learning model.

Results: Twenty-four local jurisdictions (16 virtual, 8 in-person) were included. Compared to in-person learning, virtual learning was significantly associated with a relative increase in condom use from 2019 to 2021 (DID odds ratio [DID-OR], 1.42; 95% confidence interval [95% CI], 1.12–1.79) and relative decreases in STI testing (DID-OR, 0.75; 95% CI, 0.59–0.96), chlamydia

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diagnoses (DID incidence rate ratio [DID-IRR], 0.86; 95% CI, 0.84–0.88), and gonorrhea diagnoses (DID-IRR, 0.83; 95% CI, 0.79–0.87). Learning model was not significantly associated with changes in sexual intercourse ever or in past 3 months, multiple sex partners in past 3 months, alcohol/drug use before last sex, or ever HIV testing.

Conclusions: Efforts are needed to maintain access to sexual health services during and after public health emergencies involving schools and increase STI testing access for students, especially those who attended school virtually.

The COVID-19 pandemic and associated public health measures significantly disrupted the daily lives of high school students. The reduction or elimination of in-person learning reduced social and physical connections, changed the context for social interactions, and reduced access to school-based health services^{1,2} with potential consequences for sexual behaviors, human immunodeficiency virus (HIV)/sexually transmitted infection (STI) testing, and STI transmission.³ After initial closures of nearly all schools in spring 2020, the Centers for Disease Control and Prevention (CDC) and professional organizations including the American Academy of Pediatrics advocated for returning to in-person learning,^{4,5} and school policies varied across the United States for the 2020–2021 school year with a mix of in-person, virtual, and hybrid learning.⁶ Understanding the effects of learning models on adolescent sexual health has potential to inform responses to future public health emergencies and strategies for maintaining equitable access to sexual health services. Further, findings have potential to inform pandemic recovery efforts, including settings and populations to prioritize.

Literature reviews have documented decreases in numbers of sex partners, frequency of sex, and access to sexual and reproductive health services, including HIV/STI testing, among adolescents and young adults globally as a result of the pandemic.^{7–12} However, most reviewed studies occurred early in the pandemic during the most restrictive lockdowns, and few included adolescent-specific data. In the United States, the National Youth Risk Behavior Survey (YRBS) indicated that lifetime HIV testing, past-year STI testing, and having sex ever or in the past 3 months decreased among high school students from 2019 to 2021 while condom use at last sex remained stable.^{13,14} In addition, a national analysis of laboratory testing data found reductions in chlamydia and gonorrhea screening volumes and increases in test positivity during initial lockdowns in 2020 among adolescents.¹⁵ However, the contribution of longer-term virtual learning on these changes and its relative impact on adolescent sexual health more generally is understudied.

To examine how learning model affected adolescent sexual health during the COVID-19 pandemic, we compared changes in sexual behaviors, HIV/STI testing, and STI diagnosis rates from 2019 to 2021 between jurisdictions where high school students attended school primarily virtually versus in-person during the 2020–2021 school year.

METHODS

Data Sources

We used data from local jurisdictions participating in YRBS to assess changes in sexual behaviors and HIV/STI testing and from county-level gonorrhea and chlamydia case report

data from CDC's AtlasPlus to assess changes in STI diagnosis rates. The YRBS is a biennial survey of health-related behaviors and experiences conducted in-person in school among representative samples of 9th to 12th grade students in the United States by state, territorial, or local departments of health and education.^{16,17} AtlasPlus is an interactive tool that includes US surveillance data on chlamydia and gonorrhea case reports by county, diagnosis year, age, race/ethnicity, and sex.¹⁸

Learning Model Ascertainment

We used data from the COVID-19 School Data Hub (CSDH; <https://www.covidschooldatahub.com/>) to determine the predominant school learning model (in-person vs virtual) for the 2020–2021 school year in 28 local jurisdictions that participated in the 2019 and 2021 cycles of YRBS. These data report learning models (virtual, hybrid, or in-person) and, in some cases, the number of students participating in each model for school districts or individual schools. We prioritized district-level data¹⁹ when available (13/28 districts), followed by school-level data²⁰ for all schools including 9th to 12th grade students in the relevant school district(s) (15/28 districts). When CSDH data were only available for part of the school year or were otherwise insufficient to make a determination, we used legal epidemiological methods similar to previous CDC COVID-19 policy analyses^{21,22}; reviewing governmental websites for relevant school, executive, or administrative policies and confirming with additional sourced documentation from district websites and local news. When a single YRBS jurisdiction included multiple school districts or we relied on school-level data and the districts or schools within the jurisdiction reported different learning models, respectively, we attempted to identify a predominant learning model across districts/schools for the YRBS jurisdiction.

