A comparison of psychiatric inpatient admissions in youth before and during the COVID-19 pandemic

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Abstract

Background: The current understanding of the effect of COVID-19 on child and youth admissions to psychiatric inpatient units over time is limited, with conflicting findings and many studies focusing on the initial wave of the pandemic. Objectives: This study identified changes in psychiatric inpatient admissions, and reasons for admission, including suicidality and self-harm, before and during the COVID-19 pandemic. Method: This time series study analyzed 3,723 admissions of youth (ages 0-18.88 years) admitted to four major psychiatry inpatient units in a large Canadian city between January 1, 2016 and December 31st, 2021. Pre-pandemic (before March 11, 2020) and during-pandemic (after March 11, 2020) trends of admissions were explored using a Bayesian structural time series model (BSTS). Results: The model revealed that overall admissions during the pandemic period exceeded what would have been predicted in the absence of a pandemic, a relative increase of 29%. Additionally, a rise in the total number of admissions due to self-harm and suicidality (29% increase), externalizing/behavioral issues (69% increase), and internalizing/emotional issues (28% increase) provided strong evidence of increased admissions compared to what might have been expected from pre-pandemic numbers. Conclusions: There was strong evidence of increases in psychiatric inpatient admissions during the COVID-19 pandemic compared to expected trends based on pre-pandemic data. To ensure accessible and continuous mental health supports and services for youth and their families during future pandemics, these findings highlight the need for rapid expansion of inpatient mental health services, similar to what occurred in many intensive care units across Canada.

Key Words: COVID-19 pandemic; child and youth mental health; inpatient psychiatric admissions
Introduction

The COVID-19 pandemic introduced public health measures that resulted in unprecedented changes in schooling, work, financial disruptions, and social isolation (1). There is significant concern that these disruptions to youth’s daily lives may lead to long-term adverse consequences, including mental health problems (2). Since the onset of the pandemic, knowledge related to these concerns has grown rapidly, and some researchers have found increases in the rates of mental health symptoms and demands for mental health services among youth (3–6). Trends in health care utilization due to mental health concerns is a critical metric that can help determine the overall impact of the COVID-19 pandemic on youth mental health.

Over the course of the pandemic, studies have documented initial reductions in emergency department and psychiatric outpatient and inpatient service utilization (7–13), likely reflecting the tightening of public health restrictions and the fear of attending healthcare settings during a pandemic (14–16). Studies that include longer term data (i.e., ≥3 months) have highlighted that health care utilization due to psychiatric concerns have significantly increased compared to pre-COVID levels (8,10,17), especially among adolescent girls (18–21). However, some studies continue to demonstrate decreased use of psychiatric inpatient services over time (22,23). Thus, the directionality of these psychiatric care utilization patterns as the pandemic continues warrants further investigation. In addition, much of the extant research has originated from outside of Canada (7,10,12,20,23–32); only five studies have examined psychiatric healthcare utilization trends in Canada (9,18,33–35), and only one of these studies specifically examined inpatient hospitalizations due to mental health concerns (34). The current study fills these critical knowledge gaps by examining the long-term trends of youth inpatient psychiatry service utilization in Canada as these settings can provide an indication of how COVID-19 has impacted the mental health of youth with the highest needs.

The impact of COVID-19 on suicide and self-harm rates in adolescents is particularly concerning, given the already steadily rising rates of suicide among youth in some countries (36–39). Furthermore, self-harm (intentional non-fatal self-injury) requiring hospitalization is the single strongest predictor of suicide in youth (40–42). Two recent meta-analyses highlighted increased suicidal behaviours, including suicidal ideation, suicide attempts and self-harm during the COVID-19 pandemic, particularly among females and older adolescents (43,44). Madigan and colleagues specifically investigated pediatric emergency department visits across 18 countries, finding an overall increase in visits for suicidal behaviours during the pandemic, and a decrease in emergency department visits for other mental health-related concerns (44). Of the few studies examining youth mental health service utilization in Canada, one study demonstrated that outpatient referrals for self-harm increased only among females (45), while another study found increases in ambulatory care visits and admissions due to suicidality or self-harm for both males and females (35). Studies conducted prior to COVID have highlighted that hospital presentations for self-harm after the age of 12 years is increasingly common and gender differences occur in that for every one boy who presents to hospital there are on average five to six girls (46). Furthermore, individuals who identify as non-binary are at increased risk for hospitalizations for suicidality or self-harm (47). These previous studies have mainly focused on mental health care visits for suicide and self-harm in other settings, rather than inpatient care, and have not included data after the initial waves of the pandemic (post-2020). Consequently, there is a crucial knowledge gap, which this study aims to fill, regarding the impact of COVID-19 on psychiatric inpatient hospitalizations for suicide and self-harm in Canada.
of COVID-19 on child and youth inpatient admissions, particularly in Canada.

