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Cumulative trauma from multiple natural disasters increases mental health burden on residents of Fort McMurray

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ABSTRACT

Background: Fort McMurray, a city in northern Alberta, Canada, has experienced multiple traumatic events in the last five years, including the 2016 wildfire, the 2020 floods, and the COVID-19 pandemic. Traumatic events often lead to increased mental health burdens in affected communities.

Objective: To assess if the number of traumatic events experienced by residents of Fort McMurray correlates with the prevalence and severity of mental health issues experienced.

Methodology: A cross-sectional study using an online survey questionnaire was used to gather demographic, trauma (wildfire, flooding, and COVID-19), and clinical information from the resident of Fort McMurray between April 24 to June 2 2021. Likely Generalized Anxiety Disorder (GAD), Major Depressive Disorder (MDD), Post-Traumatic Stress Disorder (PTSD) and low resilience were measured using standardised rating scales. Data were analyzed with SPSS version 26 using Chi-Square tests and multivariate regression analysis.

Results: Respondents who experienced COVID-19 and either flood or wildfire traumas ($N = 101$) were eleven times more likely to have GAD symptoms (OR: 11.39; 95% CI: 1.43–91.04), four times more likely to have likely MDD, (OR: 3.85; 95% CI: .995–14.90), ten times more likely to have likely PTSD (OR: 10.47; 95% CI: 1.28–85.67), and low resilience (OR: 10.56; 95% CI: 1.21–92.17). Respondents who experienced COVID-19, flooding, and wildfire traumas ($N = 47$) were eighteen times more likely to express GAD symptoms (OR: 18.30; 95% CI: 2.20–152.45) and more than eleven times likely to have likely PTSD (OR: 11.41; 95% CI: 1.34–97.37) in comparison to the respondents who experienced COVID-19 only trauma ($N = 19$).

Conclusion: Measures to reduce climate change and associated natural disasters could reduce the impact of cumulative trauma and associated mental health burden in vulnerable populations. It is essential that more mental health resources are mobilised to support communities impacted by multiple natural disasters.

HIGHLIGHTS
The number of traumatic disasters experienced in residents of Fort McMurray five years after the 2016 wildfires, a year after the 2020 flooding, and during the COVID-19 pandemic correlates with the prevalence and severity of the mental health conditions reported in this study.

El trauma acumulativo por múltiples desastres naturales incrementa la carga de salud mental de los residentes de Fort McMurray

Antecedentes: Fort McMurray es una ciudad en el norte de Alberta, Canadá, que ha experimentado múltiples eventos traumáticos en los últimos cinco años, incluyendo el incendio forestal del 2016, las inundaciones del 2020 y la pandemia por la COVID-19. Los eventos traumáticos con frecuencia conducen a una mayor carga de salud mental en las comunidades afectadas.

Objetivo: Evaluar si el número de eventos traumáticos experimentados por los residentes de Fort McMurray se correlacionan con la prevalencia y la severidad de los problemas de salud mental experimentados.

Métodos: Se realizó un estudio transversal utilizando un cuestionario en línea para recolectar información demográfica relacionada con el trauma (incendio forestal, inundación y COVID-19) y con la información clínica de los residentes de Fort McMurray entre el 24 de abril y el 2 de junio del 2021. Se midió la probabilidad del trastorno de ansiedad generalizada (TAG), del trastorno depresivo mayor (TDM), del trastorno de estrés postraumático (TEPT) y de una baja resiliencia utilizando escalas de medición estandarizadas. Los datos fueron analizados con el programa SPSS versión 26 utilizando las pruebas de Chi cuadrado y el análisis multivariado de regresión.

Resultados: Los encuestados que experimentaron la COVID-19 y los traumas por las inundaciones o los incendios forestales ($N=101$) tenían once veces más probabilidad de tener síntomas de TAG (OR: 11.39; 95% CI: 1.43–91.04), cuatro veces más probabilidad de tener un TDM (OR: 3.85; 95% CI:.995–14.90), diez veces más probabilidad de tener TEPT (OR: 10.47; 95% CI: 1.28–85.67) y una baja resiliencia. Los encuestados que experimentaron traumas tanto por la COVID 19, por las inundaciones y por los incendios forestales ($N=47$) tenían dieciocho veces más probabilidad de expresar síntomas de TAG (OR: 18.30; 95%

CI: 2.20–152.45) y más de once veces la probabilidad de tener TEPT (OR: 11.41; 95% CI: 1.34–97.37) en comparación con los encuestados que experimentaron a la COVID-19 como su única experiencia traumática (*N*=19).

Conclusiones: Las medidas para reducir el cambio climático y los desastres naturales asociados podrían reducir el impacto acumulativo de las experiencias traumáticas y la carga de salud mental asociada en poblaciones vulnerables. Es esencial que se movilicen más recursos de salud mental para brindar apoyo a las comunidades afectadas por múltiples desastres naturales.

多重自然灾害造成的累积创伤增加了麦克默里堡居民的心理健康负担

背景：加拿大艾伯塔省北部城市麦克默里堡在过去五年中经历了多重创伤性事件，包括2016 年的野火、2020 年的洪水和 COVID-19 疫情。创伤性事件通常会导致受影响社区的心理健康负担增加。

目的：评估麦克默里堡居民所经历创伤事件的数量是否与所经历心理健康问题的流行率和严重程度相关。

方法：一项使用在线调查问卷的横断面研究用于收集 2021 年 4 月 24 日至 6 月 2 日期间麦克默里堡居民的人口统计、创伤（野火、洪水和 COVID-19）和临床信息。使用标准化评分量表测量可能的广泛性焦虑障碍 (GAD)、重性抑郁障碍 (MDD)、创伤后应激障碍 (PTSD) 和低心理韧性。使用卡方检验和多元回归分析，使用 SPSS 26 版对数据进行分析。

