

**Identifying the Mental Health Burden of Firefighters in a
Northwestern Ontario Professional Fire Service in Context of COVID-19**

by

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A thesis

presented to Lakehead University

in partial fulfillment of the

thesis requirements for the degree of

Master of Science in Kinesiology

Thunder Bay, Ontario, Canada, 2022

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Acknowledgements

During my time at Lakehead University, I have been incredibly grateful for the mentorship that Dr. Kathryn E. Sinden provided me. Dr. Sinden, thank you for your continuous guidance, encouragement, support, and training. You have helped me to develop my skill set and knowledge, which has allowed me to improve as a student, researcher, and professional. You have always driven and encouraged me to achieve my full potential. Thank you also for the valuable discussions and lessons that have helped me through several challenges and be successful during my master's degree. I would also like to thank my committee members, Dr. Aislin Mushquash, Dr. Nicholas Ravanelli, and Dr. Paolo Sanzo, for their continuous support, insight, and encouragement. You have each significantly impacted my learning and success within this program.

Thank you to the Thunder Bay Fire Rescue service for their support, contribution, and participation, which has provided me with the opportunity to conduct this research. I would also like to thank Regan Bolduc for his continuous support, hard work, involvement, and encouragement of this research project, as well as my overall learning and success.

My family, especially my parents, Jakub and Agnieszka, and my boyfriend, Alex, have been incredibly supportive of this journey and my education. They have always encouraged me to work hard and to continuously learn (including from my mistakes), which I will forever be thankful for. In doing so, they helped me to transition into life in Thunder Bay. For more than this, I am incredibly grateful for their unconditional love and cannot thank them enough.

I would also like to extend a thank you to all of my friends – new and old – for their continuous support and encouragement. Each of you have played a role in my transition to Lakehead University, which has made my time here incredible and unforgettable.

Abstract

Background: Mental health disorders are among the top five causes of lost-time and workplace disability claims among Canadian firefighters, along with traumatic injuries, cancer, cardiovascular disease, and respiratory disease (Ramsden et al., 2018). Critical incidents (CIs) are work-related trauma experiences that emergency response personnel are commonly exposed to that adversely impact mental health (Wagner et al., 2020). Among many other factors, CI exposures can cause detrimental emotional, psychological, and physiological stress, increasing the risk of developing posttraumatic stress disorder (PTSD; Kehl et al., 2014). In a recent study, 91% of firefighters in a local fire service experienced a CI and 86% experienced symptoms of PTSD (Sinden et al., 2020). Carmassi et al. (2020) identified that the coronavirus disease-2019 (COVID-19) increases the risk for mental health injuries, including PTSD. Other influencing factors that impact the risk of PTSD include years of service, age, and gender (Del Ben et al., 2006; Thurnell-Read & Parker, 2008).

Research Purpose and Objective: The purpose of this thesis was to determine the mental health burden among Thunder Bay Fire Rescue (TBFR) firefighters in the context of the COVID-19 pandemic. The following research objectives were subsequently developed: 1) to identify the TBFR firefighter's CI exposure in the context of COVID-19, 2) to identify the TBFR firefighter's PTSD risk in the context of COVID-19, and 3) to identify how factors that predict PTSD risk have changed in the context of COVID-19.

Methodology: Active duty TBFR firefighters were invited to participate. As part of a longitudinal study, firefighters who participated in phase one of this study (baseline) were invited to participate in phase two (during COVID-19). To analyze the changes in the context of COVID-19, a subset of firefighters who participated in both phases was included ($n = 78$).

Previous participation and other demographic information (i.e., gender and years of service) were determined by administering a demographic questionnaire. Exposure to CIs and COVID-19 were identified by administering a 25-item version of the Critical Incident Inventory (CII-25), encompassing the original 24-item CII (CII-24). Lastly, administration of the PTSD Checklist for the DSM-5 (PCL-5) identified the firefighter's risk of PTSD.

