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# THE IMPACT OF VIRTUAL INSTRUCTION ON THE TRANSITION TO COLLEGE: EVIDENCE FROM COVID-19

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The Impact of Virtual Instruction on the Transition to College: Evidence from COVID-19
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## ABSTRACT

During the COVID-19 pandemic, virtual instruction reduced in-person support that may have helped high school students transition to college. Using national school-level data on FAFSA submissions, ACT participation, and first-year college enrollment, we estimate a difference-in-differences model that exploits cross-school variation in virtual instruction during the 2020/2021 school year. A fully virtual school year reduced FAFSA submissions by 4.2 percentage points, ACT participation by 4.8 percentage points, and first-year college enrollment by 2.5 percentage points. FAFSA submissions partially rebounded after reopening, but ACT participation and college enrollment did not. Effects were substantially larger in disadvantaged schools.

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COVID-19 disrupted nearly every stage of the educational pipeline in the United States. In spring 2020, school buildings closed abruptly and instruction moved online in most parts of the country as policymakers attempted to limit virus transmission (EdWeek 2020). During the following academic year, however, schools diverged sharply in how they delivered instruction. Some returned to regular in-person schooling relatively quickly, some remained almost entirely virtual, and others adopted hybrid arrangements that blended online and in-person instruction. This cross-school variation created large differences in the extent to which students continued to interact in person with teachers, counselors, and peers.

Most work on pandemic schooling has focused on learning loss; however, the transition from high school to college could be particularly sensitive to virtual instruction. Students must learn about aid, register for tests, monitor deadlines, and decide whether to matriculate. Schools often support these tasks through counselors, teachers, and repeated in-person reminders. When instruction moves online, those supports may weaken even if classes continue.

This paper studies whether greater exposure to virtual instruction during the first pandemic school year reduced students' progress along the path to college. We focus on three outcomes that capture distinct stages of that process: FAFSA submission, ACT test-taking, and first-year college enrollment. FAFSA completion captures whether students apply for federal aid, ACT participation captures continued engagement with the college application process, and first-year enrollment captures realized college entry.

There are several reasons to expect instructional mode to matter. In-person schooling may provide practical help with high-friction tasks such as completing the FAFSA or registering for admissions tests. It may also increase salience by exposing students to repeated reminders from counselors, teachers, and peers. During a period of unusual uncertainty, reduced contact with school personnel may also have weakened students' expectations that college was feasible or worthwhile. At the same time, the net effect is not obvious ex ante, since remote learning may have reduced some costs

and pandemic-era policy changes may have offset some barriers.

To answer this question, we combine several sources of school-level administrative data. We use the COVID School Data Hub (CSDH) to measure each school's instructional mode during the 2020/2021 school year. We merge those data to school-level FAFSA submissions from Federal Student Aid, ACT participation from ACT Inc., first-year college enrollment from the National Student Clearinghouse (NSC), and demographic characteristics from the National Center for Education Statistics (NCES). The resulting panel covers 14,005 public high schools from the 2015/2016 through 2021/2022 school years, which we refer to as school years 2015 through 2021 for brevity.

Our empirical strategy exploits cross-school differences in how much of the 2020 school year was spent in virtual instruction. We estimate a school-level difference-in-differences model with school and year fixed effects, comparing outcomes in schools that were more versus less virtual during the pandemic relative to their own pre-pandemic trends. The identification comes from the broad national variation in pandemic instructional mode, while controlling flexibly for school characteristics and local pandemic conditions.

We find that more virtual schooling led to lower college-going. In our preferred continuous-treatment specification, moving from fully in-person to fully virtual instruction for the 2020 school year reduces FAFSA submission rates by 4.2 percentage points, ACT test-taking rates by 4.8 percentage points, and first-year college enrollment by 2.5 percentage points. These are economically meaningful effects and are similar in magnitude, though opposite in sign, to estimates from successful college-going interventions (Bettinger et al. 2012; Carrell and Sacerdote 2017; Castleman and Page 2015). These patterns also appear in alternative discrete treatment specifications that compare majority-virtual, always-in-person, and always-virtual schools.

The persistence patterns differ across outcomes. FAFSA submissions partially recover after schools reopen: in 2021 the estimated gap between previously more-virtual and less-virtual schools narrows by more than half. By contrast, we find little evi-

dence of a rebound in ACT participation or first-year college enrollment. This may be because FAFSA completion can occur later in the cycle, and grade-11 students may partially catch up once in-person support resumes. ACT testing and initial college enrollment may be harder to recover after deadlines have passed or early stage preparation has been missed, such that grade-11 students are equally affected.

The negative effects of virtual instruction are also highly unequal. Schools with above-median shares of students eligible for free or reduced price lunch experienced much larger declines in FAFSA completion and college enrollment. The point estimates imply that the negative effect of virtual instruction on these outcomes is more than three times larger in higher-poverty schools. This pattern suggests that school-based guidance and reminders are especially important for disadvantaged students, who may be disproportionately first-generation college students and have fewer alternative sources of information and support outside school.

Our paper contributes to two related literatures. First, it extends research on pandemic schooling disruptions by studying college-going rather than test scores or K–12 enrollment (Dee et al. 2023; Goldhaber et al. 2022; Jack et al. 2023). Second, it speaks to the literature on interventions that facilitate the transition from high school to college. A large body of evidence shows that reducing informational frictions and providing timely assistance can raise college-going (Bettinger et al. 2012; Carrell and Sacerdote 2017; Castleman and Long 2016; Castleman and Page 2015). We study the opposite shock: a broad decline in access to informal in-school support. More broadly, the paper highlights a channel through which school closures may generate long-term costs beyond learning loss, since college attendance has important long-run consequences for adult outcomes (Buckles et al. 2016; Hoekstra 2009; Zimmerman 2014).

The rest of the paper proceeds as follows. Section I describes the data and sample construction. Section II presents the empirical framework. Section III reports the main results, heterogeneity, and robustness checks. Section IV discusses potential mechanisms and interpretation. Section V concludes.

# I Data

Our analysis combines seven data sources that, together, provide a broad picture of how pandemic instructional mode affected the transition to college. These sources are: (i) school-level pandemic learning-mode data from the COVID School Data Hub, (ii) school-level FAFSA submissions from Federal Student Aid, (iii) school-level ACT participation from ACT Inc., (iv) school-level first-year college enrollment from the National Student Clearinghouse, (v) school-level demographics from the National Center for Education Statistics, (vi) county-level unemployment rates from the Bureau of Labor Statistics, and (vii) county-level COVID-19 case and death rates from the *New York Times*. Unless otherwise noted, the data span school years 2015 through 2021. In this section, we describe each source, discuss sample construction, and explain how we define our main outcomes and treatment measure.

## National Center for Education Statistics (NCES) School Data

We begin with the NCES Common Core of Data school and district files. These files provide annual school-level information on total enrollment, grade-specific enrollment, racial composition, sex composition, free or reduced price lunch eligibility, and teacher counts. We define a public high school as a school with positive grade-12 enrollment in the NCES data. This baseline definition yields 28,674 public high schools.

The NCES data serve three roles. First, they provide the denominators used to normalize outcomes across schools of different sizes. We therefore scale FAFSA and college enrollment by grade-12 enrollment and ACT participation by grade-11-and-12 enrollment. Second, the NCES data supply time-varying school controls that help account for compositional changes over time. Third, they allow for heterogeneity analysis across different types of schools.

## Pandemic Learning-Mode Data

Our treatment variable comes from the COVID School Data Hub (CSDH), which records school-level instructional mode during the 2020 school year.[1] CSDH classifies instruction as in-person, virtual, or hybrid. In-person denotes that all or most students had access to traditional five-day-per-week in-person instruction. Virtual denotes that all or most students received online instruction five days per week. Hybrid captures arrangements in between, such as alternating schedules or partial reopening (Jack et al. 2023).

Our preferred treatment measure is the fraction of the August 2020 through July 2021 period that a school spent under virtual instruction. A month classified as hybrid is coded as one-half virtual and one-half in-person.[2] This continuous treatment captures the full intensity of moving from fully virtual to fully in-person.

The CSDH school-level data do not observe instructional mode from March through July 2020. Accordingly, we classify schools using learning modes from August 2020 through June 2021. Anecdotally, the cross-school variation in instructional mode during that first shutdown period (March through June 2020) appears limited because most schools moved quickly into remote learning (EdWeek 2020). We also assume that widespread virtual instruction was negligible prior to March 2020.

Of the 28,674 public high schools in the NCES universe, 16,021 (55.9 percent) have learning-mode data. Coverage is not national because the availability of school-level instructional-mode data varies across states. Among schools with learning-mode data, 14,005 (87.4 percent) have information for at least one of our three main outcomes. This is our broad estimation sample.

[1] The school-level CSDH data used here cover 35 states: Alabama, Alaska, Arizona, Arkansas, California, Colorado, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Kentucky, Louisiana, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, Nevada, New Hampshire, New Mexico, New York, North Carolina, North Dakota, Oregon, Rhode Island, South Dakota, Texas, Utah, Vermont, West Virginia, and Wisconsin (COVID-19 School Data Hub 2023).

[2] The main results are very similar when using schools that were always in-person or were always virtual (see Table A.6).

## FAFSA Submissions

We measure financial-aid application behavior using monthly cumulative FAFSA submissions from Federal Student Aid. FAFSA completion is a particularly useful outcome because it captures a concrete, policy-relevant step in the college-going process. The FAFSA is required for most federal student aid programs, including Pell Grants, subsidized and unsubsidized student loans, and Federal Work-Study. Prior research shows that the complexity of the application process can deter otherwise eligible students, and that assistance with FAFSA completion can increase college attendance (Bettinger et al. 2012). A decline in FAFSA submissions is therefore meaningful even if it does not map one-for-one into college enrollment.

The FAFSA data span school years 2015 through 2021. Because the publicly posted series is cumulative within each application cycle, we recover monthly flows by differencing consecutive months.[3] Our baseline FAFSA outcome is total submissions within a FAFSA year per grade-12 enrollment, where a FAFSA year runs from October of calendar year $t$ through September of calendar year $t+1$. For example, the FAFSA submissions matched to school year 2021 are the submissions made between October 2021 and September 2022 for aid in the 2022 academic year. We also report estimates for shorter windows running through January, March, and July in Table A.2 to assess whether the effects are concentrated early or late in the application cycle.

## ACT Data

We measure standardized test-taking using school-level counts of ACT test-takers obtained from ACT Inc. The ACT data span school years 2015 through 2021, and 10,066 of the 16,021 schools with learning-mode information (62.8 percent) appear in the ACT sample.

ACT participation is informative because it captures engagement with the college

[3] A data-construction challenge for this data is that the NCES school identifiers appear in the archival FAFSA files only from November 2022 onward. We therefore construct a crosswalk in two steps. First, we use the later files with exact NCES identifiers. Second, for earlier years, we implement a fuzzy match based on state, city, and school name. This procedure yields matches for 13,957 of the 16,021 schools (87.1 percent) with learning-mode information.

application process. In many parts of the country, taking the ACT is a deliberate action associated with college planning, so pandemic disruptions may have reduced participation.

Our baseline ACT analysis excludes states in which the ACT was mandatory for high-school students.[4] This restriction focuses attention on settings where ACT participation plausibly reflects college-going behavior rather than state testing mandates. If the test is required by the state, a decline in participation could reflect implementation of the mandate rather than students' own decisions. Table A.3 reports estimates separately by testing-regime status.

One limitation of the ACT outcome is that testing centers themselves were also disrupted. A decline in participation may therefore reflect both lower student demand and reduced testing supply. Both channels represent ways in which the transition to college may have become more difficult.

## College Enrollment Data

We measure realized college entry using high-school-level first-year college enrollment counts from the National Student Clearinghouse (NSC). The NSC data span school years 2017 through 2021, and 9,396 of the 16,021 schools with learning-mode data (58.6 percent) appear in the NSC sample.

Our enrollment outcome captures college attendance within the first year after high-school graduation. For example, for the cohort graduating in the spring of 2020, any college enrollment observed before May 2021 is counted as first-year college enrollment. We include NSC enrollments recorded in the summer before the first fall term because some institutions begin earlier in the academic calendar.

College enrollment is our most downstream outcome and therefore the outcome of greatest substantive interest. Unlike FAFSA submission or ACT participation, enrollment incorporates the cumulative effect of many prior decisions and can therefore be

[4]The excluded mandatory states are Alabama, Hawaii, Kentucky, Montana, Nebraska, Nevada, North Carolina, Wisconsin, and Wyoming.

interpreted as the net effect of virtual schooling on the transition to college.

## Additional Data

We supplement the school-level data with county-level COVID-19 case and death rates from the *New York Times* based on reports from state and local health agencies and county-level unemployment rates from the Bureau of Labor Statistics. These local controls help account for the fact that pandemic severity and labor-market conditions may have affected both the decision to remain virtual and students' college-going behavior.

## Summary Statistics

Figure A.1 plots trends in the total FAFSA submissions, ACT test-taking, and first-year college enrollment for a balanced panel of high schools. Each series falls sharply around the onset of the pandemic, and the subsequent recovery is limited. This descriptive evidence is consistent with a broad pandemic-era decline in college-going, but it does not identify the potential role for instructional mode.

Figure 1 presents the distributions of our treatment and outcome variables. The distribution of our treatment, the fraction of the 2020 school year spent virtually, has clear spikes at 0 and 1, indicating many schools that either remained fully in-person or fully virtual throughout the year. There is also a noticeable spike at 0.5, driven by schools that reopened after one semester or were hybrid throughout the year. The other three panels show that about a third of students took the ACT and two-thirds submitted a FAFSA and enrolled in college.

Table 1 reports summary statistics by majority-virtual status. Relative to majority in-person schools, majority-virtual schools are larger, have a lower fraction of White students, have more students per teacher, and have higher shares of students eligible for free or reduced price lunch. These patterns show that virtual instruction was more common in school environments that were already different along dimensions linked to educational opportunity. They also align with prior evidence that higher-

poverty schools were more likely to operate remotely during COVID-19 (Goldhaber et al. 2022). These differences motivate our use of school fixed effects, year fixed effects, and time-varying controls in the regression analysis.