The present study identified changes in trends of psychiatric inpatient admissions before and during the COVID-19 pandemic in four major psychiatric inpatient units in Calgary, Alberta, Canada for youth with specific mental health related presentations. We also examined inpatient admission trends based on youth age and gender. As a secondary aim, we investigated differences in inpatient treatment statistics (e.g., length of stay in the hospital, psychological functioning at admission and discharge) between pre- and during the pandemic.

### Method

#### Participants

Admissions data comprised of youth (ages 0-18.88 years) admitted to four major psychiatric inpatient units in Calgary, Alberta, Canada between January 1\textsuperscript{st}, 2016, and December 31\textsuperscript{st}, 2021. As there are only five inpatient units in Calgary, these four units are anticipated to represent the majority of the psychiatric inpatient units in the surrounding urban area situated in varying settings (e.g., downtown, and other areas) and thus were considered representative of the community. We excluded inpatient admissions for children and youth with a primary listed diagnosis of a neurodevelopmental disability (e.g., autism, fetal alcohol spectrum disorder, attention-deficit/hyperactivity disorder) as these youth may have been differentially impacted by the pandemic compared to neurotypical youth (58). This resulted in a final sample size of 3,723 admissions. Demographic information is presented in Table 1. All data collection and analyses were approved by the University of Calgary Conjoint Faculties Research Ethics Board. Given that this study utilized anonymous archival data, informed consent was not required.

#### Measures and Variables

The following data was collected retrospectively from electronic medical records: (i) age, (ii) gender, (iii) admission date, (iv) discharge date, (v) pre-existing mental health diagnoses, and (vi) referral reason. Upon admission, unit mental health staff (e.g., psychologist, social worker, nurse, psychiatrist) denoted in the electronic medical record the primary reason for referral from a drop-down checklist of 15 pre-existing categories. Given limited number of patients (small cell size) presenting with addictive issues, adjustment

| Table 1. Summary of demographic information for pre-pandemic and during pandemic admissions |
|------------------------------------------|----------------------|----------------------|----------------------|
|                                          | Pre-Pandemic         | During Pandemic       | Total               |
|                                          | (n = 2388)           | (n = 1335)           | (N = 3723)          |
| Gender                                   | % (n)                | % (n)                | % (n)               |
| Male                                     | 36.3 (867)           | 37.2 (497)           | 36.6 (1364)         |
| Female                                   | 58.2 (1390)          | 58.1 (776)           | 58.2 (2166)         |
| Transgender                               | 2.7 (65)             | 2.6 (35)             | 2.7 (100)           |
| Other                                    | 2.4 (57)             | 1.9 (26)             | 2.2 (83)            |
| Missing                                  | 0.0 (1)              | 0.0 (0)              | 0.0 (1)             |
| Referral Reason                          |                      |                      |                     |
| Suicidality/Self-Harm                    | 69.1 (1649)          | 66.7 (891)           | 68.2 (2540)         |
| Externalizing/Behavioral Issues          | 7.0 (166)            | 12.1 (161)           | 8.8 (327)           |
| Aggression/Harm to others                | 6.7 (161)            | 6.3 (84)             | 6.6 (245)           |
| Thought Disturbances/ Perceptual Issues  | 5.5 (132)            | 5.0 (67)             | 5.3 (199)           |
| Internalizing/Emotional Issues           | 4.3 (102)            | 4.3 (58)             | 4.3 (160)           |
| Other\(^1\)                              | 7.1 (170)            | 5.5 (73)             | 6.5 (243)           |
| M (SD)                                   | 15.36 (1.87)         | 14.62 (2.23)         | 15.09 (2.04)        |

