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# A comparative analysis of pediatric mental health-related emergency department utilization in Montréal, Canada, before and during the COVID-19 pandemic

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## Abstract

**Background:** Reports on longitudinal trends in mental health-related (MHR) emergency department (ED) utilization spanning the pre- and post-pandemic periods are lacking, along with evidence comparing healthcare services utilization by sociodemographic subgroups. The aim of this study was to evaluate COVID-19-associated changes in MHR ED utilization among youth overall and by age, sex, and socio-economic status (SES).

**Methods:** This retrospective cross-sectional study analyzed MHR ED utilization before and during the COVID-19 pandemic at a large urban pediatric tertiary care hospital in Montréal, Canada. All ED visits for children (5–11 years) and adolescents (12–17 years) between April 1, 2016 and November 30, 2021 were included. The main outcome was the monthly count of MHR ED visits. Pre-pandemic and pandemic periods were compared using an interrupted time series design. The effect of seasonality (in months), age (in years), sex (male or female), and SES (low, average, high) were compared using a generalized additive model.

**Results:** There were a total of 437,147 ED visits (204,215 unique patients) during the 5-year study period of which 9748 (5.8%) were MHR visits (7,686 unique patients). We observed an increase of 69% (95% CI, +53% to +85%;  $p = 0.001$ ) in the mean monthly count of MHR ED visits during the pandemic period, which remained significant after adjusting for seasonality (44% increase, 95% CI, +38% to +51%;  $p = 0.001$ ). The chance of presenting for a MHR ED visit increased non-linearly with age. There were increased odds of presenting for a MHR ED visit among girls between the pre-pandemic and pandemic periods (OR 1.42, 95% CI 1.29–1.56). No difference by SES group during and before the COVID-19 pandemic was found [OR 1.01, 95% CI 0.89–1.15 (low); OR 1.09, 95% CI 0.96–1.25 (high)].

**Conclusions:** Our study shows important increases in MHR ED utilization among youth, and especially among girls, during the first 20 months of the COVID-19 pandemic, highlighting the need for sustained, targeted and scalable mental health resources to support youth mental health during the current and future crises.

## Background

Since COVID-19 was declared a global pandemic [1], public health measures implemented to reduce transmission of the virus have led to considerable changes in the delivery of pediatric healthcare services [2]. Delivery modes, such as telemedicine, rapidly gained

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importance [3, 4], while utilization of most in-person services plummeted in the first months of the pandemic [5]. Large fluctuations in pediatric emergency department (ED) utilization have been observed [6–17]. Pediatric EDs are integral to the assessment, treatment and coordination of care for children and adolescents, and often serve as a safety net for vulnerable and underserved patients [18]. Increasingly, EDs also play a pivotal role in pediatric mental health emergencies, as exemplified by the rising pre-pandemic trends in mental health-related (MHR) ED visits documented in the last decade [19, 20].

Reported number and proportion of MHR ED visits have not consistently followed the pattern of overall pediatric ED visits following the pandemic onset. While both MHR and overall ED visits first decreased during 2020 [7–12, 14–17, 21–25], some studies have reported increased MHR ED utilization during 2021 and early 2022 [13, 26]. During this time, overall pediatric ED utilization has remained lower than pre-COVID-19 levels [6, 26].

So far, the bulk of the evidence regarding changes in pediatric MHR ED utilization has originated from the United States [6, 9, 12, 15–17, 21–23, 26], with few studies from other parts of the world [7, 8, 10, 11, 13, 14, 24, 25], thereby limiting the generalizability of findings to other countries. Potential regional and national differences could stem from varying COVID-19 epidemiology, public health responses, healthcare systems, socio-economic and sociocultural factors, and availability of mental health services [27]. Moreover, it remains unclear whether MHR ED utilization has differed across pediatric subpopulations. To date, only two studies have examined sociodemographic-specific differences—notably, related to age, sex and socio-economic status (SES) [13, 26]. The first was conducted in two large pediatric centers in New South Wales, Australia, and found increased MHR ED utilization among youth between June 2020 and February 2021, with higher increases among girls and children from socioeconomically advantaged areas [13]. The second study, which analyzed data from the National Syndromic Surveillance Program in the US, showed that adolescent girls aged 12–17 years accounted for the largest increases in both the number and proportion of MHR ED visits seen in 2020, 2021 and January 2022 when compared to 2019 [26]. Additional research is required to prevent further exacerbation of intersectional inequalities in youth mental health [28], and to inform effective service planning and resource allocation in pediatric emergency care.