结果：经历过 COVID-19 和洪水或野火创伤（*N*=101）的受访者有 11 倍的可能性出现 GAD 症状（OR：11.39；95% CI：1.43–91.04），有 4 倍的可能性有 MDD（OR：3.85；95% CI：0.995–14.90），有 10 倍的可能性有 PTSD（OR：10.47；95% CI：1.28–85.67），和低心理韧性（OR：10.56；95% CI：1.21–92.17）。与仅经历过 COVID-19 创伤的受访者（*N*=19）相比，经历过 COVID-19、洪水和野火创伤的受访者 (*N*=47) 出现 GAD 症状的可能性高出 18 倍（OR：18.30；95% CI：2.20–152.45），患 PTSD 的可能性高出 11 倍以上（OR：11.41；95% CI：1.34–97.37）。

结论：减少气候变化和相关自然灾害的措施可以减少累积创伤和相关心理健康负担对弱势群体的影响。必须动员更多的心理健康资源来支持受多重自然灾害影响的社区。

1. Introduction

Natural disasters, including wildfires and floods, are commonly associated with climate change. Worldwide, about 400 natural disasters occur yearly (Waldman, 2018). In the past two decades, natural disasters have negatively affected about 800 million people and led to the loss of 3 million lives (Noji, 1991). Exposure to climate-induced natural disasters significantly alters affected individuals' routines, leading to the disruption of work, school, and home life (Agyapong et al., 2020; Ibrahim, 2016). Climate-induced natural disasters endanger the health of hundreds of millions of people and significantly increase levels of morbidity and mortality (Waldman, 2018). It is predicted that climate change, especially the rise in extreme temperature, is bound to increase weather-related natural disasters (Myers, 2016), thus creating long-lasting issues for affected communities. The risk to personal safety and that of loved ones, as well as damage or loss of property, can have a profound effect on survivors' mental health for a long time (To, Eboreime, & Agyapong, 2021). It can also lead to both immediate and perpetual mental health complications such as depression, anxiety, and post-traumatic stress disorder (PTSD) (Agyapong et al., 2019; Agyapong et al., 2020; Briere & Elliott, 2000; Goldmann & Galea, 2014). Irrespective of whether the exposure to disasters is indirect or direct, a disaster can have a major impact on the social and psychological functioning of individuals (Bhugra & van Ommeren, 2006). Published literature over the past three decades indicates that the burden of PTSD among individuals exposed to disasters is substantial (Neria, Nandi, & Galea, 2008). Thirty-three percent of respondents showed symptoms of probable PTSD after a wildfire in California (Psarros, Theleritis, Martinaki, & Bergiannaki, 2008). Higher prevalence of depression in adults have also been reported after wildfire (33% less than 1year; 10.9% after 3–4years), and this can perpetuate for up to 10 years (8.3% 10years) (Bryant et al., 2021; Marshall, Schell, Elliott, Rayburn, & Jaycox, 2007; To et al., 2021). A cross-sectional study of an adult population in Greece 6 months after the wildfires reported a significantly high prevalence of depression, anxiety, somatisation, and phobic anxiety symptoms (Agyapong et al., 2018; To et al., 2021).

Flooding is the most frequently occurring (47%) of all weather-related natural disasters in the past 20 years (Wahlstrom & Debarati, 1995–2015). Flooding can also result in a significant increase in depression, anxiety, and psychological distress among adults (Agyapong et al., 2018; Goldmann & Galea, 2014)**.** The devastating effect of a flood is apparent in the increased death tolls from flooding in many parts of the world, including India, with a death toll of 6,500 people in 2013, 2,100 people in Pakistan in 2010 and 1900 people in China in 2010 (Wahlstrom & Debarati, 1995–2015). Flooding disasters may have negative effects on the mental health of survivors for a prolonged period (Dai et al., 2016), typically causing bodily harm and mental health challenges like PTSD, which affects individuals' social and functional

capability (Dai et al., 2016; Fernandez et al., 2015). Survivors can also experience psychological stress, physical health ailments, water health-and-safety issues related to the floods, as well as increased psychological health problems (Carroll, Balogh, Morbey, & Araoz, 2010).

A significant attribute of a traumatic incident is its ability to cause fear in response to the threat of possible injury or death (Spitzer et al., 2002). Both wildfire and flooding pose these threats and hence heighten anxiety. The increase in exposure to natural disasters and trauma also impacts an individual's level of resilience (Mao & Agyapong, 2021). Individuals who survive multiple traumatic events often experience long- and short-term problems that impact their lives (Gnass et al., 2018). Published studies have found that pre-existing distress increases mental disorders and reduces resilience post-natural disasters (Chen, Bagrodia, Pfeffer, Meli, & Bonanno, 2020). Literature also suggests that pre-existing diagnosis of an anxiety disorder reduces resilience post-disaster and makes respondents prone to other mental health illnesses (Agyapong et al., 2018; Agyapong et al., 2019; Mao & Agyapong, 2021). Similarly, depression predicts low resilience in trauma-exposed individuals (Bonanno, Galea, Bucciarelli, & Vlahov, 2007). In addition, ongoing adverse life events can contribute to an individual's risk of developing psychopathology post-trauma and shows how cumulative stressors may worsen human resilience (To et al., 2021). Consequently, with the exposure to multiple traumatic disasters, it is of interest if residents exposed to two or three traumatic disasters experienced mental health impacts that are in any way different from mental health impacts experienced by other residents of the city who may have experienced only one traumatic disaster.