“Virtual” jurisdictions typically reported virtual learning from the beginning of the 2020–2021 school year (or shortly thereafter) through at least February 2021 with some moving to hybrid or in-person learning toward the end of the school year. “In-person” jurisdictions primarily reported in-person learning for the entire school year. Two jurisdictions were excluded from analyses because the multiple school districts in each YRBS consortium reported conflicting models for the majority of the school year and therefore no predominant model could be determined. Supplemental Digital Content 1, <http://links.lww.com/OLQ/B202> provides detailed information regarding these determinations.

Sexual Behavior and Testing Outcomes

Self-reported sexual behavior outcomes included the following with denominators in parentheses: ever had sexual intercourse (all respondents), sexual intercourse in the past 3 months (ever had sexual intercourse), and >1 sex partner in the past 3 months, condom use at last sexual intercourse, and alcohol or drug use before last sexual intercourse (sexual intercourse in the past 3 months). Self-reported testing outcomes included ever having been tested for HIV and testing for an STI other than HIV in the past 12 months (ever had sexual intercourse). Ever having sexual intercourse was determined by the question, “Have you ever had sexual intercourse?” or, if that question was not asked, by reporting ≥1 lifetime partner when asked, “During your life, with how many people have you had sexual intercourse?”

STI Diagnosis Rates

For each YRBS jurisdiction included in our analysis, we extracted rates per 100,000 of reported chlamydia and gonorrhea diagnoses among 15- to 19-year-olds, stratified by sex and race/ethnicity, from the corresponding county in AtlasPlus. When YRBS jurisdictions were a single county, this was a 1:1 match. For city-level YRBS jurisdictions other than New York City, we used data from the county where the city is located; in all such cases, the YRBS jurisdiction was the county seat and comprised ~25% to 85% of the county's population (Supplemental Digital Content 1, <http://links.lww.com/OLQ/B202>). To generate citywide rates for New York City, we used the average of the rates among 15- to 19-year-olds for each of the city's five counties weighted by the proportion of the city's 15- to 19-year-olds residing in each county based on 2020 US Census data.²³

Analyses

Local jurisdictions participating in YRBS in 2019 and 2021 were included in the analysis if it was possible to determine the predominant learning model for the 2020–2021 school year and data were available in the public-use dataset or upon request from the jurisdiction.

To assess the effect of virtual learning on our outcomes, we used difference-in-differences (DID) analyses to estimate the relative changes in each outcome from 2019 (preexposure) to 2021 (post-exposure) between jurisdictions where high school students primarily attended school virtually (exposed) and jurisdictions where they primarily attended school in-person (control) during the 2020–2021 school year. In all regression models, the DID term was parameterized as the interaction between year (2019 vs 2021) and learning model (virtual versus in-person).

YRBS Analyses

Sexual behavior and testing outcomes were treated as binary (either yes vs no or yes vs no/don't know or not sure). We used Rao-Scott χ^2 tests to assess overall changes from 2019 to 2021 in all included jurisdictions and logistic regression for DID analyses. We estimated the percentage of respondents reporting each outcome by survey year and learning model, the absolute change in these percentages from 2019 to 2021 within each learning model, and the absolute difference in these 2 percentages (virtual minus in-person change; an estimate of the DID), both overall and stratified by self-reported sex and race/ethnicity. Due to limited power to detect interactions with smaller sample sizes, we conducted regression models only among sub-groups representing $\geq 10\%$ of the total study population. Where jurisdictions did not ask the question(s) informing an outcome or its denominator in either cycle, we excluded this jurisdiction from analyses for that outcome.

We conducted two sets of sensitivity analyses. The first addresses the YRBS survey administration period changing from spring 2019 to fall 2021 in 14 (58%) of the 24 included jurisdictions, more frequently among in-person (5/8 = 63%) than virtual jurisdictions (9/16 = 56%).¹⁷ These shifts resulted in changes in calendar months being considered during recall periods for certain outcomes, overall age distribution, and within-grade age distribution. To generate DID estimates without the potential bias introduced by these differential changes, we conducted sensitivity analyses restricted to the 10 jurisdictions that administered YRBS

during the same semester in both cycles. Second, we explored whether sex of sexual contacts impacted sex-stratified estimates. Given the relatively small sample sizes for respondents with same-sex contacts and our interest in STIs, we defined categories as female respondents with female contacts only, female respondents with male contacts, male respondents with female contacts only, and male respondents with male contacts.

