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COVID-19 and the Mental Health of Adolescents in British Columbia

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June 2023

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Abstract

We use linked individual-level data on school enrollment, physician services received, and prescription medications to measure the effect of the COVID-19 pandemic and associated disruptions on mental health treatment received by adolescents in British Columbia. We also investigate whether these effects are mediated by socioeconomic status and schooling mode. The results suggest substantial increases for non-Indigenous English home language girls in treatment for depression/anxiety, ADHD, eating disorders and other mental health conditions. Indigenous and non-English home language girls also show increases in treatment for depression/anxiety, and Indigenous girls show increases in treatment for ADHD. In contrast, boys show no change or even reductions in treatment for most mental health conditions. These effects vary somewhat by socioeconomic status, but we find no evidence that they vary substantially by schooling mode.

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1 Introduction

Isolation from face-to-face contacts, reduced access to school-based mental health and support services, limits on opportunities for physical activity and changes in exposure to home environments brought on by the global COVID-19 pandemic may have seriously undermined the mental health of children and youth. Poor mental health among children and youth is of direct concern because of the suffering that it entails and because even short-term mental health problems can have serious consequences in childhood and adolescence (Busch et al. 2014; Currie and Stabile 2009). Moreover, a majority of mental health disorders in adulthood begin before the age of 15 (Kim-Cohen et al. 2003; Kessler et al. 2001; 2007) and the effects of conditions like anxiety and depression on decision-making, risk-taking and preferences (Ridley et al. 2020) may alter students' pathways through school and work and are associated with undesirable adult outcomes including reduced earnings and well-being (Prinz et al. 2018).

This paper investigates the use of physician services and prescription medications to treat mental health disorders among adolescents before and during the COVID-19 pandemic. We use longitudinal student-level education records for the Grade 8-11 school-age population in British Columbia (B.C.), Canada, linked to physicians' billing records from the province's universal public health insurance system from September 2016 to March of 2021 and the universe of community pharmacy prescription medication dispensing events from September 2016 to August of 2021. We estimate event-study and before-after models for monthly physician services related to depression and anxiety, attention-deficit/hyperactivity disorders (ADHD), psychotic disorders, eating disorders, substance use disorders and conduct disorders, and for three categories of psychotropic medications commonly prescribed to treat mental health conditions in adolescents – antidepressant/anti-anxiety medications, stimulants and other medications commonly used for management of ADHD symptoms, and anti-psychotics.

Our work extends the small but growing literature that uses population health records to track mental health related interactions with the health care system among adolescents during the pandemic. Previous studies that use population health records to study changes in mental health treatment during the pandemic have investigated physician services related to overall mental health conditions, mood disorders, psychotic disorders, substance use disorders and neurodevelopmental problems in Ontario, Canada (Saunders et al. 2022), overall mental health care treatment (Hvide and Johnsen 2022), ADHD, anxiety, depression and sleep disorders (Evensen et al. 2022), and eating disorders (Surén et al. 2022) in Norway, eating disorders, autism, ADHD, panic disorders, hypochondriasis, anxiety disorders, anorexia nervosa, depressive disorders and bipolar disorders in Korea (Kim et al. 2022), and prescriptions for antidepressant medication in Australia (Costa et al. 2022) and antidepressant, anxiolytic/sedative-hypnotic, antipsychotic and stimulant medications in Manitoba, Canada (Leong et al. 2022). In general,

these studies have found higher than predicted levels of mental health care interactions beginning either at the onset of the pandemic or following periods of lock-down, and continuing through the end of 2020 and into 2021. Studies that provide separate analysis for males and females find little (Kim et al. 2022; Evensen et al. 2022; Saunders et al. 2022) or no (Costa et al. 2022) effect of the pandemic on physician services related to mental health among adolescent boys, but significant increases in some cases among girls.

Using the information provided in the linked education data, we extend this literature in several novel ways. First, previous studies have shown that mental health care use varies across groups defined by ethnicity and immigrant status.[2] We therefore analyze mental health trends separately for Indigenous students and for two groups of non-Indigenous students: those who speak English at home and those who speak a different language at home. Home language, ethnicity and immigrant status are likely correlated, but we are aware of no analysis of the mental health effects of the pandemic that investigates the role of any of these characteristics. Second, both the need for and access to mental health care may vary with socioeconomic status (SES). We therefore control for measures of neighborhood SES and explore the effects of the pandemic on mental health care interactions across quartiles of the neighborhood SES distribution. Finally, differences in learning modes adopted by school districts when lock-downs ended may have implications for the socialization and stress that adolescents encountered during the pandemic. Compared to full-time in-person instruction, hybrid learning (i.e., a combination of in-person and remote (online) instruction) may involve loss of regular routine, reduced social contact with peers (for better or for worse) and increased demands on self-motivation and self-regulation.[3] Following a period of school closure in spring of 2020, most B.C. students returned to full-time in-person learning in September, but many school districts implemented hybrid learning models in some high school grades. We use this variation to study the potentially mediating role of learning modes on mental health trends during the pandemic. To our knowledge, only one previous study has investigated the potential role of hybrid learning, in a more limited context.[4]

[2] Gadermann et al. (2022) find that first-generation immigrant and refugee children in British Columbia had the lowest mental health diagnostic prevalence rates during the pre-COVID period, followed by second-generation immigrants and refugees. A large body of evidence shows that native-born Caucasians in high income countries are much more likely to access the mental health care system than other groups, with the lowest prevalence rates among self-identified Asians and first-generation immigrants (e.g., Abe-Kim et al. 2007; Cook et al. 2017; Georgiades et al. 2018). Clinically significant cases of mental illness may go undiagnosed when parents, teachers or physicians fail to recognize children's needs or because of constraints on information, time, or availability of care, or because of stigma or discrimination (Bharadwaj et al. 2017; Thornicroft et al. 2017).

[3] Previous research finds that both adolescents diagnosed with ADHD and their parents have reported students having difficulty engaging in remote learning during the pandemic (Becker et al. 2020; Sibley et al. 2021).

[4] Svaleryd et al. (2021) compare the change in services of psychiatric specialists and prescriptions for psychotropic medication during COVID among students at Swedish upper secondary schools, which closed for three months at

Like previous authors, we find strikingly different results for adolescent girls versus boys. Following a period of dramatic decline in the early months of the pandemic among both sexes, physician services and prescription medications related to mental health disorders generally recovered to previous levels among boys but did not increase relative to pre-pandemic trends. This pattern holds across all three sub-groups of boys that we study, despite very different patterns in the period preceding the pandemic. The picture for adolescent girls is very different. We find that physician services related to depression and anxiety increased among girls from all three ethnic and language categories and in all socioeconomic quartiles, and these increases were followed several months later by increases in prescriptions for antidepressants and anti-anxiety medications. The magnitude of the increase in physician visits was about 10% of the of the pre-COVID baseline. This group of disorders accounted for about 80% of mental health-related physician services among girls in the years immediately preceding the pandemic, so this increase implies a substantial increase in mental health service use. The magnitude of the increase in prescriptions for antidepressants and anti-anxiety medications was about 5% of the pre-COVID baseline.

In contrast to the results for depression and anxiety, results for the remaining diagnostic categories are notably different among girls from English versus non-English home language families. Among English home language girls, we find striking and precisely estimated increases in physician services related to ADHD, psychotic disorders, conduct disorders and eating disorders and in prescriptions for medications used to treat depression and anxiety, for medications commonly used to treat ADHD and for anti-psychotics. The estimated magnitudes of these increases in physician visits are moderate to large, ranging from about 15% of the pre-COVID baseline in the case of psychotic conditions to about two-thirds in the case of conduct disorders. The estimated magnitude of the increase in prescriptions for medications commonly used to treat ADHD is about 10% of the pre-COVID baseline for this group and the increase in prescriptions for anti-psychotics is about 20%. Among non-English home language girls, we estimate precise zero or negative effects in each case. Among Indigenous girls, the most pronounced change is a substantial increase in physician services related to ADHD – about 30% of the pre-COVID baseline - that is followed in late 2020 by an increase in prescriptions to treat ADHD. In the case of other disorders and prescription medications, effects for Indigenous girls tend to be small and somewhat imprecisely estimated.

the onset of the pandemic, reopened full-time in the fall, and moved to hybrid classes from January through March of 2021, to those of students at lower secondary schools, which remained open full-time throughout the period. They find that specialist mental health contacts and medication use fell among both groups relative to trend, but more so among students who experienced school closures. This relative decline persisted into 2021, when upper secondary schools were offering hybrid learning.

When we allow the effects of the pandemic in these statistically significant cases to vary by socioeconomic status, we see relatively large increases in physician services among high SES girls in cases where high SES girls were already more likely to receive treatment in the pre-COVID period, i.e., ADHD and eating disorders among English home language girls and depression and anxiety among non-English home language girls. We also find that the tendency for low-SES girls to be disproportionately prescribed anti-psychotics increased during the pandemic.

Finally, we find no evidence that the statistically significant increases in physician services and prescriptions that we observe among some groups of girls were different for those who attended hybrid versus face-to-face school programs.

2 Data sources and restrictions

We use student-level administrative data from annual sets of three linked files: school enrolment records maintained by the B.C. Ministry of Education and Childcare,[5] records of physician billing under B.C.'s universal Medical Services Plan (MSP),[6] and prescription medication dispensing records maintained under B.C.'s Pharmanet system.[7] We accessed anonymized extracts of these data files via Population Data B.C.'s Secure Research Environment (https://www.popdata.bc.ca). The extracts we use here include Ministry of Education records from the 2016/17 through 2020/21 school years, MSP records from September 2016 through March 2021 and Pharmanet records from September 2016 through August 2021. We link student-level records across files using a unique Study ID that is included in each file.

The Ministry of Education[8] file includes a small set of demographic characteristics – birth month and year, gender, language spoken at home, British Columbia residency, Aboriginal self-identification (for which we use the term Indigenous), First Nations on-reserve residency, district and school attended, grade, and program information (i.e., Special Needs, English as a Second Language and French Immersion) for each year the student is enrolled in a private or public school in B.C. We link neighborhood socioeconomic characteristics to each record using the student's postal code.[9]

[5] British Columbia Ministry of Education. K-12 Student Demographics and Achievements V03. Data Innovation Program, Province of British Columbia. Data Extract. 2021.
[6] British Columbia Ministry of Health. Medical Services Plan (MSP) Payment Information File V03. Data Innovation Program, Province of British Columbia. Data Extract. 2021.
[7] British Columbia Ministry of Health. Pharmanet V02. Data Innovation Program, Province of British Columbia. Data Extract. 2021.
[8] The Ministry of Education and Childcare was known as the Ministry of Education during the time period covered by our data.
[9] British Columbia Ministry of Education. K to 12 Socio Economic (SES) Index V01. Data Innovation Program, Province of British Columbia. Data Extract. 2021.

All B.C. residents are required to enroll in MSP, which covers the cost of all medically necessary services provided or ordered by a registered physician. Each insured individual has a unique Personal Health Number that is used for billing purposes (Government of British Columbia 2022a). The MSP file used in this study includes a record for each insured service provided to a covered individual, except for those related to workplace injuries that are covered by the B.C. Workers' Compensation Program. Physicians may bill outside the MSP system but may not charge more than the MSP prescribed rate for services; patients who pay these doctors directly may apply for reimbursement at the MSP rate (Government of British Columbia 2022b). Physicians who are reimbursed under an alternative payment plan (i.e., not fee-for-service) are required to submit the same documentation as fee-for-service physicians. All of these services are captured in our data. The MSP records include the date of service, specialty of the physician delivering the service, a billing code for the type of service provided, a diagnostic code based on the ICD-9 classification system, delivery location and additional information related to billing.