Residents of Fort McMurray, a municipality in Northern Alberta, Canada, with a population of 111,687 according to the 2018 census (Census, 2018), have experienced multiple natural disasters and hence endured multiple traumas over the past five years: wildfire in 2016, floods in 2020 and COVID 19 pandemic, the latter of which is still ongoing. These traumas are predicted to lead to increased anxiety, depression, and other mental health conditions in Fort McMurray. The 2016 Fort McMurray wildfire destroyed approximately 30,000 properties and forced about 80,000 residents to leave their homes (Fraser, 2017). The estimated cost of the wildfire was CAD $10 billion, with CAD $3.7 billion paid out by insurance providers, and the cost is expected to rise by 2026 (Weber, 2017). There was a reported rise in the prevalence of mental health disorders after exposure to the wildfire in both young and old residents of Fort McMurray, with wildfire trauma being the most important risk factor (Agyapong et al., 2018; Agyapong et al., 2020; Brown

et al., 2019a, 2021; Moosavi et al., 2019; To et al., 2021; Vio et al., 2018). In April of 2020, Fort McMurray was further hit with severe flooding, which caused a lot of disruption to livelihood damage to property. There were more than 13,000 people evacuated (Canadian Red Cross, 2021) and more than $520 million in insured damage as a result of the flooding (Malbeuf, 2020). Ice jams about 25 kilometers on the Athabasca and Clearwater Rivers resulted in the flooding. Ice jams can occur so rapidly, creating high water levels which cause flooding (Spencer, 2020). Some households, small businesses and not-for-profit organisations were directly impacted by the flooding in Fort McMurray and the surrounding area and needed support in order to recover (Canadian Red Cross, 2021). Fort McMurray, like other cities in Alberta, experienced an increase in reported Covid 19 cases in September 2021, prompting the reintroduction of a number of new restrictions to reduce transmission of the virus (Alberta, 2021), thus creating a lot of uncertainty in the community (Jain, Sahu, & Mitra, 2021). The ongoing COVID 19 pandemic has resulted in enormous psychological stress for the public, patients, and health professionals alike (Li et al., 2020). The pandemic has also led to the decline and loss of businesses and business activity across virtually all industries, challenging the mental stability of individuals who are impacted (Fairlie, 2020; Jain et al., 2021). The effect of the pandemic was evident in the increase in the one-week prevalence of moderate or high stress (84.9%–85.6%), anxiety (46.7%–47.0%), and depression symptoms (41.4%–44.0%) in residents of Alberta. and (Mrklas et al., 2020; Nkire et al., 2021).

In light of the above, the goal of this study was to assess if the prevalence and severity of likely Major Depressive Disorder (MDD), likely Generalized Anxiety Disorder (GAD), likely PTSD and low resilience vary dependent on the number of traumatic events (2016 wildfires, COVID-19 pandemic and 2020 flooding) experienced by residents of Fort McMurray. We hypothesise that residents who experienced trauma from the 2016 wildfires and/or the 2020 flooding in addition to experiencing trauma from the ongoing COVID-19 pandemic will have worse mental health conditions compared to residents who experienced trauma from only the ongoing COVID-19 pandemic. To our knowledge, this is the first study to examine and compare the cumulative mental health impact of the multiple traumatic events in FMM in the last five years.

A conceptual framework (Figure 1) was developed to illustrate the association between the various mental health conditions under study and the exposure to the different traumatic disasters. The framework was based on empirical evidence, which suggests that the number of disasters or major traumas experienced

may be correlated with the prevalence and severity of mental health conditions (Agyapong et al., 2018; Agyapong et al., 2019; Brown et al., 2019b; Xie, Xu, & Wu, 2017). The framework suggests that experiencing COVID-19 trauma only may lead to a lesser mental health burden.

2. Methodology

2.1. Study setting

This study was conducted in Fort McMurray (FMM), Alberta, Canada. Fort McMurray is the urban service area of Northern Alberta, with a total population of 111,687 according to the 2018 census (Census, 2018). There are more males (54.9%) than females (45.1%). The Municipality has a young population, with a little over 47% of the population between the ages of 20 and 44. The principal population cohort in Fort McMurray is the 30–34 age group, which accounts for 12.3% of the total population. Seniors (65 years of age and over), on the other hand, account for only 2.8% of the population (Wood Buffalo, 2019). A large proportion of the inhabitants of Fort McMurray are employed in the nearby oil sands (Dardis, 2008; Wood Buffalo, 2019).

2.2. Study design

The study was designed as a cross-sectional survey and provided to residents of Fort McMurray using a self-administered questionnaire which was sent via RED-Cap (Harris et al., 2009) by community partners of the research team, including the public and catholic school boards, Keyano College, the Canadian Mental Health Association and the Alberta Building Trades Association. No incentives were offered to respondents.

2.3. Ethical approval

The study received ethical approval from the Health Research Ethics Board of the University of Alberta (Pro00066054). Informed consent was implied when respondents completed and returned the survey responses.

2.4. Data collection and outcome measures

Data collection occurred from 24 April to 2 June 2021. The survey questionnaire took about 5–10 min to complete, and it included a blend of questions that assessed sociodemographic information, including gender, age, marital status; information on the trauma experienced from the COVID-19 pandemic, 2020 flooding and the 2016 wildfire, including the following questions:

- During the pandemic, have you been fearful about yourself, your close friends or family members contracting the coronavirus?
- Were you fearful for your life or the lives of your friends or family during the flooding?
- On the day of the evacuation, were you fearful for your life or the lives of your friends or family?

The survey also included clinical health information of the respondents, including the following questions:

- Have you previously been diagnosed with depression?
- Have you previously been diagnosed with anxiety?
- Are you currently taking an antidepressant?
- Are you currently taking sleeping tablets?

The demographic, clinical and trauma exposure questions, although not standardised, were adopted from survey questions previously used in related studies which gathered data on the mental health effects six and eighteen months after the Fort Mc Murray wildfires (Agyapong et al., 2018; Agyapong et al., 2019; Agyapong et al., 2020; Moosavi et al., 2019). Four clinical outcomes were assessed using validated screening scales for self-reported symptoms. These included the Generalized Anxiety Disorder 7-item (GAD-7) Scale (GAD-7 score $\geq$10 indicates likely GAD) (Spitzer, Kroenke, Williams, & Löwe, 2006), the Patient Health Questionnaire-9 (PHQ-9; a score $\geq$10 indicates likely MDD) (Kroenke, Spitzer, & Williams, 2001), the post-traumatic stress disorder (PTSD) Checklist-Civilian Version (PCL-C) scale (PCL-C score of $\geq$44 indicates likely PTSD) (Bovin et al., 2016; County of Los Angeles, n.d.), and the brief resilience scale (BRS) (BRS average score <3 indicates perceived low resilience) (Smith et al., 2008). The scales were studied as categorical variables for the purpose of prevalence estimates. For the severity estimates, we used the mean scores for the PHQ-9 (responses range from 0 to 27, and lower scores denote the better condition); GAD-7 (responses range from 0 to 21, and lower scores denote the better condition); PCL-C (responses range from 17 to 85, and lower scores denote the better condition); and BRS (responses range from 6 to 30, and higher scores denote the better condition).