In this study, we aimed to identify changes in MHR ED utilization before and during the COVID-19 pandemic in Montréal, Canada. We further sought to determine whether COVID-19 showed differential associations by

sociodemographic group, with respect to age, sex, and SES.

## Methods

### Study design, setting and population

For this retrospective cross-sectional study, we used an interrupted time series (ITS) design to compare MHR ED utilization before and during COVID-19 at the *Centre hospitalier universitaire* (CHU) Sainte-Justine. The CHU Sainte-Justine is a high-volume tertiary pediatric university hospital located in Montréal (Québec), Canada. The study population comprised all ED visits for children (5–11 years) and adolescents (12–17 years) between April 1, 2016, and November 30, 2021. We excluded ED visits for younger children (<5 years) as psychiatric consultation or treatment is uncommon in this age group [19]. The primary cohort was defined as all MHR ED visits with complete patient information. Visits for which patients left the hospital prior to receiving care were excluded due to lack of diagnosis. Ethical approval was obtained from the CHU Sainte-Justine Research Ethics Committee (Protocol ID: MP-21–2021-2930). All patient data were deidentified; thus, informed consent was not required. We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline [29].

### Outcomes and variables

#### Exposure

The main exposure was a dummy variable coding the pre-pandemic (0) and the pandemic period [1]. We defined the start of the pandemic period as March 1, 2020, consistent with the initial implementation of COVID-19-related public health measures in the province of Québec [30]. Thus, the pre-pandemic period spanned from April 1, 2016, to February 29, 2020, whereas the pandemic period spanned from March 1, 2020 to November 30, 2021.

#### Outcomes

The outcomes of the ITS analysis included the monthly count of MHR ED visits stratified into the pre-pandemic and pandemic periods. The outcome for the generalized additive model (GAM) was the type of ED visits, being MHR visits or non-MHR visits.

#### Sociodemographic characteristics

We employed a computer query tool (B-Care) to interrogate various hospital administrative databases. We focused on a patient-level ED database that includes demographic (sex, age and 6-digit postal code) and clinical (primary discharge diagnosis) information. The primary discharge diagnosis—recorded by the treating

physicians based on a local list of 658 diagnoses—was used to determine the type of ED visits. We report the list of included MHR ED diagnoses and related diagnostic categories in Additional file 1: Table S1.

Patients' sex assigned at birth was coded as male or female. Patients' age at diagnosis was considered both as a continuous and as a dichotomous variable (5–11 years vs 12–17 years). We selected an age cut-off at 12 years to reflect the difference between primary (elementary school) and secondary (middle and high school) education, as public health measures have differed across levels of education in Québec. SES was determined by linking the patients' postal code at the time of diagnosis with Statistics Canada's Postal Code Conversion File, thus allowing us to identify the relevant dissemination area based on the most recent Canadian Census (from 2016). We then linked this area-level information to Pampalon's material deprivation index, which combines measures of income, employment, and education. According to this index, SES is categorized into quintiles from Q1 (least materially deprived) to Q5 (most materially deprived) [31]. Based on previous literature, we combined the two lowest and the two highest quintiles to create three distinct material deprivation profiles: most privileged (Q1–Q2), average (Q3), and most deprived (Q4–Q5) [32].

### Statistical analysis

We first used descriptive statistics to summarize patient characteristics for MHR ED visits. Kruskal–Wallis and  $\chi^2$  tests were employed to compare between-time period differences for continuous and categorical variables, respectively. To investigate changes in MHR ED utilization between the pre-pandemic and pandemic periods, we conducted an ITS analysis of aggregated monthly MHR ED visits using a Bayesian structural time series model (BSTS). We treated the monthly count of MHR ED visits as a time series and the month at which the exposure first occurred as the event of interest. The outcome was decomposed into trend-cycle, seasonal, and remainder components. The seasonal component was then removed to obtain a time series adjusted for seasonal variations in MHR ED visits.

To investigate associations between sociodemographic characteristics and the outcome, a generalized additive model (GAM) with binomial response and a logistic link was specified. GAMs are an extension of generalized linear models (GLMs), whereby predictors are linked to the outcome using smooth functions, allowing for greater flexibility in incorporating nonlinear forms of the predictors [33]. Model parameters were estimated via restricted maximum likelihood (REML) [34]. The following covariates were included in the model: seasonality (in months) and age (in years), continuous variables modeled as

semi-parametric smoothed terms; COVID-19 exposure (the main exposure), sex, and SES, categorical variables modeled as parametric linear terms. For the smoothed terms, we specified factor-smooth interactions, by which a separate smooth function was estimated for each level of COVID-19 exposure (i.e., pre-pandemic and pandemic periods). An interaction between linear terms and COVID-19 exposure was also specified. As part of a sensitivity analysis, we fitted another model with age as a dichotomous variable.