\(^1\)The “Other” category includes addictive issues, adjustment problems, developmental concerns, eating issues, medication management, and family issues, as well as other non-specified reasons for referral.
problems, developmental concerns, eating issues, medication management, and family issues, as well as other non-specified reasons for referral, the research team created an “Other” category, which comprised of a combination of all the above. If a patient presented with multiple, or comorbid, concerns (e.g., suicidality and aggression), staff attempted to identify the primary issue for the patient or the issue that was impacting their functioning the most. Furthermore, the Children’s Global Assessment Scale (CGAS)(48), which is a measure of psychological and social functioning, was assessed by a clinician at both admission and discharge. On this scale, youth are given a single score between 1 and 100, based on a clinician’s assessment of prior information gathered from the child, their parent, and other supplementary information (e.g., from the child’s school). Higher scores indicate healthier functioning.

**Data Analytic Plan**

To address the primary research question of whether the number of admissions of youth to inpatient psychiatry units has been impacted by the pandemic, time series analysis of aggregated monthly inpatient admissions was conducted using a Bayesian structural time series model (BSTS). BSTS modeling is a causal time series modeling method designed to assess if a change occurring at a specific time point (in the case of the present study, the onset of the pandemic) has an impact on data collected after the change is implemented. BSTS modeling uses data collected prior to the change to model a prediction of the post-change data if no change occurred. This model acts as a synthetic control with which to compare data in the time period of interest and allows for the inference of causation (49). Although, BSTS modeling has primarily been used to analyze economic and marketing trends, recent research has used this method to examine changes in mental health related visits to emergency departments in Canadian hospitals during the earlier phases of the COVID-19 pandemic (18).

Consistent with pre-existing literature (18,34), as well as Calgary’s initial implementation of COVID-19 public health measures (50), March 11th, 2020 was chosen as the critical time point used in the model. The primary analysis examined monthly admission numbers for all patients, and this was supplemented by a series of follow-up analyses examining the number of admissions for specific referral reasons to identify trends in reason for admission. Listed reasons for admission were “Suicidality/Self-Harm”, “Externalizing/Behavioral issues”, “Aggression/Harm to others”, “Thought disturbances/Perceptual issues”, and “Internalizing/Emotional issues” and an “Other” category, which included smaller categories of referral reasons (e.g., referral for addictive issues, adjustment problems, eating issues, as well as other non-specified reasons for referral). We examined inpatient admission trends based on patient gender (male, female, and “other/self-defined reported gender [i.e., identifying as transgender or indicated other/self-defined]) and age (0-12 years old and 13-18 years old).

These analyses were run in R version 3.6.3 (51). Consistent with previous research (18), the Seasonal package (52) was used prior to running any models to remove seasonality trends from the data, allowing for a more accurate analysis of changes related to COVID-19. The CausalImpact package (49) was used to run the BSTS models. All models were run twice, once with the raw data and again with the seasonality adjusted data. All models produced similar results in terms of directionality and relative increase and only the seasonality adjusted numbers are reported to ensure the most accurate representation of the actual trends due to the removal of potentially spurious factors. Results for raw data are available in supplementary materials Table S1 for comparison.

The CausalImpact package calculates a Bayesian one-sided tail-area probability value for each model representative of the confidence in the directionality of any change relative to the model’s prediction rather than its significance, and this value was reported as a Bayesian p value in the present study. Similarly, Bayesian confidence intervals calculated by the statistical package were presented as 95% confidence intervals. All models were run with 100,000 iterations to maximize accuracy, referring to the number of Markov chain Monte Carlo (MCMC) samples used to inform inferences. Due to the lack of pre-existing literature on this topic, the priors for all models were chosen to be minimally informative and left to the default standards set by the CausalImpact package (prior.level.sd = 0.01). Based on recommendations by the package author, models were also run using a more restrictive prior of 0.1 but produced highly similar results, and so are not reported in the present paper.