2.5. Statistical analysis

Results were analyzed using SPSS Version 25 (IBM support. Release notes – IBM® SPSS® Statistics 25.0). "Multiple trauma" variable was created as a new three group variable (given that no participants have reported having no trauma), COVID-19 only trauma (one trauma) group of COVID-19 and either flooding or Wildfire traumas (two traumas) and a group of
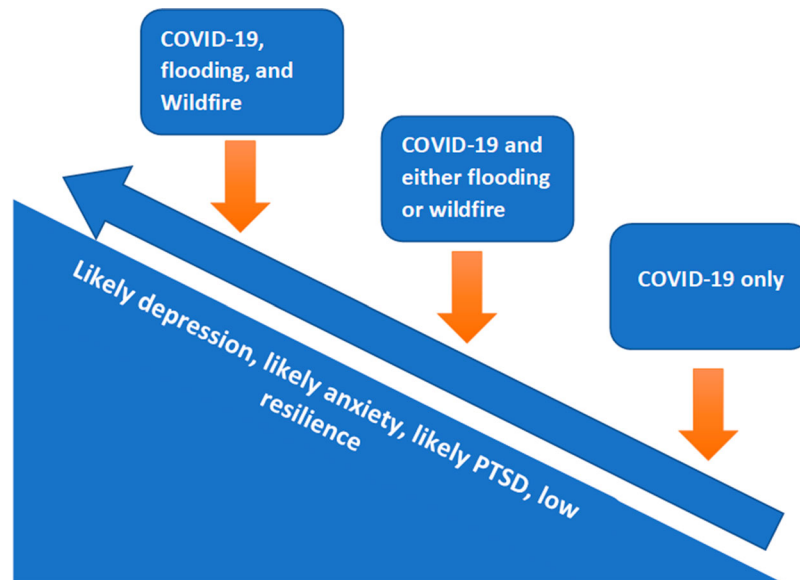
Figure 1. Conceptual framework illustrating the relationship between the number of traumatic events experienced and the mental health burden in respondents.

COVID-19, flooding and wildfire traumas (three traumas). Wildfire trauma was defined using a question related to being fearful for own life or the lives of family and friends during the wildfire evacuation. COVID-19 trauma was defined using the question related to being fearful about self and/or close friends or family members contracting COVID-19. Flooding trauma was defined using the question related to being fearful for own life or the lives of friends or family during the flooding.

In order to examine the prevalence of the mental health conditions under study (likely MDD, likely GAD, likely PTSD, and low resilience) and their correlates among the sociodemographic, clinical, and multiple trauma factors, an association analysis, using Chi-squared was performed with two-tailed significance ($p \leq .05$)

Four models of multivariate binomial logistic regression analyses were employed to identify if the multiple trauma variable was a significant predictor for each mental health condition while controlling for other relevant variables. The variables that showed either significance ($p \leq .05$) or near significance ($0.1 \geq p > 0.05$) obtained from the univariate Chi-squared analysis were included in the respective regression model. Odds ratios (OR) and confidence intervals were used to determine the effect of the multiple trauma factor among respondents to self-report likely MDD, likely GAD, likely PTSD, and low resilience, controlling for the rest of the variables in the model. Correlational analysis was performed prior to the regression analyses to exclude any strong intercorrelations (Spearman's correlation coefficient of 0.7 to 1.0 or − 0.7 to − 1.0) among predictor variables.

To compare the severity of the mental health conditions under study, we used a one-way Analysis of variance (ANOVA) with two-tailed significance (p-value $\leq .05$) was performed to assess the differences in the respective mean scores of the mental health conditions across the three categories of *multiple trauma* variable. Post-hoc analysis was employed using Tukey test, while if homogeneity of variance was violated, Welch's F test and Games-Howell post hoc test were employed. The effect size will be calculated for ANOVA analysis using partial eta squared (sum of squares between groups/Total sum of squares) (Glen, n.d.) while using an adjusted omega squared formula ($df_{bet} (F-1)/ df_{bet} (F-1 + N_T)$) upon the application of Welch's F test (EPS, n.d.).

There was no imputation of missing data, and reported data represents the complete responses.

2.6. Sample size estimation

With a population of 111,687 as of the 2018 census (Census, 2018), a 95% confidence interval, and a ±3% margin of error, the sample size needed for prevalence estimates for likely mental disorders will be 1049. With an expected survey response rate of 20%, we planned to reach 5290 residents with the online survey link.

3. Results

Overall, 186 individuals completed the survey out of 249 residents who accessed the online survey, yielding a response rate of 74.7%.

3.1. Association analysis

Table 1 represents the association of the demographic and clinically related variables with the mental health

conditions. The age of the respondents was the only sociodemographic factor that showed a significant association, namely with the low resilience outcome variable, where the lower age of the participants was associated with more likely to show low resilience.

Regarding the historical clinical variables and the multiple trauma factor, all variables demonstrated significant association with the four mental health conditions, except for receiving sleeping tablets variable, which did not show significant association with the likelihood of GAD. Participants who were diagnosed with Depression and Anxiety and those who reported taking antidepressants were more prone to express symptoms of MDD, GAD, PTSD, and low resilience. Similarly, participants who reported receiving sleeping tablets were significantly more likely to express MDD, PTSD and low resilience symptoms, but not GAD symptoms (Table 1).

Multiple trauma factor was significantly associated with the four mental health conditions, as respondents who experienced COVID-19 trauma alone seemed in a better mental health condition, compared to the respondents who had, in addition, experienced flooding and/or wildfire traumas, regarding the likelihood of MDD, GAD, PTSD, and low resilience conditions.