To test the parallel trends assumption underlying DID analyses (outcomes in virtual and in-person jurisdictions would have followed similar patterns in the intervention's absence²⁴), we visually compared overall trends in outcomes from 2013 to 2021 (except STI testing, for which data were unavailable before 2019) between virtual and in-person learning in a subset of 10 jurisdictions (6 virtual, 4 in-person) with available YRBS data, comprising 53% of respondents included in DID analyses (Supplemental Table 5, <http://links.lww.com/OLQ/B203>, Supplemental Digital Content 3, <http://links.lww.com/OLQ/B204>). The YRBS analyses account for complex sample design.²⁵

STI Diagnosis Rates Analyses

Sexually transmitted infection diagnosis rates were analyzed at the jurisdiction level using Poisson regression models with robust variance, both overall and stratified by sex. We also calculated the difference between within-learning-model percent change in rates from 2019 to 2021 and the difference in these percent changes (virtual minus in-person learning). Due to the potential impact of changes in STI testing on diagnosis rates, we conducted a sensitivity analysis for overall rates adjusting for the proportion of 15-year-olds to ≥ 18 -year-olds who reported past-year STI testing among those who reported ever having sexual intercourse in the corresponding YRBS jurisdiction and survey year. We tested the parallel trends assumption using overall diagnosis rates from 2013 to 2021 because county-level rates for 15- to 19-year-olds were unavailable before 2019 (Supplemental Digital Content 4, <http://links.lww.com/OLQ/B205>).

Analyses were conducted in SAS® OnDemand for Academics. *P* values less than 0.050 were considered statistically significant. The University of Washington Human Subjects Division determined that these secondary analyses of deidentified or aggregated data did not meet the definition of human subjects research.

RESULTS

Study Population

We included 24 of the 28 local jurisdictions participating in YRBS in 2019 and 2021 for a total of 47,661 and 40,647 respondents in each survey year, respectively. The predominant learning model for the 2020–2021 school year was virtual for 16 jurisdictions, comprising approximately two-thirds of respondents in the study sample in both survey years (Table 1). All jurisdictions with predominantly in-person learning were located in the South, whereas virtual learning jurisdictions were distributed across all four regions with large proportions of respondents from the Northeast and West. Similar proportions were non-Hispanic Black across both years and learning models (26.0–28.0%). In both years, respondents from virtual learning jurisdictions were likelier to be Hispanic/Latino and Asian and those from

in-person learning jurisdictions likelier to be non-Hispanic White. Distributions of sexual orientation were similar between learning models, but respondents from both learning models were less likely to be heterosexual in 2021 (71.3–72.3% vs 80.4–80.9% in 2019).

Sexual Behavior and Testing Outcomes

Across all jurisdictions, sexual behaviors remained stable from 2019 to 2021 except for a significant decrease in ever having sex and in both HIV and STI testing (Supplemental Table 1, <http://links.lww.com/OLQ/B202> in Supplemental Digital Content 2, <http://links.lww.com/OLQ/B203>).

Overall, condom use at last sex among those who had sexual intercourse in the past 3 months increased from 53.2% in 2019 to 56.4% in 2021 in virtual learning jurisdictions but decreased in in-person learning jurisdictions from 57.0% to 51.5%, resulting in a significant relative increase in condom use associated with virtual compared with in-person learning (DID odds ratio [OR], 1.42; 95% confidence interval [CI], 1.12–1.79; Figure 1A; Table 2). In stratified analyses, this association was significant only among female and Black respondents, although similar patterns were observed among male respondents (Table 3).

Overall, STI testing among those who ever had sexual intercourse decreased in both learning models, but more so in virtual learning (29.2% to 18.0%) than in-person learning (20.0% to 15.1%) jurisdictions, resulting in a significant relative decrease in STI testing associated with virtual learning (DID OR = 0.75, 95% CI = 0.59–0.96) [Fig. 1B; Table 2]. In stratified analyses, this association was significant only among female and White respondents, though similar patterns were observed for Black respondents. Overall, reports of ever having HIV tested among those who ever had sexual intercourse followed a similar pattern (virtual learning decreased from 29.9% to 20.3%, in-person from 23.4% to 17.9%), but the relative change was not significant except among White respondents.