Pharmanet is a province-wide network that, since 1995, has linked all B.C. community (as opposed to hospital or institution-based) pharmacies to a central data system. Every prescription medication dispensed by a community pharmacy in B.C. must be recorded on the Pharmanet system. Prescription medications dispensed in hospitals or residential treatment facilities are not captured in the Pharmanet records (Government of British Columbia 2022b). The Pharmanet records include the date the prescription was dispensed, the drug name and drug identification number (DIN), the dosage and the number of days supplied.

Our primary outcome variables are indicators of whether a student received mental health-related physician services (in the MSP data) or filled a mental health-related prescription (in the Pharmanet data) during a given month or academic (September to August) year. We define a physician service reported in the MSP data as mental health-related if the reported ICD-9 diagnostic code is associated with "organic psychotic conditions", "other psychoses", or "neurotic disorders, personality disorders and other non-psychotic mental disorders" or if the reported Ministry of Health code is associated with "Anxiety/depression". We identify mental health-related prescription medications using a list of DIN codes associated with all antidepressant, anti-psychotic, sedative and anxiolytic drugs that were dispensed to children aged 5-19 in B.C. between 2009/10 and 2020/21. This list was prepared by the B.C. Ministry of Health from Pharmanet data and drug categories. To this list we add medications approved for use in Canada for the treatment of ADHD in children. See Appendix A for details.

An important limitation of our data is that we do not observe mental health services provided by psychologists, counsellors, or social workers, whose services are not covered by MSP. However, any course of treatment requiring prescription medication will involve a physician, and both family physicians

and psychiatrists often play a role in both the initial diagnosis and subsequent management of mental health conditions.

3 Pre-COVID patterns

We begin our analysis by identifying cross-sectional relationships among key variables during a period that predates the beginning of the COVID pandemic in early 2020. These patterns and relationships are of direct interest and will also inform our methodology for measuring the impact of COVID.

Table 1 presents descriptive statistics for key student characteristics (measured annually) during the pre-COVID period, from the beginning of the 2016/17 (September to August) school year to the end of the 2018/19 school year, as well as the cross-sectional relationship between those characteristics and our annual measures of mental health care interactions. The first column provides population shares for each characteristic. As one would expect, students in our data are roughly evenly distributed by age-appropriate grade (i.e., the grade the student would normally be enrolled in based on date of birth) and gender. Just over 12% of students self-identify as Indigenous (almost all Indigenous-identifying students in B.C. speak English at home) and just over 63% of students live in non-Indigenous families that speak English at home. The next largest home language group is Chinese (6.5% of all students), followed by Punjabi (5.4%). The remaining 12.7% of students report one of dozens of other home languages.

Table 1: Student characteristics and mental health services, pre-COVID (2016/17 through 2018/19).

Sub-population	% of total	Annual % receiving treatment	
		Physician service	Prescription filled
All students	100.0	14.4	9.2
Grade (age)			
8 (age 13)	25.0	11.8	6.9
9 (age 14)	25.0	13.8	8.4
10 (age 15)	25.0	15.4	10.0
11 (age 16)	25.0	16.8	11.6
Gender			
Female	48.6	16.3	10.2
Male	51.4	12.7	8.3
Language/cultural identity			
Indigenous	12.3	22.5	15.4
Non-Indigenous by home language			
English	63.2	15.7	10.4
Chinese	6.5	6.1	2.3
Punjabi	5.4	6.8	2.6
Other	12.7	7.7	3.5

Population consists of annual observations on B.C. resident students ages 13-16 on December 31 of the current academic year. Annual percent receiving treatment is based on services received or prescriptions filled between September and August of the current academic year.

The remaining columns in Table 1 report the average share of students for whom at least one mental health-related physician service was billed to MSP during a given school year and the average share who filled at least one mental health-related prescription. On average, 14.4% of students received a mental

health-related physician service at least once in a given year. A smaller share (9.2%) filled a mental health-related prescription. The share receiving a mental health-related physician service is higher among older students, rising from 11.8% for those in the grade 8 age group to 16.8% in grade 11, while the share filling a mental health-related prescription rises from 6.9% in the grade 8 age group to 11.6% in grade 11.

Gender and cultural background both play large roles in whether students receive mental health treatment. The share of students receiving a mental health-related physician service was greater among girls than boys (16.3% of girls versus 12.7% of boys), as was the share filling a mental health-related prescription (10.2% of girls versus 8.3% of boys). Indigenous students in our data are substantially more likely than non-Indigenous English home language students to receive a mental health-related physician service (22.5% versus 15.7%) and to fill a mental health-related prescription (15.4% versus 10.4%). The share of students receiving mental health treatment is strikingly lower among non-English-speaking non-Indigenous families. For example, only 6.1% of students from Chinese-speaking families and 6.8% of students from Punjabi-speaking families receive a mental health-related physician service, compared to 15.7% of students from English-speaking families. These differences are even greater for mental health-related prescriptions: for example, only 2.3% of Chinese home language students and 2.6% of Punjabi home language students, compared to 10.4% of non-Indigenous English home language students.

We further characterize the pre-COVID baseline by disaggregating the physician service data according to the diagnostic category associated with each record. Table 2a shows that the most frequently observed mental health diagnostic category is depression and anxiety (overall, 10% of students have at least one physician record with this diagnostic code in an average year), followed by ADHD (3.7%), psychotic disorders (1.9%), conduct disorders (0.7%), substance use disorders (0.7%) and eating disorders (0.3%). Table 2b shows that prescription rates were highest for antidepressants/anti-anxiety medications (6.4%), followed by medications commonly used to treat ADHD (3.6%) and anti-psychotics (1.3%). Note that there is not a simple mapping between medications and diagnostic categories, as a given medication may be used to treat multiple conditions and multiple medications may be used to treat a given condition. Treatment for all categories of mental health disorders is more frequent in higher grades in most cases, with ADHD and conduct disorders being notable exceptions where treatment is less frequent among older students.

Gender and cultural background also have differential impacts across diagnostic categories and groups of medications. Girls are almost twice as likely as boys to receive a physician service related to a diagnosis of depression/anxiety (13.2% of girls versus 6.9% of boys) and to fill a prescription for an antidepressant or anti-anxiety medication (8.7% of girls versus 4.3% of boys) and are more than six times as likely to receive a physician service related to an eating disorder (0.6% of girls versus <0.1% of boys). Boys are

more than twice as likely as girls to receive a physician service related to ADHD (5.1% of boys versus 2.2% of girls) and to fill a prescription for an ADHD-related medication (4.8% of boys versus 2.2% of girls). Indigenous students have the highest frequencies of physician services related to all categories of mental health conditions except eating disorders. Among non-Indigenous students, English home language students are at least twice as likely to receive a mental health-related physician service in every diagnostic category and are more than three times as likely to fill a mental health-related prescription as those who speak another language at home.

Table 2a: Share of students receiving mental health-related physician services in a given school year by condition, pre-COVID (2016/17 through 2018/19).

Sub-population	**Annual % receiving physician services**						
	Depression/ Anxiety	**ADHD**	**Psychosis**	**Conduct**	**Substance**	**Eating**	**Other**
All students	10.0	3.7	1.9	0.7	0.7	0.3	1.8
Grade (age)							
8 (age 13)	7.0	4.1	1.5	0.8	0.3	0.2	1.4
9 (age 14)	9.2	3.9	1.8	0.7	0.6	0.3	1.7
10 (age 15)	11.0	3.5	2.1	0.6	0.8	0.4	1.9
11 (age 16)	12.6	3.2	2.2	0.6	1.0	0.4	2.1
Gender							
Female	13.2	2.2	2.0	0.5	0.7	0.6	2.2
Male	6.9	5.1	1.9	0.8	0.6	<0.1	1.4
Language/cultural identity							
Indigenous	15.5	6.0	3.3	1.4	2.1	0.3	2.8
Non-Indigenous by home language							
English	10.9	4.1	2.1	0.7	0.6	0.4	1.8
Chinese	4.2	1.0	1.0	0.2	0.1	0.2	1.0
Punjabi	4.6	1.0	0.6	0.4	0.3	0.1	1.2
Other	5.2	1.6	1.0	0.3	0.3	0.2	1.2

Population consists of annual observations of B.C. resident students ages 13-16 on December 31 of each academic year. Annual percent receiving physician services is based on mental health-related physician services received between September and August in that academic year. See Appendix A for definitions of diagnostic categories.

Table 2b: Share of students filling mental health-related prescriptions by drug category, pre-COVID (2016/17 through 2018/19).

Sub-population	Annual % filling prescriptions		
	Antidepressant and related	ADHD-related	Antipsychotic
All students	6.4	3.6	1.3
Grade (age)			
8 (age 13)	3.7	3.9	0.9
9 (age 14)	5.5	3.7	1.1
10 (age 15)	7.3	3.5	1.4
11 (age 16)	9.2	3.3	1.7
Gender			
Female	8.7	2.2	1.4
Male	4.3	4.8	1.2
Language/cultural identity			
Indigenous	10.7	6.1	2.7
Non-Indigenous by home language			
English	7.3	4.1	1.3
Chinese	1.5	0.8	0.3
Punjabi	1.9	0.7	0.3
Other	2.5	1.2	0.5

Population consists of annual observations of B.C. resident students ages 13-16 on December 31 of current academic year. Annual percent filling prescriptions is based on mental health-related prescriptions filled between September and August of the current academic year. See Appendix A for definitions of prescription categories.

The clear heterogeneity by gender and cultural background in rates of mental health treatment suggests that COVID impacts on treatment may exhibit similar heterogeneity. We therefore conduct our main analysis by subpopulations defined by gender and cultural background (pooling Chinese/Punjabi/Other home language students). In addition, depression/anxiety and ADHD account for a large proportion of mental health treatment among adolescents, and gender and age patterns differ substantially for these two conditions. For this reason, our main analysis treats each broad diagnostic and drug category separately.

4 COVID impacts

In order to investigate patterns of mental health care interactions during the pandemic, we turn to monthly measures of physician visits and prescriptions filled. Changes in these measures will reflect both changes on the extensive margin (i.e., the number of students entering into and exiting treatment) and changes on the intensive margin (i.e., the frequency of services among those who are in treatment). The monthly time series plot of the monthly share of students receiving mental health-related physician services through March 2021 in Figure 1a shows several clear patterns that will inform our formal analysis of COVID impacts. During the pre-COVID period, the series shows an upward trend over time and a repeating monthly pattern, with the share receiving mental health-related physician services typically rising over the school year to a May peak, followed by a substantial decline during the summer months. This pattern then restarts in September as each cohort of students progresses to the next grade. The predicted values from a regression of this series on monthly indicators and a linear trend (estimated from data through January 2020) shown alongside the raw data in Figure 1a have a close within-sample fit to the actual values but

deviate substantially from their predicted values starting in February 2020. Instead of the usual seasonal rise in spring of 2020, mental health-related physician services declined during these early COVID months. Mental health-related physician services returned to normal seasonal rates at the end of the summer followed by a steep and ongoing increase relative to predicted values through March 2021, when our data series ends.

Figure 1a. Actual and predicted monthly percent receiving mental health-related physician services, September 2016 to March 2021. Predicted values are based on regression fit to observations through January 2020.

