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Unveiling the Impact of COVID-19 School Closures on K-12 Students' Mental Health in the USA

Nadia da Costa Ilhéu
53348

Work project carried out under the supervision of:
Luís Catela Nunes
Pedro Freitas

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Nádia da Costa Ilhéu

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Abstracts

The profound effects of COVID-19 on society demand a closer examination, particularly regarding its impact on disadvantaged demographics. This study delves into the consequences of school closures and the adoption of diverse class systems during the pandemic in students' mental health. In the US, each state applied different policies regarding the share of virtual and hybrid classes and we are concerned about into what extent being exposed for longer periods to virtual/hybrid classes affects K-12 students' mental health. Notably, increased exposure to virtual/hybrid classes correlates with heightened anxiety, with boys experiencing elevated anxiety levels in 2020 and 2022, while girls exhibited increased anxiety in 2021. High school students faced more anxiety symptoms in 2020 and 2022 compared to other school levels.

Keywords: Mental Health, Covid-19, Lockdown, School Closures, K-12 Students

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1. Introduction

Covid-19 is a phenomenon that has and will continue to have huge impacts in our lives and social norms. Even though it is recent, economists have diligently delved into understanding its implications deepening into various important subjects that require our attention.

Among those topics arising from the pandemic, the impact of lockdown measures on children and adolescents stands notably pronounced. Covid-19 led to the shutdown of schools, the prohibition of social gatherings, and enforced individuals in their most formative years to remain confined at home, looking to screens for months. This extended isolation from the outside world, coupled with the absence of normal school routines and social interactions, has resulted in various consequences, many of which will likely persist in the medium and long term (Buffie et al. 2022; Hanushek 2023)

The most extensively studied impact thus far has been the learning losses experienced by K-12 students. Several economists, including Carlana et al. (2023), Halloran et al. (2021), Maldonado and De Witte (2021), and numerous others, have conducted studies revealing learning losses ranging between 0.08 and 0.21 standard deviations. Furthermore, Pisa results from 2022 have been published[2] and show a ¾ of a year decrease in mathematic scores and a half a year drop in reading capacities compared to 2018.

However, our focus should not be solely on academic performance. Students' mental health, an aspect that has garnered comparatively less attention (Arenas and Gortazar 2022; Hanushek and Woessmann 2020), demands significant consideration. Social isolation, potential exposure to abusive environments at home, and academic stress due to uncertain evaluation procedures are just a few factors that can significantly influence students' well-being, posing considerable

[2] https://www.oecd.org/publication/pisa-2022-results/

risks to their mental health. However, separating the actual effect of school closures would be significant to further understandings on this matter.

Hence, our attention is directed towards comprehending how Covid-19-induced school closures impacted students' mental health, understanding the correlation between the absence of full in-person classes and students' emotional skills and well-being. Employing a Difference in Differences (DiD) model, we focus on each state's closure policies, evaluating how different levels of exposure to virtual/hybrid classes affects K-12 students' mental health across American states, comparing outcomes both pre and post Covid-19. We also explore these effects concerning genders and school levels[3].

The main finding of this paper indicates that anxiety experienced the most significant impact among emotional skills during the period of school closures spanning from 2020 to 2022. While boys exhibit a notable increase of approx. 3 p.p in anxiety levels in both 2020 and 2022, being more affected due to increased exposure to school closures, girls showed a similar rise of approx. 3 p.p in 2021. Later, we present a potential explanation for these findings. Moreover, high school students suffered more with anxiety levels in 2020 and 2022, showing an approximate 4 p.p increase in symptoms as they had less in-person classes. On the other hand, general health and depression experienced no significant effects.

In the first section (2) of this paper we present relevant studies that already found significant conclusions on this matter. In section 3 we inform about the data utilized and how it was treated to be adequate to our needs. Next, in section 4, we introduce our methodology and how we conducted the robustness tests, and in section 5 we present the respective results and validate our estimations. Finally, in section 6, we conclude the paper and give final considerations.

[3] USA education system is divided in three levels: primary school, middle school and high school, with the middle and high school being considered the secondary school: https://www.studyusa.com/en/a/58/understanding-the-american-education-system

2. Review of Literature

Despite the limited time for assessing the effects of Covid-19, literature has already identified significant repercussions on the lives of children and adolescents. A prominent focus of study involves examining how the pandemic has impacted students' academic performance, establishing a correlation between Covid-19 and the learning setbacks experienced by children and adolescents.

In this matter, Patrinos et al. (2022) made a significant contribution by consolidating over 30 studies globally on this matter. Their findings revealed a world average learning loss of 0.17 standard deviations, equivalent to half a year of absence from school. Moreover, irrespective of the pandemic's impact, school closures themselves exert a substantial influence on learning. In line with this perspective, evidence suggests that prolonged school closures correlate with increased learning deficits among students. De Witte and François (2023) demonstrate that, as schools remain closed for longer durations, learning losses intensify.

On the other hand, Lichand et al. (2023) conducted a trial involving students during the pandemic, employing behavioral nudges through text messages to bolster their social-emotional skills. The study found that this intervention helped mitigate learning losses by 7.5% in math and 24% in reading. This compelling outcome underscores the significance of mental well-being amid the Covid-19 crisis, enabling students to better sustain their academic performance. Similarly, Iterbeke and De Witte's (2021) study highlights that "students with higher conscientiousness and openness adjusted well to the changes induced by the crisis".

Regarding the impact of Covid-19 on children and adolescents' mental health, a study by Cost et al. (2021) focused on Canadian students to investigate this issue. The study found that between 46.5% and 53.6% of children and adolescents experienced a deterioration in symptoms related to depression, anxiety, hyperactivity, irritability, and attention problems. In contrast, 11% to 19.6% reported an improvement in these areas. The authors further argued that

social isolation emerged as a primary factor contributing to increased stress among students during the pandemic, exacerbating their mental health conditions.

Supporting these findings, Skripkauskaite et al. (2021) conducted a study in the UK to examine the impact of Covid-19 during the first year of the pandemic. The study highlighted a notable increase in behavioral, emotional, and attention difficulties, particularly among primary school students. Additionally, secondary school girls, children from low-income or single households, and those without siblings faced more pronounced challenges. Echoing these results, Racine et al. (2021) revealed a doubling in the prevalence of depression and anxiety since the pandemic's onset, with girls exhibiting the most significant increase. Conversely, Ravens-Sieberer et al.'s (2021) study in Germany indicated fewer mental health issues among females. These contrasting findings suggest potential gender-specific reactions to similar circumstances. For instance, girls may develop heightened social anxiety within dysfunctional families, limiting their access to social support, while boys tend to externalize problems rather than seek assistance (Yu et al. 2022). These nuanced reactions may contribute to variations in study outcomes, alongside differences in sample demographics and data collection methods.

These divergent perspectives underscore a critical issue linked to the pandemic. Numerous studies illustrate how K-12 students have been impacted by Covid-19, experiencing heightened stress due to increased time spent at home in dysfunctional family environments and a lack of peer and teacher support (Jones et al. 2021; Mazrekaj and De Witte 2023; Hassan et al. 2023; Ravens-Sieberer et al. 2021). Research consistently emphasizes the significant influence of peer and teacher relationships on students' well-being and learning outcomes. Butler et al. (2022) investigated this correlation in the North West of England, affirming the conclusions drawn by Gilman and Huebner (2003) and Reitz et al. (2014). They found that young individuals' well-being strongly links to their interactions within their families, with peer relationships notably shaping students' behavior and identity.

Due to the lack of contact with peer and teachers, and the extended time spent in non-communicating families and confined homes settings, school closures have consequences on the social-emotional and motivational development of students (Hanushek and Woessmann 2020). Champeaux et al (2020) further highlighted the impact of limited peer interaction on the emotional well-being of K-12 students, revealing that for secondary students, this lack of interaction was attenuated by virtual interaction.

Supporting these findings, Hertz et al (2021) and Felfe et al (2023) assert that schools serve not only as educational institutions but also as crucial environments for fostering social interactions among children and adolescents. Their findings suggest a direct correlation between prolonged school closures and detrimental impacts on students' high-related quality of life (HRQoL) and increased psychometric symptoms, behavioral and emotional problems, and depressive symptoms. However, their research did not reveal any discernible effects on anxiety problems.

Conversely, as the time spent within the school environment decreases, instances of peer pressure and negative relationships with classmates also diminish. Many children and adolescents face bullying at school, which is a severe experience for students' mental health (Atkins et al. 2006), and the shift to online or reduced in-person classes offers them to escape from negative interactions by allowing them to seek refuge at home. According to Bacher-Hicks et al. (2021), the transition to online classes led to increased adult monitoring and reduced peer interaction among students, resulting in a decline in the searching of bullying in the internet. They view this as a positive outcome, suggesting that school closures might have reduced instances of bullying, potentially alleviating mental health problems among K-12 students who were victims of bullying. Similarly, Adegboye et al. (2021) found that students experiencing hyperactivity and conduct problems, who often found school environments stressful, experienced a decrease in their externalizing problems with home schooling.

Supporting this trend, Hansen et al. (2022) reported a decrease in suicidality among children and adolescents during online classes, which increased as schools resumed in-person learning. These findings illustrate a complex scenario: while some students faced worsened conditions at home due to dysfunctional family situations, many experienced improved mental health due to increased parental supervision and reduced isolation.

On another reality, some studies have reported positive impacts of Covid-19 on students' mental health. Miranda et al. (2020) presented compelling evidence indicating an improvement in children's behavior in Ireland during the pandemic. Similarly, Ford et al. (2021) discovered a noteworthy trend where a considerable number of students in English schools reported feeling happier since the onset of lockdowns and school closures. Additionally, Arenas and Gortazar (2022) found that a majority of students surveyed regarding mental health questions disagreed with statements suggesting a decline in well-being since the pandemic.

However, despite these positive findings, these conclusions are intricately linked not only to school closures but also to interactions with peers, teachers, and families, alongside fears of infection and social isolation. In fact, Viner et al. (2022) assert the complexity of disentangling the specific effects of school closures from various other influencing factors. Consequently, there is a need for diverse approaches to comprehensively understand the correlation between school closures and students' mental health.