To address the secondary aim, we examined differences in inpatient treatment statistics (e.g., length of stay in the hospital, CGAS total score at admission and discharge) during the pandemic relative to before the pandemic using Welch’s independent samples t-tests to account for unequal group sizes. The analyses for the secondary aim were completed using the open source statistical software Jamovi. To avoid violating the assumption of independent data, only a patient’s first admission to the units was included in the analysis, leaving a total of 2,559 unique patients (1,894 pre-pandemic and 665 during pandemic).
**Results**

**Primary Aim**

Overall Admissions and Self-Harm/Suicidality. BSTS modeling revealed that overall psychiatric admissions during the pandemic period exceeded what would have been predicted in the absence of a pandemic (see Table 2). There was an initial decrease in inpatient admissions followed by an overall increase in admissions after the initial stages of the pandemic (see Figure 1). During the pandemic period, the monthly admissions averaged at 61 admissions per month while the model predicted an average of 47 admissions per month if the pandemic had not occurred. This difference reflects an absolute increase of 14 admissions per month, which indicates a relative increase (or relative effect size) of 29% (95% CI [20%, 38%], p < .001). The total number of admissions due to self-harm and suicidality showed strong evidence of an increase by an average of 10 admissions per month compared to expected pre-pandemic numbers (relative effect size of 28%, 95% CI [-0.068%, 57%], p < .05). Lastly, there was strong evidence that the pandemic impacted the number of monthly admissions for the “Other” category (absolute increase of 1.7 admissions per month compared to expected pre-pandemic numbers; relative effect size of 55%, 95% CI [14%, 95%], p < .01). There was no evidence of an effect of the pandemic on admissions for Aggression/Harm and Thought Disturbances/Perceptual issues.

To determine whether certain referral reasons may be driving the overall increase in admission rates, we also examined whether COVID-19 impacted the ratio of admissions for specific referral reasons (i.e., number of admissions for a specific referral reason within a month/total number of admissions within a month). Overall, similar patterns of total number of admissions for externalizing/behavioural issues, aggression/harm to others, and perceptual issues were found. For both self-harm/suicidality and internalizing/emotional issues, results from these analysis indicated

<table>
<thead>
<tr>
<th>Model</th>
<th>Predicted Value</th>
<th>Actual Value</th>
<th>95% CI of Predicted Value</th>
<th>Probability of Causal Effect (%)</th>
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<tr>
<td>Overall Admissions</td>
<td>47</td>
<td>61</td>
<td>43, 52</td>
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<tr>
<td>Male</td>
<td>18</td>
<td>21</td>
<td>16, 21</td>
<td>&lt; .05</td>
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<td>Female</td>
<td>28</td>
<td>35</td>
<td>25, 38</td>
<td>&lt; .001</td>
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<tr>
<td>Other and Transgender</td>
<td>2.7</td>
<td>2.7</td>
<td>1.3, 4</td>
<td>0.464</td>
</tr>
<tr>
<td>Younger (0 – 12)</td>
<td>5</td>
<td>9.8</td>
<td>3.6, 6.3</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Older (13 – 18)</td>
<td>42</td>
<td>51</td>
<td>39, 46</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Suicidality/Self-Harm</td>
<td>34</td>
<td>44</td>
<td>31, 38</td>
<td>&lt; .001</td>
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<td>Externalizing/Behavioral Issues</td>
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<td>4.2</td>
<td>1.5, 3.5</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Aggression/Harm to others</td>
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<td>2.7</td>
<td>1.5, 2.9</td>
<td>0.074</td>
</tr>
<tr>
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<td>3.1</td>
<td>2.4, 3</td>
<td>0.543</td>
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<tr>
<td>Internalizing/Emotional Issues</td>
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<td>3</td>
<td>1.7, 3</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>Other*</td>
<td>3.1</td>
<td>4.8</td>
<td>1.8, 4.8</td>
<td>&lt; .01</td>
</tr>
</tbody>
</table>