# II Methodology

To analyze the impact of virtual instruction during COVID-19 on the transition to college, we estimate the school-level difference-in-differences model

$$Y_{it} = \alpha_i + \gamma_t + \beta_{2020}\left(T_i \times Year_{2020}\right) + \beta_{2021}\left(T_i \times Year_{2021}\right) + \kappa X_{it} + \varepsilon_{it} \tag{1}$$

where $i$ indexes schools and $t$ indexes school years. The dependent variable $Y_{it}$ is one of our college-going outcomes, $T_i$ is a treatment measure based on the intensity of virtual instruction in 2020, $\alpha_i$ are school fixed effects, $\gamma_t$ are year fixed effects, and $X_{it}$ is a vector of time-varying controls. We distinguish between school year 2020 and school year 2021 because most schools that were highly virtual in 2020 reopened in 2021, so the consequences of earlier virtual exposure may differ across those two periods.[5]

In our primary specifications, the main dependent variables are FAFSA submissions per grade-12 enrollment, ACT test-takers per grade-11-and-12 enrollment, or first-year college enrollment per grade-12 enrollment. We scale ACT participation by grade-11-and-12 enrollment because both juniors and seniors take the exam. The vector of controls, $X_{it}$, includes county unemployment, county COVID case rates, county COVID death rates, and school-level measures of percent White, percent Black, percent male, students per teacher, and percent eligible for free or reduced price lunch.[6] Standard errors are clustered at the school level throughout.

We use four treatment definitions. The first, and our preferred treatment measure, is a continuous measure equal to the fraction of the 2020 school year spent in virtual instruction, with hybrid months coded as one-half virtual. The second is an indicator

[5] We cannot verify reopening directly in the CSDH data because the school-level learning-mode series ends between the 2020 and 2021 school year.

[6] For covariates with missing values, we apply a dummy-variable adjustment for missing covariates so that schools are retained when only a subset of controls is observed.

for majority-virtual schools, defined as schools spending at least half of those months virtually. The third is an indicator for schools that were always in-person over that period. The fourth is an indicator for schools that were always virtual. Our preferred specifications use the continuous treatment and the majority-virtual indicator because the always-in-person and always-virtual definitions are more restrictive and therefore rely on smaller subsamples.

The parameters of interest are $\beta_{2020}$ and $\beta_{2021}$. In the continuous specification, $\beta_{2020}$ captures the difference in outcomes between a school that was fully virtual and a school that was fully in-person in 2020, relative to the corresponding pre-pandemic difference. In the discrete specifications, the coefficient captures the average difference between treatment and control schools for the relevant groups. Under the hypothesis that virtual instruction reduced access to information, reminders, and individualized support, outcomes should decline more in schools that were more virtual.

The inclusion of school fixed effects is important for interpretation. These fixed effects absorb all time-invariant differences across schools, including persistent differences in demographics, academic quality, local resources, or baseline college-going rates. Year fixed effects absorb shocks common to all schools in a given year, such as nationwide changes in admissions testing, aid rules, or pandemic conditions. The identifying variation therefore comes from whether schools with different intensities of virtual instruction experienced different changes in outcomes after the onset of the pandemic.

A central concern is that schools that chose more virtual instruction may also have experienced different local shocks during the pandemic. Those shocks could be epidemiological, economic, or political, and they could independently affect students' college-going decisions. We address this concern in several ways. First, we control for county unemployment and county COVID case and death rates, which helps account for differences in local labor markets and pandemic severity. Second, we add time-varying school demographics, allowing for the possibility that school composition changed during the pandemic. Third, we complement the baseline difference-

in-differences estimates with event-study specifications and additional models that absorb county-by-year or state-by-year shocks.

The key identifying assumption is that, absent differential exposure to virtual instruction, treated and control schools would have followed parallel trends. To assess this assumption, we estimate event-study models of the form

$$Y_{it} = \alpha_i + \gamma_t + \sum_{\tau \neq 2019} (\beta_\tau \times \mathbb{1}[\tau = t] \times T_i) + \kappa X_{it} + \varepsilon_{it} \tag{2}$$

where the notation follows that of Equation 1 and $T_i$ is either the continuous fraction virtual treatment or the majority virtual indicator.[7] We normalize the coefficient for school year 2019 to zero and plot the remaining $\beta_\tau$ estimates in Figure 2 and Figure A.2.

The event-study framework provides a diagnostic for parallel trends and shows how effects evolve over time. Across outcomes, the pre-2020 coefficients are broadly stable. To address the concern that the estimates instead reflect broader local shocks, we also estimate versions of the event study with state-by-school-year fixed effects (Figure A.4 and Table A.4) and county-by-school-year fixed effects (Figure A.5 and Table A.5). The qualitative patterns remain similar.

# III Results

## Main Results

Table 2 reports estimates from Equation 1 for the continuous treatment, and Table A.6 reports estimates for the discrete treatment definitions. For each of the three outcomes, the estimates of $\beta_{2020}$ are negative and statistically significant across specifications that include no time-varying controls (columns (1), (4), and (7)), controls for county COVID case rates, county COVID death rates, and county unemployment (columns (2), (5), and (8)), and controls for school-level demographics (columns (3),

[7] The event-study figures for the always-in-person and always-virtual treatments are reported in Figure A.3.

(6), and (9)).

Our preferred specification is the continuous-treatment model with county and school controls, namely columns (3), (6), and (9) of Table 2. In those specifications, moving from fully in-person to fully virtual instruction lowers FAFSA submission rates by 4.2 percentage points, ACT test-taking rates by 4.8 percentage points, and first-year college enrollment rates by 2.5 percentage points. Relative to baseline participation rates, these estimates imply notable reductions at each stage of the college-going process. The fact that all three outcomes move in the same direction strengthens the conclusion that virtual instruction hindered students' transition to college rather than merely shifting the timing of one isolated step.

The discrete-treatment results point in the same direction (see Table A.6). As expected, the majority-virtual estimates are smaller in magnitude than the continuous estimates because they compare schools above and below a 50 percent threshold rather than the extremes of 0 and 100 percent virtual instruction. The always-in-person and always-virtual comparisons are also qualitatively similar (see Table A.6).

The estimates of $\beta_{2021}$ indicate partial recovery for FAFSA completion but no comparable recovery for ACT test-taking or college enrollment. In column (3) of Table 2, the FAFSA coefficient falls in absolute value from 0.042 in 2020 to 0.018 in 2021, implying that roughly 57 percent of the initial gap closes after schools reopen. This pattern is consistent with the idea that some students were able to catch up on aid applications once they regained more direct access to counselors and school routines.

By contrast, the ACT and college-enrollment coefficients in 2021 remain similar in magnitude to those in 2020. This persistence suggests that the disruptions at schools associated with virtual instruction had effects that extended beyond the immediate school-closure period. One plausible reason is that some grade-10 and grade-11 students were also affected and remained off the college-going path in subsequent years. Another possibility is that virtual schools changed how they encouraged and supported students to attend college and continued using these new practices even after returning to in-person instruction.

The event-study evidence reinforces this interpretation. Figure 2 and Figure A.2 show relatively flat pre-trends for schools with different virtual exposure, followed by clear post-2020 divergences. The post-treatment evolution mirrors the main regression results: a sharp decline in 2020, some rebound for FAFSA, and much more persistent negative gaps for ACT participation and college enrollment.

The estimates with state-by-year and county-by-year fixed effects are also informative (see Figures A.4 and A.5, Tables A.4 and A.5). Because the qualitative patterns remain similar, the results are unlikely to be explained by regional shocks. Taken together, the main results imply that virtual instruction affected both intermediate and final stages of the college-going process.

## Heterogeneity

We next examine heterogeneity by school and local-area characteristics. Specifically, we estimate Equation 1 separately for schools above and below the median of share of Black students, county COVID case and death rates, and share of students eligible for free or reduced price lunch.

Tables A.7, A.8, and A.9 show relatively similar effects of virtual learning across splits by local COVID exposure and by school racial composition. The main exception is that the FAFSA rebound in 2021 appears somewhat stronger in schools below the median Black share. Overall, however, these dimensions do not reveal dramatic differences in treatment effects. This finding is useful because it suggests that the main mechanism is unlikely to operate solely through differential local disease burden.

The clearest heterogeneity appears by economic disadvantage. Table 3 shows that schools above the median free or reduced price lunch share experienced substantially larger declines in FAFSA submissions and first-year college enrollment. For FAFSA submissions, the 2020 coefficient is -5.0 percentage points for above-median schools versus -1.6 percentage points for below-median schools. For first-year college enrollment, the corresponding declines are 3.0 and 0.6 percentage points for above- and below-median schools, respectively. We find little heterogeneity in ACT test-taking.

These heterogeneity results imply that virtual instruction may have widened existing disparities in college access. Virtual learning during the pandemic could have increased inequality not only in current educational outcomes but also in long-run labor-market opportunities.

## Robustness

### Enrollment Numbers and Demographic Characteristics

Because our outcomes are normalized by enrollment, one concern is that the results could be driven mechanically by selective nonenrollment during the pandemic. If treated schools lost students in ways that changed the denominators of our outcome measures, then outcome rates could shift even if the underlying number of FAFSA submissions, ACT takers, or college entrants changed little.

To address this issue, we re-estimate Equation 1 using grade-12 enrollment, grade-11-and-12 enrollment, and total enrollment as dependent variables, and we also examine whether key school demographics change differentially across treatment groups. Table A.10 shows little evidence of large enrollment differences in 2020, although some differences emerge in 2021.

More importantly, the magnitudes are too small to explain the main results. A back-of-the-envelope calculation suggests that selective changes in grade-12 (or grade-11 and-12 for the ACT) enrollment can explain at most 3.5 percent of the FAFSA decline, 3.8 percent of the ACT decline, and 6.9 percent of the college-enrollment decline in 2020 and 17.1 percent of the FAFSA decline, 11.4 percent of the ACT decline, and 8.4 percent of the college-enrollment decline in 2021.[8] This exercise is intentionally conservative and suggests that denominator changes are not the main driver of the estimated declines.

[8]Using the pre-treatment means in Table A.1, FAFSA submissions per grade-12 enrollment equal $\frac{127.81}{192.24}$ = 66.48%. In the most extreme selection scenario, all students who did not enroll in 2021 relative to the pre-2021 period would have submitted a FAFSA had they remained enrolled. Under that assumption, the adjusted rate is $\frac{127.81-1.777}{192.24-1.777}$ = 66.17%, a decline of 0.00308 (see column 2 of Table A.10). Relative to the 2021 estimate of 0.018 in column (3) of Table 2, this accounts for $\frac{0.00308}{0.018}$ = 17.1% of the effect. Analogous calculations for the other outcomes imply even smaller shares.

We also re-estimate Equation 1 using a regression weighted by grade-11-and-12 enrollment. The results are presented in Table A.11. The results are qualitatively similar to our main specification, except that the 2021 rebound in FAFSA submissions is no longer evident.

**FAFSA — Different Time Frames of Submissions**

We also examine whether the FAFSA results depend on the portion of the application cycle used to construct the outcome. Table A.2 reports estimates when the dependent variable includes submissions only through January, March, or July rather than through September.

The 2020 coefficients are similar in magnitude across these windows. This stability indicates that the negative effect on FAFSA completion is not simply the result of temporary timing delays early in the cycle. Schools that were more virtual experienced lower submission rates throughout the application period.

At the same time, the rebound in 2021 appears only when the submission window extends through July. That pattern suggests that the recovery in FAFSA completion occurred relatively late in the cycle. One interpretation is that students in previously more-virtual schools eventually completed the FAFSA once schools reopened and in-person support returned, but they did so later than students in less-virtual schools. This interpretation is consistent with an information and salience mechanism: students may not have permanently abandoned aid applications, but the process appears to have been delayed when school-based support was weaker.

**ACT Test-Taking — Mandatory versus Nonmandatory States**

Our baseline ACT analysis excludes mandatory-testing states because changes in those states may reflect testing requirements rather than students' college-going decisions. Table A.3 shows that schools in mandatory-testing states exhibit much smaller declines in 2020, although they do show a similar decline in 2021.

Where the ACT is mandatory, schools and states may have devoted greater effort

to maintaining testing access, thereby muting the contemporaneous effect of virtual instruction. In nonmandatory states, by contrast, testing was more likely to depend on students' own initiative and on support from schools and families.

Overall, the robustness checks strengthen the main conclusions. The results are not driven by denominator changes, do not depend on one narrow FAFSA timing window, and are consistent with the idea that ACT participation is most informative where it is a meaningful college-going choice rather than a policy requirement.

# IV Discussion of Potential Mechanisms

Our empirical design is not intended to isolate mechanisms, but the results are consistent with two channels emphasized by French and Oreopoulos (2017): information and salience. When schools operate virtually, students may have fewer opportunities to receive practical guidance about financial-aid forms, admissions tests, and enrollment procedures. At the same time, college-going may become less salient when students interact less frequently with counselors, teachers, and peers who would ordinarily remind them about deadlines and next steps.

The transition from high school to college involves a series of complex tasks that are easy to delay or misunderstand, and schools ordinarily help students complete them through counseling appointments, announcements, and informal one-on-one conversations. This information and these interactions may not have occurred as often in a fully virtual setting.

The salience channel is distinct but complementary. Prior experimental work shows that reminders and nudges can materially affect college-going behavior because deadlines and forms are easy to overlook (Castleman and Long 2016; Castleman and Page 2015). In-person schooling naturally creates many such reminders. Virtual instruction reduces the frequency of these cues and may therefore lower follow-through even when students still intend to pursue college.

A third potential mechanism is that virtual instruction reduced academic engage-

ment or preparedness, thereby lowering college-going indirectly. Our estimates do not separate this channel from the more administrative channels, but the large declines in FAFSA completion suggest that administrative frictions played an important role.

The intervention evidence in the college-going literature is consistent with this interpretation. Personalized assistance, mentoring, and targeted reminders can increase college attendance in part by simplifying the process and keeping students engaged (Bettinger et al. 2012; Carrell and Sacerdote 2017; Castleman and Page 2015). Virtual instruction may have weakened the natural school-based version of these supports. Even when counselors remained available remotely, obtaining help likely became more costly than stopping by an office or receiving an in-person prompt. Students who were less organized, less informed, or less connected to school may therefore have been disproportionately affected.