3. Data

In this paper, we focus our attention on the Fall 2020 and years 2021 and 2022[4]. On the Spring semester in 2020, the US had most of schools partially open, and never went fully

[4] The data on school closures started on August 2020.

closed[5]. Consequently, the results are expected to remain largely unchanged compared to conducting the study from February onwards.

We combined two datasets: data on school closures from the Covid-19 School Data Hub and data on students' mental health from the National Survey of Children's Health (NSCH).

3.1. Covid-19 School Data Hub Data

This dataset includes information on the distribution of learning models (in-person, hybrid, or virtual) at both public school and distric levels throughout the 2020/2021 school year, across 48 states[6]. It has both monthly and yearly data, which was constructed to include every school or district per state[7]. Nonetheless, as there are missing data in some states, the researchers can assure that 30 states and the District of Columbia have clean datasets.

The in-person learning mode is characterized by having fully in-person classes for 5 days a week for all or most students. Then, hybrid mode is a combination of in-person and online instruction for all or most students. Finally, virtual classes are classified by being held fully remotely for all or the majority of students. Furthermore, this dataset gives us the annual share of each education mode per district and school[8].

3.2. The National Survey of Children's Health Data

This dataset is publicly available for each year since 2016 in the Census Bureau's NSCH page and is weighted to accurately represent the entire US child population aged between 0 and 17. The National Survey of Children's Health (NSCH) encompasses data from all 50 states and

[5] https://geo.uis.unesco.org/covid-19/covid-19

[6] The states are: Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, District of Columbia, Delaware, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Maine, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Mexico, Nevada, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming.

[7] https://assets.ctfassets.net/9fbw4onh0qc1/51GumHMBAalCkUBBHREfxO/0f4e84f44f90451b5558e7989e0d342b/CSDH_Introductory_White_Paper.pdf

[8] Is publicly available in https://www.covidschooldatahub.com

the District of Columbia, covering a range of student characteristics, physical and emotional health indicators, access to healthcare, familial and neighborhood contexts, parental attributes and mental health status, and family dynamics. As the K-12 education system in the US typically starts at age 5, our analysis excludes children below this age and the states lacking information on the learning model.

The data for this dataset is derived from an annual survey where parents answer on behalf of their children. Initially, a screening instrument identifies households with children, and subsequently, one child is randomly selected as the subject for the topical questionnaire. Initially, our analysis focuses on datasets from 2019 onwards. Then, to ensure robustness in our analysis, we also incorporate datasets from 2016, 2017, and 2018 for additional testing and validation. It is important to clarify that each year individuals differ, hence, we will be working with repeated cross-sectional data.

Within this dataset, the variables general health, depression and anxiety, were chosen to represent students' mental health[9]. The general health variable is reported on a scale from 1 to 5, with 1 denoting "excellent", 2 "very good", 3 "good", 4 "fair", and 5 "poor". For simplification purposes, we inverted this scale from 5 to 1. The remaining variables are defined as binary, where 0 signifies "the doctor or any other healthcare provider never indicated that this child has depression/anxiety", and 1 represents "the doctor or any other healthcare provider has indicated that this child has depression/anxiety".

3.3. Datasets Treatment

As the learning model dataset provided us the overall share for each learning model per district, we aggregated those shares to create a mean of each learning model per state. Then, to construct our treatment variable, the share of virtual and hybrid classes, representing the new

[9] In Appendix C we present the results for 6 more variables to corroborate our results and give some insights in other psychological symptoms.

learning models introduced in response to Covid-19, was aggregated, while in-person classes were retained to serve as our control.

For our outcome variables, as we are working with binary data for most variables, we applied thresholds to the values for general health. We defined as 0 responses from 1 to 3 due to fewer observations within these levels compared to levels 4 and 5 combined (see Table B.2 in the appendix). For responses 4 and 5, we assigned the value 1. The remaining variables were not changed as they were already binary.

Additionally, in subsequent phases of the research, students will be divided by sex and categorized into primary school (ages 5 to 10), middle school (ages 11 to 13), and secondary school (ages 14 and above) levels for further examination.

The National Survey of Child Health (NSCH) typically collects its data around June or July each year. In both 2021 and 2022, we merged the dataset on mental health with the learning model dataset. However, for the 2020 dataset, since we couldn't use the 2021 data, we performed a mean calculation using the available monthly data, specifically accounting for the period from August to December 2020.

4. Methodology Approach

4.1. Empirical Strategy

This paper aims to explore the impact of Covid-19-related school closures on K-12 students' well-being by employing a Difference in Differences (DiD) approach[10]. This method allows us to identify a causal impact between the treatment variable and the outcomes, while also controlling for the confounding factors, addressing time dynamics, as well as mitigating potential biases associated with unchanging factors over time and selection biases.

[10] We also performed an OLS regression to understand the immediate impact of school closures on students' mental health: Appendix A

Furthermore, the DiD analysis enables us to compare changes in mental health outcomes before and after school closures among both treated (experiencing online or hybrid classes) and untreated groups (experiencing in-person classes), providing a nuanced understanding of the specific implications of these closures on students' mental well-being.

4.2. Difference in Differences (DiD) Approach

The aim of employing DiD approach is to compare the changes in outcomes between the treatment and control groups over time. To apply this, we observe both groups before and after treatment, assuming that, while the treatment and control groups may differ in their outcome levels, a change in these differences over time is solely due to the treatment, in this case, the implementation of classes restrictions. This assumption heavily relies on the assumption of parallel trends, signifying that in the absence of treatment, the difference between the treatment and control group is constant over time. We check this crucial assumption after discussing the main results by using data for the pre-treatment periods.

Our treatment variable denotes the restrictions imposed on the normal learning model due to Covid-19, specifically identifying students engaged in virtual or hybrid classes. Notably, we're not employing a binary treatment, as we do not identify the variable as 0 if students have in-person classes or 1 if classes are held virtually or hybrid. Instead, we seek to evaluate changes in children's mental health concerning varying shares of virtual/hybrid classes, representing different levels of treatment intensity. Given the varying proportions of virtual/hybrid classes implemented across states, treating this variable as continuous provides valuable insights into how incremental changes in the learning models impact students' mental health.

Our regression is specified as:

$$Y_{ist} = \alpha + \beta X_{ist} + \delta Treatment_{st} + \epsilon_{ist} \quad (1)$$

where Y_{ist} represents each outcome variable for student *i* from state *s* at time *t*, X_{ist} represent individual controls such as parents' current employment status, education and marital status, mother's age and students' age and race, for student *i* from state *s* at time *t.* $Treatment_{st}$ is our continuous treatment specifying the share of virtual and hybrid classes for each state *s* at time *t*.

In this specification, the main coefficient is δ, which represents how the effect of learning models changes over time after the implementation of classes restrictions. Essentially, it provides us the average treatment effect on the outcome over time.

4.3. Placebo and Parallel Trends Test

As mentioned earlier, validating our assumptions in the DiD model needs conducting a parallel trends test. Establishing the premise that different groups would behave similarly without treatment is challenging. Therefore, the parallel trends test allows us to validate the plausibility that any observed changes in outcomes between the treatment and control groups stem exclusively from the treatment itself, rather than pre-existing factors influencing outcomes.

However, as our treatment variable is continuous, directly testing this validation on our outcomes becomes unfeasible. Therefore, we devised two approaches: implementing a placebo test and transforming our continuous treatment into a binary one.

For the placebo test, we performed a DiD analysis between 2018 and 2019, where in 2019 we simulated 2020's treatment. This test aims to illustrate that, if there is any effect on students' mental health, it is exclusively from changes in learning modes. Hence, if no treatment occurred in 2019, shifting the treatment to that year should yield non-significant coefficients.

Regarding the parallel trends assessment, we established two thresholds to convert the continuous treatment into a binary variable. After analyzing our data (see Table B.3 in the appendix), we designated states with a share of virtual/hybrid classes below 0.5 as 0 and those at or above 0.5 as 1. This transformation facilitated our pre-trends test, enabling the validation of our estimates. The null hypothesis in this test is that linear trends are parallel, therefore, we must not reject it. If we reject, then there is no evidence that the differences in the outcomes after treatment are solely because of the treatment.

Another way to test for parallel trends is performing a Granger-type causality model. This test allows to test the treatment on periods before treatment. The null hypothesis is that there is no effect in anticipation of treatment – pretty much what we did for the placebo test. The expected is to not reject the null. If we reject, then we must be concerned about the identification of our DiD coefficients.

5. Results

5.1. Difference in Differences Estimates

The following tables show us the results from equation (1), with the results without controls in columns (1), (3) and (5), and the results with controls in columns (2), (4) and (6).

The estimations presented in Table 1 show us that students in 2020 suffered significantly from depression and anxiety. This suggests that increased exposure to the new learning models marginally increased the probability of K-12 students experiencing depressive and anxious symptoms. Notably, depression exhibited a coefficient of approx. 1 p.p., significant at the 5% level, while anxiety showed a coefficient of approx. 2 p.p, also significant at the 5% level. On the other hand, no significant impact was found in students' general health.