Analyses were performed using R version 4.1.2 (R Project for Statistical Computing). ITS analysis was conducted using the Causal Impact and seasonal packages [35, 36]. We used the mcgv package for GAM estimation [34]. Statistical significance was set at two-sided  $p$ -value  $< 0.05$ .

### Results

Between April 2016 and November 2021, there were a total of 437,147 ED visits (204,215 unique patients). Among these visits, children and adolescents aged 5 to 17 years accounted for 168,749 ED visits (99,313 unique patients), of which 9748 (5.8%) were MHR visits (7686 unique patients). Patient characteristics are summarized in Table 1. We found significant differences between time periods [pre-pandemic (2016–2019) and pandemic (2020, 2021)] for all patient characteristics, with the exception of SES. There were missing data for the SES (approximately 5% of visits per year), and the age of patients in the included MHR ED visits was significantly higher than that of the excluded ones (Additional file 1: Table S2). The monthly count of MHR ED visits is presented by time period, sociodemographic characteristics and diagnostic category in Figs. 1 and 2, and Additional file 1: Figure S1, respectively. The frequency of MHR ED visits per unique patient can be found in the Supplement (Additional file 1: Table S3).

Bayesian structural time series analysis revealed that after an initial decrease in MHR ED visits between March and June 2020, monthly visit counts exceeded those from pre-pandemic years as shown in Fig. 3 (deseasonalized data), Additional file 1: Figures S2, S3 (raw data) and S4 (raw and deseasonalized data). Overall, we observed an increase of 69% (95% CI, +53% to +85%;  $p = 0.001$ ) in the mean monthly count of MHR ED visits, which remained significant after adjusting for seasonality (44% increase, 95% CI, +38% to +51%;  $p = 0.001$ ). As such, during the pandemic period, the monthly count of MHR ED visits averaged 177, whereas if the pandemic had not occurred, an average of 122 (Bayesian  $CI_{95}$  114–130) would have been expected, yielding an absolute effect of +54 (Bayesian  $CI_{95}$  47–62), as shown in Additional file 1: Table S4.

**Table 1** Characteristics of ED visits, April 1, 2016 to November 2021

All ED visits	Prepandemic	Pandemic		Overall (N = 168,749)	
	2016–2019 (N = 118,728)	2020 (N = 23,317)	2021 (N = 26,704)		
MHR visits	5927 (5.0%)	1521 (6.5%)	2300 (8.6%)	9748 (5.8%)	
Other visits	112,801 (95.0%)	21,796 (93.5%)	24,404 (91.4%)	159,001 (94.2%)	
MHR ED visits	2016–2019 (N = 5927)	2020 (N = 1521)	2021 (N = 2300)	Overall (N = 9748)	p-value
Age (continuous)					
Median (IQR)	14.3 (11.0–16.0)	14.4 (11.7–16.1)	14.4 (12.2–15.9)	14.3 (11.4–16.0)	0.045
Age group					
5–11 years	1803 (30.4%)	413 (27.2%)	547 (23.8%)	2763 (28.3%)	<0.001
12+ years	4124 (69.6%)	1108 (72.8%)	1753 (76.2%)	6985 (71.7%)	
Sex					
Female	3521 (59.4%)	970 (63.8%)	1615 (70.2%)	6106 (62.6%)	<0.001
Male	2406 (40.6%)	551 (36.2%)	685 (29.8%)	3642 (37.4%)	
SES					
Most privileged	1918 (32.4%)	514 (33.8%)	805 (35.0%)	3237 (33.2%)	0.087
Average	1009 (17.0%)	252 (16.6%)	408 (17.7%)	1669 (17.1%)	
Most deprived	2755 (46.5%)	675 (44.4%)	972 (42.3%)	4402 (45.2%)	
Missing	245 (4.1%)	80 (5.3%)	115 (5.0%)	440 (4.5%)	

Data are n (%). Counts include multiple visits for the same patient. Between-time period differences were assessed using Kruskal–Wallis (for continuous variables) and  $\chi^2$  tests (for categorical variables).