*BSTS: Bayesian structural time series model

1 Reported as average admissions to inpatient units per month
2 A Bayesian one-sided tail-area probability value for each model is representative of the confidence in the directionality of any change relative to the model's prediction rather than its significance.
3 The “Other” category includes addictive issues, adjustment problems, developmental concerns, eating issues, medication management, and family issues, as well as other non-specified reasons for referral.
There was also strong evidence that the pandemic had an impact on the number of monthly admissions for both younger and older youth (see Figure 4). The number of admissions for younger youth increased by an average of 5 admissions per month (relative effect size of 97%, 95% CI [70%, 124%], $p < .001$). The number of admissions for older youth increased by an average of 9 admissions per month. However, given that a larger number of older patient admissions were expected based on pre-pandemic admission numbers, this resulted in a relative effect size of only 20% (95% CI [12%, 29%], $p < .001$). Therefore, both younger and older age groups demonstrated absolute increases in admissions compared to the predicted number of admissions as per the BSTS model.

**Secondary Aim**

There were significant decreases in all three outcome variables assessed (i.e., length of stay, and CGAS total scores at admission and discharge). First, length of stay of children and youth in the psychiatric inpatient units significantly decreased from an average of 17.7 days pre-pandemic to 14.4 days during the pandemic ($t = -3.525, p < .001$, Cohen’s $d$...
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CGAS total scores collected at admission dropped from an average of 33.88 prior to the pandemic to 27.68 during the pandemic ($t = -9.667, p < .001, \text{Cohen's } d = 0.54$). CGAS total scores collected at discharge dropped from an average of 50.65 pre-pandemic to 47.26 during the pandemic ($t = -5.565, p < .001, \text{Cohen's } d = 0.31$). Therefore, over the examined pandemic period, clinicians rated that patients were more impaired at both admission and discharge compared to before the pandemic. Figure 5 presents the timeline of these differences over the 6-year period, demonstrating that the decrease in CGAS scores was largely shown early in the pandemic while the decrease in length of stay was mostly apparent later in the pandemic.

**Discussion**

Changes in trends of pediatric psychiatric inpatient admissions due to the COVID-19 pandemic contributes to our understanding of the impact of the pandemic on the mental health functioning of youth. Overall, our findings demonstrate that the pandemic period was associated with an increase in monthly admissions averages of approximately 29% compared to what was predicted if the pandemic had not occurred. Monthly admission averages increased for primary referral reasons of suicide/self-harm, externalizing/behavioural issues, internalizing/emotional issues, and the “other” category. Furthermore, our findings highlight that the pandemic period influenced inpatient admissions for girls and boys, as well as on both younger children and older children.

In addition to psychiatric inpatient admission trends, we also analyzed differences in the length of inpatient stay and the mental health functioning of patients at admission and discharge, both prior to and during the pandemic. Our findings reveal several noteworthy patterns. First, patients were admitted to the inpatient units for shorter periods of time during the pandemic, accompanied by larger deficits in overall functioning at both admission and discharge compared to the pre-pandemic period. These findings highlight that while the general population may have been more hesitant to seek hospital care during the pandemic (14–16), individuals with greater impairment continued to access hospital services, aligning with findings from other studies.
reporting decreased overall emergency department visits but higher acuity levels among patients in the early stages of the pandemic (9,53).

Furthermore, examination of Figure 5 provides a more nuanced understanding of these trends. The graph demonstrates an initial decrease in both admission and discharge CGAS scores, followed by an increase later in the pandemic. Simultaneously, there was a small decrease in length of stay initially, followed by a larger decrease. There could be a potential association between these two patterns. During the early stages of the pandemic, it is plausible that only patients with more severe impairments sought care and were admitted. These patients may have required extended periods in the units for treatment. However, as the pandemic progressed, it is possible that children, youth, and families may have become more willing to seek care, resulting in patients with slightly better functioning being admitted. This shift in patient characteristics may have influenced the shorter lengths of hospital stays, also potentially driven by healthcare system strain and efforts to minimize COVID exposure (54).