DID estimates for ever had sexual intercourse, sexual intercourse in past 3 months, multiple sex partners in past 3 months, alcohol or drug use before last sexual intercourse, and ever tested for HIV were not significant in overall analyses (Table 2). Stratified analyses are presented in Supplemental Tables 2 (sex), 3 (race and ethnicity), 4 (same semester of survey administration), and 5 (sex and sex of sexual contacts) [all in Supplemental Digital Content 2, <http://links.lww.com/OLQ/B203>].

In sensitivity analyses limited to the 10 jurisdictions (7 virtual, 3 in-person) that administered YRBS during the same semester in both years, DID estimates for condom use, HIV testing, and STI testing were similar to overall estimates. For the remaining outcomes, estimates indicated relative decreases associated with virtual learning in same-semester jurisdictions that were not or less apparent in overall analyses, although this relative decrease was only significant for alcohol/drug use before last sexual intercourse (DID: OR, 0.64; 95% CI, 0.45–0.93). In sensitivity analyses exploring the impact of sex of sexual contacts, results were similar between female respondents overall and female respondents reporting male sexual contacts and between male respondents overall and male respondents reporting female sexual contacts only. The parallel trends assumption appeared to hold for all outcomes except condom use at last sexual intercourse (Supplemental Table 6, <http://links.lww.com/OLQ/B203>).

links.lww.com/OLQ/B203; Supplemental Digital Content 3, [http://links.lww.com/OLQ/B204](https://links.lww.com/OLQ/B204)).

STI Diagnosis Rates

Across all jurisdictions, the mean reported diagnosis rates per 100,000 15- to 19-year-olds decreased for chlamydial infection and increased for gonorrhea from 2019 to 2021 (Supplemental Table 1, [http://links.lww.com/OLQ/B202](https://links.lww.com/OLQ/B202)). Mean chlamydia diagnosis rates decreased in virtual and in-person learning jurisdictions from 2019 to 2021, but by a greater proportion in virtual learning jurisdictions (3,209 to 2,393 per 100,000 15- to 19-year-olds, a 25% relative decline) than in-person jurisdictions (2,359 to 2,054 per 100,000; 13% decline) (Fig. 1C; Table 4). Mean reported gonorrhea diagnosis rates remained stable in virtual learning jurisdictions (744 vs 740 per 100,000 in 2019 and 2021) but increased by 20% in in-person learning jurisdictions from 519 to 622 per 100,000 (Fig. 1D). These changes resulted in significant relative declines in both chlamydia and gonorrhea diagnosis rates associated with virtual learning (DID: incidence rate ratio [IRR] for chlamydia, 0.86; 95% CI, 0.84–0.88 and gonorrhea: IRR, 0.83; 95% CI, 0.79–0.87; both $P < 0.0001$). Adjusting for past-year STI testing did not affect these estimates [adjusted IRR for chlamydia = 0.86 (95%CI = 0.84–0.88) and gonorrhea = 0.82 (95%CI = 0.79–0.87); both $P < 0.0001$]. Findings were similar stratified by sex, though reported diagnosis rates were higher among female 15- to 19-year-olds than their male counterparts across years and learning models. The parallel trends assumption appeared to hold for both diagnoses (Supplemental Digital Content 4, [http://links.lww.com/OLQ/B205](https://links.lww.com/OLQ/B205)).

DISCUSSION

In a population-based sample of high school students from 24 local jurisdictions across the United States, sexual behaviors remained stable from 2019 to 2021 across all jurisdictions except for a decrease in ever having sex, and changes in most examined sexual behaviors did not significantly differ between virtual and in-person learning jurisdictions. Virtual learning was associated with a relative increase in condom use at last sex, though diverging trends prior to 2019 may have contributed to this association. Sensitivity analyses suggested that differential changes in semester of survey administration may have obscured additional relative decreases in behaviors associated with STI transmission in virtual learning jurisdictions, but only the relative decrease in substance use before or during last sex was significant. Reductions in social and physical interactions and changes in parental and peer influences due to virtual learning have been hypothesized to decrease sexual activity and behaviors associated with STI transmission,^{3,26–28} and in related analyses, virtual learning was associated with relative reductions in overall use of several substances, which may have contributed to decreases in substance use with sex.²⁹ In general, though, these findings suggest that longer-term virtual learning had limited impact on students' sexual behaviors during this period. It is possible that the effects of virtual learning in the 2020–2021 school year might be different than during the initial stages of the COVID-19 pandemic, particularly as society began to open up and opportunities for social connection outside school increased. In addition, many sexual behaviors were measured in the past 3 months, and depending on when jurisdictions returned to in-person instruction and administered

YRBS, the recall period may not have overlapped completely with the period of virtual learning.