ED, emergency department; MHR, mental health-related; SES, socio-economic status

Parametric and non-parametric GAM estimates are reported in Table 2, and represented graphically in Additional file 1: Figure S5. The GAM estimation indicated that the chance of presenting for a MHR vs non-MHR visit was influenced by seasonality (EDF = 7.34,  $p < 0.001$ ) and age (EDF = 7.14,  $p < 0.001$ ). Overall, the probability of a MHR ED visit was higher in the earlier and later months of the year (i.e., during the winter period), and tended to decrease during the summer period. However, this pattern was more pronounced during the pandemic period (EDF = 3.04,  $p < 0.01$ ), as shown in Additional file 1: Figure S5b. The chance of presenting for a MHR ED visit increased non-linearly with age. With respect to COVID-19, the effect of age (as a continuous variable) was similar between time periods for youth up to 14 years old but differed for adolescents aged 15–17 years (EDF = 4.11,  $p < 0.001$ ). More specifically, Additional file 1: Figure S5b shows a decrease for those aged 15–17 years during COVID-19, whereas an increase was observed among the latter before COVID-19. This result was corroborated in the sensitivity analysis treating age as a dichotomous variable (Additional file 1: Table S5).

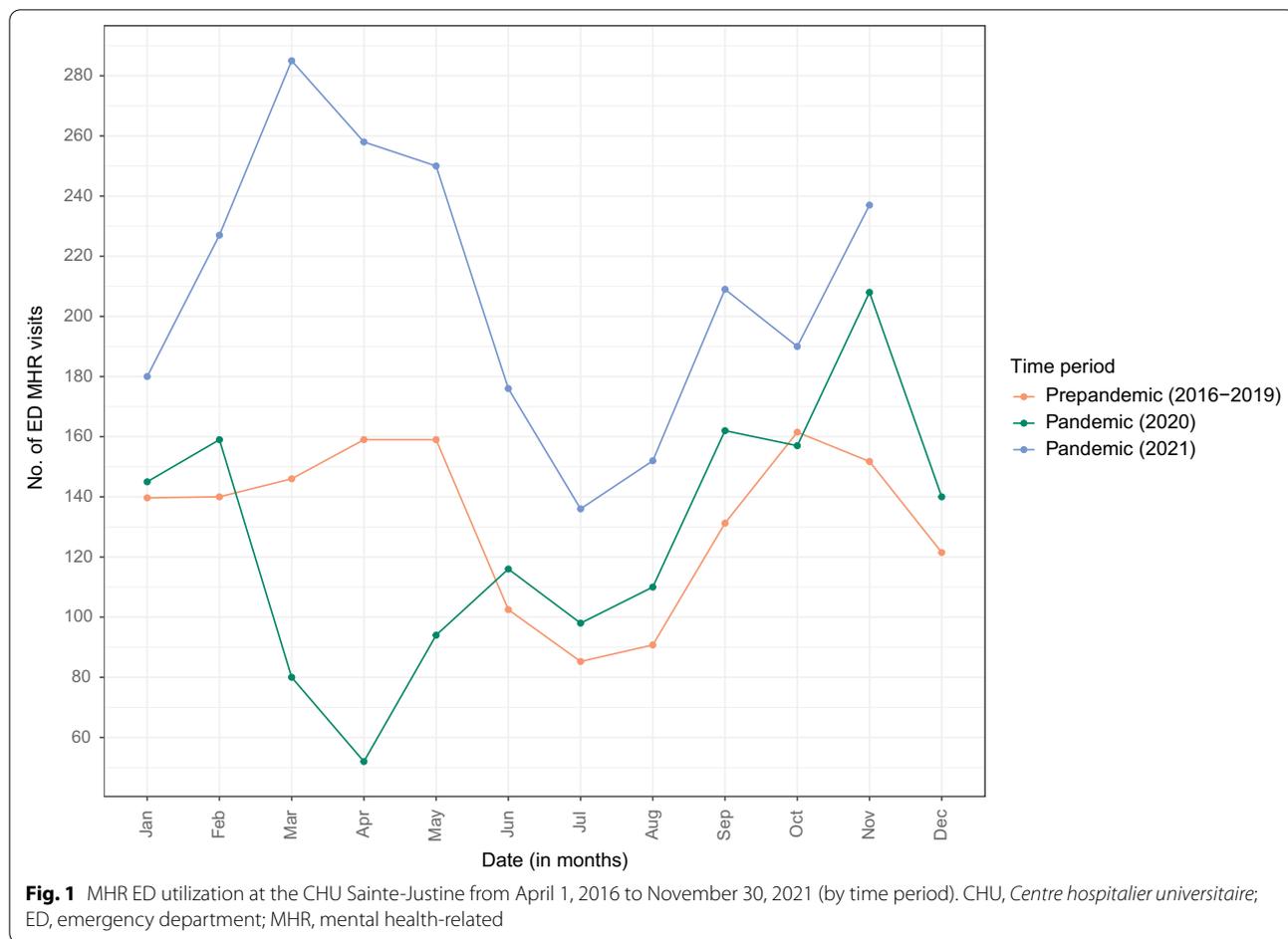
We present the parametric estimates as odds ratio (OR) and corresponding 95% CI in a forest plot (Additional file 1: Figure S5a). Female individuals were more likely to present for a MHR ED visit than male individuals,