Table 1 - Virtual/Hybrid Classes on K-12 Students' Mental Health for 2020

	General Health		Depression		Anxiety	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	0.0095	0.0113	0.0132*	0.0149**	0.0149	0.0245**
	(0.0071)	(0.0080)	(0.0070)	(0.0072)	(0.0093)	(0.0097)
Constant	0.1108***	0.2707***	0.0505***	0.0385**	0.1162***	0.0027
	(0.0015)	(0.0268)	(0.0017)	(0.0167)	(0.0020)	(0.0153)
Observations	52515	40811	52471	40789	52436	40760
R2	0.0021	0.0317	0.0029	0.0544	0.0068	0.0434
Controls	No	Yes	No	Yes	No	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

For 2021 the results show some changes:

Table 2 - Virtual/Hybrid Classes on K-12 Students' Mental Health for 2021

	General Health		Depression		Anxiety	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	0.0131*	0.0085	0.0104	0.0053	0.0071	0.0182**
	(0.0067)	(0.0069)	(0.0087)	(0.0075)	(0.0089)	(0.0087)
Constant	0.0954***	0.2379***	0.0501***	0.0183	0.1156***	-0.0331*
	(0.0011)	(0.0338)	(0.0018)	(0.0166)	(0.0019)	(0.0177)
Observations	53740	41772	53697	41746	53662	41718
R2	0.0025	0.0335	0.0030	0.0661	0.0059	0.0523
Controls	No	Yes	No	Yes	No	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

It is noteworthy that both general health and depression outcomes are statistically insignificant when accounting for controls. This suggests that the adoption of virtual/hybrid classes has not notably impacted these outcomes, contrarily to 2020 where depression was affected. Nevertheless, being more exposed to the new learning models continued to affect anxiety significantly, with a coefficient of approx. 2 p.p. with a 5% significance level.

Regarding 2022, our last year of analysis, Table 3 shows us some similar results:

Table 3 - Virtual/Hybrid Classes on K-12 Students' Mental Health for 2022

	General Health		Depression		Anxiety	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	0.0054	-0.0032	0.0133	0.0104	0.0226**	0.0199**
	(0.0082)	(0.0095)	(0.0090)	(0.0088)	(0.0106)	(0.0095)
Constant	0.1123***	0.2414***	0.0638***	0.0252*	0.1293***	-0.0112
	(0.0014)	(0.0294)	(0.0017)	(0.0146)	(0.0021)	(0.0174)
Observations	57823	44967	57733	44930	57703	44895
R2	0.0032	0.0309	0.0035	0.0648	0.0061	0.0524
Controls	No	Yes	No	Yes	No	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In 2022, the restrictions from the previous year continuied to manifest effects on students' anxiety. The significant coefficient of approx. 2 p.p for anxiety illustrates that prolonged exposure to the new learning models continued to impact students' anxiety levels more than their depressive symptoms, which diminished after the first year of the pandemic.

Overall, the effects were not as pronounced as might have been expected. General health remained unaffected, and depression only showed significant effects during the initial year of the pandemic. It is possible that, after 2020, the first year of shock due to the pandemic and the most restrictive one, students began adapting better as restrictions eased and there was a reduced reliance on virtual/hybrid classes[11], countering the increasing trend observed in depression.

Anxiety, contrarily, was the symptom most affected by not being longer physically at school over the three years.

[11] https://www.covidschooldatahub.com

5.1.1. Difference in Differences for Different Sexes

Diving into the differences between sexes, there are some highlights in these estimations worth analyzing. In columns (1), (3) and (5) we present the coefficients for girls, and in columns (2), (4) and (6) we present the results for boys.

Table 4 - Virtual/Hybrid Classes on Girls' and Boys' Mental Health for 2020

	General Health		Depression		Anxiety	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	0.0012	0.0210*	0.0214*	0.0089	0.0191	0.0315**
	(0.0087)	(0.0114)	(0.0119)	(0.0094)	(0.0150)	(0.0119)
Constant	0.2865***	0.2481***	0.0261	0.0457*	-0.0046	-0.0015
	(0.0416)	(0.0399)	(0.0209)	(0.0238)	(0.0274)	(0.0237)
Observations	19689	21122	19686	21103	19676	21084
R2	0.0364	0.0375	0.0774	0.0432	0.0672	0.0344
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

During the initial year of the pandemic, distinct patterns emerged between genders. Girls appeared to experience heightened levels of depression, significant at a 10% level with a coefficient of approx. 2 p.p. Conversely, boys showed increased anxiety in correlation with longer exposure to virtual/hybrid classes, statistically significant at a 5% level with a coefficient of approx. 3 p.p. Surprisingly, more virtual/hybrid classes seemed to positively impact boys' general health significantly at a 10% level, while no significant relation was observed for girls. This discrepancy, manifesting as increased anxiety but improved well-being among boys might be attributed to unaccounted external factors within this analysis. Factors such as increased leisure time for activities like video gaming, enhanced family time (assuming absence of home violence), or even reduced exposure to bullying, could potentially contribute to improved health.

As a year passed by, outcomes show some strange differences. Table 5 reveals that depression among girls continued to be significantly affected by exposure to different learning models. However, while boys got their anxiety ceased being significantly impacted by school closures, girls experienced significant anxiety levels in 2021. This divergence in outcomes suggests that while boys might struggle initially to adapt to changes in school dynamics, eventually settling down, girls might take longer to comprehend the detrimental consequences of not learning physically at chool.

Table 5 - Virtual/Hybrid Classes on Girls' and Boys' Mental Health for 2021

	General Health		Depression		Anxiety	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	0.0061	0.0097	0.0194*	-0.0084	0.0287**	0.0061
	(0.0093)	(0.0115)	(0.0101)	(0.0102)	(0.0141)	(0.0119)
Constant	0.1703***	0.2960***	-0.0065	0.0447*	-0.0372	-0.0178
	(0.0403)	(0.0373)	(0.0261)	(0.0248)	(0.0283)	(0.0227)
Observations	19995	21777	19983	21763	19969	21749
R2	0.0341	0.0419	0.0907	0.0512	0.0802	0.0400
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

However, the findings for 2022, as depicted in Table 6, might present a slightly misleading picture. While the previously observed significant increase in depression among girls disappears – potentially due to the passing of years since the imposition of restrictions and girls becoming more adept at coping with the situation – boys exhibit a noteworthy 10% significant increase in anxiety as they are more exposed to virtual/hybrid classes. This increase, marked by a coefficient of approx. 3 p.p, could possibly be explained by the challenges faced by younger boys entering or transitioning between K-12 school levels (such as from primary to middle school or from middle to high school). The difficulties they might encounter while adapting to the heightened educational intensity, especially in 2022 when schools returned to more normal operations, could have contributed to this rise in anxiety levels.

Table 6 - Virtual/Hybrid Classes on Girls' and Boys' Mental Health for 2022

	General Health		Depression		Anxiety	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	-0.0177	0.0112	0.0202	0.0040	0.0187	0.0259*
	(0.0110)	(0.0124)	(0.0122)	(0.0117)	(0.0181)	(0.0132)
Constant	0.1947***	0.2803***	-0.0288	0.0686***	-0.0510	0.0217
	(0.0369)	(0.0335)	(0.0232)	(0.0210)	(0.0342)	(0.0225)
Observations	21589	23378	21578	23352	21548	23347
R2	0.0360	0.0360	0.0993	0.0435	0.0863	0.0360
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5.1.2. Difference in Differences for Each Education Level

In the columns (1), (4) and (7) we present the results for primary students' outcomes; columns (2), (5) and (8) show the coefficients for middle students' outcomes; and columns (3), (6) and (9) give us the estimations for high school students.

Table 7 - Virtual/Hybrid Classes on Students' Mental Health per Education Level for 2020

	General Health			Depression			Anxiety		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Virtual/Hybrid classes	0.0108	0.0147	0.0079	-0.0024	0.0384*	0.0202	0.0114	0.0287	0.0361*
	(0.0131)	(0.0201)	(0.0119)	(0.0070)	(0.0192)	(0.0144)	(0.0140)	(0.0253)	(0.0200)
Constant	0.2082***	0.3493***	0.3333***	0.0506***	0.0949**	0.0953***	0.0057	0.1338***	0.1233***
	(0.0478)	(0.0497)	(0.0364)	(0.0172)	(0.0355)	(0.0285)	(0.0207)	(0.0374)	(0.0238)
Observations	16556	9386	14869	16547	9380	14862	16536	9372	14852
R2	0.0322	0.0450	0.0307	0.0201	0.0365	0.0337	0.0282	0.0338	0.0331
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8 - Virtual/Hybrid Classes on Students' Mental Health per Education Level for 2021

	General Health			Depression			Anxiety		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Virtual/Hybrid classes	0.0001	0.0211	0.0116	-0.0025	0.0206	0.0048	0.0088	0.0214	0.0295
	(0.0128)	(0.0226)	(0.0153)	(0.0061)	(0.0198)	(0.0197)	(0.0131)	(0.0230)	(0.0194)
Constant	0.2138***	0.3204***	0.2707***	0.0295**	0.0549	0.1088***	-0.0294	0.0477	0.1442***
	(0.0435)	(0.0571)	(0.0446)	(0.0141)	(0.0349)	(0.0364)	(0.0184)	(0.0372)	(0.0389)
Observations	18715	8956	14101	18703	8949	14094	18696	8937	14085
R2	0.0305	0.0453	0.0336	0.0187	0.0325	0.0383	0.0344	0.0337	0.0365
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9 - Virtual/Hybrid Classes on Students' Mental Health per Education Level for 2022

	General Health			Depression			Anxiety		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Virtual/Hybrid classes	-0.0063	0.0010	-0.0072	0.0017	0.0288	0.0074	0.0143	-0.0010	0.0402*
	(0.0128)	(0.0193)	(0.0154)	(0.0058)	(0.0217)	(0.0203)	(0.0145)	(0.0242)	(0.0229)
Constant	0.2394***	0.2599***	0.2763***	0.0571***	0.0662**	0.0892***	0.0045	0.1418***	0.1154***
	(0.0427)	(0.0525)	(0.0346)	(0.0190)	(0.0314)	(0.0233)	(0.0245)	(0.0439)	(0.0332)
Observations	19466	9704	15797	19454	9701	15775	19435	9688	15772
R2	0.0307	0.0356	0.0335	0.0214	0.0304	0.0362	0.0359	0.0310	0.0370
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

On a first analysis, it's evident that there is no statistically significant effect observed for primary students across the three years concerning their outcomes. However, middle school students experienced increased levels of depression in 2020 the longer the time they were exposed to new learning models. Interestingly, this effect diminished in the subsequent two years – a similar behavior to girls mentioned previously. No significant effects were discerned for other education levels in this regard.