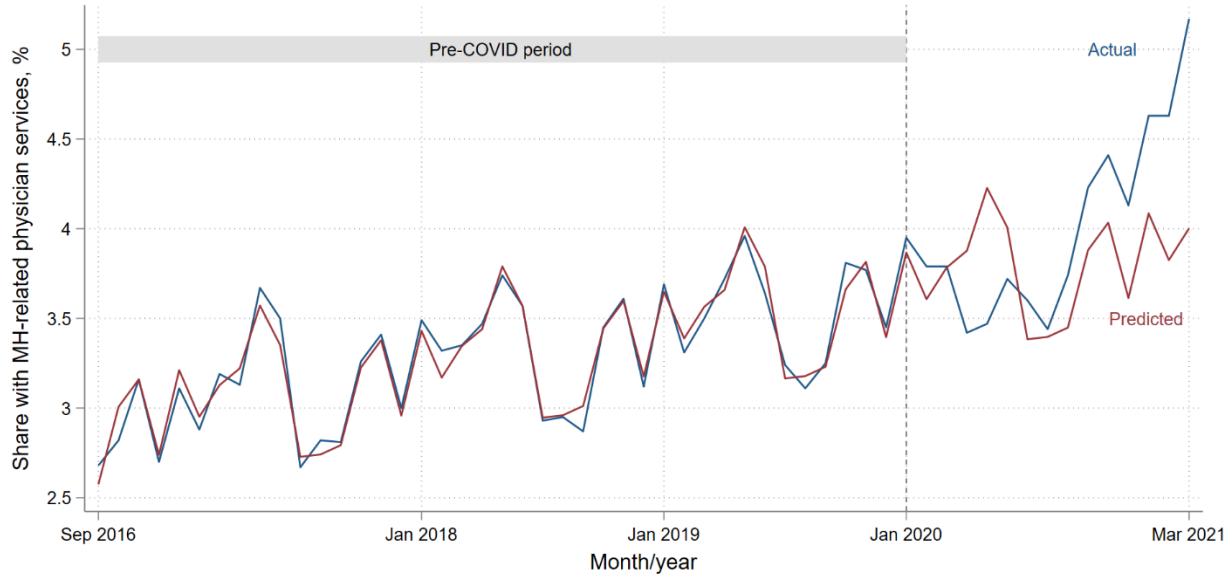
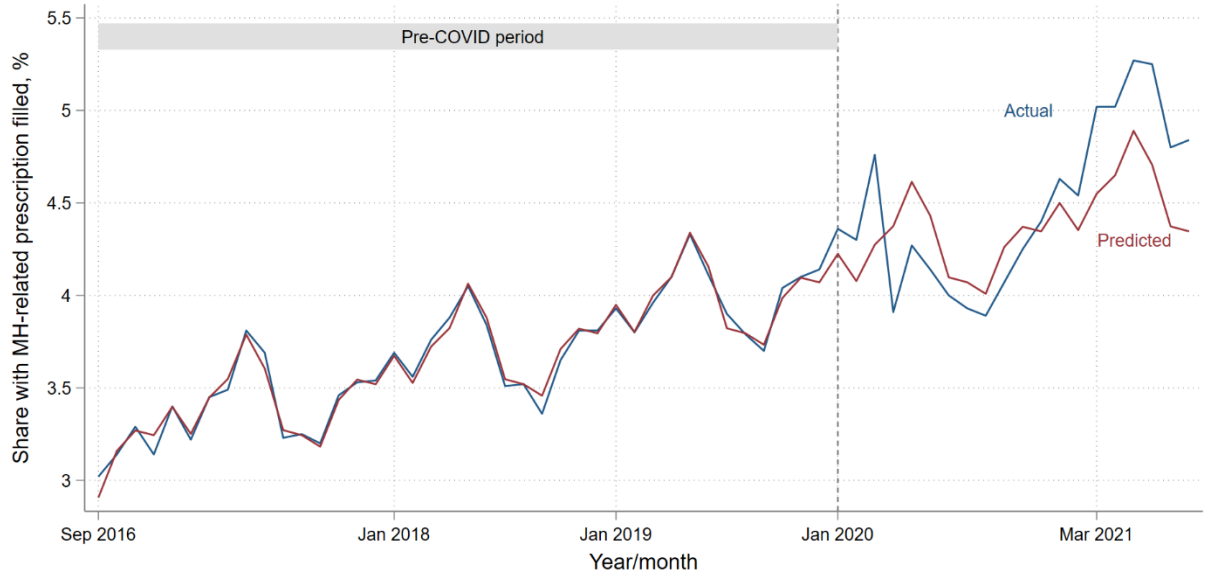


Figure 1b. Actual and predicted monthly percent filling mental health-related prescriptions, September 2016 to August 2021. Predicted values are based on regression fit to observations through January 2020.



Corresponding plots for the share of students filling a mental health-related prescription in Figure 1b show similar patterns through March 2021, and continue to rise through August 2021, the final month of our prescription data.[10] Mental health-related prescriptions were slightly above predicted rates in January and February 2020, followed by a pronounced spike in March 2020 that suggests that individuals may have been filling prescriptions in anticipation of pandemic-related disruptions. Prescriptions remained below predicted rates through the summer and then began to rise, exceeding predicted rates by late fall and remaining above-trend through August 2021.

4.1 Main results

We begin by estimating a simple before/after regression model:

$$y_{it} = \beta \times 1(e_t > 0) + \mu_{m(t)} + \lambda t + \alpha X_{it} + \epsilon_{it} \quad (1)$$

where y_{it} is an indicator that student i received a mental health treatment during month t, e_t indicates event time relative to January 2020, $\mu_{m(t)}$ is a set of month fixed effects, λt is a monthly time trend, and X_{it} is a set of student-level covariates that includes age-appropriate grade (i.e. the grade the student would normally be enrolled in based on date of birth), neighborhood SES quartile, and birth quarter.[11] The parameter β captures the average difference in the monthly frequency of the outcome variable relative to the pre-COVID average, net of seasonal effects and a linear trend and conditional on covariates. For example, a positive value indicates that the initial decline in outcomes relative to predicted rates in the early months of COVID was more than offset by subsequent increases. We interpret β as a broadly defined "COVID effect" inclusive of changes to both the social environment and health care access occurring after January 2020.

[10] The mental health services and mental health prescriptions series track one another quite closely, with more students filling a prescription than receiving physician services in a given month. Similar patterns can be observed when we disaggregate by diagnostic or drug category, though the steepness of the trend and timing of the seasonal peaks varies somewhat across categories.

[11] The inclusion of birth quarter as a control is motivated by the well-documented relative age effect in ADHD diagnoses (Evans et al. 2010; Furzer et al. 2022), and by evidence that being younger in grade is associated with reduced life satisfaction, lower self-esteem, reduced confidence in abilities, peer problems and increased internalizing symptoms (Thompson et al. 2004; Crawford et al. 2011; Patalay et al. 2015; Fumarco and Baert 2019). We find that none of the relative age effects in our regression models are statistically significant.

Table 3a: COVID effect on mental health-related physician services by sub-population.

Sub-population	COVID effect on monthly % receiving physician services					
	Depression/ Anxiety	**ADHD**	**Psychosis**	**Conduct**	**Substance**	**Eating**
Girls						
Indigenous	0.01	0.20***	0.00	0.04*	-0.08**	0.04
	(0.14)	(0.05)	(0.05)	(0.02)	(0.04)	(0.03)
Non-indigenous by home language						
English	0.26***	0.08***	0.05***	0.04***	0.00	0.05***
	(0.05)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
Non-English	0.17***	0.01	0.00	0.00	-0.01	0.00
	(0.05)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
Boys						
Indigenous	-0.21**	0.01	0.00	0.04	-0.09***	
	(0.09)	(0.07)	(0.05)	(0.03)	(0.03)	
Non-indigenous by home language						
English	-0.10***	0.00	-0.01	0.02***	-0.02**	
	(0.04)	(0.03)	(0.02)	(0.01)	(0.01)	
Non-English	0.05	0.00	0.01	0.00	0.00	
	(0.04)	(0.02)	(0.02)	(0.01)	(0.01)	
	Pre-COVID mean of monthly % receiving physician services					
All students	2.05	0.71	0.34	0.10	0.08	0.08

*Top panel reports coefficient on post-COVID indicator; control variables include time trend and indicators for month, grade, neighborhood SES quartile, and birth quarter. Estimation sample includes observations through March 2021. Eating disorder results are not reported for boys due to limited variation in the dependent variable. Standard errors clustered by student in parentheses. *** = 1%, ** = 5%, * = 10%. Bottom panel reports share of all students with mental health related physician service in the current month, September 2016 through August 2019.*

Tables 3a and 3b show our main before/after results, where we report coefficients in percentage points and standard errors are clustered by student.[12] Four key results are immediately apparent. First, a pronounced increase in the frequency of physician services related to ADHD among Indigenous girls was almost twice as large as the increase among English home language girls. Second, increases in mental health services among non-Indigenous English home language girls include statistically significant increases in physician services related to depression and anxiety disorders, ADHD, psychotic disorders, conduct disorders and eating disorders, and an increase in prescriptions for anti-psychotics. Third, increases in mental health services among non-Indigenous "other" home language girls were statistically significant only in the case of physician services related to depression and anxiety. In other cases, we obtain fairly precise zero estimates. Fourth, the frequency of mental health-related physician services or prescriptions filled among boys show essentially no increase in any category. In a number of cases, the decline among boys at the onset of the pandemic is not fully offset by the end of the period of observation, resulting in negative and statistically significant estimates. The sole exception is a

[12] We do not report results for physician services associated with diagnoses in our "other" category because the wide range of conditions in this category make results difficult to interpret. We do not report results for physician services related to eating disorders among boys because of its extremely low pre-COVID baseline in this group.

before/after increase in physician services related to conduct disorders among English home language boys. Relative to the pre-COVID mean values of each dependent variable, shown in the bottom rows of Tables 3a and 3b, the estimated COVID increases tend to be moderate in size.[13]

Table 3b: COVID effect on mental health-related prescriptions filled by sub-population.