The number of inpatient admissions related to self-harm and suicidality exhibited a notable increase compared to anticipated pre-pandemic levels, supporting recent meta-analytic findings on emergency department visits (44). In addition, we analyzed the ratio of admissions associated with specific referral reasons (number of admissions per month due to a specific referral reason divided by the overall admissions per month) to investigate whether certain referral reasons were driving the overall surge in inpatient admissions during the pandemic. Interestingly, our findings diverge from the meta-analysis conducted by Madigan and colleagues (44), which reported a decline in emergency department visits for other mental illnesses (other than self-harm/suicidality). Instead, our study revealed a decrease in the ratio of inpatient admissions for self-harm/suicide relative to all admission reasons following the onset of the pandemic compared to the expected pre-pandemic ratio. This suggests that the increase in inpatient admissions was not disproportionately influenced by self-harm or suicidality, but rather reflected a general rise in all types of admissions. To comprehend these discrepancies, it is crucial to consider the distinctions in healthcare settings. Inpatient admissions tend to encompass a specialized and severe subset of cases, whereas emergency departments cater to a broader range of mental health concerns, potentially encompassing varying levels of severity. Furthermore, it is worth noting that the meta-analysis by Madigan et al. (44) included only one Canadian sample, which did not explore emergency department visits for
mental illnesses other than self-harm (55). Hence, country-specific factors might contribute to these differences, such as variations in access to mental health services, availability of inpatient beds, and specific measures implemented during the pandemic. To gain further insights into these differences, future research could investigate the rates of emergency department visits resulting in hospitalizations both before and during the pandemic, considering both overall admissions and specific referral reasons. This would help to elucidate the nuanced interplay between different health care settings and mental health outcomes during challenging periods such as the COVID-19 pandemic.

Our study found that the pandemic had an effect on inpatient admissions for girls and boys. Previous studies have found greater mental health care utilization, primarily in emergency department visits, among adolescent girls (18–20, 56), and have suggested that girls may be more willing to seek help for mental health problems (57), and are therefore more willing to access mental health services. However, the current study suggests that among the most severe cases, both girls and boys are likely to be admitted to inpatient units. Our study also found an effect of the pandemic on both younger and older youth admissions. This was consistent with previous studies that demonstrated that the pandemic was associated with increases in emergency department utilization among older youth (44) as well as younger youth (18). As suggested by Beaudry et al. (18), older youth may be particularly vulnerable to public health measures that restrict socialization, while younger youth may have fewer coping mechanisms to deal with the stressors associated with the pandemic.

Limitations
The findings from this study should be considered in light of the following limitations. First, our findings are based on data from four inpatient psychiatric units in Calgary, Alberta, Canada and may not be generalizable to other settings. However, the public health sector funded services are similarly structured across Canada and these findings may be generalizable to other Canadian settings; further research is needed to replicate the current findings. Given that this was a retrospective study based on archival data, the comprehensiveness, validity, and reliability of the data was limited by what was available and recorded by the inpatient units. Similarly, given that referral reason was based off clinician’s judgment, and limited to one primary issue, we may have underrepresented the complexities of most patients that are admitted, as they rarely present with one issue.
Finally, despite our use of the BSTS analysis to account for pre-pandemic trends, we acknowledge that the causal inferences that the pandemic led to increases in admissions is subject to certain assumptions. While we removed seasonality and found consistency with other studies (18,44), the possibility of pre-existing trends or other influential factors cannot be ruled out. Therefore, these findings should be interpreted with some degree of caution and further research is needed to better understand the complex association between the COVID-19 pandemic and inpatient admissions.

**Conclusion**

The COVID-19 pandemic has led to unprecedented changes in healthcare utilization and the mental health of children and youth. Our study builds on a growing body of literature demonstrating that, following a decrease in healthcare service utilization in the initial wave of the pandemic, there was strong evidence of increases in mental healthcare utilization, specifically psychiatric inpatient services, associated with the pandemic. To ensure accessible and continuous mental health supports and services for youth and their families during future pandemics, these findings highlight the

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> Figure 5. Timeline of changes in admission CGAS score, discharge CGAS score and length of stay in the inpatient psychiatric units over the 6-year period

![Timeline of changes in admission CGAS score, discharge CGAS score and length of stay in the inpatient psychiatric units over the 6-year period](image)

CGAS = Children’s Global Assessment Scale. The vertical dotted line represents the start of the pandemic in March 2020.
need for rapid expanse of inpatient mental health services, similar to what occurred in many intensive care units across Canada. Ongoing research is needed to examine whether the increase in mental health service utilization is sustained, whether there is a return to pre-pandemic levels during the post-pandemic era, and whether there is an increase in the readmission rate of patients seen during the pandemic compared to those seen prior to the pandemic.