This perspective also helps explain why the detrimental effects are larger in disadvantaged schools. Students in those settings may have fewer alternative sources of college-related information outside school and may depend more heavily on school personnel for navigating forms, deadlines, and financial-aid questions. When instruction becomes virtual, that compensating role weakens.

# V Conclusion

This paper studies how virtual instruction during the COVID-19 pandemic affected the transition from high school to college. Using national school-level data on learning mode, FAFSA submissions, ACT participation, and first-year college enrollment, we show that schools that spent more of the 2020 school year in virtual instruction experienced lower college-going. Moving from fully in-person to fully virtual instruction reduced FAFSA completion, ACT participation, and first-year college enrollment by economically meaningful amounts.

The timing of these effects is also informative. FAFSA completion partially rebounds after schools reopen, suggesting that some students were able to catch up on

aid applications when in-person support returned. In contrast, ACT participation and college entry do not show a similar rebound. That persistence suggests that temporary disruptions to the transition-to-college process can have longer-lasting consequences when students miss key windows for testing, application, or matriculation.

The detrimental effects of virtual instruction are substantially larger in schools serving more economically disadvantaged students. This pattern implies that the pandemic likely widened existing inequalities in access to college and financial aid. It also points to the importance of school-based counseling and support for students who may have fewer alternative resources outside school.

Taken together, the results highlight an important cost of school closures and extended virtual instruction that goes beyond contemporaneous learning loss. The move to remote schooling appears to have reduced not only what students learned, but also whether they successfully navigated the administrative and informational steps needed to enter college. Because college attendance can shape long-run economic and health outcomes, the consequences of these disruptions may extend well beyond the pandemic years themselves.

These findings suggest a practical lesson for future disruptions to in-person schooling. When schools shift away from in-person instruction, preserving the college-going infrastructure of advising, reminders, and individualized support may be as important as preserving academic coursework. Low-cost outreach targeted at key moments in the aid and application cycle may be especially valuable, and disadvantaged schools may need additional support to prevent temporary instructional disruptions from translating into persistent losses in postsecondary access.

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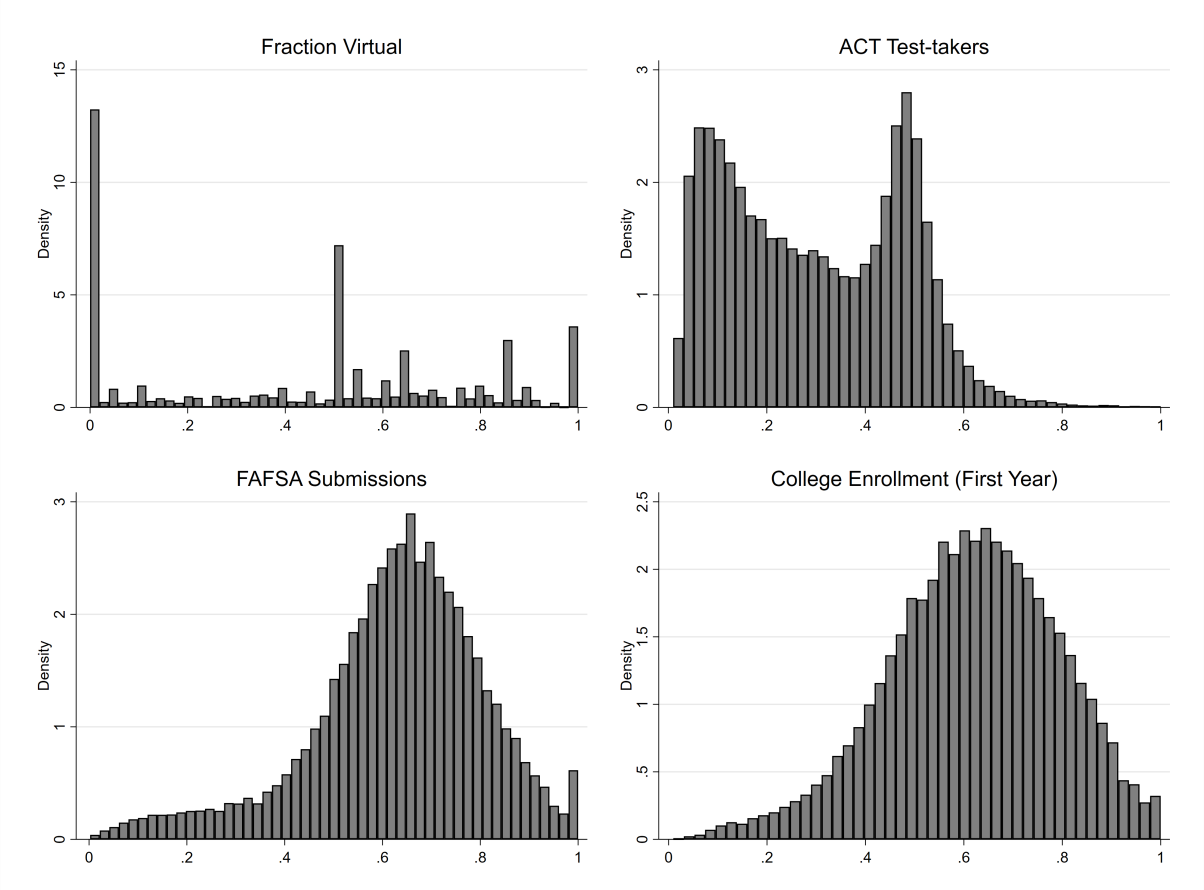
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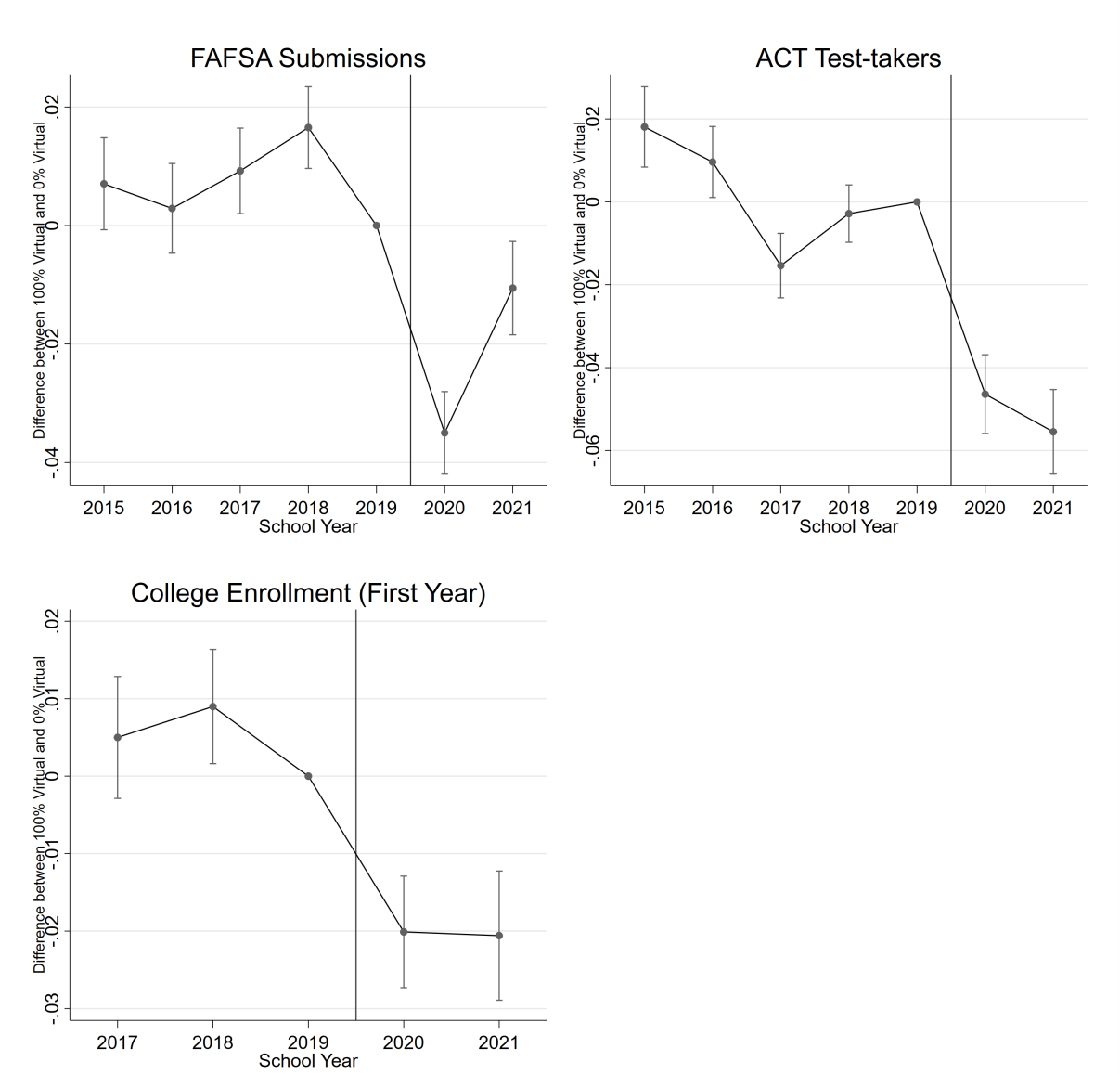
# Figures and Tables

**Figure 1:** Distribution of Treatment and Outcome Variables




*Notes.* These figures show the across-school distribution of the fraction of the period between August 2020 and July 2021 spent virtually, school-year FAFSA submissions per grade-12 enrollment, ACT test-takers per grade-11-and-12 enrollment, and first-year college enrollment per grade-12 enrollment. Hybrid instruction is classified as being half virtual and half in-person. First-year college enrollment includes enrollment in the summer before the first fall term.

**Figure 2:** Dynamic Effect of Virtual Instruction




*Notes.* These figures plot the coefficients of Equation 2 along with 95 percent confidence intervals. Each figure shows the mean differences in the outcome variables conditional on controls and school and year fixed effects between treatment and control groups at the school year level, with differences in the pre-treatment year (school year 2019) normalized to zero. The treatment variable is the fraction of the 2020 school year spent virtually, and can be interpreted as the difference between a school that is fully virtual and a school that is fully in person. The county-level controls included are unemployment rates, COVID case rates, and COVID death rates. The school-level controls included are percentage White, percentage Black, percentage male, percentage on free or reduced price lunch, and students per teacher as well as year and school fixed effects. Standard errors are clustered at the school level.

**Table 1:** School Summary Statistics by Instruction Mode

| | Minority Virtual | Majority Virtual | All | Schools |
|---|---|---|---|---|
| % Virtual in 2020/2021 School Year | 0.11 | 0.73 | 0.43 | 14005 |
| | (0.16) | (0.17) | (0.35) | |
| Total Enrollment | 713.51 | 992.96 | 856.63 | 13957 |
| | (727.56) | (816.83) | (787.06) | |
| Grade 11 and 12 Enrollment | 316.48 | 454.77 | 387.30 | 13935 |
| | (360.12) | (397.56) | (386.00) | |
| Grade 12 Enrollment | 154.71 | 224.48 | 190.45 | 13946 |
| | (176.07) | (196.79) | (190.19) | |
| FAFSA Submissions per Grade 12 Enrollment | 0.63 | 0.63 | 0.63 | 13502 |
| | (0.15) | (0.18) | (0.17) | |
| Number of ACT Test-takers per Grade 11 and 12 Enrollment | 0.34 | 0.31 | 0.33 | 10066 |
| | (0.16) | (0.18) | (0.17) | |
| College Enrollment (First Year) per Grade 12 Enrollment | 0.62 | 0.61 | 0.62 | 9338 |
| | (0.16) | (0.19) | (0.17) | |
| FAFSA Applications Submitted | 98.75 | 149.33 | 124.41 | 13553 |
| | (115.84) | (138.91) | (130.54) | |
| Number of ACT test-takers | 119.12 | 157.93 | 138.43 | 10152 |
| | (119.08) | (147.43) | (135.33) | |
| College Enrollment (First Year) | 116.95 | 168.49 | 145.44 | 9396 |
| | (137.48) | (151.90) | (147.86) | |
| % White | 0.67 | 0.42 | 0.54 | 13942 |
| | (0.29) | (0.33) | (0.34) | |
| % Male | 0.51 | 0.51 | 0.51 | 13947 |
| | (0.05) | (0.07) | (0.06) | |
| Students per Teacher | 14.35 | 17.21 | 15.77 | 13837 |
| | (4.38) | (5.01) | (4.90) | |
| % Black | 0.10 | 0.18 | 0.14 | 13926 |
| | (0.17) | (0.26) | (0.23) | |
| % Free or Reduced Price Lunch | 0.47 | 0.56 | 0.51 | 13893 |
| | (0.22) | (0.27) | (0.25) | |
| COVID Case rate per 1000 (Sep to May) | 31.64 | 30.84 | 31.23 | 13996 |
| | (52.71) | (53.11) | (52.92) | |
| COVID Death rate per 1000 (Sep to May) | 0.44 | 0.32 | 0.38 | 13996 |
| | (0.81) | (0.61) | (0.72) | |
| Unemployment Rate | 0.05 | 0.06 | 0.05 | 14005 |
| | (0.02) | (0.03) | (0.02) | |

*Notes.* This table shows the summary statistics of majority virtual schools, minority virtual schools, and all schools. Majority virtual schools are defined as schools that spent 50 percent or more of the August 2020 to July 2021 period under virtual instruction. Minority virtual schools are schools that spent less than 50 percent of the period under virtual instruction from August 2020 to July 2021. Hybrid instruction is classified as being half virtual and half in-person. The rightmost column shows the total number of schools that have non-missing values for the corresponding summary statistic.