Sub-population	COVID effect on monthly % filling prescriptions		
	Antidepressant and related	**ADHD-related**	**Antipsychotic**
Girls			
Indigenous	0.06	0.13	0.04
	(0.18)	(0.10)	(0.09)
Non-indigenous by home language			
English	0.19***	0.07**	0.10***
	(0.07)	(0.03)	(0.03)
Non-English	0.01	-0.05**	0.03
	(0.06)	(0.02)	(0.02)
Boys			
Indigenous	-0.14	-0.09	0.05
	(0.13)	(0.14)	(0.09)
Non-indigenous by home language			
English	-0.07	-0.20***	0.02
	(0.05)	(0.05)	(0.03)
Non-English	0.04	-0.06*	-0.02
	(0.04)	(0.03)	(0.02)
	Pre-COVID mean of monthly % filling prescriptions		
All students	2.31	1.50	0.53

*Top panel reports coefficient on post-COVID indicator; control variables include time trend and indicators for month, grade, neighborhood SES quartile and birth quarter. Estimation sample includes observations through August 2021. Standard errors clustered by student in parentheses. *** = 1%, ** = 5%, * = 10%. Bottom panel reports share of all students with mental health related prescription in the current month, September 2016 through August 2019.*

The before/after estimator provides clear evidence of an increase during COVID for cases where post-COVID services/prescriptions increased enough to fully offset the decline that took place during the early months of the pandemic. However, it may miss cases of interest if an increase began sufficiently late in the period of observation that it did not fully offset the decline in the early months of the pandemic. In these cases, a positive overall effect may be missed due to truncation of the data series in March 2021 (for the MSP data) or August 2021 (for the Pharmanet data). In order to detect these potential cases, we estimate an event-study model:

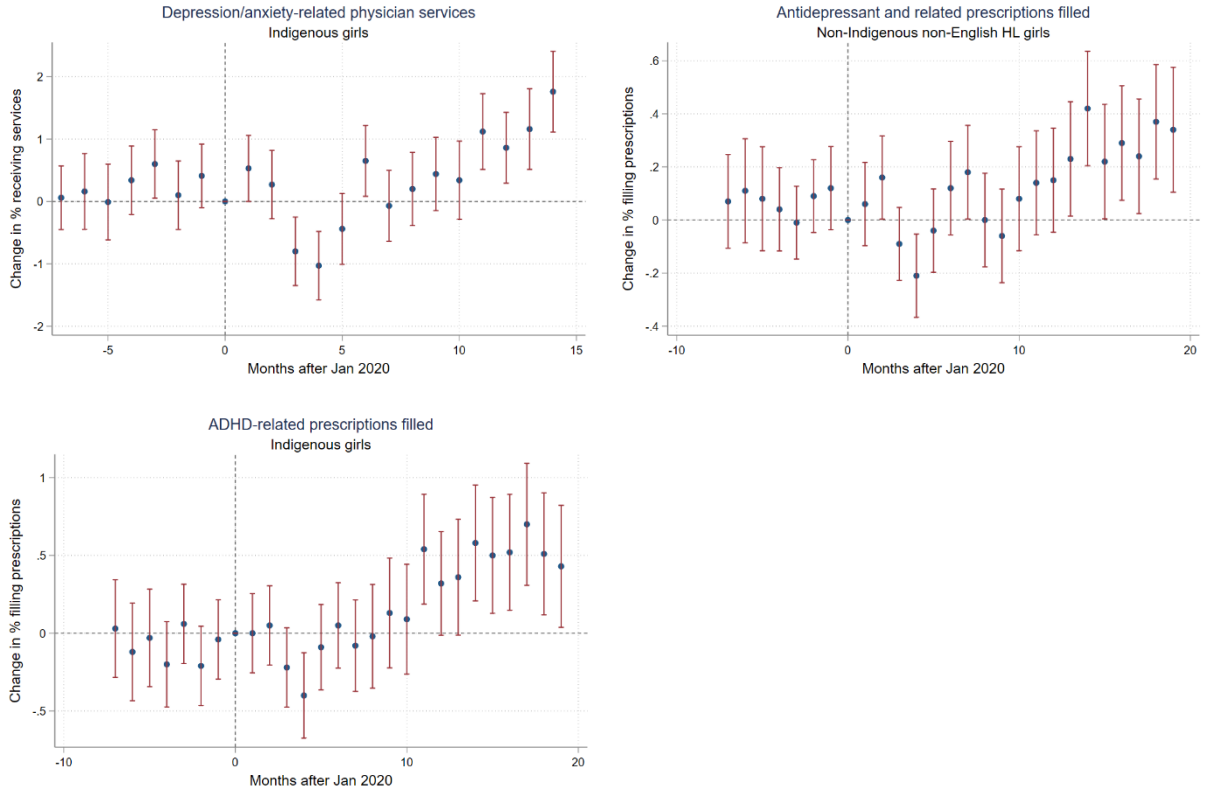
$$y_{it} = \sum_{k=1}^{K} \beta_k \times 1(e_t = k) + \sum_{k=-6}^{-1} \beta_k \times 1(e_t = k) + \beta_{-7} \times 1(e_t < -6) + \mu_{m(t)} + \lambda t + \alpha X_{it} + \epsilon_{it} \quad (2)$$

[13] Mean values of each dependent variable for each demographic sub-group, which can be used to compare the magnitudes of COVID effects to group/category-specific baseline levels, can be found in Appendix Table 1a.

where $e_t = K$ corresponds to March 2021 in the case of physician services and to August 2021 in the case of prescriptions filled. The parameter β_7, for example, measures the deviation of the observed share of students who were treated in September 2020 ($e_t = 7$) relative to its predicted value.

A full set of event study plots for all groups of girls for all diagnostic categories are available in Appendix Figure B1. Our goal here is to identify and describe cases where the before/after estimates in Table 3 show no increase during the COVID period, but the pattern of event study coefficients indicates a clear increase in outcomes by late winter of 2020 and therefore suggests an overall increase may be revealed as more data become available. We present event study estimates for these cases in Figure 2. For example, the first graph shows that physician services related to depression and anxiety among Indigenous girls began to increase substantially relative to predicted rates by late winter of 2020. We see a similar pattern for antidepressant prescriptions among other home language girls and for prescriptions for medications used to treat ADHD among Indigenous girls. These patterns lead to another interesting result: increases in mental health-related prescriptions filled followed increases in mental health-related physician services during COVID with a lag of three to six months.

Figure 2. COVID event-study effects, selected cases.



Each point reports the coefficient on an indicator for a specific month as described in equation (2); control variables include time trend and indicators for month, grade, neighborhood SES quartile and birth quarter. Capped lines indicate 95% confidence intervals. Estimation sample includes observations for physician services through March 2021 and for prescriptions through

August 2021. Cases reported are those girls where the main effect of COVID reported in Table 3 was negative or positive and statistically insignificant and where the pattern of event study coefficients indicates a clear increase in outcomes by late winter of 2020.

4.2 The role of socioeconomic status

We next investigate the role of SES in the effect of COVID on mental health outcomes by adding interactions between the post-COVID indicator and quartiles of the SES distribution to the baseline before/after model. A full set of results for the interacted model are presented in Appendix Table B2. Our goal is to investigate whether, in the cases where Table 3 reports a statistically significant overall increase, this effect contributed to narrowing or widening any pre-pandemic socioeconomic gaps in outcomes. The results in Table 4a suggest that, in most cases, the increases in physician services were experienced by students throughout the SES distribution. To the extent that these effects differ across SES quartiles, they tend to be greater among higher SES students, notably in the cases of ADHD and eating disorders among English home languages. The results in Table 4b show a very different pattern – the increases in prescriptions among English home language girls was not experienced by girls in the top quartile of the SES distribution, reinforcing the tendency for lower SES girls to fill more prescriptions for these medications.[14]

[14] The tendency for doctors to disproportionately prescribe anti-psychotic medications to low- versus higher-income children and adolescents has been documented and investigated by Currie et al. (2022) in the Canadian province of Ontario during the pre-pandemic period.

Table 4a: COVID effect on physician services by SES quartile, selected cases.

Description	COVID effect on monthly % receiving physician services						
	Indigenous girls	Non-Indigenous, English home language girls					Non-Indigenous, non-English home language girls
	ADHD	Depression/ Anxiety	ADHD	Psychosis	Conduct	Eating	Depression/ anxiety
COVID effect by SES quartile							
Q1 (bottom)	0.19***	0.29***	0.03	0.06*	0.04**	0.00	0.04
	(0.06)	(0.10)	(0.04)	(0.04)	(0.02)	(0.03)	(0.09)
Q2	0.04	0.26***	0.02	0.04	0.04***	0.05*	0.14
	(0.10)	(0.10)	(0.03)	(0.03)	(0.01)	(0.03)	(0.09)
Q3	0.37***	0.17*	0.13***	0.07**	0.03***	0.05*	0.28***
	(0.14)	(0.09)	(0.04)	(0.03)	(0.01)	(0.03)	(0.10)
Q4	0.54***	0.31***	0.13***	0.05*	0.03***	0.09***	0.20**
	(0.21)	(0.09)	(0.04)	(0.03)	(0.01)	(0.03)	(0.09)
P-value for constant effect	0.073	0.694	0.026	0.922	0.825	0.147	0.255
Baseline coefficients on SES quartile indicators							
Q2	0.31***	-0.26***	-0.05*	-0.07**	-0.02*	0.01	0.13*
	(0.08)	(0.08)	(0.03)	(0.03)	(0.01)	(0.02)	(0.07)
Q3	0.37***	-0.33***	-0.05*	-0.14***	-0.03***	0.03	0.21***
	(0.09)	(0.08)	(0.03)	(0.03)	(0.01)	(0.02)	(0.07)
Q4	0.18	-0.51***	0.00	-0.17***	-0.04***	0.07***	0.33***
	(0.11)	(0.08)	(0.03)	(0.03)	(0.01)	(0.02)	(0.07)

*Table reports coefficients on the interactions of the post-COVID indicator with the SES quartile indicators (upper panel) and coefficients on SES quartile indicators (lower panel); other control variables include time trend and indicators for month, grade and birth quarter. "P-value for constant effect" refers to a test of the restriction that the four interaction terms are the same. Estimation sample includes observations for physician services through February 2021 and for prescriptions through August 2021. Cases reported are those where the main effect of COVID reported in Table 3a was positive and statistically significant. Standard errors clustered by student in parentheses, *** = 1%, ** = 5%, * = 10%.*

Table 4b: COVID effect on prescriptions filled by SES quartile, selected cases.

Description	COVID effect on monthly % filling prescriptions		
	Non-Indigenous, English home language girls		
	Antidepressant and related	ADHD-related	Antipsychotic
COVID effect by SES quartile			
Q1(bottom)	0.28**	0.17**	0.21***
	(0.14)	(0.08)	(0.06)
Q2	0.25**	0.02	0.13**
	(0.12)	(0.06)	(0.05)
Q3	0.25**	0.11*	0.05
	(0.12)	(0.06)	(0.05)
Q4	0.01	-0.02	0.04
	(0.11)	(0.06)	(0.04)
P-value for constant effect	0.260	0.187	0.061
Baseline coefficients on SES quartile indicators			
Q2	-0.61***	-0.24***	-0.12**
	(0.12)	(0.07)	(0.05)
Q3	-0.93***	-0.28***	-0.16***
	(0.12)	(0.07)	(0.05)
Q4	-1.21***	-0.24***	-0.26***
	(0.12)	(0.07)	(0.05)

*Table reports coefficients on the interactions of the post-COVID indicator with the SES quartile indicators (upper panel) and coefficients on SES quartile indicators (lower panel); other control variables include time trend and indicators for month, grade and birth quarter. "P-value for constant effect" refers to a test of the restriction that the four interaction terms are the same. Estimation sample includes observations for physician services through February 2021 and for prescriptions through August 2021. Cases reported are those where the main effect of COVID reported in Table 3b was positive and statistically significant. Standard errors clustered by student in parentheses, *** = 1%, ** = 5%, * = 10%.*

4.3 In-person versus hybrid learning

Following a province-wide school shut-down in March 2020, the Ministry of Education tasked school districts with developing learning plans for the fall term that would keep schools open while incorporating measures to reduce the duration and frequency of contact among students. Districts were permitted to deliver up to 50% of each student's instructional time in a remote (online) format, although this approach was discouraged for younger grades. This policy resulted in a patchwork of hybrid programs as some districts offered in-person learning only, districts that offered hybrid learning did so in different grades and districts that offered hybrid learning did so for different shares of the school week.