Consistent with prior national estimates¹³ and reports describing reductions in HIV/STI testing access and volumes among adolescents and young adults,^{9–12} we found that HIV and STI testing decreased significantly across all jurisdictions from 2019 to 2021. The additional decrease associated with virtual learning—significant for STIs but not HIV—could have been due to virtual learning resulting in greater reductions in access to school-based sexual health services—a critical component of adolescent health infrastructure—or differential changes in parental supervision, student confidentiality, school connectedness, and peer influence.^{3,26–28} Other differences in policies or societal impacts between virtual and in-person jurisdictions with potential to decrease availability of testing services, such as reductions in in-person healthcare,³⁰ or adolescents' ability to seek care, such as income or health insurance loss for adolescents or their parents,³ could also have played a role. One study found children attending school in-person either entirely or through a hybrid model were less likely to have forgone care than peers attending school entirely virtually.^{31s} Regardless, even among high school students who had ever had sex, fewer than one-third had ever tested for HIV or tested for another STI in the past year across years and learning models, indicating a critical need to increase HIV/STI testing services for high school students and maintain these services during and after public health emergencies. Pandemic recovery efforts focused on catching up on health services youth may have missed during the COVID-19 pandemic might benefit from increasing access to HIV/STI testing for all adolescents and additional efforts in jurisdictions with predominantly virtual learning in 2020–2021.

Reported chlamydia diagnosis rates decreased and reported gonorrhea diagnosis rates increased from 2019 to 2021 among 15- to 19-year-olds nationally^{32s} and across all study jurisdictions, and virtual learning jurisdictions saw significant relative decreases in reported gonorrhea and chlamydia compared with in-person jurisdictions. Reported diagnosis rates do not necessarily represent underlying incidence because not all infections are diagnosed or reported to health departments.^{33s} The relative reduction observed in virtual learning jurisdictions may, in part, be due to both a decrease in the proportion of infections that are diagnosed due to relative decreases in STI testing and a decrease in incidence resulting from potential relative increases in condom use at last sex. Notably, these changes occurred in the context of limitations to STI surveillance from shifting of public health resources to COVID-19 and decreases in screening that disproportionately impacted chlamydia diagnoses.^{34s,35s} Disentangling contributions of changes in sexual behaviors, sexual networks, screening behaviors and services, and public health infrastructure on STI diagnosis rates can help STI programs prepare for future public health emergencies.

Our analysis has important strengths. Difference-in-differences is an approach that can allow for causal inference and accounts for prior trends.²⁴ In addition, using population-based data from a longstanding behavioral survey and national reported diseases database increased potential representativeness, may have limited bias from self- or proxy-perceptions of pandemic-related impacts, and allowed direct assessment of the parallel trends assumption. Our study also has limitations. First, jurisdiction decisions regarding learning model were

likely associated with other COVID-related laws, policies, and community responses, including availability and engagement with in-person activities outside school, that may also have contributed to or obscured differential changes in our outcomes, and pandemic trajectories and impacts differed by region. Second, summarizing learning model at the jurisdiction level may have led to misclassification as not all schools in a jurisdiction reported the same learning model for the entire period and some jurisdictions allowed students to attend schools in districts other than where they reside (i.e., where STI diagnoses would be reported). In addition, it was not always possible to align geographic areas perfectly for YRBS, STI diagnosis, and learning model data. Also, self-reported YRBS outcomes were sensitive to social desirability and recall bias. Fifth, we had limited power to conduct statistical evaluations of the impact of learning model on behavioral outcomes among smaller racial/ethnic groups and sexual minorities, and reported diagnoses were not available stratified by sexual orientation or—in many jurisdictions—for most racial/ethnic groups in AtlasPlus. Finally, parallel trends assumptions did not include all jurisdictions for YRBS outcomes and relied on county's overall reported diagnosis rates due to data availability.