Regarding students' anxiety, a noteworthy trend emerges. In 2020, high school students exhibited a significant increase in anxiety, indicated by a coefficient of approx. 4 p.p. significant at a 10% level. This suggests that prolonged exposure to virtual/hybrid classes heightened anxiety among high school students. Notably, this effect dissipated in 2021 but came back in 2022. The coefficient for 2022, statistically significant at a 10% level, measured approx. 4 p.p, surpassing the 2020 coefficient, indicating a heightened impact of learning

models during that period. A plausible explanation for this pattern equals the earlier observation concerning boys: the struggle to adapt to a new educational level due to the altered intensity of learning caused by the pandemic-induced disruptions. This highlights a potential medium-term effect of school closures - the challenge of readapting to normal education due to the impact of prolonged absence from in-person classes.

5.2. Placebo and Parallel Trends

5.2.1. Placebo Effect

To validate our DiD estimations, we conducted parallel trends tests and implemented a placebo experimentation, as refereed in section 4.3. In Table B.4 of the appendix, we present estimates both with and without controls. The results are disappointing, as they exhibit statistical significance for the outcomes also significant on the analyzed periods, particularly for anxiety. We obtained a statistically significant coefficient at the 1% level for students' anxiety. Nevertheless, the negative coefficient (approx. -2 p.p) suggests an unexpected deviation from the anticipated trend: the more students are exposed to virtual/hybrid classes, the less anxious they become. This unexpected result asks a deeper investigation to comprehend the circumstances leading to this outcome. Moreover, the significance of this finding hints at the potential presence of confounding factors or unobserved variables influencing this relationship.

Furthermore, when examining the results for each gender individually (refer to Table B.5 in the appendix), the outcomes significant are also those significant for the analyzed three years. However, when exploring results specific to each education level (Table B.6) all estimates are insignificant. This insight validates our previous estimates for education levels, reinforcing their validity.

5.2.2. Parallel Trends Test

The Parallel Trends and Granger tests conducted for outcomes with controls (Table B.7 in the appendix) are similar to the findings observed in the placebo test. While depression outcomes exhibit parallel trends and the Granger test does not reject the null hypothesis, the results for general health and anxiety are less satisfactory. Both the parallel trends and the Granger test for general health reject the null hypothesis at a 5% level, suggesting the possible influence of other factors beyond the treatment on our outcomes. Regarding anxiety, the parallel trends reject the null at a 5% level, but the Granger test does not. For a clearer visual representation,

Figure B.1 in the appendix illustrates the trajectories of the treatment and control groups before and after the treatment.

To disentangle these findings, we conducted tests for each gender and education level (Table B.8 and Table B.9 in the appendix). Analyzing both sexes separately, notable differences emerge. Depression outcomes consistently validate the parallel tests. However, for both boys and girls, parallel trends are evident in general health and anxiety. In girls, the null hypothesis for general health is not rejected, suggesting parallel trends, and anxiety is not rejected at a 5% level. The opposite situation happens for the Granger test. Examining the graphs in Figure B.2 and Figure B.3 similarities between both paths before treatment become more apparent.

These differences from the results without controlling for sexes show that it is important to control for sex characteristics as boys and girls react differently to similar. These divergent results from the analysis without controlling for sexes emphasize the importance of considering gender characteristics, as boys and girls exhibit differing reactions to similar situations (Yu et al., 2022).

Hence, the validated results for both sexes allow us to affirm that boys experienced heightened anxiety in 2020 and 2022, while girls displayed increased anxiety in 2021.

Moreover, it is confirmed that girls encountered greater levels of depression during the initial two years of the pandemic due to increased exposure to virtual/hybrid classes.

The analysis for different school years also yields positive results. For primary students (Table B.10), both tests for all variables do not reject the null, besides the p-trends test for general health that rejects the null at a 10% level. Similarly, Table B.11 in the appendix for middle school students' show that results remain consistent, but now it's the Granger test rejecting the null for general health at a 10% level. On the other hand, all tests demonstrate parallel trends for high school students (Table B.12). Figure B.4, Figure B.5, and Figure B.6 in the appendix provide graphical representations for better visualization of these test results.

These findings underscore the importance of carefully analyzing various student characteristics to assess and validate estimations accurately. However, it is crucial to remain cautious as we assume our treatment as 0 for total in-person classes and 1 for no in-person classes. While we assume that the results do not deviate from what would be expected for parallel trends with a continuous treatment, it's essential to remain aware that subtle changes might arise.

6. Conclusion

This paper employs a DiD approach to analyze the impact of school closures on K-12 students' mental health. Our findings reveal that K-12 students in the US did not experience significant depression attributed to virtual or hybrid classes in years 2021 and 2022, neither saw their general health decreased. However, in 2020, students became more depressive as they had less in-person classes, with a coefficient of approx. 1 p.p. Additionally, middle school students were the most affected in 2020 with a coefficient of approx. 4 p.p.

There is clear evidence that anxiety was the most affected symptom from 2020 to 2022, with estimations of approx. 2 p.p each year, meaning that anxiety symptoms increased as

students were exposed longer to virtual/hybrid classes. Furthermore, our findings indicate that boys suffered more with school closures, as their coefficients is approx. 3 p.p in 2020 and 2022, while girls did not display a significant result. Nevertheless, in 2021, while boys saw no significant increase in anxiety, girls experienced a significant increase in anxiety with a coefficient of approx. 3 p.p. We explain these differences in results with the possible challenges in adapting to rapid changes in school dynamics that boys might feel, while girls adapt rapidly but take more time to perceive the consequences of learning at home. The return to high levels of anxiety symptoms for boys in 2022 may be explained by younger boys entering primary school with less developed capabilities, or boys transitioning between K-12 school levels and feeling difficulties to adapt to a new year – specially to a new education intensity as in-person classes returned – with so many learning losses experienced before. This may reveal a possible mid-term effect on students' mental health.

Furthermore, our study investigated the repercussions of school closures across different education levels, revealing that high school students were the most affected. They exhibited an increase in anxiety symptoms of approx. 4 p.p as the exposure to more virtual/hybrid classes increases. This conclusion aligns with the studies conducted by Ravens-Sieberer et al. (2021) and Racine et al. (2021), supporting the notion that older adolescents experienced reduced mental well-being during the pandemic.

Moreover, the results obtained from a DiD in other variables (see Appendix C) reinforce the non-significant impacts on students' mental health form 2020 until 2022. However, long-terms impacts remain uncertain, as learning losses start to accumulate (Buffie et al. 2023) and the difficulties regarding students' scores achievements may interfere with their mental health. Nevertheless, in the short term, there are no significant effects in all symptoms besides anxiety, allowing us to understand that online classes are not harmful regarding students' mental health. This might help with policymaking, as governments could be less concerned about students'

emotional skills and well-being when shutting down schools. Nevertheless, anxiety is still an important aspect of students' lives, and must not be disregarded when applying virtual/hybrid classes. More well-prepared educators and effective virtual platforms may alleviate anxiety symptoms, as students are less preoccupied about assessments approaches, for example.

Regarding the limitations on this work, our mental health dataset relies on parental responses, potentially introducing bias due to their limited understanding of their children's behavior or potential exaggeration in their responses. Additionally, our school closures dataset starts only from August 2020. As the initial wave of Covid-19 in the US saw partial school closures rather than full closures, we assume minimal deviation in the results from our presented findings. Moreover, our inability to conduct a parallel test for continuous variables led us to modify our treatment into a binary form. While we assume this alteration will not drastically impact the parallel trends of our variables, it does not precisely equal the real trends. Furthermore, as our parallel trends for the estimations with controls are weak, there may be some factors that we did not account for in this analysis. Lastly, our focus solely on evaluating the impact of school closures might overshadow other influential factors. The broader aspects of being away from peers and educators, fear of infection, substandard home conditions, and other related factors might have significant influence on students' mental health beyond the virtual or hybrid learning system.

With this work we contributed to the few studies on the consequences of Covid-19 in students' mental health, recognizing its recent emergence and the vast scope for further investigation. Future contributions in this field might involve exploring the long-term impacts of school closures in students' mental health, as well as the relationship between learning setbacks and mental health. Additionally, there remains much to comprehend regarding how these mental health effects will influence the future work and social lives of children and adolescents in the years to come.

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Appendix A - Ordinary Least Squares (OLS) Approach

First in our research, we proceeded to apply an OLS approach to understand the immediate impact of school closures in in K-12 students' mental health. Nevertheless, it is important to state that, while these estimations provide initial insights, they may not be sufficiently to isolate the exclusive effects of school closures on mental health due to potential confounding variables and time-related dynamics. Furthermore, an OLS regression does not compare the outcomes between different years.

Our OLS regression uses the following specification:

$$Y_{it} = \alpha + \beta X_{it} + \delta Virtual\&Hybrid_{it} + \epsilon_{it} \quad (2)$$

where Y_{it} represents the outcomes for mental health, for student *i* at time t, X_{it} a set of control variables which includes students and respective parents' characteristics, and $Virtual\&Hybrid_{it}$ the aggregated share of virtual and hybrid classes that students experienced given their state. The standard errors are clustered at state level as students in the same state have the same share of virtual and hybrid classes, with all states having different values.

In this regression, the aim is to find the coefficient for $\delta Virtual\&Hybrid_{it}$, δ, that measures the immediate responses of the outcomes on the new learning models.

Our initial findings for 2020 are displayed in Table A.1, detailing three variables: general health, depression, and anxiety. Columns (1), (3), and (5) show the coefficients indicating the immediate response of the outcomes to more exposure to the new learning models without any controls. Columns (2), (4), and (6) introduce the results with additional controls.