**Table 2:** Effect of Virtual Instruction on the Transition to College

| VARIABLES | (1) FAFSA Submissions | (2) FAFSA Submissions | (3) FAFSA Submissions | (4) ACT Test-takers | (5) ACT Test-takers | (6) ACT Test-takers | (7) College Enrollment | (8) College Enrollment | (9) College Enrollment |
|---|---|---|---|---|---|---|---|---|---|
| % Virtual * School Year 2020 | -0.033*** | -0.043*** | -0.042*** | -0.068*** | -0.058*** | -0.048*** | -0.028*** | -0.026*** | -0.025*** |
| | [0.003] | [0.003] | [0.003] | [0.005] | [0.005] | [0.005] | [0.003] | [0.003] | [0.003] |
| % Virtual * School Year 2021 | -0.014*** | -0.018*** | -0.018*** | -0.080*** | -0.064*** | -0.058*** | -0.029*** | -0.026*** | -0.025*** |
| | [0.003] | [0.003] | [0.004] | [0.005] | [0.005] | [0.005] | [0.003] | [0.004] | [0.004] |
| Unemployment Rate | | 0.402*** | 0.384*** | | -0.575*** | -0.598*** | | -0.246*** | -0.244*** |
| | | [0.047] | [0.047] | | [0.063] | [0.068] | | [0.056] | [0.059] |
| COVID Case Rate per 1000 | | -0.000*** | -0.000*** | | -0.000** | -0.000*** | | -0.000*** | -0.000*** |
| | | [0.000] | [0.000] | | [0.000] | [0.000] | | [0.000] | [0.000] |
| COVID Death Rate per 1000 | | -0.006*** | -0.006*** | | 0.016*** | 0.017*** | | -0.001 | -0.000 |
| | | [0.001] | [0.001] | | [0.002] | [0.002] | | [0.001] | [0.001] |
| % White | | | 0.001 | | | 0.029 | | | 0.069** |
| | | | [0.022] | | | [0.032] | | | [0.029] |
| % Black | | | 0.043 | | | -0.064 | | | -0.023 |
| | | | [0.035] | | | [0.048] | | | [0.050] |
| % Male | | | -0.122*** | | | -0.056 | | | -0.172*** |
| | | | [0.023] | | | [0.037] | | | [0.032] |
| Students per Teacher | | | -0.000*** | | | 0.000*** | | | 0.000 |
| | | | [0.000] | | | [0.000] | | | [0.000] |
| % Free or Reduced Price Lunch | | | 0.013** | | | 0.013* | | | 0.020*** |
| | | | [0.005] | | | [0.007] | | | [0.006] |
| Observations | 85,497 | 85,497 | 85,497 | 39,871 | 39,871 | 39,871 | 39,928 | 39,928 | 39,928 |
| R-squared | 0.719 | 0.720 | 0.720 | 0.814 | 0.815 | 0.816 | 0.840 | 0.841 | 0.842 |
| Mean | 0.633 | 0.633 | 0.633 | 0.280 | 0.280 | 0.280 | 0.618 | 0.618 | 0.618 |
| Percentage Change 2020 | -0.0524 | -0.0672 | -0.0662 | -0.245 | -0.208 | -0.173 | -0.0447 | -0.0427 | -0.0399 |
| Percentage Change 2021 | -0.0227 | -0.0290 | -0.0277 | -0.287 | -0.229 | -0.206 | -0.0473 | -0.0425 | -0.0409 |
| Number of schools | 13101 | 13101 | 13101 | 7286 | 7286 | 7286 | 8776 | 8776 | 8776 |

*Notes.* This table shows the ordinary least squares estimates of Equation 1. The dependent variables are FAFSA submissions per grade-12 enrollment, number of ACT test-takers per grade-11-and-12 enrollment and first-year college enrollment per grade-12 enrollment. Hybrid instruction is classified as being half virtual and half in-person. First-year college enrollment is inclusive of entry before first fall enrollment. For all specifications, the treatment variable is the fraction of the 2020 school year that a school spent in virtual instruction. All specifications include school and year fixed effects. Specifications (1) to (6) use data spanning school years 2015 to 2021, whereas specifications (7) to (9) use data spanning school years 2017 to 2021. Specifications (1), (4) and (7) do not include any controls, specifications (2), (5) and (8) include county-level controls and specifications (3), (6) and (9) include both county-level and school-level controls. The county and school-level controls are subjected to dummy variable adjustment to account for schools that only have data on a subset of the controls. Standard errors are clustered at the school level and are presented in square brackets. *** p<0.01, ** p<0.05, * p<0.1

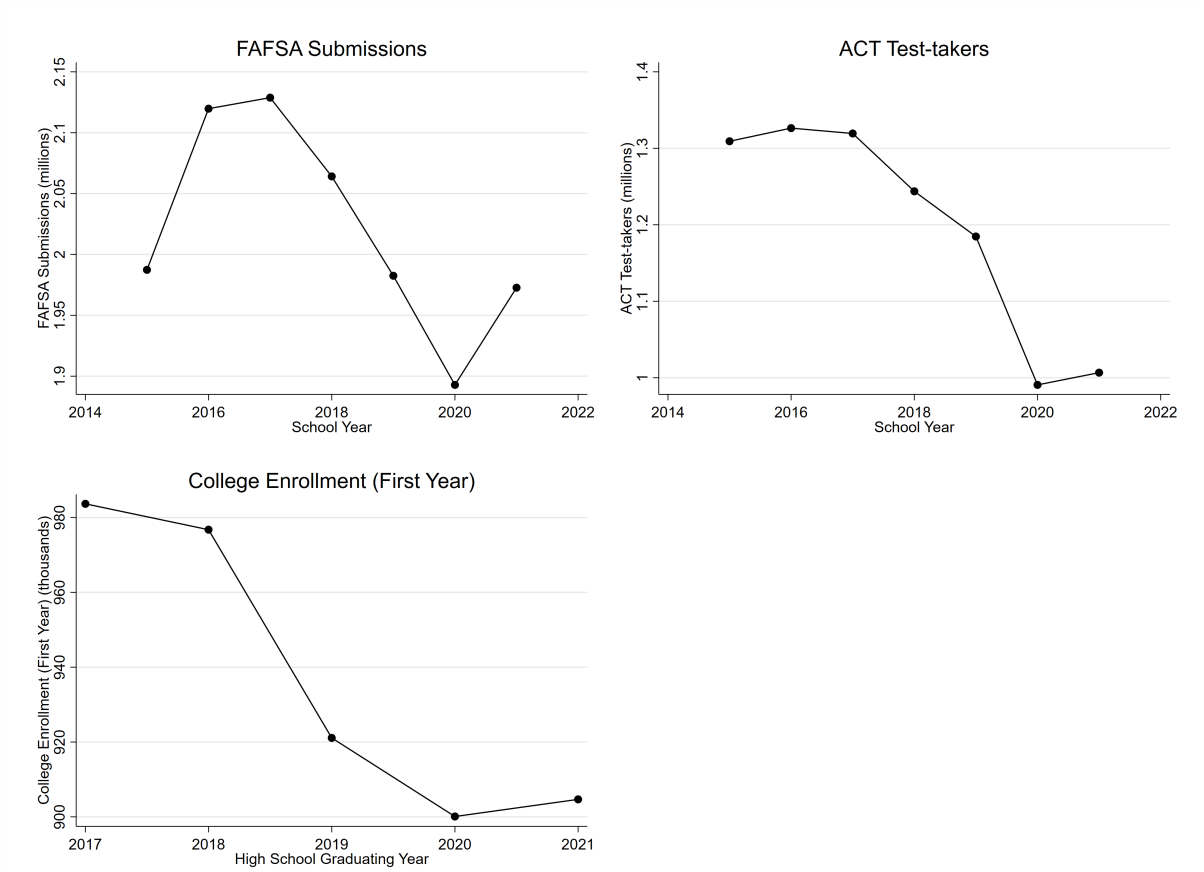
**Table 3:** Effect of Virtual Instruction by Free or Reduced Price Lunch Status

| VARIABLES | (1) FAFSA Submissions Above | (2) FAFSA Submissions Below | (3) ACT Test-takers Above | (4) ACT Test-takers Below | (5) College Enrollment Above | (6) College Enrollment Below |
|---|---|---|---|---|---|---|
| % Virtual * School Year 2020 | -0.050*** | -0.016*** | -0.052*** | -0.042*** | -0.030*** | -0.006 |
| | [0.005] | [0.004] | [0.009] | [0.006] | [0.005] | [0.005] |
| % Virtual * School Year 2021 | -0.036*** | -0.008 | -0.060*** | -0.051*** | -0.032*** | -0.016*** |
| | [0.006] | [0.005] | [0.009] | [0.007] | [0.006] | [0.005] |
| Unemployment Rate | 0.468*** | 0.430*** | -0.206** | -0.898*** | -0.211** | -0.102 |
| | [0.069] | [0.075] | [0.104] | [0.105] | [0.095] | [0.093] |
| COVID Case Rate per 1000 | -0.000*** | -0.000*** | -0.000* | -0.000* | -0.000* | -0.000* |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| COVID Death Rate per 1000 | -0.006*** | -0.004** | 0.007** | 0.019*** | 0.002 | -0.001 |
| | [0.002] | [0.002] | [0.003] | [0.003] | [0.003] | [0.002] |
| % White | 0.061* | -0.083*** | 0.024 | -0.061 | 0.084 | 0.044 |
| | [0.034] | [0.030] | [0.055] | [0.047] | [0.054] | [0.043] |
| % Black | 0.096** | -0.172*** | -0.045 | 0.038 | 0.042 | -0.294*** |
| | [0.046] | [0.059] | [0.064] | [0.090] | [0.067] | [0.097] |
| % Male | -0.112*** | -0.156*** | -0.062 | -0.011 | -0.151*** | -0.207*** |
| | [0.035] | [0.035] | [0.053] | [0.057] | [0.053] | [0.050] |
| Students per Teacher | -0.000* | -0.000 | -0.001 | 0.000*** | 0.000 | 0.000 |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| % Free or Reduced Price Lunch | 0.001 | 0.006 | 0.033*** | -0.028* | 0.009 | -0.003 |
| | [0.008] | [0.009] | [0.010] | [0.015] | [0.010] | [0.011] |
| Observations | 41,126 | 42,336 | 17,591 | 19,080 | 18,948 | 19,648 |
| R-squared | 0.731 | 0.697 | 0.833 | 0.812 | 0.827 | 0.822 |
| Mean | 0.624 | 0.646 | 0.282 | 0.274 | 0.560 | 0.675 |
| Number of schools | 6217 | 6218 | 3053 | 3054 | 4156 | 4156 |

*Notes.* This table shows the ordinary least squares estimates of Equation 1. The dependent variables are FAFSA submissions per grade-12 enrollment, number of ACT test-takers per grade-11-and-12 enrollment and first-year college enrollment per grade-12 enrollment. Hybrid instruction is classified as being half virtual and half in-person. First-year college enrollment is inclusive of entry before first fall enrollment. For all specifications, the treatment variable is the fraction of the 2020 school year that a school spent in virtual instruction. All specifications include school and year fixed effects. Specifications (1), (3) and (5) only use data from schools that are above the median share of students eligible for free-or-reduced price lunch, whereas specifications (2) to (4) and (6) only use data from schools that are below the median share of students eligible for free-or-reduced-price lunch. Specifications (1) to (4) use data spanning school years 2015 to 2021, whereas specifications (5) and (6) use data spanning school years 2017 to 2021. We apply a dummy-variable adjustment to the county- and school-level controls to account for schools that only have data on a subset of the controls. Standard errors are clustered at the school level and are presented in square brackets. *** p<0.01, ** p<0.05, * p<0.1