In conclusion, our findings underscore the importance of school, clinic, and community efforts to increase access to sexual health services among adolescents. Strategies are needed for maintaining these services during public health emergencies involving schools and reaching adolescents and young adults who missed opportunities for HIV/STI testing during the COVID-19 pandemic. Schools can strengthen efforts toward offering comprehensive sexual health education with information about HIV/STI testing; providing sexual health service referrals; and offering such services in school-based health centers. Such efforts can be complemented by provider and clinic-based efforts to increase STI testing among adolescents, such as provider trainings on STI screening and quality improvement initiatives to increase sexual history taking and screening.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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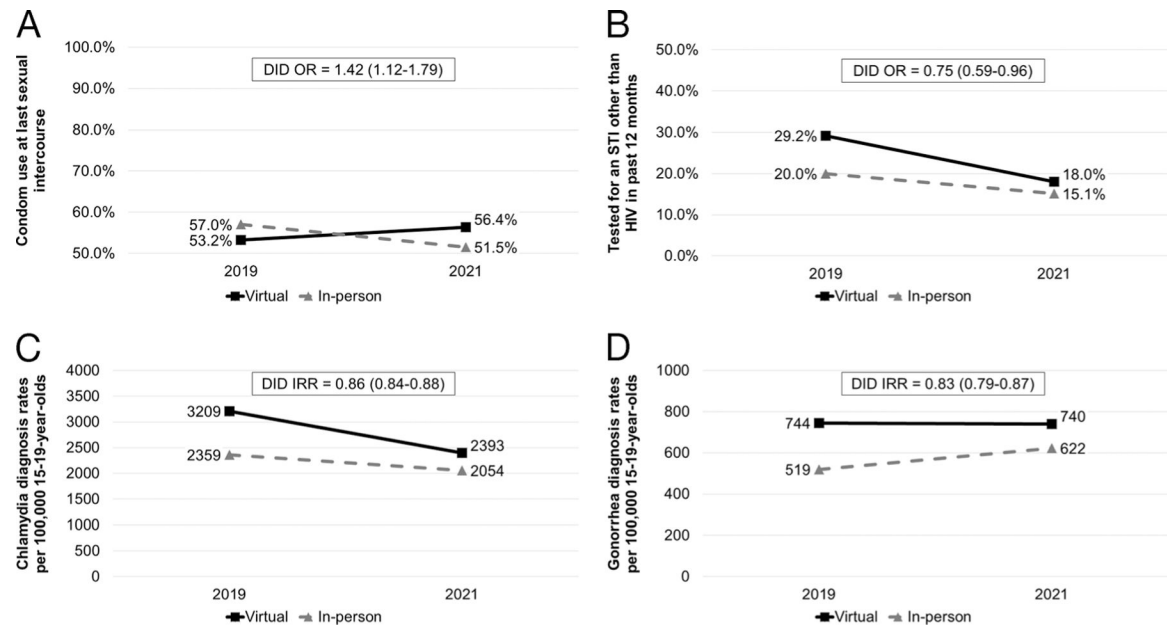
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**Figure 1.**

Estimated effects of virtual (vs in-person) learning on condom use, STI testing, and chlamydia and gonorrhea diagnosis rates. Effects estimated using DID analyses. Figure only includes outcomes with DID terms significant at $P < 0.050$ in overall analyses. 95% CIs in parentheses. Note different y-axis scales.

TABLE 1.
Sociodemographic Characteristics of YRBS Respondents in 24 Local Jurisdictions, Stratified by School Learning Model for the 2020–2021 School Year and YRBS Survey Year