3.2. Multivariate binary logistic regression analyses

From Table 1, there was no variable that showed a trend towards significance ($.1 \geq p > .05$) with any of the outcome variables. Therefore, we incorporated only variables that showed statistical significance ($p \leq .05$) on the Chi-squared analyses into the four logistic regression models (for each respective outcome measure). The variable *currently taking antidepressants* was highly correlated with the variable of *having been diagnosed with depression,* so it was removed from the corresponding logistic regression models. The regression models produced the following results:

The model predicting the likely MDD was statistically significant; X^2 (df = 5; $n = 165$) = 33.17, $p < .00$, accounting for 18.2% (Cox and Snell R^2) to 24.3% (Nagelkerke R^2) of the variance; and correctly classified 69.7% of the cases.

The model predicting the likely GAD was statistically significant; X^2 (df = 4; $n = 163$) = 31.35, $p < .00$, accounting for 17.5% (Cox and Snell R^2) to 23.5% (Nagelkerke R^2) of the variance; and correctly classified 68.7% of the cases.

The model predicting the likely PTSD was statistically significant; X^2 (df = 5; $n = 160$) = 40.06, $p < .00$, accounting for 22.1% (Cox and Snell R^2) to 29.9% (Nagelkerke R^2) of the variance; and correctly classified 73.8% of the cases.

The model predicting the low resilience was statistically significant; X^2 (df = 7; $n = 167$) = 47.93, $p < .00$, accounting for 24.9% (Cox and Snell R^2) to 33.9% (Nagelkerke R^2) of the variance; and correctly classified 74.9% of the cases.

Table 2 demonstrates the results of the logistic regression analyses regarding the predictive effect of the multiple trauma variable on the four mental health conditions while controlling for other demographic and clinically related variables. From the table, the multiple trauma variable was the only significant predictor for the likely GAD (model 2) with the highest contribution to the model (Wald = 7.62) after controlling the other variables. Respondents who experienced COVID-19 and either flood or wildfire traumas were eleven times more likely to endorse GAD symptoms compared to the respondents who experienced only COVID-19 trauma (OR: 11.39; 95% CI: 1.43–91.04). Similarly, the respondents who experienced COVID-19, flooding and wildfire traumas were eighteen times more likely to express GAD symptoms, compared to the respondents who experienced COVID-19 only trauma (OR: 18.30; 95% CI: 2.20–152.45), while controlling for other model variables.

From Table 2, models 3 and 4 showed that the multiple trauma variable did not contribute significantly to the model, although there was a trend towards significance. Additionally, the respondents who experienced COVID-19 and either flooding or wildfire traumas were more than ten times significantly likely to have likely PTSD (model 3) (OR: 10.47; 95% CI: 1.28–85.67) and low resilience (model 4) (OR: 10.56; 95% CI: 1.21–92.17), when compared to the respondents who experienced COVID-19 only trauma. Likewise, the respondents who experienced COVID-19, flooding and wildfire traumas were more than eleven times likely to have likely PTSD (OR: 11.41; 95% CI: 1.34–97.37) and low resilience (OR: 12.73; 95% CI: 1.38–117.37), compared to the respondents who experienced COVID-19 only trauma while controlling for the other variables in the respective models.

In model 1, the multiple trauma variable did not contribute significantly to the model. However, the respondents who experienced COVID-19 and either flooding or wildfire traumas were four times more likely to show MDD symptoms compared to the respondents who experienced COVID-19 only trauma (OR: 3.85; 95% CI: .995–14.90).

3.3. Analysis of variance

As the homogeneity of variance was violated for the PHQ-9, GAD-7 and PCL-C scales, Welch's F test and Games Howell test for post hoc comparisons were used (Tables 3 and 4).

One-way ANOVA analyses examining the severity of the mental health conditions revealed a significant

Table 1. Chi-square association between the demographic and clinical variables and mental health conditions.

Variables	Moderate-to-severe depression N (%)	Chi^2 value	P value	Likely anxiety N (%)	Chi^2 value	P value	Likely PTSD N (%)	Chi^2 value	P value	Low resilience N (%)	Chi^2 value	P value
Gender												
Male	9 (39.1)	0.37	.55	8 (34.8)	0.65	.42	7 (31.8)	0.65	.42	6 (25.0)	1.84	.18
Female	67 (45.9)			63 (43.8)			58 (40.8)			58 (39.5)		
Age in years												
< 25y	5 (55.6)	1.01	.6	4 (44.4)	1.85	.4	4 (50.0)	0.45	.8	7 (77.8)	8.10*	.02
26–40	33 (47.8)			33 (48.5)			27 (40.3)			28 (40.6)		
>40	38 (41.8)			34 (37.8)			34 (38.2)			29 (31.2)		
Marital Status												
Married/Partner/Cohabiting	53 (43.1)	0.65	.72	48 (39.7)	1.85	.4	44 (36.7)	2.41	.3	45 (36.3)	1.12	.57
Divorce/Widowed/Separated	8 (50.0)			9 (56.3)			9 (56.3)			5 (31.3)		
Single	15 (50.0)			14 (46.7)			12 (42.9)			14 (45.2)		
Have been diagnosed with depression												
Yes	38 (70.4)	20.69*	<.001	34 (64.2)	14.87*	<.001	35 (67.3)	24.37*	<.001	34 (63.0)	21.98*	<.001
No	38 (33.0)			37 (32.5)			30 (26.8)			30 (25.6)		
Have been diagnosed with anxiety												
Yes	44 (62.0)	14.30*	<.001	41 (58.6)	12.71*	<.001	41 (59.4)	19.49*	<.001	41 (56.9)	20.23*	<.001
No	32 (32.7)			30 (30.9)			24 (25.3)			23 (23.2)		
Currently taking antidepressants												
Yes	32 (59.3)	6.55*	.01	29 (54.7)	4.73*	.03	29 (56.9)	9.28*	<.01	30 (55.6)	11.08*	<.01
No	44 (38.3)			42 (36.8)			36 (31.90)			34 (29.1)		
Currently taking sleeping tablets												
Yes	16 (84.2)	13.32*	<.001	10 (55.6)	1.4	.24	13 (76.5)	10.76*	<.01	13 (68.4)	8.77*	<.01
No	60 (40.0)			61 (40.9)			52 (35.4)			51 (33.6)		
Multiple trauma												
COVID-19 trauma	3 (15.8)	8.05*	.02	1 (5.3%)	15.63*	<.001	1 (5.3)	11.78*	<.01	1 (5.3)	10.44*	>.01
COVID-19 and either Wildfire or flooding traumas	49 (49.0)			43 (43.9)			41 (43.2)			41 (40.6)		
COVID-19, Flooding and Wildfire traumas	24 (52.2)			27 (58.7)			23 (50.0)			22 (46.8)		