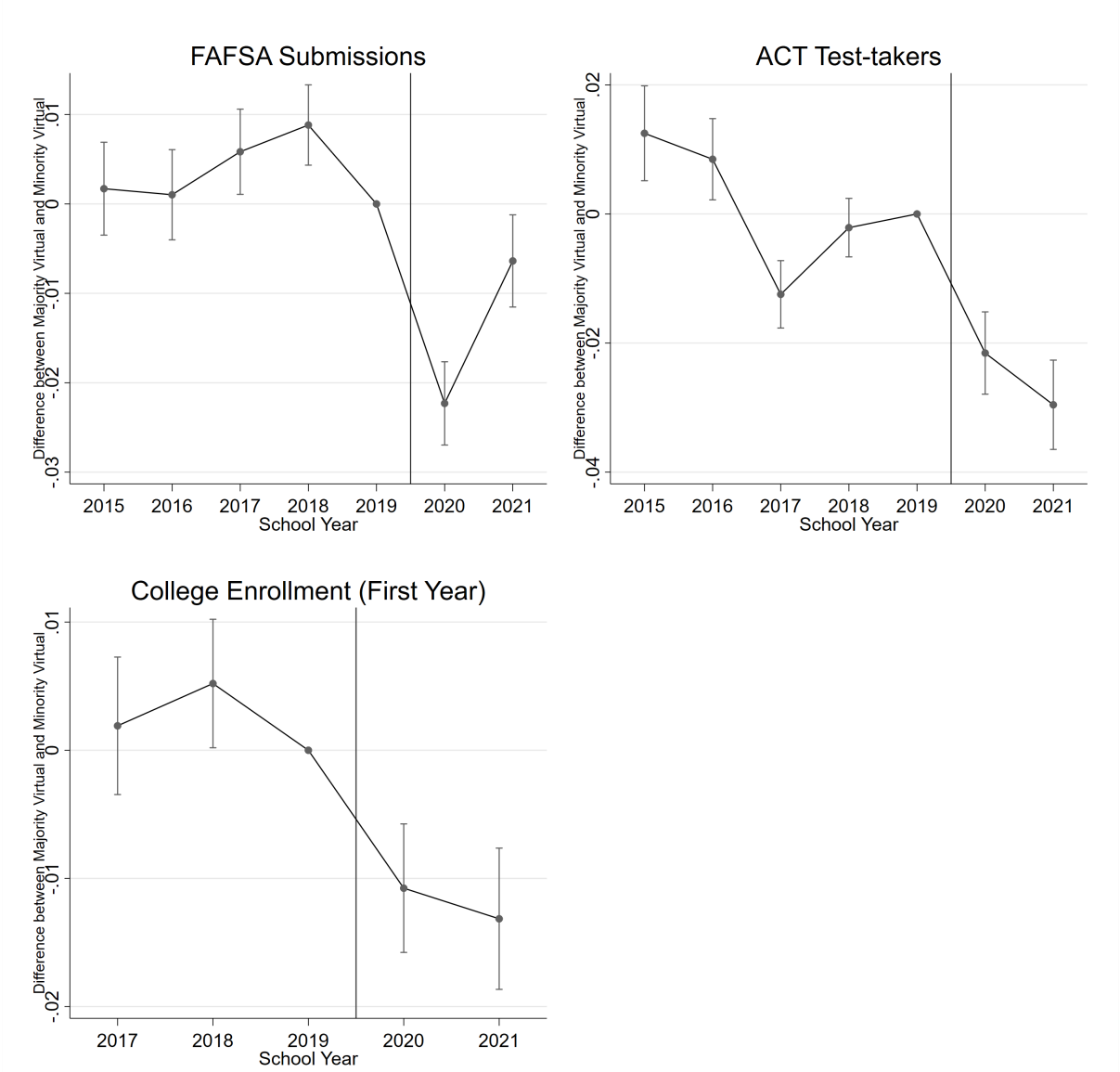
# A Additional Figures and Tables

**Figure A.1:** Trends in Outcome Variables



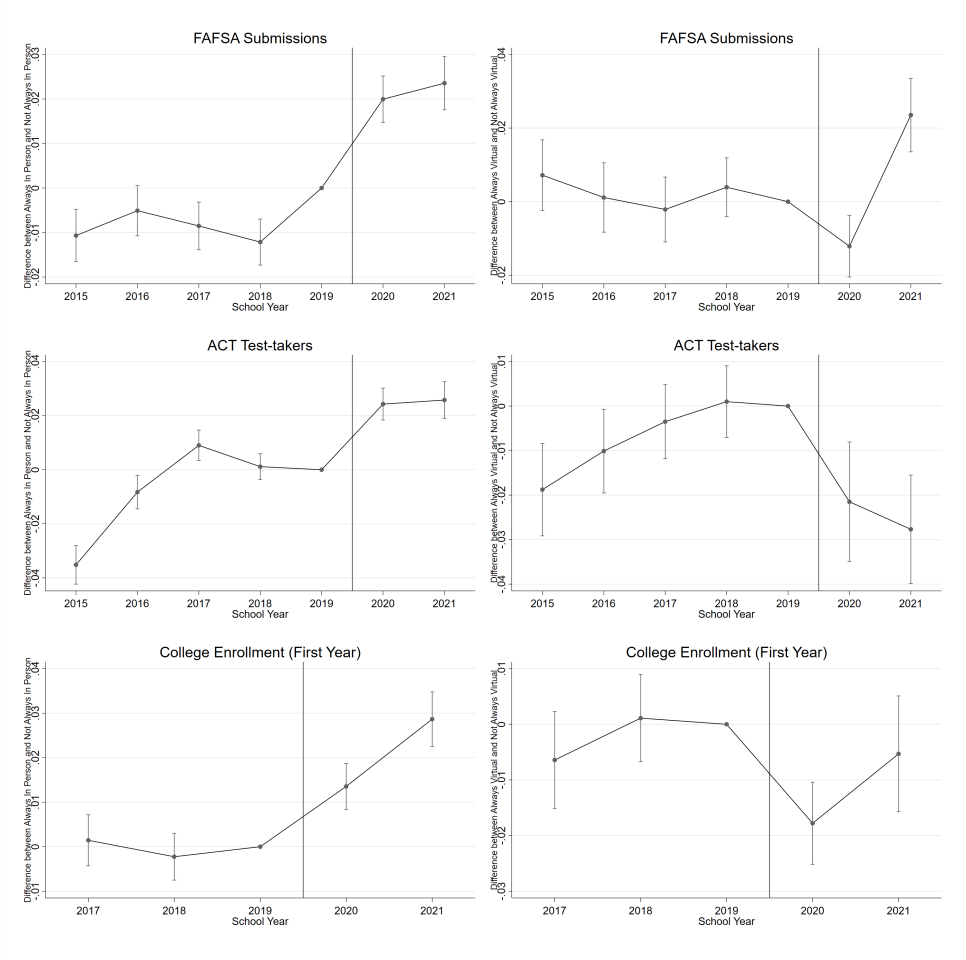

*Notes.* These figures show the total ACT test-takers, FAFSA submissions and first-year college enrollment by school year/high school graduating year. Each total is calculated only using schools that had non-missing values of the outcome variable across all years (balanced panel).

**Figure A.2:** Dynamic Effect of Virtual Instruction, Majority Virtual



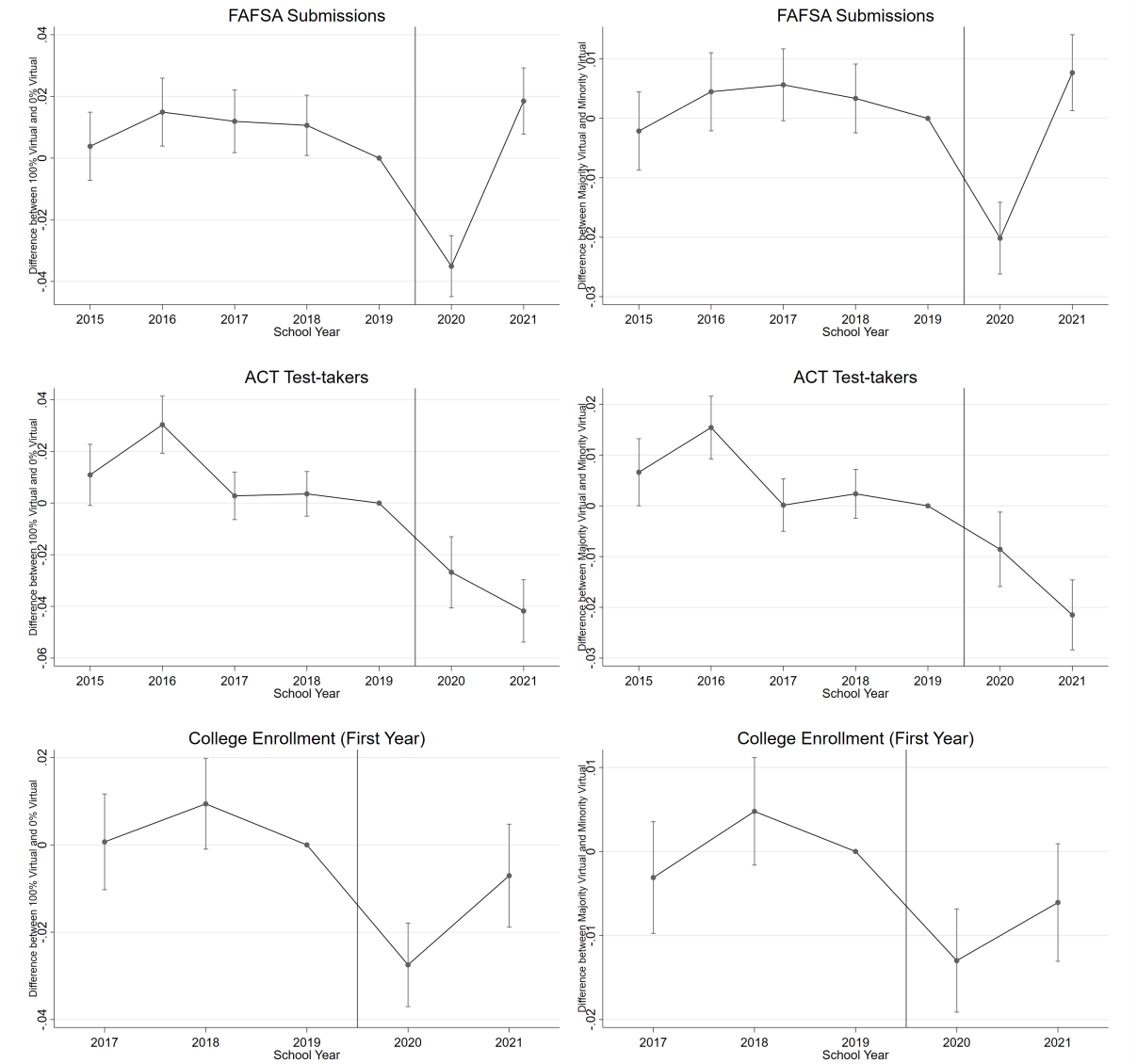

*Notes.* These figures plot the coefficients of Equation 2 along with 95 percent confidence intervals. Each figure shows the mean differences in the outcome variables conditional on controls and school year fixed effects between treatment and control groups at the school year level, with differences in the pre-treatment year (school year 2019) normalized to zero. The treatment variable is whether the fraction of the 2020 school year spent virtually is greater than or equal to 50 percent (Majority Virtual), and the coefficients can be interpreted as the difference between a majority-virtual and minority-virtual school. The county-level controls included are unemployment rates, COVID case rates, and COVID death rates. The school-level controls included are percentage White, percentage Black, percentage male, percentage on free-or-reduced-price lunch, and students per teacher as well as year and school fixed effects. Standard errors are clustered at the school level.

**Figure A.3:** Dynamic Effect of Virtual Instruction, Always In-Person, Always Virtual



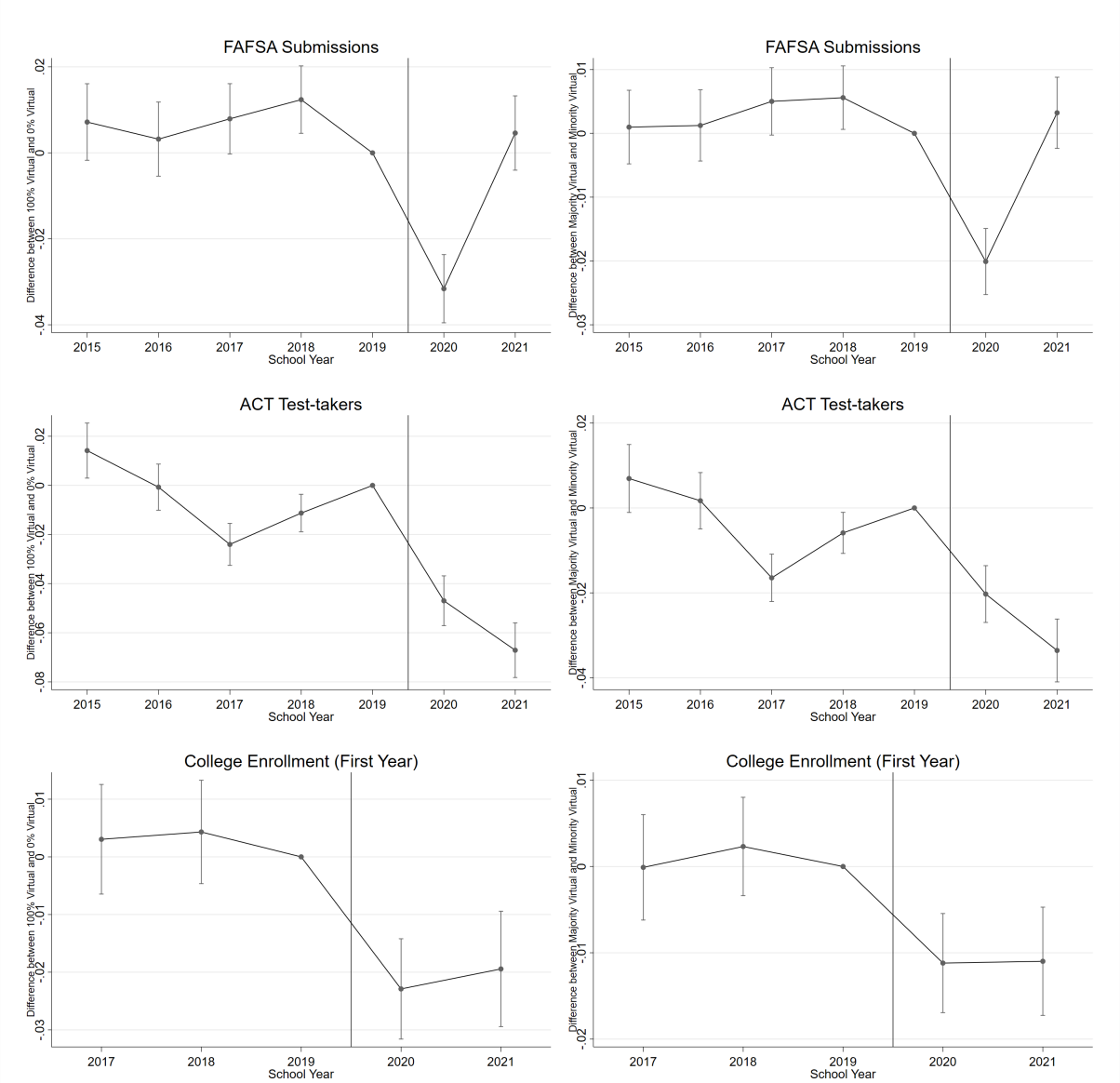

*Notes.* These figures plot the coefficients of Equation 2 along with 95 percent confidence intervals. Each figure shows the mean difference of different outcome variables conditional on controls and school year fixed effects between treatment and control groups at the school year level, with differences in the pre-treatment year (school year 2019) normalized to zero. The treatment variable for the figures in the left column is whether the school is always in-person in the 2020 school year, and the treatment variable for figures in the right column is whether a school is always virtual in the 2020 school year. The county-level controls included are unemployment rates, COVID case rates, and COVID death rates. The school-level controls included are percentage White, percentage Black, percentage male, percentage on free-or-reduced-price lunch, and students per teacher as well as year and school fixed effects. Standard errors are clustered at the school level.

**Figure A.4:** Dynamic Effect of Virtual Instruction Including State-by-School-Year Fixed Effects




*Notes.* These figures plot the coefficients of Equation 2 with state-by-school-year fixed effects included, along with 95 percent confidence intervals. Each figure shows the mean difference of different outcome variables conditional on controls and school year fixed effects between treatment and control groups at the school year level, with differences in the pre-treatment year (school year 2019) normalized to zero. The treatment variable for the figures in the left column is the fraction of the 2020 school year spent virtually, and the treatment variable for the figures in the right column is whether a school spent more than or equal to 50 percent of the 2020 school year under virtual instruction (majority virtual). The county-level controls included are unemployment rates, COVID case rates, and COVID death rates. The school-level controls included are percentage White, percentage Black, percentage male, percentage on free-or-reduced-price lunch, and students per teacher as well as year and school fixed effects. Standard errors are clustered at the school level.