YRBS Survey Year	School Learning Model (2020–2021 School Year)		Virtual		In-Person	
	2019	2021	2019	2021	2019	2021
Unweighted n (% of total for year)	32,358 (67.9%)	27,058 (66.6%)	15,303 (32.1%)	13,589 (33.4%)		
Sex						
Female	49.4%	48.8%	50.0%	49.4%		
Male	50.6%	51.2%	50.0%	50.6%		
Age						
≤12	0.6%	0.5%	0.9%	0.8%		
13	1.6%	1.5%	0.4%	0.5%		
14	17.6%	22.2%	11.2%	16.8%		
15	25.2%	25.0%	24.9%	24.9%		
16	24.6%	24.4%	24.6%	24.8%		
17	21.5%	21.1%	24.5%	22.5%		
≥18	9.0%	5.3%	13.5%	9.6%		
Race and ethnicity						
American Indian/Alaska Native	1.1%	0.6%	0.7%	0.6%		
Asian	10.1%	10.7%	4.0%	3.1%		
Black/African American	26.0%	26.5%	27.7%	28.0%		
Hispanic/Latino	43.4%	44.3%	32.6%	35.6%		
Native Hawaiian/Pacific Islander	0.9%	0.3%	0.7%	0.5%		
White	15.2%	14.9%	30.7%	29.1%		
Multiple, non-Hispanic	3.3%	2.7%	3.5%	3.2%		
Sexual orientation *						
Heterosexual	80.9%	71.3%	80.4%	72.3%		
Gay or lesbian	3.3%	3.9%	4.2%	5.2%		
Bisexual	9.9%	11.7%	10.2%	11.7%		
Not sure	5.8%	—	5.2%	—		
I describe my sexual identity some other way	—	4.5%	—	3.7%		
I am not sure about my sexual identity	—	5.6%	—	4.9%		

School Learning Model (2020–2021 School Year)				
YRBS Survey Year	Virtual		In-Person	
	2019	2021	2019	2021
Don't know what this question is asking	—	2.9%	—	2.1%
Sex of sexual contacts [†]				
Female respondents with female sexual contacts only	5.5%	5.5%	4.1%	5.8%
Female respondents with male sexual contacts	41.6%	41.3%	45.4%	42.4%
Male respondents with female sexual contacts only	46.3%	46.8%	45.0%	43.5%
Male respondents with male sexual contacts	6.6%	6.4%	5.5%	8.2%
Census region				
Midwest	11.9%	12.4%	0%	0%
Northeast	48.8%	50.8%	0%	0%
South	7.5%	7.6%	100%	100%
West	31.8%	29.2%	0%	0%

* Response options changed from the 2019 to 2021 survey.

[†] Among respondents reporting any sexual contact in response to the question “During your life, with whom have you had sexual contact?” All analyses are survey-weighted. Virtual learning jurisdictions included: Los Angeles, CA; Oakland, CA; San Francisco, CA; Chicago, IL; Boston, MA; Gaston Co., NC; Newark, NJ; Albuquerque, NM; New York City, NY; Cleveland, OH; Portland, OR; Philadelphia, PA; Nashville, TN; Shelby Co., TN; Seattle, WA. In-person learning jurisdictions included: Broward Co, FL; Duval Co., FL; Hillsborough Co., FL; Orange Co., FL; Palm Beach Co., FL; Pasco Co., FL; Spartanburg Co., SC; Ft. Worth, TX.

TABLE 2.
Sexual Behaviors and HIV/STI Testing Among YRBS Respondents, Stratified by School Learning Model for the 2020–2021 School Year and YRBS Survey Year

YRBS Survey Year	Virtual			In-Person			DID		
	2019	2021	Difference	2019	2021	Difference	Absolute	OR	95% CI
Ever had sexual intercourse *	30.3%	22.2%	-8.1%	35.6%	26.7%	-8.9%	0.8%	1.00	0.85–1.18
Sexual intercourse in past 3 months †	65.5%	64.0%	-1.5%	66.8%	66.8%	0.0%	-1.5%	0.94	0.78–1.13
Multiple sex partners in past 3 months ‡	21.6%	20.4%	-1.3%	21.0%	18.4%	-2.6%	1.3%	1.09	0.81–1.48
Condom use at last sexual intercourse ‡	53.2%	56.4%	3.1%	57.0%	51.5%	-5.5%	8.6%	1.42	1.12–1.79
Alcohol or drug use before last sexual intercourse ‡	18.0%	16.7%	-1.2%	18.4%	19.7%	1.3%	-2.5%	0.84	0.63–1.13
Ever tested for HIV †	29.9%	20.3%	-9.6%	23.4%	17.9%	-5.5%	-4.0%	0.84	0.66–1.07
Tested for STI other than HIV, past 12 months †	29.2%	18.0%	-11.2%	20.0%	15.1%	-4.9%	-6.3%	0.75	0.59–0.96

All analyses are survey-weighted. Bold indicates significance at $P < 0.050$. Outcomes were analyzed among:

* all respondents

† respondents reporting ever having had sexual intercourse

‡ respondents reporting having had sexual intercourse in past 3 months.