Acknowledgements
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Conflict of Interest
The authors have no financial relationships or other ties to disclose.

References


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**Method**

**Analysis Code Templates**
Data was prepared such that each month of the six years corresponded to a number, with January 2016 being 1 and December 2021 being 72. For each month from 1 to 72 the number of admissions was calculated. All models were then run using the below scripts and the entire dataset (main analysis) as well as subsets of the dataset separated by gender (male, female, and other/undefined), age (younger, older) and admission reason. Separation into the unique datasets based on these variables was completed prior to running any analyses and so the code is not included below.

```r
library (CausalImpact)
library (seasonal)

#Method 1 - Raw Data
data = monthly_admisions$Freq
pre.period <- c (1, 50)
post.period <- c (51, 72)

model <- CausalImpact (data, pre.period, post.period,
model.args = list (niter = 100000))

plot (model)
print (model)

#Method 2 - Season Adjusted
x = as.data.frame(seas(ts(monthly_admisions$Freq, start = c(2016,1), end = c(2021, 12), frequency = 12), x11 = ""))
data2 = x$final
pre.period <- c(1, 50)
post.period <- c(51, 72)

model <- CausalImpact(data2, pre.period, post.period,
model.args = list(niter = 100000))

plot (model)
print (model)
```

**Statistical Equations**
Both the observation equation (1) and state equation (2) implemented in the CausalImpact R package are reported below as described in a paper by Brodersen and colleagues (2015) on the topic of BSTS modeling.

\[
y_t = Z_t^{\top} \alpha_t + \varepsilon_t \tag{1}
\]

\[
\alpha_{t+1} = T_t \alpha_t + R_t \eta_t \tag{2}
\]

**S1 Results**
For the purposes of comparison to the seasonality adjusted data presented in the main paper, the results of analyses conducted on the raw data are presented in Table S1. Seasonality adjusted data were presented in the main paper in an effort to portray the most accurate effect of COVID-19 on admission numbers with the removal of potentially spurious factors as well as to replicate the methodology employed by similar published literature examining the pandemic.
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<table>
<thead>
<tr>
<th>Model</th>
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<th>95% CI of Predicted Value(^2)</th>
<th>(p^3)</th>
<th>Probability of Causal Effect (%)</th>
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<td>99.9</td>
</tr>
<tr>
<td>Suicidality/Self-Harm</td>
<td>34</td>
<td>44</td>
<td>31, 38</td>
<td>&lt; .001</td>
<td>99.9</td>
</tr>
<tr>
<td>Externalizing/Behavioral Issues</td>
<td>2.5</td>
<td>4.2</td>
<td>1.5, 3.5</td>
<td>&lt; .001</td>
<td>99.9</td>
</tr>
<tr>
<td>Aggression/Harm to others</td>
<td>2.2</td>
<td>2.8</td>
<td>1.5, 3</td>
<td>.078</td>
<td>92.0</td>
</tr>
<tr>
<td>Thought Disturbances/ Perceptual Issues</td>
<td>3</td>
<td>3</td>
<td>1.9, 4.2</td>
<td>.479</td>
<td>52.0</td>
</tr>
<tr>
<td>Internalizing/Emotional Issues</td>
<td>2.3</td>
<td>3</td>
<td>1.6, 3.1</td>
<td>&lt; .05</td>
<td>97.1</td>
</tr>
<tr>
<td>Other(^4)</td>
<td>3</td>
<td>8.4</td>
<td>1.1, 5</td>
<td>&lt; .001</td>
<td>99.9</td>
</tr>
</tbody>
</table>

\(^1\) BSTS: Bayesian structural time series model
\(^2\) Reported as average admissions to inpatient units per month
\(^3\) A Bayesian one-sided tail-area probability value for each model is representative of the confidence in the directionality of any change relative to the model’s prediction rather than its significance
\(^4\) The “Other” category includes addictive issues, adjustment problems, developmental concerns, eating issues, medication management, and family issues, as well as other non-specified reasons for referral.