**Figure A.5:** Dynamic Effect of Virtual Instruction Including County-by-School-Year Fixed Effects




*Notes.* These figures plot the coefficients of Equation 2 with county-by-school-year fixed effects included, along with 95 percent confidence intervals. Each figure shows the mean difference of different outcome variables conditional on controls and school year fixed effects between treatment and control groups at the school year level, with differences in the pre-treatment year (school year 2019) normalized to zero. The treatment variable for the figures in the left column is the fraction of the 2020 school year spent virtually, and the treatment variable for the figures in the right column is whether a school spent more than or equal to 50 percent of the 2020 school year under virtual instruction (majority virtual). The county-level controls included are unemployment rates, COVID case rates, and COVID death rates. The school-level controls included are percentage White, percentage Black, percentage male, percentage on free-or-reduced-price lunch, and students per teacher as well as year and school fixed effects. Standard errors are clustered at the school level.

**Table A.1:** School Summary Statistics by Instruction Type, Pre-2020

| | Minority Virtual | Majority Virtual | All | Schools |
|---|---|---|---|---|
| % Virtual in 2020/2021 School Year | 0.11 | 0.73 | 0.42 | 13653 |
| | (0.16) | (0.17) | (0.35) | |
| Total Enrollment | 715.24 | 1004.83 | 863.12 | 13585 |
| | (726.39) | (812.14) | (784.83) | |
| Grade 11 and 12 Enrollment | 318.23 | 461.09 | 391.20 | 13573 |
| | (359.92) | (396.67) | (385.80) | |
| Grade 12 Enrollment | 155.40 | 227.52 | 192.24 | 13574 |
| | (175.71) | (195.83) | (189.71) | |
| FAFSA Submissions per Grade 12 Enrollment | 0.64 | 0.65 | 0.65 | 12882 |
| | (0.15) | (0.17) | (0.16) | |
| Number of ACT Test-takers per Grade 11 and 12 Enrollment | 0.35 | 0.31 | 0.33 | 9946 |
| | (0.16) | (0.18) | (0.17) | |
| College Enrollment (First Year) per Grade 12 Enrollment | 0.63 | 0.63 | 0.63 | 9033 |
| | (0.16) | (0.18) | (0.17) | |
| FAFSA Applications Submitted | 100.48 | 154.63 | 127.81 | 12915 |
| | (115.95) | (139.61) | (131.26) | |
| Number of ACT Test-takers | 121.80 | 159.03 | 140.83 | 10039 |
| | (120.93) | (147.70) | (136.55) | |
| College Enrollment (First Year) | 119.06 | 172.99 | 149.15 | 9106 |
| | (139.17) | (154.52) | (150.33) | |
| % White | 0.68 | 0.42 | 0.55 | 13583 |
| | (0.29) | (0.33) | (0.34) | |
| % Male | 0.51 | 0.51 | 0.51 | 13583 |
| | (0.05) | (0.07) | (0.06) | |
| Students per Teacher | 14.37 | 17.29 | 15.81 | 13448 |
| | (4.29) | (4.88) | (4.80) | |
| % Black | 0.10 | 0.18 | 0.14 | 13575 |
| | (0.17) | (0.26) | (0.23) | |
| % Free or Reduced Price Lunch | 0.46 | 0.56 | 0.51 | 13556 |
| | (0.21) | (0.27) | (0.25) | |
| Unemployment Rate | 0.05 | 0.06 | 0.05 | 13653 |
| | (0.02) | (0.03) | (0.02) | |

*Notes.* This table shows the summary statistics of majority virtual, minority virtual, and all schools pre-2020. Majority virtual schools are defined as schools that spent more than or equal to 50 percent of the 2020 school year under virtual instruction. Minority virtual schools are schools that spent less than 50 percent of months under virtual instruction for the 2020 school year. Hybrid instruction is classified as being half virtual and half in-person. The rightmost column shows the total schools that have non-missing values for the corresponding summary statistic.

**Table A.2:** Effect of Virtual Instruction on FAFSA Submissions during Different Time Periods

| VARIABLES | (1) Oct to Jan | (2) Oct to Jan | (3) Oct to Jan | (4) Oct to Mar | (5) Oct to Mar | (6) Oct to Mar | (7) Oct to Jul | (8) Oct to Jul | (9) Oct to Jul |
|---|---|---|---|---|---|---|---|---|---|
| % Virtual * School Year 2020 | -0.034*** | -0.042*** | -0.046*** | -0.040*** | -0.050*** | -0.056*** | -0.034*** | -0.046*** | -0.053*** |
| | [0.008] | [0.008] | [0.009] | [0.011] | [0.011] | [0.013] | [0.013] | [0.013] | [0.015] |
| % Virtual * School Year 2021 | -0.071*** | -0.069*** | -0.070*** | -0.055*** | -0.054*** | -0.057** | -0.033 | -0.033 | -0.035 |
| | [0.019] | [0.018] | [0.020] | [0.021] | [0.020] | [0.022] | [0.023] | [0.022] | [0.024] |
| Unemployment Rate | | 0.235* | 0.376* | | 0.232 | 0.403* | | 0.375* | 0.526** |
| | | [0.120] | [0.206] | | [0.163] | [0.237] | | [0.192] | [0.260] |
| COVID Case Rate per 1000 (Sep to May) | | -0.000*** | -0.000*** | | -0.000*** | -0.000*** | | -0.001** | -0.001** |
| | | [0.000] | [0.000] | | [0.000] | [0.000] | | [0.000] | [0.000] |
| COVID Death Rate per 1000 (Sep to May) | | -0.002 | -0.003 | | -0.003 | -0.004 | | -0.003 | -0.005 |
| | | [0.002] | [0.002] | | [0.003] | [0.003] | | [0.003] | [0.004] |
| % White | | | 0.077 | | | 0.056 | | | 0.136 |
| | | | [0.060] | | | [0.075] | | | [0.130] |
| % Black | | | 0.727 | | | 0.799 | | | 0.868 |
| | | | [0.584] | | | [0.607] | | | [0.613] |
| % Male | | | 0.468 | | | 0.484 | | | 0.474 |
| | | | [0.695] | | | [0.718] | | | [0.722] |
| Students per Teacher | | | -0.000 | | | -0.000 | | | -0.000*** |
| | | | [0.000] | | | [0.000] | | | [0.000] |
| % Free or Reduced Price Lunch | | | -0.039 | | | -0.059 | | | -0.038 |
| | | | [0.036] | | | [0.039] | | | [0.044] |
| Observations | 84,711 | 84,711 | 84,711 | 85,122 | 85,122 | 85,122 | 85,793 | 85,793 | 85,793 |
| R-squared | 0.456 | 0.457 | 0.458 | 0.436 | 0.437 | 0.437 | 0.403 | 0.403 | 0.404 |
| Mean | 0.371 | 0.371 | 0.371 | 0.498 | 0.498 | 0.498 | 0.612 | 0.612 | 0.612 |
| Number of schools | 13281 | 13281 | 13281 | 13350 | 13350 | 13350 | 13482 | 13482 | 13482 |

*Notes.* This table shows the ordinary least squares estimates of equation 1. The dependent variables are FAFSA submissions per grade-12 enrollment for different FAFSA submission time periods (October to January, October to March, and October to July). Hybrid instruction is classified as being half virtual and half in-person. For all specifications, the treatment variable is the fraction of the 2020 school year that a school spent in virtual instruction. All specifications include school and year fixed effects. All specifications use data spanning school years 2015 to 2021. Specifications (1), (4) and (7) do not include any controls, specifications (2), (5) and (8) include county-level controls and specifications (3), (6) and (9) include both county-level and school-level controls. The county and school-level controls are subjected to dummy variable adjustment to account for schools that only have data on a subset of the controls. Standard errors are clustered at the school level and are presented in square brackets. *** p<0.01, ** p<0.05, * p<0.1

**Table A.3:** Effect of Virtual Instruction on ACT test-takers by Mandatory Status

| VARIABLES | (1) Non-mandatory | (2) Non-mandatory | (3) Non-mandatory | (4) Mandatory | (5) Mandatory | (6) Mandatory |
|---|---|---|---|---|---|---|
| % Virtual * School Year 2020 | -0.068*** | -0.058*** | -0.048*** | -0.011* | -0.011* | -0.010* |
| | [0.005] | [0.005] | [0.005] | [0.006] | [0.006] | [0.006] |
| % Virtual * School Year 2021 | -0.080*** | -0.064*** | -0.058*** | -0.064*** | -0.061*** | -0.061*** |
| | [0.005] | [0.006] | [0.006] | [0.006] | [0.006] | [0.006] |
| Unemployment Rate | | -0.575*** | -0.598*** | | -0.041 | -0.055 |
| | | [0.070] | [0.076] | | [0.083] | [0.082] |
| COVID Case Rate per 1000 | | -0.000** | -0.000** | | -0.000** | -0.000* |
| | | [0.000] | [0.000] | | [0.000] | [0.000] |
| COVID Death Rate per 1000 | | 0.016*** | 0.017*** | | 0.005** | 0.004** |
| | | [0.002] | [0.002] | | [0.002] | [0.002] |
| % White | | | 0.029 | | | 0.040 |
| | | | [0.036] | | | [0.039] |
| % Black | | | -0.064 | | | 0.028 |
| | | | [0.054] | | | [0.060] |
| % Male | | | -0.056 | | | -0.021 |
| | | | [0.041] | | | [0.035] |
| Students per Teacher | | | 0.000*** | | | -0.000 |
| | | | [0.000] | | | [0.000] |
| % Free or Reduced Price Lunch | | | 0.013* | | | 0.012 |
| | | | [0.008] | | | [0.007] |
| Observations | 40,760 | 40,760 | 40,760 | 12,236 | 12,236 | 12,236 |
| R-squared | 0.820 | 0.821 | 0.822 | 0.419 | 0.419 | 0.420 |
| Mean | 0.281 | 0.281 | 0.281 | 0.481 | 0.481 | 0.481 |
| Number of schools | 8175 | 8175 | 8175 | 1891 | 1891 | 1891 |

*Notes.* This table shows the ordinary least squares estimates of equation 1. The dependent variables are the number of ACT test-takers per grade-11-and-12 enrollment for mandatory and non-mandatory states. Hybrid instruction is classified as being half virtual and half in-person.For all specifications, the treatment variable is the fraction of the 2020 school year that a school spent in virtual instruction. All Specifications use data spanning school years 2015 to 2021 and include both county-level and school-level controls. Specifications (1) and (4) do not include any controls, specifications (2) and (5) include county-level controls and specifications (3) and (6) include both county-level and school-level controls. The county and school-level controls are subjected to dummy variable adjustment to account for schools that only have data on a subset of the controls. Standard errors are clustered at the school level and are presented in square brackets. *** p<0.01, ** p<0.05, * p<0.1

**Table A.4:** Effect of Virtual Instruction Including State-by-School-Year Fixed Effects

| VARIABLES | (1) FAFSA Submissions | (2) FAFSA Submissions | (3) FAFSA Submissions | (4) ACT Test-takers | (5) ACT Test-takers | (6) ACT Test-takers | (7) College Enrollment | (8) College Enrollment | (9) College Enrollment |
|---|---|---|---|---|---|---|---|---|---|
| % Virtual * School Year 2020 | -0.038*** | -0.044*** | -0.043*** | -0.037*** | -0.035*** | -0.036*** | -0.032*** | -0.032*** | -0.031*** |
| | [0.004] | [0.004] | [0.004] | [0.006] | [0.006] | [0.006] | [0.004] | [0.004] | [0.004] |
| % Virtual * School Year 2021 | 0.016*** | 0.010** | 0.011** | -0.055*** | -0.051*** | -0.051*** | -0.010** | -0.011** | -0.010** |
| | [0.005] | [0.005] | [0.005] | [0.005] | [0.006] | [0.006] | [0.005] | [0.005] | [0.005] |
| Unemployment Rate | | 0.194*** | 0.200*** | | -0.005 | -0.004 | | 0.043 | 0.049 |
| | | [0.064] | [0.064] | | [0.074] | [0.074] | | [0.084] | [0.084] |
| COVID Case Rate per 1000 | | -0.000 | -0.000 | | -0.000 | -0.000 | | 0.000 | 0.000 |
| | | [0.000] | [0.000] | | [0.000] | [0.000] | | [0.000] | [0.000] |
| COVID Death Rate per 1000 | | -0.007*** | -0.007*** | | 0.008*** | 0.008*** | | -0.003* | -0.003* |
| | | [0.001] | [0.001] | | [0.002] | [0.002] | | [0.002] | [0.002] |
| % White | | | 0.019 | | | 0.011 | | | 0.086*** |
| | | | [0.021] | | | [0.029] | | | [0.029] |
| % Black | | | 0.068** | | | -0.072* | | | 0.014 |
| | | | [0.035] | | | [0.039] | | | [0.050] |
| % Male | | | -0.132*** | | | -0.040 | | | -0.172*** |
| | | | [0.023] | | | [0.032] | | | [0.032] |
| Students per Teacher | | | -0.000** | | | 0.000* | | | 0.000** |
| | | | [0.000] | | | [0.000] | | | [0.000] |
| % Free or Reduced Price Lunch | | | 0.019*** | | | 0.004 | | | 0.018*** |
| | | | [0.006] | | | [0.007] | | | [0.006] |
| Observations | 85,494 | 85,494 | 85,494 | 39,866 | 39,866 | 39,866 | 39,926 | 39,926 | 39,926 |
| R-squared | 0.737 | 0.738 | 0.738 | 0.885 | 0.885 | 0.885 | 0.849 | 0.849 | 0.849 |
| Mean | 0.633 | 0.633 | 0.633 | 0.280 | 0.280 | 0.280 | 0.618 | 0.618 | 0.618 |
| Percentage Change 2020 | -0.0607 | -0.0688 | -0.0675 | -0.132 | -0.127 | -0.128 | -0.0515 | -0.0511 | -0.0497 |
| Percentage Change 2021 | 0.0259 | 0.0155 | 0.0169 | -0.198 | -0.181 | -0.182 | -0.0168 | -0.0172 | -0.0167 |
| Number of schools | 13101 | 13101 | 13101 | 7286 | 7286 | 7286 | 8776 | 8776 | 8776 |