Table A.1– Immediate Impact of Virtual/Hybrid classes on Students' Mental Health in 2020

	General Health		Depression		Anxiety	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	0.0069	0.0099*	0.0021	0.0100	0.0142	0.0326***
	(0.0071)	(0.0056)	(0.0079)	(0.0063)	(0.0143)	(0.0119)
Constant	0.0899***	0.2532***	0.0683***	0.0457**	0.1400***	-0.0030
	(0.0048)	(0.0333)	(0.0045)	(0.0192)	(0.0087)	(0.0212)
Observations	31101	23770	31067	23751	31036	23730
R2	0.0001	0.0322	0.0000	0.0535	0.0001	0.0406
Controls	No	Yes	No	Yes	No	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Upon analysis, the coefficients for general health and anxiety exhibit statistical significance when controls are applied. Notably, students' general health demonstrates an increase corresponding to increased exposure to virtual/hybrid classes, indicated by a coefficient of approx. 0.99 p.p, significant at the 10% level. Conversely, anxiety appears to worsen with the implementation of these new learning models. In the case of depression, no statistically significant estimation is observed. This suggests that while the learning models have an impact on depression, the effect lacks sufficient significance to establish a clear relationship between the variables. This observation leads to the prediction of a potential negative association with anxiety and a probable positive correlation with general health. However, the apparent contradiction – students becoming more anxious while showing improved general health – raises valid concerns

For the remaining years, Table A.2 and Table A.3, all values lack statistical significance. Consequently, despite any potential positive or negative associations, no causal relationship can be established. Nevertheless, these outcomes serve as a benchmark; performing an OLS regression does not confirm any direct causal relationship between the treatment and the outcomes.

Table A.2- Immediate Impact of Virtual/Hybrid classes on Students' Mental Health in 2021

	General Health		Depression		Anxiety	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	0.0099	0.0061	-0.0055	-0.0031	-0.0031	0.0175
	(0.0069)	(0.0061)	(0.0086)	(0.0068)	(0.0150)	(0.0112)
Constant	0.0883***	0.2319***	0.0786***	0.0348	0.1536***	-0.0377
	(0.0040)	(0.0375)	(0.0052)	(0.0220)	(0.0083)	(0.0234)
Observations	32326	24731	32293	24708	32262	24688
R2	0.0001	0.0355	0.0000	0.0737	0.0000	0.0589
Controls	No	Yes	No	Yes	No	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.3 - Immediate Impact of Virtual/Hybrid classes on Students' Mental Health in 2022

	General Health		Depression		Anxiety	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	0.0119	-0.0007	-0.0042	-0.0004	0.0059	0.0187
	(0.0116)	(0.0087)	(0.0088)	(0.0073)	(0.0144)	(0.0145)
Constant	0.0913***	0.2239***	0.0834***	0.0413**	0.1620***	0.0057
	(0.0060)	(0.0308)	(0.0055)	(0.0165)	(0.0083)	(0.0259)
Observations	36409	27926	36329	27892	36303	27865
R2	0.0001	0.0307	0.0000	0.0700	0.0000	0.0550
Controls	No	Yes	No	Yes	No	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Additionally, we conducted further analyses to explore the impact on both genders and across different school years, Table A.4, Table A.5, Table A.6, Table A.7, Table A.8 and Table A.9. A quick look reveals that in 2020 and 2022 boys experienced heightened levels of anxiety. However, in 2021, there was no significant reaction. These findings are similar to the DiD estimations, nevertheless, the significancy of these results is higher, which may indicate that the DiD is controlling for factors that are affecting the OLS coefficients. Furthermore, in 2020, the anxiety levels of middle and high school students were affected by increased exposure to virtual/hybrid classes, while other outcomes and years displayed insignificant estimations in this regard.

Table A.4 - Immediate Impact of Virtual/Hybrid classes on Girls' and Boys' Mental Health in 2020

	General Health		Depression		Anxiety	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	0.0070	0.0132*	0.0058	0.0137	0.0179	0.0462***
	(0.0059)	(0.0077)	(0.0089)	(0.0083)	(0.0138)	(0.0127)
Constant	0.3285***	0.1525***	0.0647**	0.0175	0.0043	-0.0287
	(0.0535)	(0.0394)	(0.0270)	(0.0185)	(0.0366)	(0.0280)
Observations	11551	12219	11545	12206	11541	12189
R2	0.0412	0.0352	0.0775	0.0411	0.0645	0.0307
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (3) and (5) present the coefficients for girls, while columns (2), (4) and (6) present those for boys.

Table A.5 - Immediate Impact of Virtual/Hybrid classes on Girls' and Boys' Mental Health in 2021

	General Health		Depression		Anxiety	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	0.0087	0.0030	0.0014	-0.0089	0.0148	0.0171
	(0.0090)	(0.0085)	(0.0092)	(0.0081)	(0.0136)	(0.0129)
Constant	0.1987***	0.2658***	0.0352	0.0387	-0.0097	-0.0520*
	(0.0486)	(0.0474)	(0.0368)	(0.0253)	(0.0380)	(0.0269)
Observations	11857	12874	11842	12866	11834	12854
R2	0.0357	0.0420	0.0999	0.0570	0.0894	0.0427
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (3) and (5) present the estimations for girls, while columns (2), (4) and (6) present those for boys.

Table A.6 - Immediate Impact of Virtual/Hybrid classes on Girls' and Boys' Mental Health in 2022

	General Health		Depression		Anxiety	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	-0.0071	0.0060	-0.0013	0.0018	0.0063	0.0322**
	(0.0087)	(0.0107)	(0.0105)	(0.0083)	(0.0185)	(0.0131)
Constant	0.2176***	0.2290***	0.0146	0.0586***	-0.0367	0.0367
	(0.0386)	(0.0392)	(0.0285)	(0.0217)	(0.0461)	(0.0315)
Observations	13451	14475	13437	14455	13413	14452
R2	0.0390	0.0320	0.1099	0.0431	0.0913	0.0351
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (3) and (5) present the coefficients for girls, while columns (2), (4) and (6) present those for boys.

Table A.7 - Immediate Impact of Virtual/Hybrid classes on Mental Health in 2020 for Each Level of Education

	General Health			Depression			Anxiety		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Virtual/Hybrid classes	0.0095	0.0079	0.0108	-0.0032	0.0173	0.0206	0.0141	0.0416**	0.0472**
	(0.0080)	(0.0130)	(0.0101)	(0.0044)	(0.0119)	(0.0140)	(0.0109)	(0.0186)	(0.0202)
Constant	0.1981***	0.3339***	0.3103***	0.0497***	0.0850	0.1164***	0.0176	0.1142**	0.0935***
	(0.0469)	(0.0664)	(0.0473)	(0.0184)	(0.0510)	(0.0321)	(0.0349)	(0.0567)	(0.0277)
Observations	9693	5415	8662	9686	5410	8655	9677	5408	8645
R2	0.0337	0.0431	0.0313	0.0234	0.0346	0.0304	0.0264	0.0282	0.0277
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (4) and (7) present the coefficients for primary school students, columns (2), (5) and (8) for middle school students, and columns (3), (6) and (9) for high school students.

Table A.8 - Immediate Impact of Virtual/Hybrid classes on Mental Health in 2021 for Each Education Level

	General Health			Depression			Anxiety		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Virtual/Hybrid classes	0.0002	0.0054	0.0167	-0.0041	-0.0035	-0.0030	0.0096	0.0262	0.0243
	(0.0069)	(0.0168)	(0.0117)	(0.0040)	(0.0135)	(0.0190)	(0.0099)	(0.0219)	(0.0205)
Constant	0.2046***	0.3382***	0.2794***	0.0111	0.0311	0.1975***	-0.0349	0.0070	0.1590***
	(0.0495)	(0.0706)	(0.0519)	(0.0136)	(0.0352)	(0.0598)	(0.0263)	(0.0456)	(0.0561)
Observations	11852	4985	7894	11842	4979	7887	11837	4973	7878
R2	0.0314	0.0435	0.0348	0.0195	0.0328	0.0317	0.0378	0.0287	0.0353
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (4) and (7) present the results for primary school students, columns (2), (5) and (8) for middle school students, and columns (3), (6) and (9) for high school students.

Table A.9 - Immediate Impact of Virtual/Hybrid classes on Mental Health in 2022 for Each Education Level

	General Health			Depression			Anxiety		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Virtual/Hybrid classes	0.0005	-0.0064	-0.0019	-0.0004	0.0069	-0.0070	0.0169	0.0056	0.0263
	(0.0091)	(0.0117)	(0.0113)	(0.0042)	(0.0135)	(0.0145)	(0.0113)	(0.0227)	(0.0222)
Constant	0.2393***	0.2162***	0.2658***	0.0561**	0.0682*	0.1433***	0.0409	0.1529**	0.1318***
	(0.0487)	(0.0712)	(0.0361)	(0.0264)	(0.0378)	(0.0273)	(0.0392)	(0.0657)	(0.0441)
Observations	12603	5733	9590	12593	5731	9568	12576	5724	9565
R2	0.0316	0.0307	0.0337	0.0228	0.0278	0.0323	0.0372	0.0276	0.0331
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (4) and (7) present the results for primary school students, columns (2), (5) and (8) for middle school students, and columns (3), (6) and (9) for high school students.

Appendix B - Summary Statistics and Tests' Results

Table B.1 - Summary Statistics

Variables	Mean	Std. dev.	Min	Max	N
General Health	4.559	0.689	1	5	53967
Depression	0.058	0.233	0	1	53846
Anxiety	0.120	0.325	0	1	53825
Parent 1 Employment	0.802	0.398	0	1	52037
Parent 2 Employment	0.853	0.355	0	1	44104
Parent 1 Education	6.184	1.927	1	9	54103
Parent 2 Education	5.804	2.097	1	9	44157
Parent 1 Marital Status	1.550	1.163	1	6	52076
Parent 2 Marital Status	1.232	0.738	1	6	44032
Mother's age	30.488	5.729	18	45	53081
Student's age	8.605	5.308	0	17	54103
Student's sex	0.516	0.500	0	1	54103

Notes: General Health is identified with 1 "poor", 2 "fair", 3 "good", 4 "very good", and 5 "excellent"; depression and anxiety are 0 if there is no depression/anxiety, while 1 signifies having depression/anxiety; parent employment is characterized by 0 if the parent was not employed on at least 50 out of the past 52 weeks, and 1 the parent was; for parental education the value 1 represents the 8th grade or less, 2 shows a 9th-12th grade with no diploma level, having High School Diploma or GED[12] completed is represented by value 3, 4 identifies those who completed a vocational, trade or business school program, the parents who have some College Credit but no degree answered 5, 6 identifies those parents with an Associate Degree, 7 those with Bachelor's Degree, 8 for the parents with a Master's Degree and 9 for Doctorate parents; for the parent marital status, 1 signifies married, 2 represents a parent that is not married but lives with a partner, 3 for those never married, 4 for the divorced ones, 5 for

[12] General Educational Development is an alternative program to high school, for those unable to complete high school level.

separated and 6 for the widowed ones; finally, for students' sex, value 0 represents females and 1 males.