both before (OR 1.42, 95% CI 1.35–1.50) and during the COVID-19 pandemic (OR 2.02, 95% CI 1.73–2.35). By contrast, the chance was lower among youth who were the most materially deprived [OR 0.77, 95% CI 0.71–0.83 (pre-pandemic); OR 0.78, 95% CI 0.70–0.86 (pandemic)] and those who were the most materially privileged [OR 0.84, 95% CI 0.78–0.91 (pre-pandemic); OR 0.92, 95% CI 0.82–1.02 (pandemic)], compared to their counterparts in the average SES group.

Between the pre-pandemic and pandemic periods, the chance of presenting for a MHR ED visit increased among female individuals (OR 1.42, 95% CI 1.29–1.56). No difference by SES group during and before the COVID-19 pandemic was found [OR 1.01, 95% CI 0.89–1.15 (most deprived); OR 1.09, 95% CI 0.96–1.25 (most privileged)].

## Discussion

This retrospective cross-sectional study found that the COVID-19 pandemic period was associated with an increase in MHR ED utilization, irrespective of its overall trend and annual seasonality. Monthly counts of MHR ED visits increased by approximately 44% during COVID-19 compared to prior years. During the pandemic period, the odds of presenting for a MHR ED visit were higher among girls than those during the

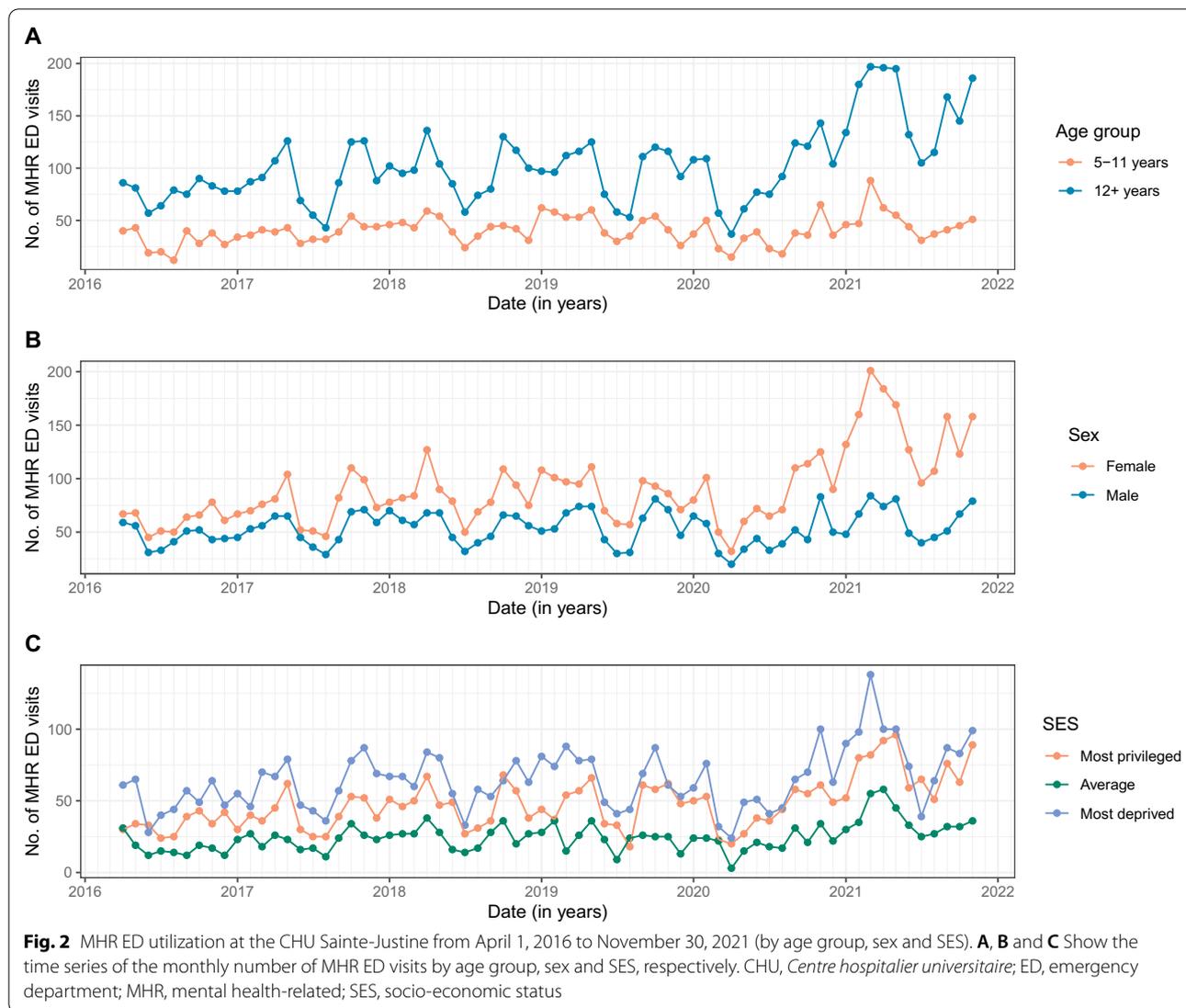


pre-pandemic period. Conversely, lower odds of presenting for a MHR ED visit were found in older adolescents (> 15 years) during COVID-19. To our knowledge, these findings are the first to describe the magnitude of changes in MHR ED utilization in youth during COVID-19 by sociodemographic factors in Canada.