*Notes.* This table shows the ordinary least squares estimates of equation 1 but with state-by-school-year fixed effects included. The dependent variables are FAFSA submissions per grade-12 enrollment, number of ACT test-takers per grade-11-and-12 enrollment and first-year college enrollment per grade-12 enrollment. Hybrid instruction is classified as being half virtual and half in-person. First-year college enrollment is inclusive of entry before first fall enrollment. For all specifications, the treatment variable is the fraction of the 2020 school year that a school spent in virtual instruction. Specifications (1) to (6) use data spanning school years 2015 to 2021, whereas specifications (7) to (9) use data spanning school years 2017 to 2021. Specification (1), (4) and (7) do not include any controls, specifications (2), (5) and (8) includes county-level controls and specifications (3), (6) and (9) include both county-level and school-level controls. The county and school-level controls are subjected to dummy variable adjustment to account for schools that only have data on a subset of the controls. Standard errors are clustered at the school level and are presented in square brackets. *** p<0.01, ** p<0.05, * p<0.1

**Table A.5:** Effect of Virtual Instruction Including County-by-School-Year FE

| VARIABLES | (1) FAFSA Submissions | (2) FAFSA Submissions | (3) FAFSA Submissions | (4) ACT Test-takers | (5) ACT Test-takers | (6) ACT Test-takers | (7) College Enrollment | (8) College Enrollment | (9) College Enrollment |
|---|---|---|---|---|---|---|---|---|---|
| % Virtual * School Year 2020 | -0.031*** | -0.038*** | -0.038*** | -0.061*** | -0.051*** | -0.043*** | -0.027*** | -0.026*** | -0.025*** |
| | [0.003] | [0.003] | [0.003] | [0.005] | [0.005] | [0.005] | [0.004] | [0.004] | [0.004] |
| % Virtual * School Year 2021 | 0.001 | -0.002 | -0.001 | -0.085*** | -0.070*** | -0.063*** | -0.025*** | -0.023*** | -0.022*** |
| | [0.004] | [0.004] | [0.004] | [0.005] | [0.006] | [0.006] | [0.004] | [0.004] | [0.004] |
| Unemployment Rate | | 0.184*** | 0.160*** | | -0.742*** | -0.767*** | | -0.342*** | -0.343*** |
| | | [0.054] | [0.055] | | [0.078] | [0.081] | | [0.071] | [0.073] |
| COVID Case Rate per 1000 | | -0.000*** | -0.000*** | | -0.000* | -0.000* | | -0.000* | -0.000* |
| | | [0.000] | [0.000] | | [0.000] | [0.000] | | [0.000] | [0.000] |
| COVID Death Rate per 1000 | | -0.006*** | -0.006*** | | 0.013*** | 0.014*** | | -0.004** | -0.003* |
| | | [0.001] | [0.001] | | [0.002] | [0.002] | | [0.002] | [0.002] |
| % White | | | 0.001 | | | 0.038 | | | 0.074** |
| | | | [0.022] | | | [0.032] | | | [0.029] |
| % Black | | | 0.029 | | | -0.069 | | | -0.014 |
| | | | [0.035] | | | [0.045] | | | [0.051] |
| % Male | | | -0.118*** | | | -0.068* | | | -0.170*** |
| | | | [0.023] | | | [0.037] | | | [0.032] |
| Students per Teacher | | | -0.000*** | | | 0.000 | | | 0.000* |
| | | | [0.000] | | | [0.000] | | | [0.000] |
| % Free or Reduced Price Lunch | | | 0.005 | | | 0.015** | | | 0.010 |
| | | | [0.005] | | | [0.007] | | | [0.006] |
| Observations | 85,315 | 85,315 | 85,315 | 39,518 | 39,518 | 39,518 | 39,696 | 39,696 | 39,696 |
| R-squared | 0.734 | 0.735 | 0.735 | 0.841 | 0.842 | 0.843 | 0.850 | 0.851 | 0.851 |
| Mean | 0.633 | 0.633 | 0.633 | 0.280 | 0.280 | 0.280 | 0.618 | 0.618 | 0.618 |
| Percentage Change 2020 | -0.0492 | -0.0602 | -0.0593 | -0.218 | -0.182 | -0.154 | -0.0440 | -0.0426 | -0.0410 |
| Percentage Change 2021 | 0.00107 | -0.00341 | -0.00221 | -0.302 | -0.251 | -0.225 | -0.0404 | -0.0375 | -0.0354 |
| Number of schools | 13078 | 13078 | 13078 | 7229 | 7229 | 7229 | 8732 | 8732 | 8732 |

*Notes.* This table shows the ordinary least squares estimates of equation 1 but with county-by-school-year fixed effects included. The dependent variables are FAFSA submissions per grade-12 enrollment, number of ACT test-takers per grade-11-and-12 enrollment and first-year college enrollment per grade-12 enrollment. Hybrid instruction is classified as being half virtual and half in-person. First-year college enrollment is inclusive of entry before first fall enrollment. For all specifications, the treatment variable is the fraction of the 2020 school year that a school spent in virtual instruction. Specifications (1) to (6) use data spanning school years 2015 to 2021, whereas specifications (7) to (9) use data spanning school years 2017 to2021. Specification (1), (4) and (7) do not include any controls, specifications (2), (5) and (8) includes county-level controls and specifications (3), (6) and (9) include both county-level and school-level controls. The county and school-level controls are subjected to dummy variable adjustment to account for schools that only have data on a subset of the controls. Standard errors are clustered at the school level and are presented in square brackets. *** p<0.01, ** p<0.05, * p<0.1

## **Table A.6:** Effect of Virtual Instruction, Discrete Treatments

| VARIABLES | (1) FAFSA Submissions | (2) FAFSA Submissions | (3) FAFSA Submissions | (4) ACT Test-takers | (5) ACT Test-takers | (6) ACT Test-takers | (7) College Enrollment | (8) College Enrollment | (9) College Enrollment |
|---|---|---|---|---|---|---|---|---|---|
| Majority Virtual * School Year 2020 | -0.026*** | | | -0.023*** | | | -0.013*** | | |
| | [0.002] | | | [0.004] | | | [0.002] | | |
| Majority Virtual * School Year 2021 | -0.010*** | | | -0.031*** | | | -0.016*** | | |
| | [0.003] | | | [0.004] | | | [0.003] | | |
| Always In Person * School Year 2020 | | 0.027*** | | | 0.031*** | | | 0.021*** | |
| | | [0.002] | | | [0.003] | | | [0.003] | |
| Always In Person * School Year 2021 | | 0.031*** | | | 0.032*** | | | 0.031*** | |
| | | [0.003] | | | [0.004] | | | [0.003] | |
| Always Virtual * School Year 2020 | | | -0.014*** | | | -0.015** | | | -0.016*** |
| | | | [0.004] | | | [0.007] | | | [0.004] |
| Always Virtual * School Year 2021 | | | 0.022*** | | | -0.022*** | | | -0.004 |
| | | | [0.005] | | | [0.007] | | | [0.005] |
| Unemployment Rate | 0.347*** | 0.308*** | 0.269*** | -0.643*** | -0.698*** | -0.677*** | -0.281*** | -0.320*** | -0.310*** |
| | [0.051] | [0.051] | [0.051] | [0.076] | [0.076] | [0.077] | [0.066] | [0.066] | [0.066] |
| COVID Case Rate per 1000 | -0.000*** | -0.000*** | -0.000*** | -0.000*** | -0.000* | -0.000*** | -0.000*** | -0.000 | -0.000*** |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| COVID Death Rate per 1000 | -0.006*** | -0.007*** | -0.003** | 0.020*** | 0.019*** | 0.024*** | 0.000 | -0.002 | 0.003 |
| | [0.001] | [0.001] | [0.001] | [0.002] | [0.002] | [0.002] | [0.002] | [0.002] | [0.002] |
| % White | -0.001 | 0.001 | 0.003 | 0.024 | 0.029 | 0.031 | 0.064* | 0.069** | 0.070** |
| | [0.023] | [0.024] | [0.024] | [0.036] | [0.036] | [0.036] | [0.033] | [0.033] | [0.033] |
| % Black | 0.045 | 0.045 | 0.054 | -0.059 | -0.059 | -0.057 | -0.021 | -0.016 | -0.013 |
| | [0.039] | [0.039] | [0.039] | [0.054] | [0.054] | [0.054] | [0.057] | [0.057] | [0.057] |
| % Male | -0.122*** | -0.123*** | -0.123*** | -0.056 | -0.057 | -0.055 | -0.172*** | -0.174*** | -0.173*** |
| | [0.025] | [0.025] | [0.025] | [0.041] | [0.041] | [0.041] | [0.037] | [0.037] | [0.037] |
| Students per Teacher | -0.000*** | -0.000*** | -0.000*** | 0.000*** | 0.000*** | 0.000*** | 0.000 | 0.000 | 0.000 |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| % Free or Reduced Price Lunch | 0.014** | 0.013** | 0.017*** | 0.017** | 0.016** | 0.022*** | 0.022*** | 0.020*** | 0.025*** |
| | [0.006] | [0.006] | [0.006] | [0.008] | [0.008] | [0.008] | [0.007] | [0.007] | [0.007] |
| Observations | 85,898 | 85,898 | 85,898 | 40,760 | 40,760 | 40,760 | 40,490 | 40,490 | 40,490 |
| R-squared | 0.723 | 0.724 | 0.723 | 0.821 | 0.821 | 0.820 | 0.846 | 0.846 | 0.846 |
| Mean | 0.633 | 0.633 | 0.633 | 0.281 | 0.281 | 0.281 | 0.617 | 0.617 | 0.617 |
| Number of schools | 13502 | 13502 | 13502 | 8175 | 8175 | 8175 | 9338 | 9338 | 9338 |
| Treatment | 6947 | 3964 | 1069 | 3891 | 2579 | 708 | 5163 | 2458 | 868 |
| Control | 6555 | 9538 | 12433 | 4284 | 5596 | 7467 | 4175 | 6880 | 8470 |

*Notes.* This table shows the ordinary least squares estimates of equation 1.The dependent variables are FAFSA submissions per grade-12 enrollment, number of ACT test-takers per grade-11-and-12 enrollment and first-year college enrollment per grade-12 enrollment. Hybrid instruction is classified as being half virtual and half in-person. First-year college enrollment is inclusive of entry before first fall enrollment. Specifications (1) to (6) use data spanning school years 2015 to 2021, whereas specifications (7) to (9) use data spanning school years 2017 to 2021. For specifications (1), (4) and (7), the treatment group is all schools that were majority virtual (more than equal to 50 percent of 2020 August to 2021 July under virtual instruction) virtual) and the control group are schools that were minority virtual (less than 50 percent of 2020 August to 2021 July under virtual instruction). For specifications (2),(5) and (8), the treatment group is all schools that were fully in-person from the time period of 2020 August to 2021 July and the control group is the schools that were not fully in-person (i.e. either hybrid or virtual) in at least one month during the same time period. For specifications (3), (6) and (9), the treatment group is all schools that were fully virtual from the time period of 2020 August to 2021 July and the control group is the schools that were not fully virtual (i.e. either hybrid or in-person) in at least one month during the same time period.The county and school-level controls included are subjected to dummy variable adjustment to account for schools that only have data on a subset of the controls. Standard errors are clustered at the school level and are presented in square brackets. *** p<0.01, ** p<0.05, * p<0.1

**Table A.7:** Effect of Virtual Instruction by Above and Below Median COVID

| VARIABLES | (1) FAFSA Submissions Above | (2) FAFSA Submissions Below | (3) ACT Test-takers Above | (4) ACT Test-takers Below | (5) College Enrollment Above | (6) College Enrollment Below |
|---|---|---|---|---|---|---|
| % Virtual * School Year 2020 | -0.046*** | -0.038*** | -0.056*** | -0.044*** | -0.038*** | -0.014*** |
| | [0.005] | [0.004] | [0.009] | [0.006] | [0.005] | [0.005] |
| % Virtual * School Year 2021 | -0.005 | -0.036*** | -0.038*** | -0.071*** | -0.026*** | -0.029*** |
| | [0.006] | [0.005] | [0.009] | [0.008] | [0.006] | [0.006] |
| Unemployment Rate | 0.432*** | 0.425*** | -0.335*** | -0.712*** | -0.175* | -0.362*** |
| | [0.078] | [0.084] | [0.128] | [0.138] | [0.094] | [0.101] |
| COVID Case Rate per 1000 | -0.000*** | -0.000*** | -0.000 | -0.000*** | -0.000 | -0.000*** |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| COVID Death Rate per 1000 | -0.004** | -0.014*** | 0.016*** | 0.018*** | -0.004* | 0.003 |
| | [0.002] | [0.002] | [0.003] | [0.003] | [0.002] | [0.003] |
| % White | 0.040 | -0.030 | 0.034 | 0.114* | 0.080 | 0.083* |
| | [0.034] | [0.033] | [0.063] | [0.058] | [0.052] | [0.043] |
| % Black | -0.009 | 0.079 | 0.121 | -0.093 | 0.006 | 0.011 |
| | [0.057] | [0.057] | [0.093] | [0.083] | [0.085] | [0.078] |
| % Male | -0.097*** | -0.183*** | -0.022 | -0.019 | -0.184*** | -0.195*** |
| | [0.035] | [0.038] | [0.055] | [0.071] | [0.053] | [0.052] |
| Students per Teacher | 0.000** | -0.000*** | -0.001*** | 0.000*** | 0.000*** | 0.000* |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| % Free or Reduced Price Lunch | -0.006 | 0.024*** | 0.024** | 0.008 | 0.004 | 0.032*** |
| | [0.008] | [0.008] | [0.011] | [0.011] | [0.010] | [0.009] |
| Observations | 40,874 | 40,898 | 13,486 | 13,653 | 19,031 | 18,722 |
| R-squared | 0.708 | 0.723 | 0.793 | 0.815 | 0.830 | 0.857 |
| Mean | 0.630 | 0.631 | 0.331 | 0.299 | 0.623 | 0.619 |
| Number of schools | 6222 | 6223 | 2027 | 2045 | 4050 | 4070 |