Results: Although there was no significant change in CI exposures over time, further analysis of the CII-24 subscales identified a significant increase in the TBFR firefighter's exposures to CIs referred to as trauma to self, $z = 2.61, n = 78, p = .009$. A statistically significant change in the firefighter's PTSD risk was identified, suggesting that the firefighters experienced worsened mental health risk in the context of COVID-19, $z = 2.94, n = 78, p = .003$. Additionally, the inclusion of COVID-19 exposure ($\rho = .32, n = 78, p = .004$) as a CI was a stronger predictor of PTSD risk than when it was excluded ($\rho = .30, n = 78, p = .007$). As well, there was a statistically significant difference in PTSD risk when comparing low and high COVID-19 exposure, $U = 997, z = 2.37, p = .018, r = .27$. Lastly, the examination of influencing factors over time identified that age and CI exposure continued to be the best predictors of the TBFR firefighter's PTSD risk.

Conclusion: Study findings suggested that the TBFR firefighters experienced worsened mental health outcomes, and that COVID-19 has impacted their CI exposures and PTSD risk. Exposure to COVID-19 was related to high PTSD risk; further suggesting that pandemics' impacts should be closely examined and considered when assessing emergency response personnel's mental health. Study findings identified the TBFR firefighter's current mental health burden. The study findings will inform the development of evidence-informed programming to support mental health disorder reduction and prevention for the TBFR firefighters.

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List of Abbreviations

ANOVA	Analysis of Variance
CI	Critical incident
CII	Critical Incident Inventory
COVID-19	Coronavirus disease-2019
DSM-5	Diagnostic and Statistical Manual of Mental Disorders (5 th edition)
iKT	Integrative knowledge translation
KT	Knowledge translation
KTA	Knowledge-to-action
MERS	Middle East respiratory syndrome-related coronavirus
PCL-5	Posttraumatic Stress Disorder Checklist for the DSM-5
PTSD	Posttraumatic stress disorder
RTW	Return-to-work
SARS	Severe acute respiratory syndrome
TBFR	Thunder Bay Fire Rescue
VIF	Variance inflation factor

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Chapter 1: LITERATURE REVIEW

Coronavirus SARS-CoV-2, or coronavirus disease-2019 (COVID-19), is a highly contagious respiratory virus that can present symptomatically and asymptotically. COVID-19 originated in Wuhan, China, in December 2019 (Velavan & Meyer, 2020). The virus was first reported in Ontario, Canada, on January 25, 2020. On March 11, 2020, the province announced its first death due to the virus. A state of emergency was declared six days later (Nielson, 2021). During the worldwide COVID-19 pandemic, many changes impacted individual needs, emergency protocols, and overall demands. Pandemics such as the 2003 severe acute respiratory syndrome (SARS) outbreak and the 2012 Middle East respiratory syndrome-related coronavirus (MERS) have been seen as traumatic events (Carmassi et al., 2020).

Critical incidents (CIs) are identified as work-related trauma experiences that emergency response personnel are commonly exposed to that adversely impact mental health (Wagner et al., 2020). CI exposures can cause detrimental emotional, psychological, and physiological stress, increasing the risk of developing posttraumatic stress disorder (PTSD; Kehl et al., 2014). In addition to job-related exposures that increase the risk for adverse mental health, firefighters, among other emergency response personnel, have been impacted by COVID-19 in various work-related and personal contexts (Carmassi et al., 2020). In a previous study implemented prior to the COVID-19 pandemic, 91% of Thunder Bay Fire Rescue (TBFR) firefighters were exposed to a CI, and 86% were at high risk for PTSD (Sinden et al., 2020). Due to the pandemic's impact on emergency response personnel, the overriding purpose of this study was to determine the mental health burden in the context of COVID-19 among the TBFR firefighters by identifying their CI exposure and PTSD risk.