Our findings support a substantial increase in MHR ED utilization in the pandemic period compared to the pre-pandemic period, despite an initial decrease in the first 3 months of COVID-19. These findings corroborate with previous international studies [7–12, 14–17, 21–24]. The strongest increase appeared to take place during winter months, a period when public health measures, including school closures were stricter [37]. In Canada, and specifically in Québec, where access to primary healthcare services remains limited for many, even in non-pandemic times [38], the loss of supportive school and community structures could have contributed to this increased utilization of ED services.

Our analyses revealed that the odds of presenting to the ED for MHR diagnoses were greater among girls, and that this was intensified by the pandemic. These results

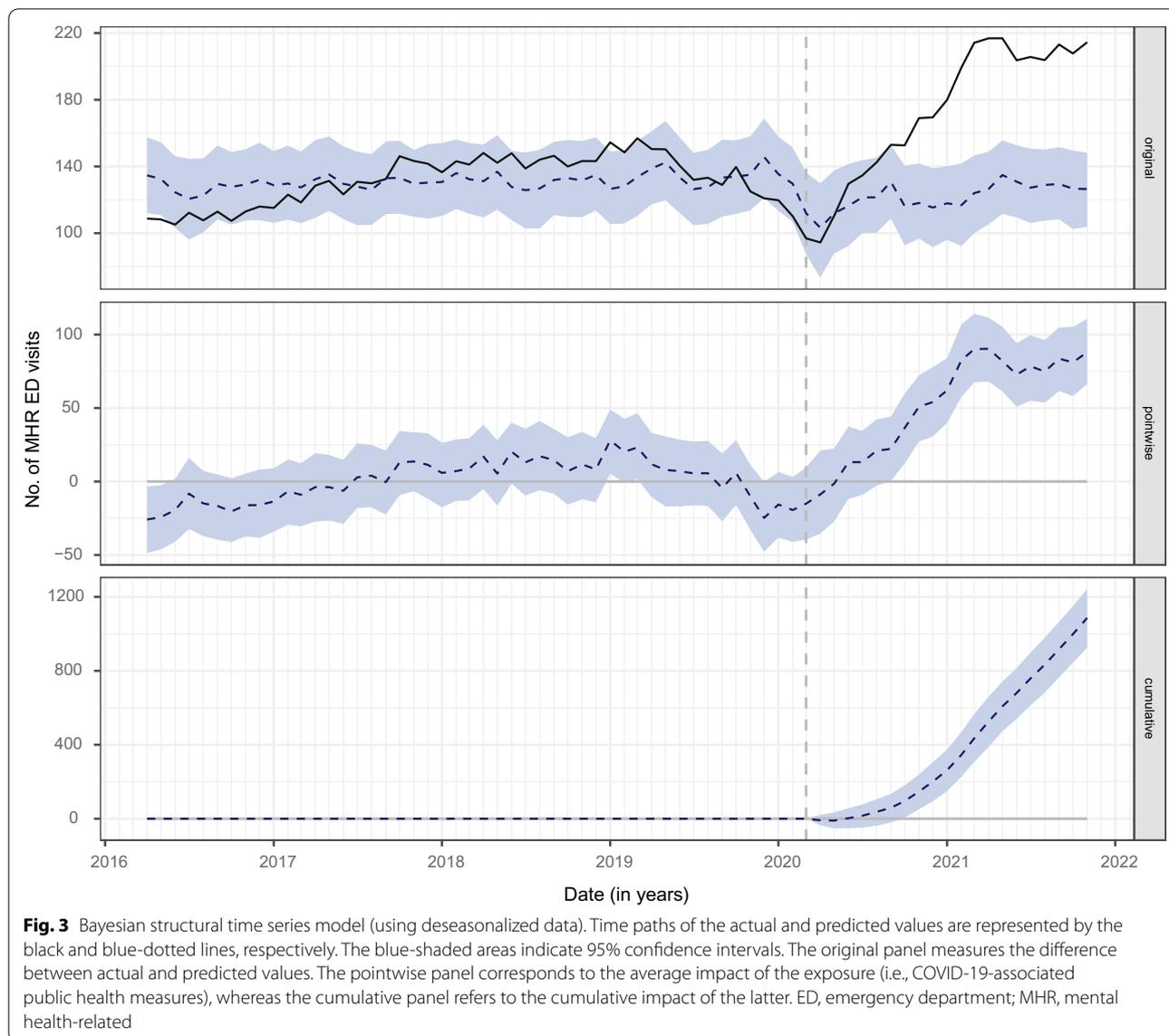
coincide with those obtained in Australia and the US [13, 26]. In fact, an increase in MHR ED utilization among adolescent girls aged 12–17 years was also seen in New South Wales during the first year of the pandemic (January 2020 to February 2021) [13]. Weekly ED visits for adolescent girls also increased for eating and tic disorders in 2020–2021 and depression and obsessive–compulsive disorder in 2021 compared to 2019 in the US [26]. Conversely, while some studies have suggested an increase in MHR symptoms among girls since the onset of the pandemic [39, 40], a repeated cross-sectional study using representative data from Ontario and Québec, Canada’s two largest provinces, showed that the increases in mental health symptoms among adolescents appeared to be similar between boys and girls. Further, these trends were no greater between the years 2018 and 2019 (pre-pandemic) than between the years 2019 and 2020 (pre/post onset of the pandemic) [41]. It can thus be suggested that reasons other than changes in population-level mental health symptomatology, such as increases in help-seeking behaviors, may have contributed to the increased odds of MHR ED presentations among girls vs boys [42].