Hybrid learning was most commonly adopted by larger school districts serving urban and suburban communities.[15] In light of evidence that urban and rural communities had very different experiences during COVID (e.g., Cabot and Bushnik 2022), we focus our investigation of the potential mediating role

[15] For example, while only 21 of the 60 school districts adopted hybrid learning for grade 10 students, these districts include all of the largest 11 districts and account for over 70% of all grade 10 students. See Appendix A for further details.

of hybrid learning on variation in the effect of COVID across grades rather than across districts.[16] To isolate this effect, we create two measures of hybrid learning: (i) a (time-invariant) indicator that a district introduced hybrid learning in any grade; and (ii) a (time-invariant) indicator that a student's district introduced hybrid learning to the student's own grade. We include these measures and their interactions with the post-COVID indicator, along with interactions between grade-specific indicators and the post-COVID indicator, in our before/after model. The coefficient on the interaction between the post-COVID indicator and the second hybrid learning indicator (i.e., that a student's district introduced hybrid learning to the student's own grade) captures differences in the response to COVID among students who were exposed to hybrid learning and students in the same set of districts who were not (because hybrid learning was not offered to their grade), while allowing for differences in the response to COVID across grades that is common to all districts.

Table 5a: COVID effects on physician services by learning mode, selected cases.

Description	**COVID effect on monthly % receiving physician services**						
	Indigenous girls	**Non-Indigenous, English home language girls**					**Non-Indigenous, non-English home language girls**
	ADHD	**Depression/ anxiety**	**ADHD**	**Psychosis**	**Conduct**	**Eating**	**Depression/ anxiety**
COVID effect w/interaction terms							
Post x (grade 8)	0.18	0.15	-0.01	0.09**	0.05***	0.01	-0.01
	(0.11)	(0.11)	(0.04)	(0.04)	(0.02)	(0.03)	(0.21)
Post x (grade 9)	0.04	0.18	0.05	0.09**	0.03	0.02	0.14
	(0.10)	(0.11)	(0.04)	(0.04)	(0.02)	(0.03)	(0.22)
Post x (grade 10)	0.20**	0.53***	0.10**	0.05	0.03	0.04	0.35
	(0.09)	(0.12)	(0.04)	(0.04)	(0.02)	(0.04)	(0.23)
Post x (grade 11)	0.14	0.44***	0.07	0.08**	0.01	0.00	0.50**
	(0.09)	(0.12)	(0.04)	(0.04)	(0.02)	(0.04)	(0.23)
Post x (hybrid in any grade)	0.26	-0.01	0.06	-0.05	0.01	0.05	-0.04
	(0.17)	(0.12)	(0.05)	(0.04)	(0.02)	(0.03)	(0.21)
Post x (hybrid in own grade)	-0.17	-0.13	-0.02	0.02	0.01	0.00	-0.06
	(0.19)	(0.13)	(0.05)	(0.04)	(0.02)	(0.04)	(0.12)

*Table reports coefficient on interactions of post-COVID indicator with grade and learning mode indicators; control variables include time trend and indicators for month, grade, neighborhood SES quartile, birth quarter, and any-grade and own-grade hybrid indicators. Estimation sample includes observations through February 2021. Cases reported are those where the main effect of COVID on physician services reported in Table 3a was positive and statistically significant. Standard errors clustered by student in parentheses. *** = 1%, ** = 5%, * = 10%.*

For each of the selected cases reported in Table 3 (i.e., where we have found clear evidence of an increase in mental health services or prescriptions in a specific population group), Table 5 shows the estimates for the post-COVID indicator and its various interactions. The final row shows the coefficient of interest. The

[16] Given that some students enroll in private school, distance learning programs and home-schooling, and some students are enrolled in a grade other than the one indicated by their date of birth (due to, for example, red-shirting), the hybrid learning variables are correlated with but not identical to the actual learning environments of each student.

effect is not statistically significant for any case, and in most cases the point estimates are small. These results provide no evidence that hybrid learning played a meaningful mediating role in the increases in mental health services among girls reported in Table 3. A full set of results for the interacted model are presented in Appendix Table B3.

Table 5b: COVID effects on prescriptions filled by learning mode, selected cases.

Description	COVID effect on monthly % filling prescriptions		
	Non-Indigenous English home language girls		
	Antidepressant and related	ADHD-related	Antipsychotic
COVID effect w/interaction terms			
Post x (grade 8)	0.18	0.12	0.20***
	(0.14)	(0.09)	(0.06)
Post x (grade 9)	0.38***	0.15*	0.27***
	(0.14)	(0.08)	(0.06)
Post x (grade 10)	0.60***	0.24***	0.22***
	(0.16)	(0.08)	(0.07)
Post x (grade 11)	0.78***	0.14*	0.22***
	(0.16)	(0.08)	(0.07)
Post x (hybrid in any grade)	-0.42***	-0.24**	-0.14**
	(0.15)	(0.10)	(0.06)
Post x (hybrid in own grade)	0.00	0.15	-0.07
	(0.16)	(0.10)	(0.06)

*Table reports coefficient on interaction of post-COVID indicator with grade and learning mode indicators; control variables include time trend and indicators for month, grade, neighborhood SES quartile, birth quarter, and any-grade and own-grade hybrid indicators. Estimation sample includes observations through August 2021. Cases reported are those where the main effect of COVID on prescription medications reported in Table 3b was positive and statistically significant. Standard errors clustered by student in parentheses. *** = 1%, ** = 5%, * = 10%.*

5 Conclusion

The results in this paper suggest that the mental health of adolescent girls in British Columbia suffered significantly through the first year and a half of the pandemic. Increases in physician services related to depression and anxiety, the most common diagnosis among adolescent girls in the four years preceding the pandemic, were pronounced and widespread across ethnic and cultural communities and socioeconomic strata. Apart from the obvious suffering that this increase reflects, adolescent depression has been causally linked to a variety of long-term consequences, including educational attainment, employment, earnings and criminal activity (e.g., Fletcher 2010, 2013; Goodman et al. 2011; Lundborg et al. 2014; Anderson et al. 2015). These direct effects of depression on outcomes may understate the overall effects of pandemic-related depression on girls - having a greater share of same-gender peers with depression has been found to increase own rates of depression among girls (Fruehwirth et al. 2019; Giulietti et al. 2022) and to cause higher rates of depression, lower college attendance and a lower likelihood of working and lower income among adult females (Giuliettei et al. 2022).

Likewise, ADHD has been associated with poor long-term outcomes including lower educational attainment and greater likelihood of welfare receipt and criminal activity (e.g., Currie and Stabile 2006;

Fletcher and Wolfe 2008, 2009; Currie et al. 2010; Fletcher 2014). The increased use of physician services and prescription medications for ADHD suggests that adolescent girls with ADHD experienced difficulties during the pandemic. These girls may face a longer road than others to recovery from the learning and social losses experienced during COVID. At the same time, however, the increase in physician services during the pandemic may reflect increased recognition of dysfunction among girls who were previously under-diagnosed. Underdiagnosis of ADHD is thought to be particularly common among girls because they are more likely than boys to experience comorbid depression that masks their ADHD symptoms (Quinn and Madhoo 2014), because physicians may use different criteria when diagnosing ADHD in boys versus girls (e.g., Bruchmuller et al. 2012; Hinshaw 2018; Marquardt 2022) and because girls with ADHD tend to be inattentive rather than impulsive or hyperactive and therefore are less likely than boys to be disruptive in class.[17] To the extent that the pandemic brought this disorder to light for some girls, the associated access to appropriate supports and treatment may serve as a silver lining.

Eating disorders are potentially life-threatening conditions that affect a person's emotional and physical health in a severe way. Disordered patterns of eating tend to be persistent and may lead to hospitalization and death (Ham et al. 2013). The marked increase in the use of physician services in relation to eating disorders among high-SES English home language girls during the first year of the pandemic is therefore of significant concern despite the relatively small numbers affected. Again, however, some of this increase in physician services may reflect previously undiagnosed cases that came to light as individuals' symptoms deteriorated during the pandemic. Underdiagnosis in general can be an issue in relation to some eating disorders, particularly bulimia nervosa (Ham et al. 2015; Arduini et al. 2019) and earlier diagnosis of eating disorders has been shown to reduce the risk of hospitalization and death. In this sense, again, there may be a silver lining to some cases. At the same time, the relatively low and unchanging frequency of physician services related to eating disorders among other home language and Indigenous girls should be interpreted with caution. Evidence from the U.S. shows that, while bulimia is more prevalent among girls who are black or low SES compared to white and high SES girls, these same groups are less likely to have a corresponding diagnosis (Ham et al. 2015). To the extent that the large gap between treatment for eating disorders among English home language girls and other home language and Indigenous girls reflects unmet needs, this gap appears to have grown during the first year of the pandemic.

[17] Furzer et al. (2022) show that, relative to parents' assessments of children's behavior, the tendency of teachers to overidentify behavior problems among children who are relatively young in grade and under-identify them among children who are relatively old in grade is more pronounced among girls than boys, so that older girls with ADHD are particularly at risk of being missed in the referral and diagnostic process.

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Appendix A: Data background

This appendix provides additional background information on how the data were prepared for analysis.

A1 Classification of mental health-related diagnoses and medications

Table A1 below provides details on how we classify mental health diagnoses in the MSP data. Each service in the MSP data has at least one associated diagnosis coded according to the ICD-9 classification system. Our indicator for receiving mental health-related physician service is based on the first three digits of the ICD-9 code for the primary diagnosis associated with the service record.

Table A1: Classification of mental health diagnoses.

Category	Included ICD-9 codes
Depression/anxiety	300 (neurotic disorders), 309 (adjustment reaction), 311 (depressive disorder), 313 (emotional disturbance), 50B (anxiety/depression).
ADHD	314 (hyperkinetic syndrome).
Psychosis	295 (schizophrenia), 296 (affective psychosis), 297 (paranoia), 298 (other nonorganic psychoses), 299 (psychoses of childhood).
Conduct disorder	312 (conduct disturbance).
Substance disorder	291 (psychosis induced by alcohol), 292 (psychosis induced by drugs), 303 (alcohol dependence), 304 (drug dependence), 305 (non-dependent drug abuse).
Eating disorder	3071 (anorexia), 3075 (other eating disorders).
Other	290 (dementia), 293 (delirium not associated with drugs or alcohol), 294 (persistent mental disorders due to conditions classified elsewhere), 301 (personality disorders), 306 (physiological malfunction due to mental factors), 308 (acute reaction to stress), 316 (psychic factors associated with diseases classified elsewhere). 307 (special syndromes or disorders not elsewhere classified) excluding 3071 and 3075.

Table A2 provides details on how we classify mental health-related prescription medications in the Pharmanet data. Each medication dispensed has a drug identification number (DIN) that can then be mapped to the chemical/generic name of the drug. Table A2 provides the basic drug types included in each of our three broad categories, along with chemical/generic names for some commonly-used drugs of each type.

Table A2: Classification of mental health-related prescription medications.

Category	Included drugs
Antidepressant and related	*Antidepressants*: fluoxetine, sertraline, escitalopram, trazodone, citalopram, venlafaxine, bupropion, etc.
	Anxiolytics: lorazepam, clonazepam, etc.
	Sedatives: clobazam, zopiclone, etc.
ADHD-related	*Stimulants*: methylphenidate, dextroamphetamine, dextroamphetamine sulfate.
	Agonists: guanfacine.
	NPRIs: atomoxetine.
Antipsychotic	*Antipsychotics*: quetiapine, risperidone, aripiprazole, olanzapine, etc.