*$p < .05$.

difference of the mean scores for each of the PHQ-9 (Welch's $F(2, 59.76) = 22.13$, $p < .001$); GAD-7 (Welch's $F(2, 61.09) = 27.42$, $p < .001$); PCL-C (Welch's $F(2, 66.56) = 26.98$, $p < .001$); and BRS ($F(2, 164) = 13.41$, $p < .001$) scales across the groups of multiple trauma variable. The results are shown in Table 3.

The effect size was estimated as high ($\geq.14$) across the four study outcome measures; the estimated omega squared ($\omega^2 = .2$) indicated that approximately 20% of the total variance in the PHQ-9 score is accounted for for for by the multiple trauma variable with three levels. Similarly, approximately 24%, 25% and 14% of the variation in the GAD-7, PCL-C (using omega squared) and BRS (using partial eta squared, ηp^2) scores, respectively, are accounted for by the multiple trauma variable with three levels.

Table 4 demonstrates the post hoc analysis, the Games-Howell post hoc procedure demonstrated a significantly lower mean scores (better condition) of the group of COVID-19 only trauma, when compared to the group of COVID-19 and either flooding or Wildfire traumas, in respect to the PHQ-9 ($M = 4.21$, $SD = 3.84$) and ($M = 10.44$, $SD = 6.65$); GAD-7 ($M = 3.58$, $SD = 3.36$) and ($M = 9.54$, $SD = 6.02$); and PCL-C ($M = 26.79$, $SD = 7.78$) and ($M = 40.96$, $SD = 16.00$) scales, respectively.

Additionally, significant higher mean scores of the group of COVID-19, flooding and wildfire traumas were demonstrated when compared to the group of COVID-19 only trauma, in respect to the PHQ-9 ($M = 12.30$, $SD = 6.92$); GAD-7 ($M = 11.28$, $SD = 5.47$); and PCL-C ($M = 45.80$, $SD = 14.95$) scales, respectively.

Regarding the resilience scale, a higher score (better condition) was reported in the group of COVID-19 only trauma ($M = 24.11$, $SD = 4.90$) when compared to the group of COVID-19 and either flooding or Wildfire traumas ($M = 18.55$, $SD = 4.59$) and to the group of COVID-19, flooding and wildfire traumas ($M = 17.68$, $SD = 4.91$) in respect to the BRS score.

The results conclude that the exposure to the COVID-19 only trauma rendered a better mental health condition in respect to the MDD, GAD, PTSD, and resilience conditions when compared to the group of COVID-19 and either flooding or wildfire traumas; and with the group of COVID-19, flooding and wildfire traumas.

4. Discussion

Residents of Fort McMurray are yet to recover from the effects of the 2016 wildfires and the 2020 flooding and must deal with the mental health effects of the

Table 2. Summary from four multivariate logistic regression models for respondents' likelihood to present with moderate-to-severe depression, likely anxiety, likely PTSD, and low resilience, with focus on the type of trauma, while controlling for background demographic and clinical variables.

Characteristics	(1) Likely MDD			(2) Likely GAD			(3) Likely PTSD			(4) Low resilience		
	OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
Multiple trauma variable COVID-19 only Trauma			.14			.02			.08			.08
COVID-19 and either flooding or wildfire Traumas	3.85	1.00–14.90	.05	11.39	1.43–91.04	.02	10.47	1.28–85.67	.03	10.56	1.21–92.17	.03
COVID-19, flooding, and Wildfire Traumas	3.82	.91–15.93	.07	18.30	2.20–152.45	.01	11.41	1.34–97.37	.03	12.73	1.38–117.37	.03

OR: Odds ratio; CI: confidence interval; MDD: Major depressive disorder; GAD: Generalized anxiety disorder; PTSD: Post-traumatic stress disorder.
*Significance at $p \leq .05$.

ongoing pandemic. Our results confirm our study hypothesis that respondents who experienced COVID-19 trauma alone may be in a better mental health condition, compared to the respondents who had, in addition, experienced flooding and/or wildfire traumas, regarding the likelihood of MDD, GAD, PTSD, and low resilience conditions. Our study further suggests that the number of traumatic disasters experienced correlates with both the prevalence and severity of mental health conditions COVID 19 is a traumatic event that continues to have a negative impact on individuals. However, the effects of the pandemic are compounded by prior exposure to other natural disasters. The result of the previous study found that pre-existing mental health conditions were significant predictors for psychological distress (McPherson, McAloney-Kocaman, McGlinchey, Faeth, & Armour, 2021).

Our study has established that the combination of one or more previous natural disasters with COVID-19 trauma increases both the prevalence of likely GAD and the severity of anxiety symptoms in residents. Residents who have a prior history of exposure to one traumatic event, either wildfire or flooding, may have pre-existing mental health issues which increase their vulnerability. The past traumatic experience has a negative impact on the mental health and increases symptoms of depression, anxiety and stress (Bryant et al., 2018; Kirsch et al., 2016). Research by Xie et al. indicates that the cumulative effect of exposure to two earthquakes on mental health problems was serious compared to one (Xie et al.,

2017). The 1-month prevalence for GAD symptomatology six months after the wildfire disaster in FMM was 19.8% (Agyapong et al., 2018). This is approximately eight times higher than the rates of GAD in the general Canadian population, which was 2.5% in 2012 (Agyapong et al., 2018; Pelletier, O'Donnell, McRae, & Grenier, 2017). This shows that the trauma of wildfire significantly increases likely GAD in the residents of FMM compared to the general population. Floods also pose an added strain on an individual's mental health leading to GAD symptoms (Tang, Liu, Liu, Xue, & Zhang, 2014). Hence, COVID-19 trauma, with one of these prior traumas, would most likely increase the prevalence of GAD and severity of anxiety symptoms as reported in our study.