Table B.2 - General Health Tabulation

General Health	Freq.	Percent	Description	Binary
1	66	0.122	"Poor"	0
2	600	1.112	"Fair"	0
3	3951	7.321	"Good"	0
4	13852	25.67	"Very Good"	1
5	35498	65.78	"Excellent"	1
Total	53967	100.00		

Notes: The table provides the summary of general health and the equivalent value when recodified to a binary variable.

Table B.3 - School Closures Summary

Variable	Mean	Std. dev.
Virtual/hybrid classes	0.522	0.296

Notes: The table provides the mean and standard deviation for the share of virtual and hybrid classes (treatment variable).

Table B.4 – Placebo Test in 2019 With and Without Controls

	General Health		Depression		Anxiety	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	-0.0076	-0.0104	-0.0101*	-0.0077	-0.0172**	-0.0232***
	(0.0087)	(0.0089)	(0.0052)	(0.0070)	(0.0083)	(0.0086)
Constant	0.1082***	0.1525***	0.0508***	-0.0646***	0.0955***	-0.0413***
	(0.0013)	(0.0113)	(0.0009)	(0.0080)	(0.0014)	(0.0113)
Observations	43432	34882	43387	34860	43407	34870
R2	0.0030	0.0275	0.0031	0.0446	0.0059	0.0316
Controls	No	Yes	No	Yes	No	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (3) and (5) present the coefficients for the placebo regression without controls, while columns (2), (4) and (6) present the ones with controls.

Table B.5 - Placebo Test in 2019 for Girls and Boys

	General Health		Depression		Anxiety	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	0.0005	-0.0211**	-0.0221**	0.0050	-0.0292**	-0.0207*
	(0.0139)	(0.0088)	(0.0098)	(0.0098)	(0.0132)	(0.0120)
Constant	0.0973***	0.1988***	-0.1000***	-0.0311***	-0.0924***	0.0046
	(0.0153)	(0.0142)	(0.0137)	(0.0109)	(0.0141)	(0.0150)
Observations	16670	18212	16668	18192	16664	18206
R2	0.0280	0.0320	0.0638	0.0312	0.0534	0.0211
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (3) and (5) present the estimations for girls, while columns (2), (4) and (6) present those for boys.

Table B.6 - Placebo Test in 2019 for Each Education Level

	General Health			Depression			Anxiety		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Virtual/Hybrid classes	-0.0056	-0.0204	-0.0026	0.0022	-0.0253	-0.0064	-0.0221	-0.0263	-0.0230
	(0.0110)	(0.0189)	(0.0149)	(0.0061)	(0.0166)	(0.0162)	(0.0150)	(0.0213)	(0.0176)
Constant	0.2544***	0.2494***	0.3318***	0.0475***	0.1062***	0.1384***	-0.0008	0.1138***	0.1054***
	(0.0423)	(0.0510)	(0.0443)	(0.0169)	(0.0349)	(0.0365)	(0.0239)	(0.0409)	(0.0355)
Observations	13785	7852	12523	13767	7853	12519	13765	7856	12530
R2	0.0367	0.0484	0.0323	0.0234	0.0365	0.0347	0.0316	0.0333	0.0312
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (4) and (7) present the results for primary school students, columns (2), (5) and (8) for middle school students, and columns (3), (6) and (9) for high school students.

Table B.7 – Parallel and Granger Tests for General Health, Depression and Anxiety

Outcomes	F-Statistic and P-Value		Outcomes	F-Statistic and P-Value	
General Health	F-Statistic	F(1,47) = 4.16	General Health	F-Statistic	F(3,47) = 2.87
	P-Value	0.047		P-Value	0.046
Depression	F-Statistic	F(1,47) = 0.18	Depression	F-Statistic	F(3,47) = 0.42
	P-Value	0.675		P-Value	0.737
Anxiety	F-Statistic	F(1,47) = 4.20	Anxiety	F-Statistic	F(3,47) = 1.78
	P-Value	0.046		P-Value	0.163

(a) Parallel Trends Test (b) Granger Test

Table B.8 - Parallel and Granger Tests for General Health, Depression and Anxiety for Girls

Outcomes	F-Statistic and P-Value		Outcomes	F-Statistic and P-Value	
General Health	F-Statistic	F(1,47) = 2.39	General Health	F-Statistic	F(3,47) = 2.25
	P-Value	0.129		P-Value	0.095
Depression	F-Statistic	F(1,47) = 1.15	Depression	F-Statistic	F(3,47) = 1.18
	P-Value	0.289		P-Value	0.328
Anxiety	F-Statistic	F(1,47) = 2.85	Anxiety	F-Statistic	F(3,47) = 1.54
	P-Value	0.098		P-Value	0.216

(a) Parallel Trends Test (b) Granger Test

Table B.9 - Parallel and Granger Tests for General Health, Depression and Anxiety for Boys

Outcomes	F-Statistic and P-Value		Outcomes	F-Statistic and P-Value	
General Health	F-Statistic	F(1,47) = 1.37	General Health	F-Statistic	F(3,47) = 0.62
	P-Value	0.248		P-Value	0.602
Depression	F-Statistic	F(1,47) = 0.32	Depression	F-Statistic	F(3,47) = 0.62
	P-Value	0.577		P-Value	0.607
Anxiety	F-Statistic	F(1,47) = 1.70	Anxiety	F-Statistic	F(3,47) = 1.35
	P-Value	0.199		P-Value	0.269

(a) Parallel Trends Test (b) Granger Test

Table B.10 - Parallel and Granger Tests for General Health, Depression and Anxiety for Primary School

Outcomes	F-Statistic and P-Value		Outcomes	F-Statistic and P-Value	
General Health	F-Statistic	F(1,47) = 3.91	General Health	F-Statistic	F(3,47) = 1.03
	P-Value	0.054		P-Value	0.388
Depression	F-Statistic	F(1,47) = 0.04	Depression	F-Statistic	F(3,47) = 0.34
	P-Value	0.833		P-Value	0.798
Anxiety	F-Statistic	F(1,47) = 0.64	Anxiety	F-Statistic	F(3,47) = 1.69
	P-Value	0.427		P-Value	0.182

(a) Parallel Trends Test (b) Granger Test

Table B.11 - Parallel and Granger Tests for General Health, Depression and Anxiety for Middle School

Outcomes	F-Statistic and P-Value		Outcomes	F-Statistic and P-Value	
General Health	F-Statistic	F(1,47) = 1.44	General Health	F-Statistic	F(3,47) = 2.50
	P-Value	0.236		P-Value	0.070
Depression	F-Statistic	F(1,47) = 0.31	Depression	F-Statistic	F(3,47) = 0.57
	P-Value	0.583		P-Value	0.640
Anxiety	F-Statistic	F(1,47) = 0.89	Anxiety	F-Statistic	F(3,47) = 0.23
	P-Value	0.350		P-Value	0.875

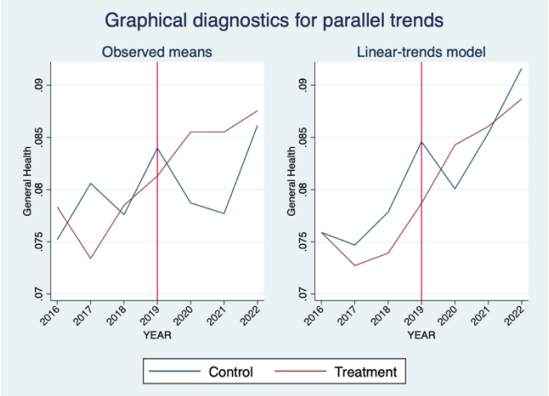
(a) Parallel Trends Test (b) Granger Test

Table B.12 - Parallel and Granger Tests for General Health, Depression and Anxiety for High School

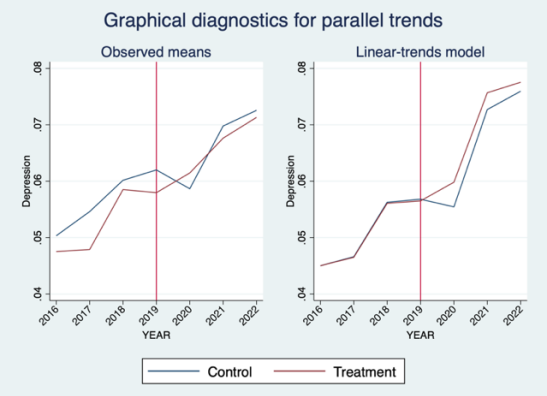
Outcomes	F-Statistic and P-Value		Outcomes	F-Statistic and P-Value	
General Health	F-Statistic	F(1,47) = 0.09	General Health	F-Statistic	F(3,47) = 0.64
	P-Value	0.764		P-Value	0.592
Depression	F-Statistic	F(1,47) = 0.15	Depression	F-Statistic	F(3,47) = 0.52
	P-Value	0.699		P-Value	0.670
Anxiety	F-Statistic	F(1,47) = 1.59	Anxiety	F-Statistic	F(3,47) = 1.15
	P-Value	0.213		P-Value	0.339