A2 Classification of school districts by planned learning environment

The analysis in Section 4.3 is based on a classification of B.C. public school districts by their September 2020 plans for in-person versus remote learning environments in each grade. Classifications were constructed by the authors on the basis of detailed plans posted on each district's website in August and September 2020, along with any district communications to parents and other stakeholders that were also posted to the district's website at that time. The full set of documents used for classification is available on request from the authors.

1. Based on the available documentation, each district/grade was assigned an estimate of in-person learning time as a percentage of normal class time. In some cases, district plans were coded as range of plausible values rather than a single estimate. For example, a district might say that "at least half" of the school day would be spent in-person, which would be coded as a range of 50-100% in-person time.
2. Every district/grade whose plans implied a value or range of values other than 100% in-person was coded as providing hybrid learning.

Table A3 below reports the full set of districts and grades, along with their planned value or range of in-person times. Note that these in-person times reflect the published initial plans for public schools; actual in-person learning time may have deviated from plans in response to changes in local conditions, enrollment in private school, or participation in distance education or homeschooling programs. Our analysis in Section 4.3 includes all students – public and private – to ensure the before/after comparisons are made over a stable population of students.

Table A3: Districts and grades with hybrid learning plans in 2020/21 academic year. All other districts and grades were planned to be 100% in-person.

School district	Grade(s)	% in-person
23 Central Okanagan	10-12	75
34 Abbotsford	9-12	60
35 Langley	10	70-100
35 Langley	11-12	70
36 Surrey	10-12	66.7
37 Delta	10-12	50-100
38 Richmond	10-12	50
39 Vancouver	8-12	50
40 New Westminster	9-12	80
41 Burnaby	10-12	70
42 Maple Ridge	10-12	70-100
43 Coquitlam	9-12	70
44 North Vancouver	10-12	50-100
45 West Vancouver	10-12	50-100
54 Bulkley Valley	10-12	50-100
61 Greater Victoria	9-12	70
62 Sooke	9-12	50
63 Saanich	9-12	75-100
67 Okanagan Skaha	10-12	75
68 Nanaimo-Ladysmith	8-12	70-100
75 Mission	7-9	90
75 Mission	10-12	35-100
92 Nisga'a	K-12	50

Appendix B: Additional results

Tables B1a and B1b show monthly pre-COVID shares of students receiving mental health related physician services or filling mental health-related prescriptions. Results from these tables are used in Section 4.1 of the main text to contextualize the effect sizes reported in Tables 3a and 3b.

Figures B1a-B1c show the full set of event study results for girls. Selected results from these figures are reported in Figure 2 and discussed in Section 4.1 of the main text.

Tables B2a-B2f show the full set of results by SES quartile for girls. Selected results from these tables are reported in Table 4 and discussed in Section 4.2 of the main text.

Tables B3a-B3f show the full set of results by learning mode for girls. Selected results from these tables are reported in Table 5 and discussed in Section 4.3 of the main text.

Table B1a: Monthly share of students receiving mental health-related physician services by condition, pre-COVID (2016/17 through 2018/19).

Sub-population	Monthly % receiving physician services						
	Depression/ Anxiety	ADHD	Psychosis	Conduct	Substance	Eating	Other
Girls							
Indigenous	4.38	0.74	0.66	0.16	0.32	0.12	0.41
Non-indigenous by home language							
English	3.14	0.44	0.36	0.06	0.07	0.18	0.27
Non-English	1.10	0.12	0.16	0.02	0.02	0.09	0.15
Boys							
Indigenous	1.79	1.44	0.48	0.25	0.21		0.21
Non-indigenous by home language							
English	1.46	1.11	0.37	0.14	0.06		0.16
Non-English	0.61	0.32	018	0.05	0.03		0.10

Population consists of monthly observations of B.C. resident students ages 13-16 on December 31 of the current academic year. Percent receiving mental health services is based on services received during current month. See Appendix A for definitions of diagnostic categories.

Table B1b: Monthly share of students filling mental health-related prescriptions by drug category, pre-COVID (2016/17 through 2018/19).

Sub-population	Monthly % filling prescriptions		
	Antidepressant and related	ADHD-related	Antipsychotic
Girls			
Indigenous	4.98	1.92	1.11
Non-indigenous by home language			
English	3.46	0.92	0.52
Non-English	0.86	0.18	0.13
Boys			
Indigenous	2.42	3.72	1.33
Non-indigenous by home language			
English	1.85	2.33	0.56
Non-English	0.45	0.44	0.17

Population consists of monthly observations of B.C. resident students ages 13-16 on December 31 of the current academic year. Percent filling mental health prescription is based on prescriptions filled during current month. See Appendix A for definitions of drug categories.

Figure B1a: COVID event-study effects, Indigenous girls.

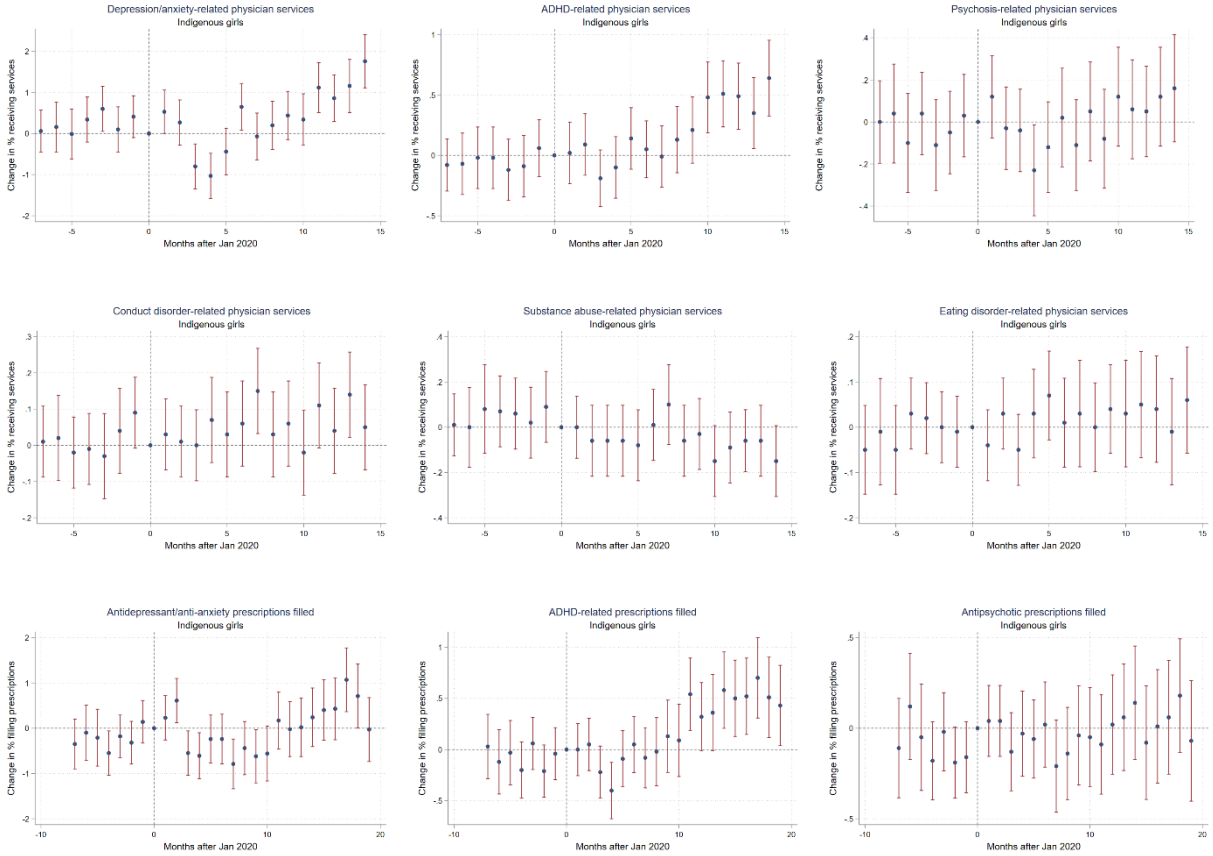

Figure B1b: COVID event-study effects, non-Indigenous English home language girls.

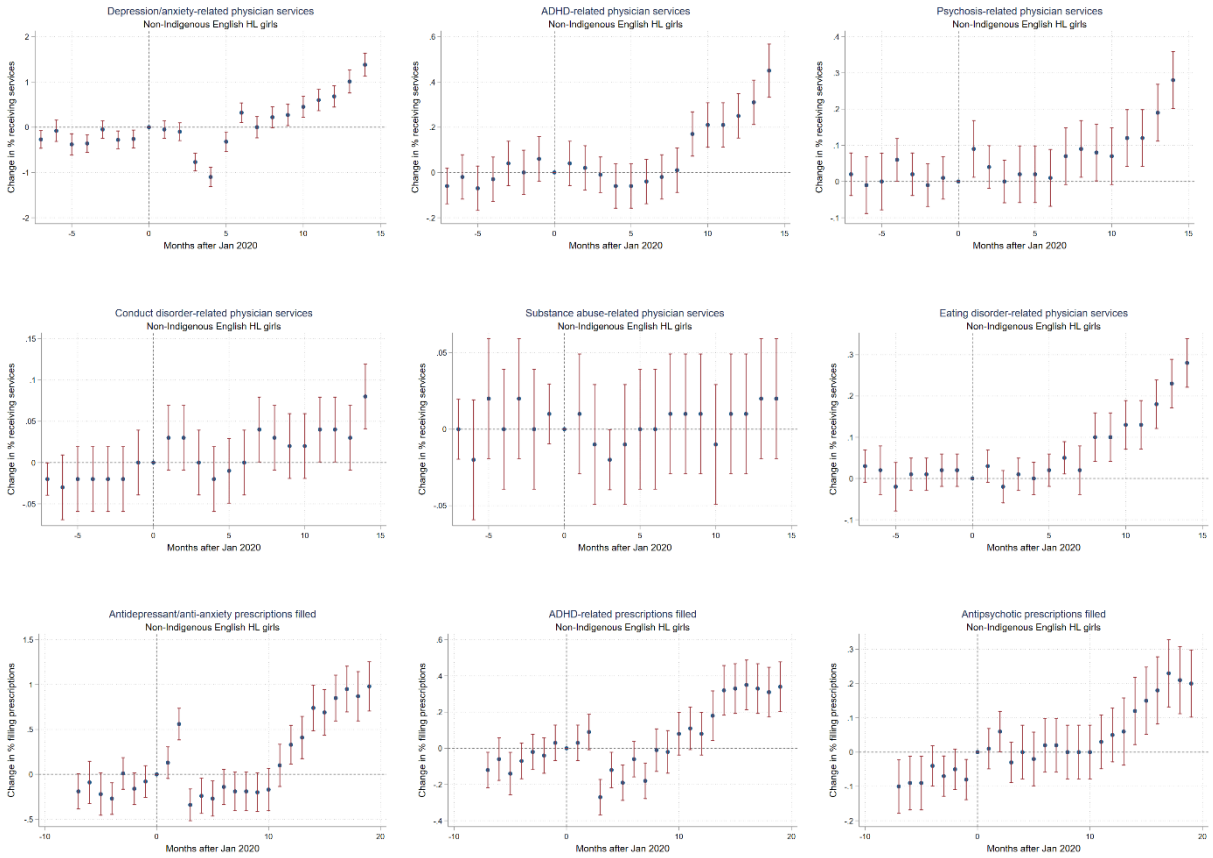

Figure B1c: COVID event-study effects, non-Indigenous non-English home language girls.