In our study, there was a higher proportion of MHR ED visits by older (12–17 years) vs younger (5–11 years) youth, though increases in visit counts during the pandemic period could be seen in both age groups. Our findings are consistent with a recent Canadian study on healthcare services utilization for eating disorders in Ontario which showed a similar increase in MHR ED visits among younger (age 3–13 years) and older (ages 14–17 years) youths [43]. Interestingly, our non-linear estimate of the effect of age on MHR ED utilization was slightly smaller among older adolescents (ages 15–17 years) during the pandemic (vs pre-pandemic) period. Adolescence coincides with a key period of brain development and the formation of one’s personal and social identity [44]. Adolescents may be particularly vulnerable to public health preventive measures that can lead to disruptions in their social life [45], but, as they

get older, may also be able to develop new coping strategies such as connecting with peers online and outdoors, and engaging in leisure and health-promoting activities. Younger youth, who may not have the means or capacity to develop the same coping mechanisms, appear to have been equally, if not more strongly affected by school closures and other pandemic-related measures, which may have contributed to the increase in MHR ED utilization seen in this age group [46].

Our study revealed that prior to the onset of the pandemic, MHR ED visits were less likely to be attributed to youth from both socioeconomically advantaged and disadvantaged areas when compared to those from average SES areas. Our model indicated that this same pattern remained during the pandemic. Indeed, our data showed an absolute increase in number of visits that was similar for all three SES groups,



suggesting that pandemic-related effects on pediatric healthcare service utilization were similar across the SES spectrum. Our findings differ from those reported by Hu and colleagues in Australia, where increases in MHR ED utilization were higher for youth from socio-economically advantaged areas [13]. Though increased utilization of MHR ED services may serve as an indicator of worsening youth mental health in some circumstances, this indicator alone does not adequately capture the exacerbation of existing healthcare inequalities among youth from lower vs higher SES, and may be more reflective of SES-related differences in access to appropriate services [47, 48].