Our study has also established that the combination of one or more previous natural disasters with COVID-19 trauma increases both the prevalence of likely MDD and the severity of depression symptoms in residents. Prevalence of MDD six months post-wildfire (23.4%) was much higher than the self-reported prevalence for the history of depressive disorder diagnosis pre-wildfire (11%) (Agyapong et al., 2020) in residents of Fort McMurray. With additional trauma, including the 2020 flooding and the COVID-19 pandemic, the increased prevalence of likely MDD is understandable. Floods are known to have a negative effect on survivors' mental health for a prolonged period (Dai et al., 2016), leading to increased MDD. A systematic review also revealed that experiencing trauma from natural disasters is a significant risk factor (OR = 2.28) for developing depression (Bonde

Table 3. One-way analysis of variance comparing the mean scores on PHQ-9, GAD-7, PTSD Checklist 5 and BRS across three multiple trauma groups.

Characteristics	COVID-19 only Trauma		COVID-19 and either flooding or wildfire Traumas**		COVID-19, flooding, and Wildfire Traumas**		df	F (ANOVA/Welch)	P	Effect size
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)				
PHQ-9 score[a]	19	4.21 (3.84)	100	10.44 (6.65)	46	12.30 (6.92)	2, 59.76	22.13	<.001	0.20
GAD-7 score[a]	19	3.58 (3.36)	98	9.54 (6.02)	46	11.28 (5.47)	2, 61.09	27.42	<.001	0.24
PTSD Checklist 5[a]	19	26.79 (7.78)	95	40.96 (16.00)	46	45.80 (14.95)	2, 66.56	26.98	<.001	0.25
BRS	19	24.11 (4.90)	101	18.55 (4.59)	47	17.68 (4.91)	2, 164	13.41	<.001	0.14

[a] Welch test was used.
**Sample size varies across the conditions because of missing data.

Table 4. Tukey and Games-Howell post hoc multiple comparisons.

(I) Multiple traumas	(J) Multiple traumas	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower bound	Upper bound
(1) Dependent Variable: PHQ-9 total [a]						
A	B	−6.23*	1.10	.00	−8.91	−3.55
	C	−8.09*	1.35	.00	−11.34	−4.85
B	A	6.23*	1.10	.00	3.55	8.91
	C	−1.86	1.22	.28	−4.77	1.04
C	A	8.09*	1.35	.00	4.85	11.34
	B	1.86	1.22	.28	−1.04	4.77
(2) Dependent Variable: GAD-7 total [a]						
A	B	−5.96*	.98	.00	−8.34	−3.58
	C	−7.70*	1.12	.00	−10.39	−5.02
B	A	5.96*	.98	.00	3.58	8.34
	C	−1.74	1.01	.20	−4.15	.66
C	A	7.70*	1.12	.00	5.02	10.39
	B	1.74	1.01	.20	−.66	4.15
(3) Dependent Variable: PCL-C total [a]						
A	B	−14.17*	2.42	.00	−20.01	−8.33
	C	−19.02*	2.84	.00	−25.83	−12.20
B	A	14.17*	2.42	.00	8.33	20.01
	C	−4.85	2.75	.19	−11.39	1.70
C	A	19.02*	2.84	.00	12.20	25.83
	B	4.85	2.75	.19	−1.70	11.39
(4) Dependent Variable: BRS total						
A	B	5.55*	1.18	.00	2.76	8.34
	C	6.42*	1.28	.00	3.39	9.46
B	A	−5.55*	1.18	.00	−8.34	−2.76
	C	.87	.83	.55	−1.10	2.84
C	A	−6.42*	1.28	.00	−9.46	−3.39
	B	−.87	.83	.55	−2.84	1.10

A: COVID-19 only trauma; B: COVID-19 and either flooding or Wildfire traumas; C: COVID-19, Flooding and Wildfire traumas.
[a]Games-Howell test was used.
*Significance level at .05 level.

et al., 2016). This explains the increase in likely MDD prevalence among the respondents who experienced cumulative COVID-19 pandemic, flooding and wildfire traumas. These findings, however, contrast with the results of a study that assessed the mental health impacts of the 2008 economic crisis and subsequent Hurricane Sandy. It was reported in this study that there were mixed trajectories of depression symptomatology in study participants. Specifically, the study found that more than eight out of ten individuals had no change in depression from baseline, and about one in ten actually saw an improvement in their depression symptomatology after the disasters, suggesting that cumulative trauma did not increase either the prevalence or the severity of depression among the study population (Mandavia & Bonanno, 2019). Furthermore, in a study to investigate whether experiencing multiple major health events diminishes rates of resilience and increases rates of mortality using a large population-based prospective cohort, it was reported that major health events do not decrease rates of resilience but do increase the severity of symptoms among those on the emergent depression trajectory. It was also reported that emergent depression increased mortality compared with all others, but among those in this class, rates were not different in response to single versus multiple health events (Morin, Galatzer-Levy, Maccallum, & Bonanno, 2017). It is possible that the results of this study differs from these two studies because of the types of traumas under study. Whilst these two studies involved economic recession plus hurricane and multiple health events respectively as the traumatic events, and this study involved COVID-19 pandemic, wildfires, and flooding as the traumatic events impacting respondents.