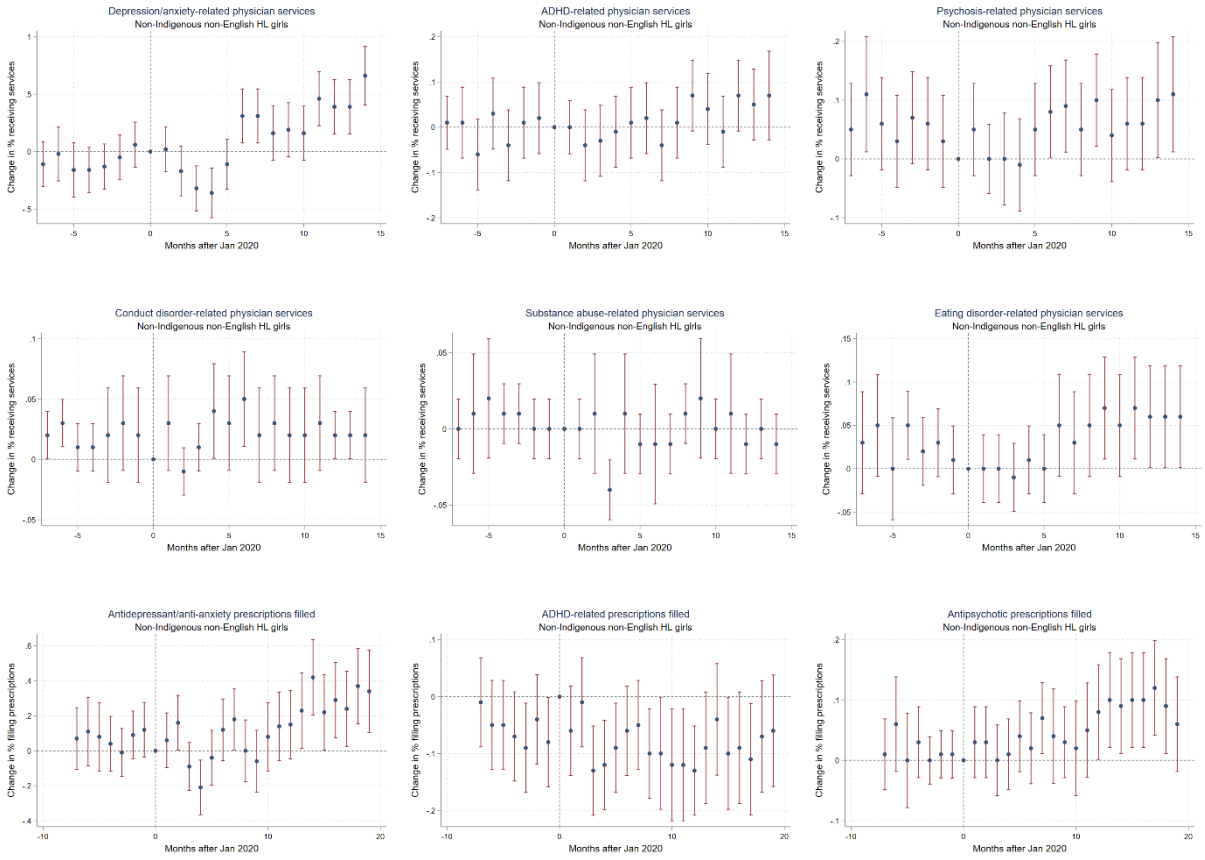

Table B2a: COVID effects on mental health-related physician services by SES quartile for Indigenous girls.

Description	COVID effect on monthly % receiving physician services					
	Depression/ Anxiety	ADHD	Psychosis	Conduct	Substance	Eating
COVID effect by SES quartile						
Q1(bottom)	-0.22	0.19***	0.02	0.02	-0.09**	0.03
	(0.17)	(0.06)	(0.06)	(0.03)	(0.04)	(0.04)
Q2	0.38	0.04	-0.04	0.08*	-0.12**	0.13**
	(0.24)	(0.10)	(0.09)	(0.04)	(0.05)	(0.05)
Q3	0.19	0.37***	0.02	0.01	-0.06	-0.06
	(0.31)	(0.14)	(0.11)	(0.05)	(0.06)	(0.06)
Q4	0.00	0.54***	-0.12	0.11	0.10	-0.08
	(0.46)	(0.21)	(0.18)	(0.07)	(0.11)	(0.13)
P-value for constant effect	0.136	0.073	0.828	0.394	0.260	0.082
Baseline coefficients on SES quartile indicators						
Q2	0.25	0.31***	0.05	0.07**	-0.02	0.02
	(0.17)	(0.08)	(0.06)	(0.03)	(0.03)	(0.03)
Q3	0.42**	0.37***	0.00	0.05	-0.04	0.10**
	(0.21)	(0.09)	(0.08)	(0.04)	(0.05)	(0.05)
Q4	0.97***	0.18*	0.15	0.00	-0.12**	0.20**
	(0.33)	(0.11)	(0.15)	(0.04)	(0.06)	(0.10)

*Table reports coefficients on the interactions of the post-COVID indicator with the SES quartile indicators (upper panel) and coefficients on SES quartile indicators (lower panel); other control variables include time trend and indicators for month, grade and birth quarter. "P-value for constant effect" refers to a test of the restriction that the four interaction terms are the same. Estimation sample includes observations for physician services through February 2021. Standard errors clustered by student in parentheses, *** = 1%, ** = 5%, * = 10%.*

Table B2b: COVID effects on mental health-related prescriptions filled by SES quartile for Indigenous girls.

Description		COVID effect on monthly % filling prescriptions		
		Antidepressant and related	**ADHD-related**	**Antipsychotic**
COVID effect by SES quartile				
	Q1(bottom)	-0.31	0.06	0.06
		(0.22)	(0.14)	(0.12)
	Q2	0.58*	0.07	0.11
		(0.33)	(0.20)	(0.18)
	Q3	0.36	0.33	-0.11
		(0.42)	(0.29)	(0.20)
	Q4	0.34	0.42	-0.01
		(0.59)	(0.37)	(0.30)
P-value for constant effect		0.070	0.691	0.822
Baseline coefficients on SES quartile indicators				
	Q2	0.32	0.44**	0.02
		(0.24)	(0.19)	(0.13)
	Q3	0.08	0.68***	-0.02
		(0.29)	(0.24)	(0.15)
	Q4	0.48	0.11	-0.03
		(0.43)	(0.30)	(0.21)

*Table reports coefficients on the interactions of the post-COVID indicator with the SES quartile indicators (upper panel) and coefficients on SES quartile indicators (lower panel); other control variables include time trend and indicators for month, grade and birth quarter. "P-value for constant effect" refers to a test of the restriction that the four interaction terms are the same. Estimation sample includes observations for prescriptions through August 2021. Standard errors clustered by student in parentheses, *** = 1%, ** = 5%, * = 10%.*

Table B2c: COVID effects on mental health-related physician services by SES quartile for non-Indigenous English home language girls.

Description	COVID effect on monthly % receiving physician services					
	Depression/ Anxiety	**ADHD**	**Psychosis**	**Conduct**	**Substance**	**Eating**
COVID effect by SES quartile						
Q1(bottom)	0.29***	0.03	0.06*	0.04***	-0.01	0.00
	(0.10)	(0.04)	(0.04)	(0.02)	(0.01)	(0.03)
Q2	0.26***	0.02	0.04	0.04***	-0.02**	0.05*
	(0.10)	(0.03)	(0.03)	(0.01)	(0.01)	(0.03)
Q3	0.17*	0.13***	0.07**	0.03***	0.00	0.05*
	(0.09)	(0.04)	(0.03)	(0.01)	(0.01)	(0.03)
Q4	0.31***	0.13***	0.05*	0.03***	0.02	0.09***
	(0.09)	(0.04)	(0.03)	(0.01)	(0.01)	(0.03)
P-value for constant effect	0.694	0.026	0.922	0.825	0.052	0.147
Baseline coefficients on SES quartile indicators						
Q2	-0.26***	-0.05*	-0.07**	-0.02	-0.01	0.01
	(0.08)	(0.03)	(0.03)	(0.01)	(0.01)	(0.02)
Q3	-0.33***	-0.05*	-0.14***	-0.03***	-0.03***	0.03
	(0.08)	(0.03)	(0.03)	(0.01)	(0.01)	(0.02)
Q4	-0.51***	0.00	-0.17***	-0.04***	-0.04***	0.07***
	(0.08)	(0.03)	(0.03)	(0.01)	(0.01)	(0.02)

*Table reports coefficients on the interactions of the post-COVID indicator with the SES quartile indicators (upper panel) and coefficients on SES quartile indicators (lower panel); other control variables include time trend and indicators for month, grade and birth quarter. "P-value for constant effect" refers to a test of the restriction that the four interaction terms are the same. Estimation sample includes observations for physician services through February 2021. Standard errors clustered by student in parentheses, *** = 1%, ** = 5%, * = 10%.*

Table B2d: COVID effects on mental health-related prescriptions filled by SES quartile for non-Indigenous English home language girls.

Description	**COVID effect on monthly % filling prescriptions**		
	Antidepressant and related	**ADHD-related**	**Antipsychotic**
COVID effect by SES quartile			
Q1(bottom)	0.28**	0.17**	0.21***
	(0.14)	(0.08)	(0.06)
Q2	0.25**	0.02	0.13**
	(0.12)	(0.06)	(0.05)
Q3	0.25**	0.11*	0.05
	(0.12)	(0.06)	(0.05)
Q4	0.01	-0.02	0.04
	(0.11)	(0.06)	(0.04)
P-value for constant effect	0.260	0.187	0.061
Baseline coefficients on SES quartile indicators			
Q2	-0.61***	-0.24***	-0.12**
	(0.12)	(0.07)	(0.05)
Q3	-0.93***	-0.28***	-0.16***
	(0.12)	(0.07)	(0.05)
Q4	-1.21***	-0.24***	-0.26***
	(0.12)	(0.07)	(0.05)

*Table reports coefficients on the interactions of the post-COVID indicator with the SES quartile indicators (upper panel) and coefficients on SES quartile indicators (lower panel); other control variables include time trend and indicators for month, grade and birth quarter. "P-value for constant effect" refers to a test of the restriction that the four interaction terms are the same. Estimation sample includes observations for prescriptions through August 2021. Standard errors clustered by student in parentheses, *** = 1%, ** = 5%, * = 10%.*

Table B2e: COVID effects on mental health-related physician services by SES quartile for non-Indigenous non-English home language girls.