For the following outcomes, jurisdictions in parentheses did not ask questions necessary for the numerator or denominator and were excluded from analyses for that outcome: sexual intercourse and multiple sex partners in past 3 months (Nashville, TN; Oakland, CA), condom use (Nashville, TN; Oakland, CA; Portland, OR; Spartanburg Co., SC); alcohol or drug use (Chicago, IL; Gaston Co., NC; Nashville, TN; Oakland, CA); and HIV testing (Gaston Co., NC; Spartanburg Co., SC).

TABLE 3.
Difference-in-Differences Estimates of the Effect of Virtual (vs In-Person) Learning in the 2020–2021 School Year on Sexual Behaviors and HIV/STI Testing Among YRBS Respondents

Outcomes	DID OR (95% CI)						Administered Survey in Same Semester*
	Overall	Sex		Race and Ethnicity			
		Female	Male	Black	Hispanic	White	
Ever had sexual intercourse	1.00 (0.85–1.18)	1.09 (0.90–1.31)	0.90 (0.72–1.12)	0.88 (0.67–1.16)	1.05 (0.85–1.30)	1.16 (0.85–1.58)	0.80 (0.63–1.00)
Sexual intercourse in past 3 months	0.94 (0.78–1.13)	0.70 (0.54–0.91)	1.17 (0.89–1.53)	0.76 (0.54–1.06)	1.03 (0.78–1.37)	0.87 (0.56–1.38)	0.82 (0.64–1.05)
Multiple sex partners in past 3 months	1.09 (0.81–1.48)	1.15 (0.75–1.78)	1.02 (0.64–1.62)	1.32 (0.70–2.49)	1.01 (0.70–1.47)	0.93 (0.51–1.68)	0.89 (0.58–1.36)
Condom use at last sexual intercourse	1.42 (1.12–1.79)	1.45 (1.08–1.95)	1.39 (0.99–1.97)	1.86 (1.19–2.90)	1.23 (0.87–1.75)	1.08 (0.63–1.84)	1.41 (1.06–1.86)
Alcohol or drug use before last sexual intercourse	0.84 (0.63–1.13)	0.87 (0.59–1.28)	0.79 (0.52–1.22)	0.49 (0.27–0.87)	0.88 (0.53–1.46)	0.78 (0.42–1.45)	0.64 (0.45–0.93)
Ever tested for HIV	0.84 (0.66–1.07)	0.75 (0.53–1.06)	0.96 (0.71–1.29)	0.63 (0.36–1.10)	1.23 (0.83–1.82)	0.53 (0.30–0.91)	0.75 (0.52–1.08)
Tested for STI other than HIV, past 12 months	0.75 (0.59–0.96)	0.63 (0.46–0.88)	0.90 (0.63–1.29)	0.62 (0.37–1.04)	1.08 (0.76–1.54)	0.46 (0.28–0.75)	0.73 (0.52–1.03)

Bold indicates significance at $P < 0.050$. All estimates are from survey-weighted logistic regression. Difference-in-differences estimates from the interaction term between survey year (2019 vs 2021) and learning model (virtual vs in-person).

* Including 10 jurisdictions that administered YRBS during the same semester (either spring or fall) in both 2019 and 2021.

TABLE 4.
Chlamydia and Gonorrhea Diagnosis Rates Per 100,000 15- to 19-Year-Olds by 2020–2021 School Year Learning Model and Year

School Learning Model (2020–2021)				In-Person		DID Estimates		
Year	2019	2021	Relative Change	2019	2021	Relative Change	IRR	95%CI
<i>Chlamydia diagnosis rates</i>								
Overall	3209	2393	–25%	2359	2054	–13%	0.86	0.84–0.88
Female	4751	3548	–25%	3597	3073	–15%	0.87	0.86–0.89
Male	1688	1258	–25%	1148	1060	–8%	0.81	0.78–0.84
<i>Gonorrhea diagnosis rates</i>								
Overall	744	740	–1%	519	622	20%	0.83	0.79–0.87
Female	897	881	–2%	635	752	18%	0.83	0.79–0.87
Male	593	601	1%	404	493	22%	0.83	0.78–0.87

DID IRR estimate from interaction term between year (2019 vs 2021) and learning model (virtual vs in-person) in Poisson regression model with robust variance.