This study has also established that the combination of one or more previous natural disasters with COVID-19 trauma increases both the prevalence of likely PTSD and the severity of PTSD symptoms in residents. PTSD is the most frequently reported and assessed mental health problem after a disaster exposure (Norris et al., 2002). Residents of Fort McMurray continue to battle with symptoms of depression and anxiety due to the wildfire and flooding, which are usually precursors for PTSD (Norris et al., 2002). A study of respondents deployed in the Afghanistan mission showed that the prevalence of PTSD was highest among those with a history of depression before deployment, even in the absence of a pre-deployment history of PTSD (Beliveau, Sampasa-Kanyinga, Colman, & Zamorski, 2019). Furthermore, the results of a cross-sectional study of PTSD symptoms in Norway also showed that pre-existing psychiatric diagnoses, higher levels of anxiety, and depression symptoms were associated with more PTSD symptoms (Johnson, Ebrahimi, & Hoffart, 2020). Individual losses from disasters have also been linked with symptoms of PTSD (Peek-Asa, Ramirez, Young, & Cao, 2012). As such, prior

exposure to either wildfire or flood would increase the likelihood of PTSD. In China, the results of a study showed that more than one-third of individuals with a psychiatric diagnosis met diagnostic criteria for PTSD during the COVID-19 pandemic (Hao et al., 2020). This indicates that COVID 19 alone can increase PTSD in residents. Hence with additional traumas, the prevalence of PTSD is expected to be much higher. In contrast, in the study which assessed the incremental mental health impacts of the 2008 economic crisis and subsequent Hurricane Sandy, only those in the incremental depression group had significant PTSD symptoms following Hurricane Sandy (Mandavia & Bonanno, 2019).

Finally, our study has established that the combination of one or more previous natural disasters with COVID-19 trauma increases both the prevalence of low resilience and the severity of low resilience symptoms in residents. A past traumatic experience such as wildfire has a negative impact on mental health and increases symptoms of depression, anxiety and stress (Bryant et al., 2018; Kirsch et al., 2016) which can lower resilience. A previous study revealed that depression predicts low resilience in trauma-exposed individuals (Bonanno et al., 2007), and a history of anxiety was a risk factor of low resilience 18 months after the Fort McMurray wildfire (Moosavi et al., 2019). Individuals with high resilience scores after experiencing a wildfire had lower scores on screening measures for mental health disorders, including PTSD, depression, and anxiety (Brown et al., 2019b; Silveira et al., 2021; To et al., 2021). A study in the United Kingdom after a flood reported several people suffered from anxiety and stress in different forms, which reduced resilience (Carroll, Morbey, Balogh, & Araoz, 2009). Cumulatively, these provide possible explanations for the low resilience in residents of FMM with two or more traumas.

5. Limitations

This study has a number of limitations. First, the online survey questions related to wildfire, flooding and COVID 19 pandemic traumas were not validated, thus may not accurately measure the experience of trauma from these disasters. However, these variables are relevant from a face validity perspective as important predictors rather than outcomes (Connell et al., 2018). Second, although the instruments used to assess mental health outcomes were validated and standardised proxy scales, they are nonetheless not diagnostic. Third, demographic variables in the study did not reflect the demographics of Fort McMurray, and therefore, the study findings may not be generalisable. Fourth, although COVID 19 pandemic has been a major source of stress for many people, it is arguable if the pandemic can be considered as a traumatic

event similar to wildfire and flooding. Fifth, this study did not include neighbourhoods in Fort McMurray as a variable in the analysis. There can be marked variability in the impact that natural disasters such as flooding and wildfire can have on residents of a city-based, for example, on the neighbourhoods in which they live. Sixth, the present study was cross-sectional and may warrant more longitudinal pathway analyses. Seventh, the overall study sample size of 186 was much smaller than our expected sample size of 1049, thus increasing the margin of error for our prevalence estimates from the expected 3% to about 7%. Finally, there were only nineteen participants in the COVID-19 only trauma group, which limits the generalizability of our study findings. In addition, we did not include variables that will help determine if respondents in the COVID-19 only trauma group were new residents to the city, and so it has not been possible to definitively say that these residents were in FortMcMurray during the flooding and wildfire but did not experience trauma from these natural disasters. Despite these limitations, our study provides important insights and evidence on the mental health effects of multiple traumatic events in Fort McMurray, which would be of interest to policymakers in planning mental health support as the COVID-19 pandemic rages on.

6. Conclusion, policy implications and future directions

This study has established that respondents who experienced trauma from the 2016 wildfires and/or the 2020 flooding in Fort McMurray, in addition to experiencing trauma from the ongoing COVID-19 pandemic, had worse mental health outcomes compared to respondents who experienced trauma from only the COVID-19 pandemic. The study has further established that mental health burdens correlate with the number of traumatic disasters experienced by the respondents. The study result adds to the clinical and research evidence related to the field of trauma and disasters and highlights the need for governments and health policymakers to prioritise mental health supports during the ongoing COVID-19 pandemic for vulnerable communities. It is essential for communities that have had previous natural disasters to be offered evidence-based, easily scalable and cost-effective population-level interventions such as supportive text messaging programmes (Agyapong, 2020; Agyapong et al., 2016, 2017; Agyapong, Ahern, McLoughlin, & Farren, 2012; Agyapong, McLoughlin, & Farren, 2013; Agyapong, Milnes, McLoughlin, & Farren, 2013; O'Reilly et al., 2019), which have been established to reduce stress, anxiety and depression in subscribers of the Text4Hope programme in Alberta, Canada during the COVID-19 pandemic (Agyapong,

Hrabok, Vuong, Gusnowski et al., 2020; Agyapong, Hrabok, Vuong, Shalaby et al., 2020; Agyapong, Hrabok et al., 2021; Agyapong, Shalaby et al., 2021; Shalaby et al., 2021). Our results also highlight the need for governments and multinational agencies such as the United Nations to achieve consensus and implement pragmatic policies and programmes to check climate change events, including wildfires and flooding. Policies aimed to reduce deforestation and promote afforestation are believed to have the potential to slow down climate change, thus reducing the occurrence of both wildfires and flooding and achieving sustainability goals (Watson et al., 2018). Future studies need to examine the influence of other personal traumas such as adverse childhood experiences, sexual trauma, and domestic violence on mental health outcomes in populations impacted by natural disasters.

Data availability statement

Data associated with this study is available at Science Data Bank: DOI: 10.11922/sciencedb.01417.

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