*Notes.* This table shows the ordinary least squares estimates of equation 1. The dependent variables are FAFSA submissions per grade-12 enrollment, number of ACT test-takers per grade-11-and-12 enrollment and first-year college enrollment per grade-12 enrollment. Hybrid instruction is classified as being half virtual and half in-person. First-year college enrollment is inclusive of entry before first fall enrollment. For all specifications, the treatment variable is the fraction of the 2020 school year that a school spent in virtual instruction. Specifications (1), (3) and (5) only uses data from schools that are in counties above the median COVID case rate per 1,000 people, whereas specifications (2), (4) and (6) only uses data from schools that are below the median COVID case Rate per 1,000 people. Specifications (1) to (4) use data spanning school years 2015 to 2021, whereas specifications (5) and (6) uses data spanning school years 2017 to 2021. The county and school-level controls included are subjected to dummy variable adjustment to account for schools that only have data on a subset of the controls. Standard errors are clustered at the school level and are presented in square brackets. *** p<0.01, ** p<0.05, * p<0.1

**Table A.8:** Effect of Virtual Instruction by Above and Below Median COVID Death Rate

| VARIABLES | (1) FAFSA Submissions Above | (2) FAFSA Submissions Below | (3) ACT Test-takers Above | (4) ACT Test-takers Below | (5) College Enrollment Above | (6) College Enrollment Below |
|---|---|---|---|---|---|---|
| % Virtual * School Year 2020 | -0.045*** | -0.037*** | -0.050*** | -0.052*** | -0.026*** | -0.023*** |
| | [0.005] | [0.004] | [0.008] | [0.007] | [0.005] | [0.005] |
| % Virtual * School Year 2021 | -0.007 | -0.034*** | -0.034*** | -0.092*** | -0.023*** | -0.033*** |
| | [0.005] | [0.005] | [0.009] | [0.008] | [0.006] | [0.006] |
| Unemployment Rate | 0.535*** | 0.319*** | -0.143 | -0.600*** | -0.242** | -0.336*** |
| | [0.077] | [0.085] | [0.130] | [0.131] | [0.095] | [0.104] |
| COVID Case Rate per 1000 | -0.000*** | -0.000*** | -0.000** | -0.000* | -0.000*** | 0.000 |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| COVID Death Rate per 1000 | -0.001 | -0.028*** | 0.017*** | -0.007 | 0.002 | -0.007* |
| | [0.002] | [0.003] | [0.003] | [0.004] | [0.002] | [0.004] |
| % White | 0.042 | -0.027 | 0.052 | -0.040 | 0.095* | 0.070* |
| | [0.036] | [0.033] | [0.062] | [0.056] | [0.056] | [0.042] |
| % Black | 0.004 | 0.082 | 0.091 | -0.156* | -0.013 | 0.027 |
| | [0.058] | [0.057] | [0.081] | [0.088] | [0.091] | [0.074] |
| % Male | -0.116*** | -0.159*** | -0.010 | -0.010 | -0.217*** | -0.162*** |
| | [0.036] | [0.038] | [0.058] | [0.064] | [0.052] | [0.055] |
| Students per Teacher | 0.000 | -0.000*** | -0.000** | 0.000*** | 0.000** | 0.000* |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| % Free or Reduced Price Lunch | -0.006 | 0.038*** | 0.028*** | -0.025* | 0.011 | 0.032*** |
| | [0.007] | [0.009] | [0.009] | [0.015] | [0.010] | [0.009] |
| Observations | 40,785 | 40,987 | 13,363 | 13,776 | 18,809 | 18,944 |
| R-squared | 0.669 | 0.758 | 0.799 | 0.807 | 0.820 | 0.866 |
| Mean | 0.635 | 0.626 | 0.343 | 0.287 | 0.610 | 0.631 |
| Number of schools | 6221 | 6224 | 2022 | 2050 | 4052 | 4068 |

*Notes.* This table shows the ordinary least squares estimates of equation 1. The dependent variables are FAFSA submissions per grade-12 enrollment, number of ACT test-takers per grade-11-and-12 enrollment and first-year college enrollment per grade-12 enrollment. Hybrid instruction is classified as being half virtual and half in-person. First-year college enrollment is inclusive of entry before first fall enrollment. For all specifications, the treatment variable is the fraction of the 2020 school year that a school spent in virtual instruction. Specifications (1), (3) and (5) only uses data from schools that are in counties above the median COVID death rate per 1,000 people, whereas specifications (2), (4) and (6) only uses data from schools that are below the median COVID death rate per 1,000 people. Specifications (1) to (4) use data spanning school years 2015 to 2021, whereas specifications (5) and (6) uses data spanning school years 2017 to 2021. The county and school-level controls included are subjected to dummy variable adjustment to account for schools that only have data on a subset of the controls. Standard errors are clustered at the school level and are presented in square brackets. *** p<0.01, ** p<0.05, * p<0.1

**Table A.9:** Effect of Virtual Instruction by Above and Below Median Percent Black

| VARIABLES | (1) FAFSA Submissions Above | (2) FAFSA Submissions Below | (3) ACT Test-takers Above | (4) ACT Test-takers Below | (5) College Enrollment Above | (6) College Enrollment Below |
|---|---|---|---|---|---|---|
| % Virtual * School Year 2020 | -0.042*** | -0.040*** | -0.043*** | -0.051*** | -0.020*** | -0.025*** |
| | [0.004] | [0.005] | [0.007] | [0.009] | [0.004] | [0.006] |
| % Virtual * School Year 2021 | -0.061*** | 0.007 | -0.048*** | -0.064*** | -0.037*** | -0.014** |
| | [0.005] | [0.006] | [0.008] | [0.009] | [0.005] | [0.006] |
| Unemployment Rate | 0.196*** | 0.663*** | -0.407*** | -0.700*** | -0.278*** | -0.151 |
| | [0.066] | [0.080] | [0.101] | [0.112] | [0.090] | [0.100] |
| COVID Case Rate per 1000 | -0.000*** | -0.000*** | -0.000** | -0.000 | -0.000* | -0.000 |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| COVID Death Rate per 1000 | -0.011*** | -0.003 | 0.022*** | 0.014*** | -0.001 | -0.001 |
| | [0.002] | [0.002] | [0.003] | [0.003] | [0.003] | [0.002] |
| % White | 0.082** | -0.021 | 0.152*** | -0.045 | 0.140*** | 0.017 |
| | [0.034] | [0.033] | [0.056] | [0.052] | [0.051] | [0.048] |
| % Black | 0.097** | -0.001 | 0.036 | 0.011 | -0.000 | -0.036 |
| | [0.043] | [0.141] | [0.064] | [0.196] | [0.062] | [0.214] |
| % Male | -0.187*** | -0.090*** | -0.073 | -0.022 | -0.182*** | -0.141*** |
| | [0.042] | [0.034] | [0.062] | [0.054] | [0.054] | [0.052] |
| Students per Teacher | -0.000** | -0.000 | 0.000*** | -0.000 | 0.000** | 0.000** |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| % Free or Reduced Price Lunch | 0.001 | 0.023** | 0.021** | 0.003 | 0.026*** | 0.013 |
| | [0.007] | [0.009] | [0.009] | [0.014] | [0.008] | [0.012] |
| Observations | 39,164 | 40,049 | 18,231 | 17,610 | 18,871 | 18,687 |
| R-squared | 0.774 | 0.682 | 0.834 | 0.804 | 0.878 | 0.811 |
| Mean | 0.646 | 0.625 | 0.276 | 0.272 | 0.604 | 0.633 |
| Number of schools | 5903 | 5904 | 2979 | 2980 | 4034 | 4034 |

*Notes.* This table shows the ordinary least squares estimates of equation 1. The dependent variables are FAFSA submissions per grade-12 enrollment, number of ACT test-takers per grade-11-and-12 enrollment and first-year college enrollment per grade-12 enrollment. Hybrid instruction is classified as being half virtual and half in-person. First-year college enrollment is inclusive of entry before first fall enrollment. For all specifications, the treatment variable is the fraction of the 2020 school year that a school spent in virtual instruction. Specifications (1), (3) and (5) only uses data from schools that are above the median percentage Black students, whereas specifications (2), (4) and (6) only uses data from schools that are below the median percentage Black students. Specifications (1) to (4) use data spanning school years 2015 to 2021, whereas specifications (5) and (6) uses data spanning school years 2017 to 2021. The county and school-level controls included are subjected to dummy variable adjustment to account for schools that only have data on a subset of the controls. Standard errors are clustered at the school level and are presented in square brackets. *** p<0.01, ** p<0.05, * p<0.1

**Table A.10:** Effect of Virtual Instruction on School Characteristics as Outcomes

| VARIABLES | (1) Grade 11 and 12 Enrollment | (2) Grade 12 Enrollment | (3) Total Enrollment | (4) % FRPL | (5) % Black | (6) % White |
|---|---|---|---|---|---|---|
| % Virtual * School Year 2020 | -1.112 | 0.430 | -4.649 | -0.012*** | -0.004*** | 0.001 |
| | [1.583] | [0.889] | [3.517] | [0.003] | [0.001] | [0.001] |
| % Virtual * School Year 2021 | -4.003** | -1.777* | -13.701** | -0.015*** | -0.007*** | -0.002 |
| | [1.940] | [1.071] | [5.948] | [0.003] | [0.001] | [0.001] |
| Observations | 90,842 | 90,869 | 90,934 | 88,134 | 87,388 | 90,572 |
| R-squared | 0.989 | 0.985 | 0.987 | 0.917 | 0.995 | 0.995 |
| Mean | 387.3 | 190.5 | 856.6 | 0.515 | 0.142 | 0.540 |
| Number of schools | 13935 | 13946 | 13957 | 13893 | 13926 | 13942 |

*Notes.* This table shows the ordinary least squares estimates of equation 1 on various school characteristics. The dependent variables are grade-11-and-12 enrollment, grade-12 enrollment, total high school enrollment, percentage free-and-reduced-price lunch, percentage Black and percentage White. Hybrid instruction is classified as being half virtual and half in-person. For all specifications, the treatment variable is the fraction of the 2020 school year that a school spent in virtual instruction. All specifications use data spanning shcool years 2015 to 2021 and include county and school-level controls. The county and school-level controls included are subjected to dummy variable adjustment to account for schools that only have data on a subset of the controls. Standard errors are clustered at the school level and are presented in square brackets. *** p<0.01, ** p<0.05, * p<0.1

**Table A.11:** Effect of Virtual Instruction weighted by Grade-11-and-12 Enrollment

| VARIABLES | (1) FAFSA Submissions | (2) FAFSA Submissions | (3) FAFSA Submissions | (4) ACT Test-takers | (5) ACT Test-takers | (6) ACT Test-takers | (7) College Enrollment | (8) College Enrollment | (9) College Enrollment |
|---|---|---|---|---|---|---|---|---|---|
| % Virtual * School Year 2020 | -0.020*** | -0.029*** | -0.028*** | -0.060*** | -0.054*** | -0.044*** | -0.016*** | -0.014*** | -0.011*** |
| | [0.003] | [0.003] | [0.003] | [0.005] | [0.005] | [0.005] | [0.003] | [0.003] | [0.003] |
| % Virtual * School Year 2021 | -0.026*** | -0.039*** | -0.037*** | -0.073*** | -0.056*** | -0.051*** | -0.027*** | -0.027*** | -0.025*** |
| | [0.004] | [0.004] | [0.004] | [0.007] | [0.007] | [0.007] | [0.003] | [0.003] | [0.004] |
| Unemployment Rate | | 0.593*** | 0.535*** | | -0.445*** | -0.501*** | | -0.210*** | -0.258*** |
| | | [0.048] | [0.048] | | [0.068] | [0.074] | | [0.053] | [0.058] |
| COVID Case Rate per 1000 | | -0.000*** | -0.000*** | | -0.000** | -0.000*** | | -0.000* | -0.000** |
| | | [0.000] | [0.000] | | [0.000] | [0.000] | | [0.000] | [0.000] |
| COVID Death Rate per 1000 | | -0.017*** | -0.017*** | | 0.020*** | 0.023*** | | -0.005*** | -0.005*** |
| | | [0.001] | [0.001] | | [0.003] | [0.003] | | [0.001] | [0.001] |
| % White | | | 0.056** | | | -0.003 | | | 0.128*** |
| | | | [0.023] | | | [0.042] | | | [0.029] |
| % Black | | | 0.113*** | | | -0.039 | | | -0.024 |
| | | | [0.034] | | | [0.067] | | | [0.049] |
| % Male | | | -0.143*** | | | -0.018 | | | -0.182*** |
| | | | [0.023] | | | [0.053] | | | [0.034] |
| Students per Teacher | | | -0.000 | | | 0.000*** | | | 0.000 |
| | | | [0.000] | | | [0.000] | | | [0.000] |
| % Free or Reduced Price Lunch | | | 0.019*** | | | -0.000 | | | 0.026*** |
| | | | [0.005] | | | [0.011] | | | [0.006] |
| Observations | 85,898 | 85,898 | 85,898 | 40,760 | 40,760 | 40,760 | 40,490 | 40,490 | 40,490 |
| R-squared | 0.800 | 0.804 | 0.804 | 0.803 | 0.805 | 0.806 | 0.899 | 0.900 | 0.901 |
| Mean | 0.648 | 0.648 | 0.648 | 0.228 | 0.228 | 0.228 | 0.643 | 0.643 | 0.643 |
| Number of schools | 13502 | 13502 | 13502 | 8175 | 8175 | 8175 | 9338 | 9338 | 9338 |

*Notes.* This table shows the ordinary least squares estimates of equation 1, weighted by grade-11 and 12 enrollment. The dependent variables are FAFSA submissions per grade-12 enrollment, number of ACT test-takers per grade-11-and-12 enrollment and first-year college enrollment per grade-12 enrollment. Hybrid instruction is classified as being half virtual and half in-person. First-year college enrollment is inclusive of entry before first fall enrollment. For all specifications, the treatment variable is the fraction of the 2020 school year that a school spent in virtual instruction. All specifications include school and year fixed effects. Specifications (1) to (6) use data spanning school years 2015 to 2021, whereas specifications (7) to (9) use data spanning school years 2017 to 2021. Specifications (1), (4) and (7) do not include any controls, specifications (2), (5) and (8) include county-level controls and specifications (3), (6) and (9) include both county-level and school-level controls. The county and school-level controls are subjected to dummy variable adjustment to account for schools that only have data on a subset of the controls. Standard errors are clustered at the school level and are presented in square brackets. *** p<0.01, ** p<0.05, * p<0.1