(a) Parallel Trends Test (b) Granger Test

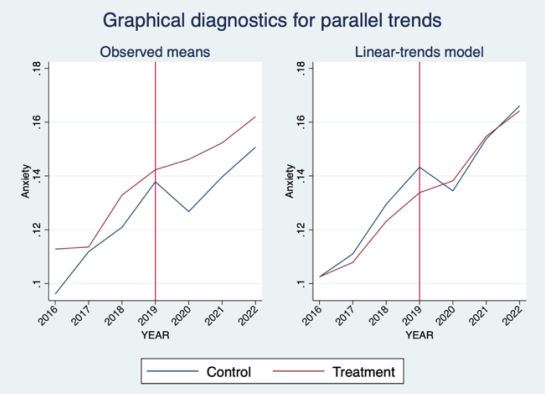
Figure B.1 - Parallel Trends With Controls



(a) General Health



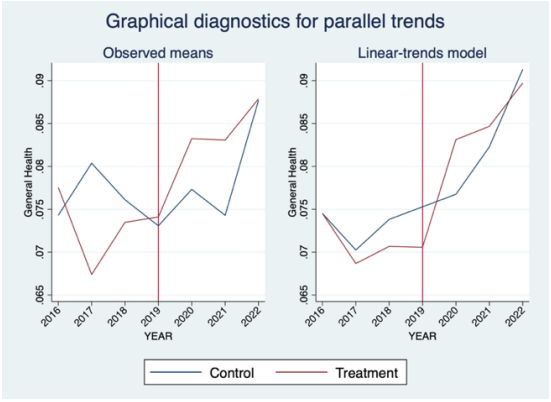
(b) Depression



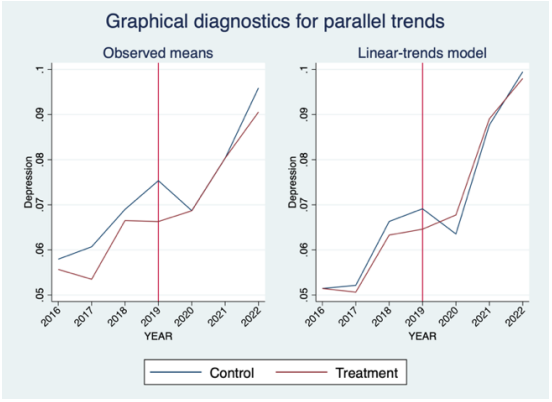
(c) Anxiety

Notes: The graphs on the left show the changes on the observed means throughout the years; the graphs on the right present the findings on the parallel trends test.

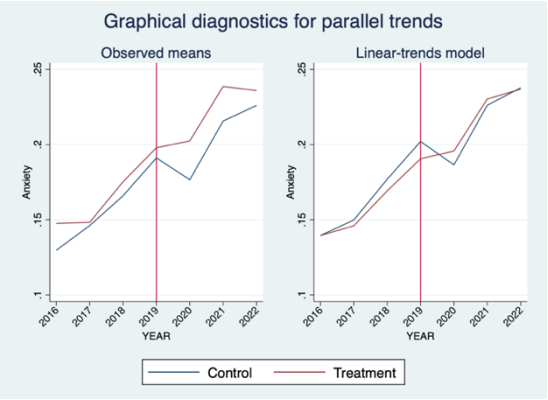
Figure B.2 - Parallel Trends for Girls



(a) General Health



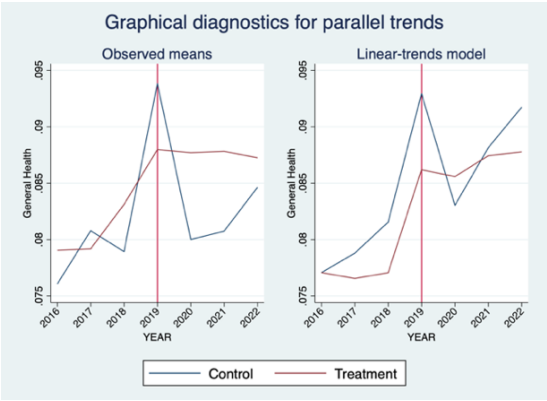
(b) Depression



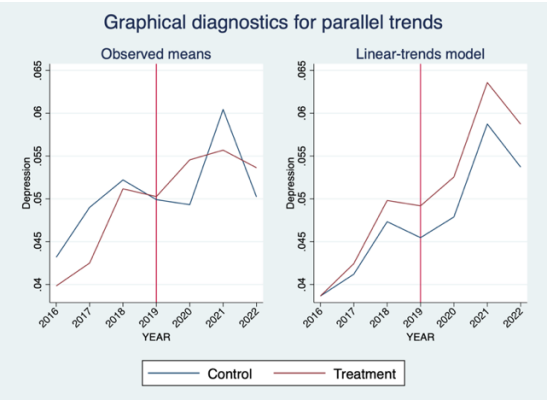
(c) Anxiety

Notes: The graphs on the left show the changes on the observed means throughout the years; the graphs on the right present the findings on the parallel trends test.

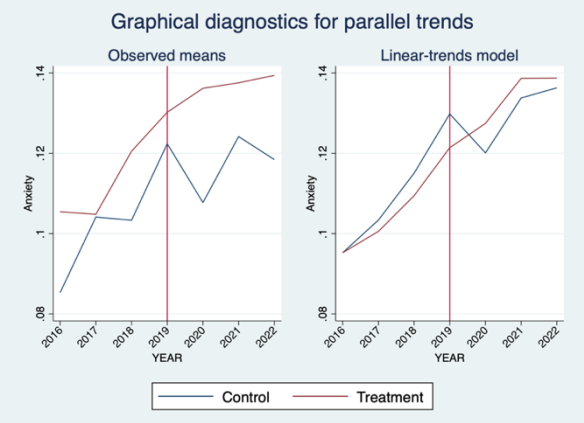
Figure B.3 – Parallel Trends for Boys



(a) General Health



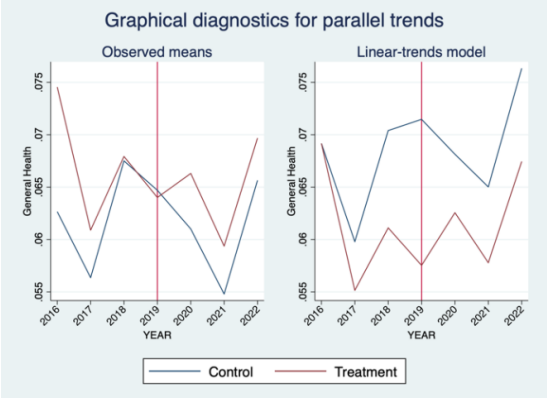
(b) Depression



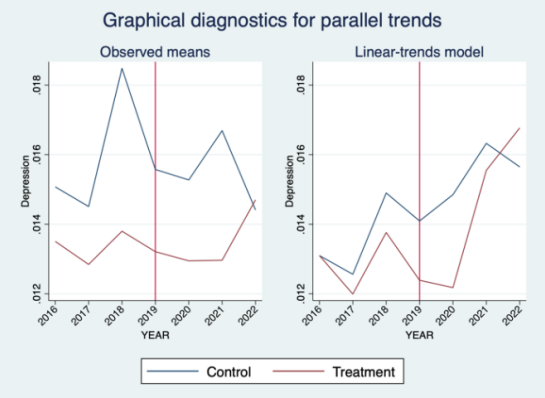
(c) Anxiety

Notes: The graphs on the left show the changes on the observed means throughout the years; the graphs on the right present the findings on the parallel trends test.

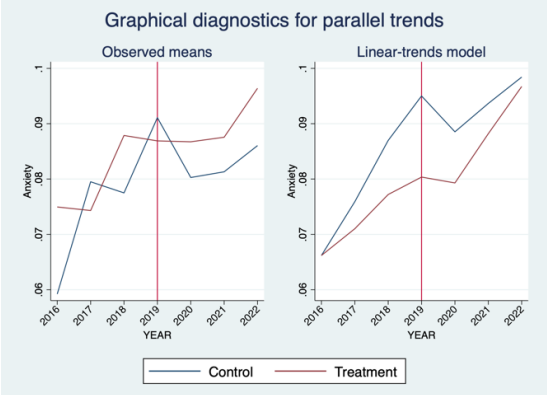
Figure B.4 - Parallel Trends for Primary Students



(a) General Health



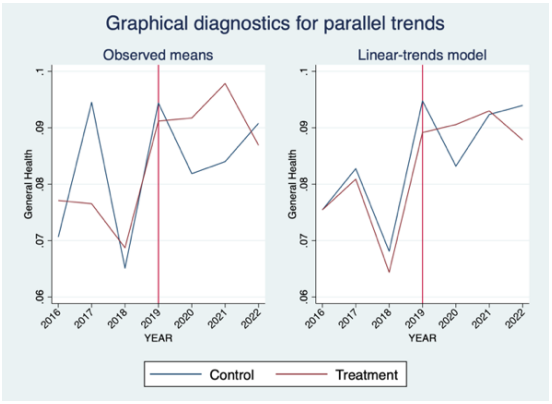
(b) Depression



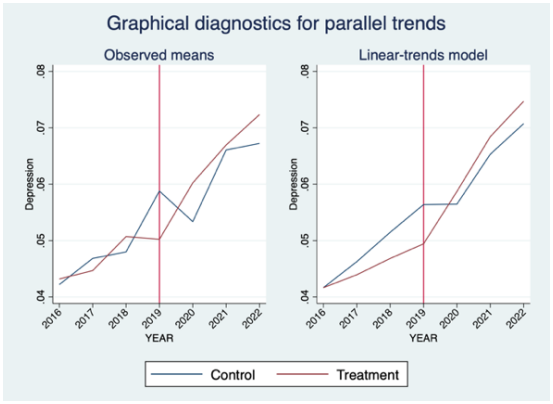
(c) Anxiety

Notes: The graphs on the left show the changes on the observed means throughout the years; the graphs on the right present the findings on the parallel trends test.