**Limitations**

There are limitations to our study. First, our findings are based on a single, large, tertiary pediatric center, and might not be generalizable to other clinical settings. However, this center is the largest pediatric hospital with the greatest number of ED visits in the province. Second, the comprehensiveness of the outcome and patient characteristics was limited by data availability. We could only identify the primary diagnosis as recorded by the treating physician at the ED (without confirmation by a mental health provider), despite it being common for patients to present multiple diagnoses. Third, when considering SES, the geocoding of postal codes could not provide

**Table 2** Semi-parametric GAM for MHR ED utilization, April 1, 2016 to November 2021

	Parametric terms		
	Estimate	SE	p-value
Intercept	-3.312	0.039	< 0.001
Time period			
Prepandemic (ref)			
Pandemic	0.126	0.067	0.062
Sex			
Male (ref)			
Female	0.353	0.028	< 0.001
SES			
Most deprived	-0.267	0.038	< 0.001
Average (ref)			
Most privileged	-0.174	0.040	< 0.001
Sex (female): time period (pandemic)	0.348	0.048	< 0.001
SES (most deprived): time period (pandemic)	0.012	0.064	0.850
SES (most privileged): time period (pandemic)	0.089	0.067	0.184
	Smooth terms		
	EDF		p-value
Seasonality	7.345		< 0.001
Age	7.137		< 0.001
Seasonality: time period (pandemic)	3.038		0.004
Age: time period (pandemic)	4.106		< 0.001

The colon symbol is employed to represent the interaction between two terms. age and seasonality are measured in years and months, respectively

ED, emergency department; EDF, effective degrees of freedom (of the functional parameters); GAM, generalized additive model; MHR, mental health-related; SE, standard error (for the parameter estimate); SES, socio-economic status

patient-level data and resulted in missing data (~5% overall). Use of census information on dissemination areas from 2016, rather than the exact year during which the ED visits occurred, might have introduced bias. Finally, MHR ED utilization (as measured by the monthly number of visits) offers only a single viewpoint on youth mental health, and should therefore be considered in the larger context of other physician- and non-physician-based mental healthcare services utilization [2]. Increased MHR ED utilization could also be a reflection of other societal disruptions, such as the loss of access to other school- and community-based services [49].

**Conclusions**

The COVID-19 pandemic has placed an unprecedented stress on pediatric mental health services as shown by abrupt increases in MHR ED visits. While EDs can serve an important purpose in providing rapid mental health services for youth in situations of crisis, there is a need for sustained, targeted and scalable mental health

resources to support youth mental health. This appears to be especially true for girls and should be considered in preparation for future public health crises.

**Abbreviations**

CHU: *Centre hospitalier universitaire*; COVID-19: Coronavirus disease 2019; ED: Emergency department; GAM: Generalized additive model; GLM: Generalized linear model; ITS: Interrupted time series; MHR: Mental health-related; REML: Restricted maximum likelihood; SES: Socioeconomic status; STROBE: Strengthening the Reporting of Observational Studies in Epidemiology; UK: United Kingdom; US: United States.

**Supplementary Information**

The online version contains supplementary material available at <https://doi.org/10.1186/s12991-022-00398-y>.

**Additional file 1: Table S1.** MHR ED diagnoses included in the study sample. **Table S2.** Patient characteristics of included vs. excluded MHR ED visits. **Table S3.** Frequency of the number of MHR ED visits per unique patient. **Table S4.** Posterior estimates of the causal impact of COVID-19 on MHR ED visits, April 1, 2016 to November 30, 2021. **Table S5.** Semi-parametric GAM for MHR ED utilization, April 1, 2016 to November 30, 2021 (with age group as a dichotomous variable). **Figure S1.** MHR ED utilization at the CHU Sainte-Justine from April 1, 2016 to November 30, 2021 (by diagnostic category). **Figure S2.** Bayesian structural time series model (with raw data). **Figure S3.** Decomposition of additive time series. **Figure S4.** Original and deseasonalized time series. **Figure S5.** Graphical representation of the parametric and smooth terms included in the semi-parametric GAM

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**Author contributions**

NC and OD conceived the study. GB and NC designed the study. JG oversaw the data collection and AS performed the data extraction. OD obtained ethical approval. GB had full access to all data and conducted the analyses, with feedback from AB. GB and NC drafted the manuscript. AB, MO and MCG revised the manuscript for important intellectual content. All authors contributed to the interpretation of data and read and approved the final manuscript.

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**Availability of data and materials**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Declarations**

**Ethics approval and consent to participate and consent for publication**

Ethical approval was obtained from the CHU Sainte-Justine Research Ethics Committee (Protocol ID: MP-21–2021-2930). All patient data were deidentified; thus, informed consent was not required.

**Competing interests**

The authors declare that they have no competing interests.

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