Description	COVID effect on monthly % receiving physician services					
	Depression/ Anxiety	**ADHD**	**Psychosis**	**Conduct**	**Substance**	**Eating**
COVID effect by SES quartile						
Q1(bottom)	0.04	0.00	0.05	0.02*	-0.01*	-0.03
	(0.09)	(0.02)	(0.03)	(0.01)	(0.01)	(0.02)
Q2	0.14	-0.02	0.01	-0.01	0.00	0.02
	(0.09)	(0.02)	(0.04)	(0.01)	(0.01)	(0.02)
Q3	0.28***	0.02	-0.03	-0.01	-0.01	-0.01
	(0.10)	(0.03)	(0.03)	(0.01)	(0.01)	(0.02)
Q4	0.20**	0.02	-0.01	0.01	0.00	0.03
	(0.09)	(0.03)	(0.04)	(0.01)	(0.01)	(0.03)
P-value for constant effect	0.255	0.580	0.301	0.084	0.296	0.228
Baseline coefficients on SES quartile indicators						
Q2	0.13*	0.05**	0.04	0.00	0.00	0.00
	(0.07)	(0.02)	(0.03)	(0.01)	(0.01)	(0.02)
Q3	0.21***	0.08***	0.07**	0.00	0.00	0.04*
	(0.07)	(0.02)	(0.03)	(0.01)	(0.01)	(0.02)
Q4	0.33***	0.14***	0.08***	-0.01	-0.01***	0.10***
	(0.07)	(0.02)	(0.03)	(0.01)	(0.00)	(0.03)

*Table reports coefficients on the interactions of the post-COVID indicator with the SES quartile indicators (upper panel) and coefficients on SES quartile indicators (lower panel); other control variables include time trend and indicators for month, grade and birth quarter. "P-value for constant effect" refers to a test of the restriction that the four interaction terms are the same. Estimation sample includes observations for physician services through February 2021. Standard errors clustered by student in parentheses, *** = 1%, ** = 5%, * = 10%.*

Table B2f: COVID effects on mental health-related prescriptions filled by SES quartile for non-Indigenous non-English home language girls.

Description		COVID effect on monthly % filling prescriptions		
		Antidepressant and related	ADHD-related	Antipsychotic
COVID effect by SES quartile				
	Q1(bottom)	-0.12	-0.01	0.06
		(0.10)	(0.04)	(0.04)
	Q2	0.07	-0.07*	0.04
		(0.10)	(0.03)	(0.04)
	Q3	0.10	-0.07*	0.01
		(0.10)	(0.04)	(0.04)
	Q4	-0.03	-0.04	0.02
		(0.09)	(0.04)	(0.04)
P-value for constant effect		0.338	0.611	0.815
Baseline coefficients on SES quartile indicators				
	Q2	0.04	0.05	0.00
		(0.09)	(0.04)	(0.04)
	Q3	0.06	0.09**	0.01
		(0.09)	(0.04)	(0.04)
	Q4	0.15	0.16***	0.07*
		(0.10)	(0.04)	(0.04)

*Table reports coefficients on the interactions of the post-COVID indicator with the SES quartile indicators (upper panel) and coefficients on SES quartile indicators (lower panel); other control variables include time trend and indicators for month, grade and birth quarter. "P-value for constant effect" refers to a test of the restriction that the four interaction terms are the same. Estimation sample includes observations for prescriptions through August 2021. Standard errors clustered by student in parentheses, *** = 1%, ** = 5%, * = 10%.*

Table B3a: COVID effects on mental health-related physician services by learning mode, Indigenous girls.

Description	COVID effect on monthly % receiving physician services					
	Depression/ anxiety	ADHD	Psychosis	Conduct	Substance	Eating
COVID effect w/interaction terms						
Post x (grade 8)	0.09	0.18	0.03	-0.01	-0.07	0.00
	(0.23)	(0.11)	(0.08)	(0.04)	(0.05)	(0.04)
Post x (grade 9)	-0.13	0.04	-0.03	0.03	-0.09*	0.06
	(0.24)	(0.10)	(0.09)	(0.04)	(0.05)	(0.05)
Post x (grade 10)	-0.13	0.20**	0.06	0.04	-0.10*	0.09*
	(0.24)	(0.09)	(0.10)	(0.04)	(0.06)	(0.05)
Post x (grade 11)	0.15	0.14	0.08	0.08	-0.11*	0.02
	(0.25)	(0.09)	(0.10)	(0.05)	(0.06)	(0.05)
Post x (hybrid in any grade)	-0.01	0.26	0.09	0.00	0.12**	0.01
	(0.33)	(0.17)	(0.11)	(0.04)	(0.06)	(0.05)
Post x (hybrid in own grade)	0.07	-0.17	-0.27*	0.02	-0.15*	-0.04
	(0.39)	(0.19)	(0.14)	(0.06)	(0.08)	(0.07)

*Table reports coefficient on interactions of post-COVID indicator with grade and learning mode indicators; control variables include time trend and indicators for month, grade, neighborhood SES quartile, birth quarter, and any-grade and own-grade hybrid indicators. Estimation sample includes observations through February 2021. Standard errors clustered by student in parentheses. *** = 1%, ** = 5%, * = 10%.*

Table B3b: COVID effects on mental health-related prescriptions filled by learning mode, Indigenous girls.

Description	COVID effect on monthly % filling prescriptions		
	Antidepressant and related	ADHD-related	Antipsychotic
COVID effect w/interaction terms			
Post x (grade 8)	-0.19	0.29	0.00
	(0.31)	(0.24)	(0.17)
Post x (grade 9)	-0.31	-0.22	-0.19
	(0.32)	(0.20)	(0.16)
Post x (grade 10)	0.12	0.02	0.32*
	(0.34)	(0.19)	(0.17)
Post x (grade 11)	0.14	0.38**	0.43**
	(0.34)	(0.19)	(0.19)
Post x (hybrid in any grade)	0.09	-0.28	0.05
	(0.42)	(0.34)	(0.23)
Post x (hybrid in own grade)	0.30	0.44	-0.39
	(0.52)	(0.40)	(0.28)

*Table reports coefficient on interaction of post-COVID indicator with grade and learning mode indicators; control variables include time trend and indicators for month, grade, neighborhood SES quartile, birth quarter, and any-grade and own-grade hybrid indicators. Estimation sample includes observations through August 2021. Standard errors clustered by student in parentheses. *** = 1%, ** = 5%, * = 10%.*

Table B3c: COVID effects on mental health-related physician services by learning mode, non-Indigenous English home language girls.

Description	COVID effect on monthly % receiving physician services					
	Depression/ anxiety	ADHD	Psychosis	Conduct	Substance	Eating
COVID effect w/interaction terms						
Post x (grade 8)	0.15	-0.01	0.09**	0.05***	-0.01	0.01
	(0.11)	(0.04)	(0.04)	(0.02)	(0.01)	(0.03)
Post x (grade 9)	0.18	0.05	0.09**	0.03	-0.02	0.02
	(0.11)	(0.04)	(0.04)	(0.02)	(0.01)	(0.03)
Post x (grade 10)	0.53***	0.10**	0.05	0.03	-0.02*	0.04
	(0.12)	(0.04)	(0.04)	(0.02)	(0.01)	(0.04)
Post x (grade 11)	0.44***	0.07	0.08**	0.01	-0.02	0.00
	(0.12)	(0.04)	(0.04)	(0.02)	(0.02)	(0.04)
Post x (hybrid in any grade)	-0.01	0.06	-0.05	0.01	0.02**	0.05
	(0.12)	(0.05)	(0.04)	(0.02)	(0.01)	(0.03)
Post x (hybrid in own grade)	-0.13	-0.02	0.02	0.01	0.00	0.00
	(0.13)	(0.05)	(0.04)	(0.02)	(0.01)	(0.04)

*Table reports coefficient on interactions of post-COVID indicator with grade and learning mode indicators; control variables include time trend and indicators for month, grade, neighborhood SES quartile, birth quarter, and any-grade and own-grade hybrid indicators. Estimation sample includes observations through February 2021. Standard errors clustered by student in parentheses. *** = 1%, ** = 5%, * = 10%.*

Table B3d: COVID effects on mental health-related prescriptions filled by learning mode, non-Indigenous English home language girls.

Description	COVID effect on monthly % filling prescriptions		
	Antidepressant and related	ADHD-related	Antipsychotic
COVID effect w/interaction terms:			
Post x (grade 8)	0.18	0.12	0.20***
	(0.14)	(0.09)	(0.06)
Post x (grade 9)	0.38***	0.15*	0.27***
	(0.14)	(0.08)	(0.06)
Post x (grade 10)	0.60***	0.24***	0.22***
	(0.16)	(0.08)	(0.07)
Post x (grade 11)	0.78***	0.14*	0.22***
	(0.16)	(0.08)	(0.07)
Post x (hybrid in any grade)	-0.42***	-0.24**	-0.14**
	(0.15)	(0.10)	(0.06)
Post x (hybrid in own grade)	0.00	0.15	-0.07
	(0.16)	(0.10)	(0.06)

*Table reports coefficient on interaction of post-COVID indicator with grade and learning mode indicators; control variables include time trend and indicators for month, grade, neighborhood SES quartile, birth quarter, and any-grade and own-grade hybrid indicators. Estimation sample includes observations through August 2021. Standard errors clustered by student in parentheses. *** = 1%, ** = 5%, * = 10%.*

Table B3e: COVID effects on mental health-related physician services by learning mode, non-Indigenous non-English home language girls.

Description	COVID effect on monthly % receiving physician services					
	Depression/ anxiety	ADHD	Psychosis	Conduct	Substance	Eating
COVID effect w/interaction terms						
Post x (grade 8)	-0.01	0.00	0.07	-0.01	-0.02	0.05
	(0.21)	(0.06)	(0.06)	(0.02)	(0.02)	(0.08)
Post x (grade 9)	0.14	0.06	0.08	0.00	-0.02	0.01
	(0.22)	(0.06)	(0.07)	(0.02)	(0.02)	(0.09)
Post x (grade 10)	0.35	0.10*	0.11	-0.01	-0.02	0.01
	(0.23)	(0.06)	(0.07)	(0.02)	(0.02)	(0.09)
Post x (grade 11)	0.50**	0.11*	0.16	-0.02	-0.01	0.06
	(0.23)	(0.06)	(0.08)	(0.02)	(0.02)	(0.09)
Post x (hybrid in any grade)	-0.04	-0.04	-0.14**	0.00	0.02	-0.03
	(0.21)	(0.06)	(0.06)	(0.02)	(0.02)	(0.08)
Post x (hybrid in own grade)	-0.06	-0.04	0.04	0.03*	-0.01	-0.01
	(0.12)	(0.04)	(0.04)	(0.02)	(0.01)	(0.05)

*Table reports coefficient on interactions of post-COVID indicator with grade and learning mode indicators; control variables include time trend and indicators for month, grade, neighborhood SES quartile, birth quarter, and any-grade and own-grade hybrid indicators. Estimation sample includes observations through February 2021. Standard errors clustered by student in parentheses. *** = 1%, ** = 5%, * = 10%.*

Table B3f: COVID effects on mental health-related prescriptions filled by learning mode, non-Indigenous non-English home language girls.

Description	COVID effect on monthly % filling prescriptions		
	Antidepressant and related	ADHD-related	Antipsychotic
COVID effect w/interaction terms			
Post x (grade 8)	-0.07	-0.11	0.02
	(0.21)	(0.08)	(0.08)
Post x (grade 9)	0.05	-0.03	0.04
	(0.21)	(0.08)	(0.08)
Post x (grade 10)	0.08	0.13	0.16*
	(0.23)	(0.09)	(0.09)
Post x (grade 11)	0.49**	0.09	0.22**
	(0.23)	(0.09)	(0.10)
Post x (hybrid in any grade)	-0.20	-0.03	-0.06
	(0.21)	(0.08)	(0.08)
Post x (hybrid in own grade)	0.10	-0.06	-0.03
	(0.12)	(0.05)	(0.06)

*Table reports coefficient on interaction of post-COVID indicator with grade and learning mode indicators; control variables include time trend and indicators for month, grade, neighborhood SES quartile, birth quarter, and any-grade and own-grade hybrid indicators. Estimation sample includes observations through August 2021. Standard errors clustered by student in parentheses. *** = 1%, ** = 5%, * = 10%.*