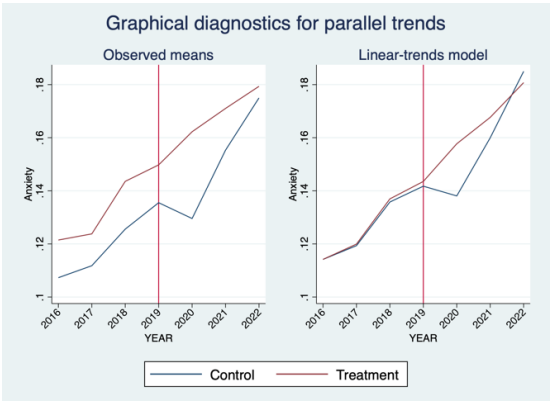
Figure B.5 - Parallel Trends for Middle School Students



(a) General Health



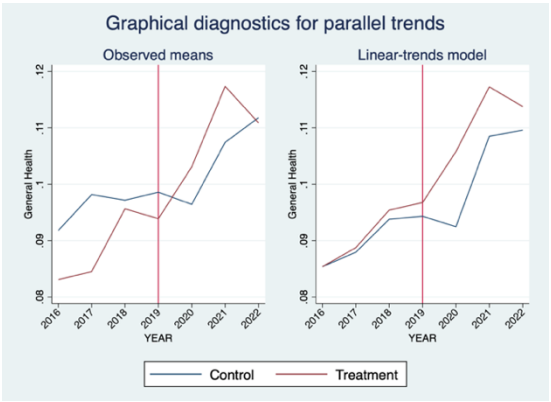
(b) Depression



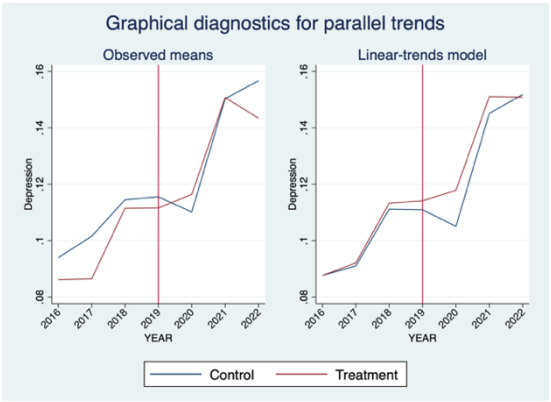
(c) Anxiety

Notes: The graphs on the left show the changes on the observed means throughout the years; the graphs on the right present the findings on the parallel trends test.

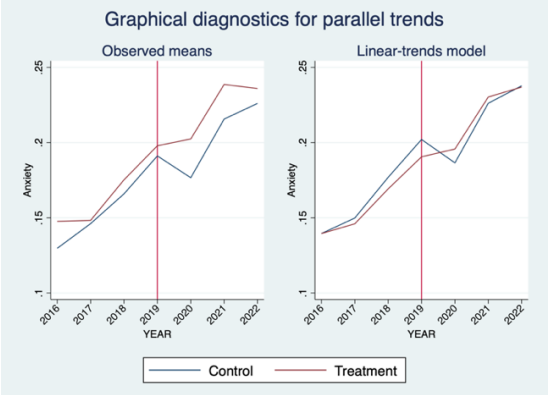
Figure B.6 - Parallel Trends for High School Students



(a) General Health



(b) Depression



(c) Anxiety

Notes: The graphs on the left show the changes on the observed means throughout the years; the graphs on the right present the findings on the parallel trends test.

Appendix C - Extra Results

The variables "behavior problems", "developmental delay" and "speech disorder" have a value of 0 if any doctor or health care provider ever told the parent that the child has behavior or conduct problems/developmental delay/speech disorder, and 1 if yes. "Professional treatment" represents any mental health professional treatment or counseling that the child received during the last 12 months from a professional. It has a value of 0 if no, and the child effectively did not need any treatment, 1 if no but the child needed, and 2 if yes. Again, as we did for general health, in order to transform the variable into a binary one, we analyzed the distribution between the three values and decided to turn into 0 values 0 and 1 as no need of treatment, and 1 for the value 2, as needing treatment. The variable "emotions behavior" identifies if, in the last 12 months, the child took any medication due to difficulties with their emotions, concentration, or behavior. The variable presents a value of 0 if no, and a value of 1 if yes. Lastly, "difficulties concentrating" show students' serious difficulty concentrating, remembering, or making decisions, with a value of 0 if no, and a value of 1 if yes.

The results show no effects on these outcomes besides a significant increase in behavior problems, with a coefficient of approx. 2 p.p. All the other coefficients show no significance

regarding the DiD with controls. This corroborates the premise that more exposure to virtual/hybrid classes does not have a significant impact on the overall K-12 students' mental health in the US.

Table C.1 - Virtual/Hybrid Classes on K-12 Students' Behavior Problems, Developmental Delay and Speech Disorder for 2020

	Behavior Problems		Devel. Delay		Speech Disorder	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	0.0078	0.0203**	-0.0011	0.0062	0.0047	0.0067
	(0.0093)	(0.0096)	(0.0078)	(0.0092)	(0.0080)	(0.0098)
Constant	0.0967***	0.1171***	0.0645***	0.0920***	0.0825***	0.0911***
	(0.0022)	(0.0167)	(0.0018)	(0.0155)	(0.0019)	(0.0148)
Observations	52475	40775	52431	40759	52459	40779
R2	0.0024	0.0274	0.0022	0.0156	0.0017	0.0128
Controls	No	Yes	No	Yes	No	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (3) and (5) present the coefficients without controls, while columns (2), (4) and (6) present those with controls.

Table C.2 - Virtual/Hybrid Classes on K-12 Students' Professional Treatment, Emotions Medication and Difficulties Concentrating for 2020

	Professional Treat.		Emotions Behavior		Dif. Concentrating	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	0.0045	0.0128	0.0036	0.0079	0.0050	0.0125
	(0.0084)	(0.0107)	(0.0073)	(0.0088)	(0.0085)	(0.0091)
Constant	0.1152***	0.0401*	0.1257***	0.0476***	0.1202***	0.1515***
	(0.0019)	(0.0224)	(0.0015)	(0.0168)	(0.0020)	(0.0174)
Observations	52370	40768	51982	40512	48606	37605
R2	0.0040	0.0380	0.0058	0.0376	0.0030	0.0271
Controls	No	Yes	No	Yes	No	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (3) and (5) present the coefficients without controls, while columns (2), (4) and (6) present those with controls.

Table C.3 - Virtual/Hybrid Classes on K-12 Students' Behavior Problems, Developmental Delay and Speech Disorder for 2021

	Behavior Problems		Devel. Delay		Speech Disorder	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	-0.0057	-0.0017	-0.0175**	-0.0119	0.0035	0.0094
	(0.0091)	(0.0086)	(0.0069)	(0.0092)	(0.0089)	(0.0121)
Constant	0.1099***	0.1267***	0.0545***	0.0793***	0.0720***	0.0803***
	(0.0021)	(0.0216)	(0.0014)	(0.0173)	(0.0016)	(0.0179)
Observations	53683	41717	53672	41722	53666	41719
R2	0.0026	0.0267	0.0019	0.0147	0.0017	0.0128
Controls	No	Yes	No	Yes	No	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (3) and (5) present the coefficients without controls, while columns (2), (4) and (6) present those with controls.

Table C.4 - Virtual/Hybrid Classes on K-12 Students' Professional Treatment, Emotions Medication and Difficulties Concentrating for 2021

	Professional Treat.		Emotions Behavior		Dif. Concentrating	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	-0.0162	-0.0111	-0.0094	-0.0103	0.0032	0.0066
	(0.0100)	(0.0104)	(0.0102)	(0.0112)	(0.0108)	(0.0108)
Constant	0.1182***	0.0124	0.1310***	0.0454**	0.1122***	0.1254***
	(0.0018)	(0.0184)	(0.0016)	(0.0176)	(0.0018)	(0.0204)
Observations	53578	41715	52943	41240	48251	37285
R2	0.0038	0.0439	0.0061	0.0446	0.0041	0.0288
Controls	No	Yes	No	Yes	No	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (3) and (5) present the coefficients without controls, while columns (2), (4) and (6) present those with controls.

Table C.5 - Virtual/Hybrid Classes on K-12 Students' Behavior Problems, Developmental Delay and Speech Disorder for 2022

	Behavior Problems		Devel. Delay		Speech Disorder	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	-0.0061	0.0016	-0.0045	-0.0010	0.0133	0.0132
	(0.0096)	(0.0099)	(0.0086)	(0.0108)	(0.0087)	(0.0098)
Constant	0.0944***	0.0647***	0.0575***	0.0617***	0.0720***	0.0421**
	(0.0015)	(0.0155)	(0.0016)	(0.0125)	(0.0016)	(0.0178)
Observations	57807	44962	57717	44901	57738	44915
R2	0.0025	0.0397	0.0020	0.0213	0.0016	0.0245
Controls	No	Yes	No	Yes	No	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (3) and (5) present the coefficients without controls, while columns (2), (4) and (6) present those with controls.

Table C.6 - Virtual/Hybrid Classes on K-12 Students' Professional Treatment, Emotions Medication and Difficulties Concentrating for 2021

	Professional Treat.		Emotions Behavior		Dif. Concentrating	
	(1)	(2)	(3)	(4)	(5)	(6)
Virtual/Hybrid classes	0.0074	0.0113	0.0005	0.0005	-0.0021	0.0042
	(0.0082)	(0.0104)	(0.0115)	(0.0130)	(0.0087)	(0.0087)
Constant	0.1065***	0.0033	0.1226***	-0.0001	0.1205***	0.1074***
	(0.0015)	(0.0196)	(0.0017)	(0.0163)	(0.0015)	(0.0156)
Observations	57630	44911	57011	44449	52540	40652
R2	0.0039	0.0442	0.0055	0.0434	0.0035	0.0302
Controls	No	Yes	No	Yes	No	Yes

Standard errors in parentheses
Source: Own Calculations
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Columns (1), (3) and (5) present the coefficients without controls, while columns (2), (4) and (6) present those with controls.