Mental health disorders are among the top five causes of lost-time and workplace disability claims among Canadian firefighters, along with traumatic injuries, cancer, cardiovascular disease, and respiratory disease (Ramsden et al., 2018). In the workplace, mental health injuries/disorders have become more prevalent, requiring additional support, and overall, increasing the concern for individuals with mental health disorders. This also impacts employers financially due to the increased use of healthcare and disability leave plans, with reductions in productivity (Coduti et al., 2016). As such, there is a need for increased support for those who develop mental health disorders by providing pathways that facilitate worker access to evidence-informed treatment and care (Coduti et al., 2016). Consequently, the overall purpose of this study was to identify the impacts of CIs on PTSD risk in the context of COVID-19. Study findings will be utilized to further develop policies and procedures aimed to decrease the impact of mental health disorders among the TBFR firefighters. This initial literature review was intended to highlight foundational summaries and relations as an overview of the contents explored within this thesis. The following section reviews the relationship between CI exposures and PTSD risk.

1.1 Critical Incident Exposures on Mental Health

A CI is a work-related experience or exposure to trauma which causes an emotional and psychological impact (Wagner et al., 2020). Firefighting is a high risk-occupation where firefighters experience various injuries, diseases, and disorders, including mental health disorders. Mental health disorders are often related to trauma exposure (a CI). Traumatic events include exposure to at least one of the following: calls that result in excessive media attention, injury or death to children, personal loss or injury, mission failure, human error, and other traumatic stimuli (Harris et al., 2002). Firefighters are routinely exposed to CIs, which results in emotional and psychological impacts that can be detrimental to their mental health (Ramsden et

al., 2018; Wagner et al., 2020). As a result of trauma exposure, CIs may impact a firefighter's physical, emotional, behavioural, social, and/or psychological ability to perform at their full potential, inhibiting their ability to perform properly (Mayo Clinic Staff, 2019). Approximately 92% of firefighters will experience a CI at least once throughout their career (Nazari et al., 2020). Furthermore, previous studies reported that within two months, nearly 85% of firefighters experienced a CI (MacDermid et al., 2019; Sinden et al., 2020). As previously mentioned, CIs often result from a traumatic experience, causing an emotional impact on those experiencing the event (Wagner et al., 2020). Firefighting is an occupation that exposes emergency response personnel to a wide variety of emotionally impacting events. Due to the high prevalence of CI exposure and its impact on firefighters, there is an increased risk for mental health disorders, including PTSD (Kehl et al., 2014).

As a result of the various CIs that emergency response personnel are exposed to, they are at an increased risk of PTSD compared to other related mental health disorders (i.e., major depressive disorder, substance abuse disorder, and generalized anxiety disorder; Carleton et al., 2019; Haugen et al., 2012; Vujanovic & Tran, 2021). PTSD is a mental health disorder experienced following a traumatic event, resulting in a series of diagnostic symptoms concerning the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), including intrusive thoughts, avoidance, alterations in mood/cognition, and alterations in activity/arousal (APA, 2020; Wallace et al., 2020). PTSD symptoms can be divided into three sub-categories, including trauma reexperiencing, avoiding/reducing trauma-inducing stimuli, and experiences of high arousal, each of which can be initiated due to a single event or repeated CI exposure (Heinrichs et al., 2005). Due to the demands of the occupation and the prevalence of CIs among firefighters, PTSD can be a consequence of such exposure (Kehl et al., 2014). A recent study identified that

44.5% of public safety personnel reported a mental health disorder, including 23.2% being diagnosed with PTSD (Carleton et al., 2019). A study performed by Heinrichs et al. (2005) identified that within two years of active service, approximately 35% of firefighters would develop symptoms diagnosable for PTSD. In another firefighter population, 24.5% met the criteria for PTSD diagnosed based on their symptom experiences and 46.2% were subsyndromal for PTSD (Wagner et al., 1998). Similar risks for PTSD have been identified among the TBFR firefighter population studied by Sinden et al. (2020). Furthermore, COVID-19 impacts the general population and emergency response personnel negatively (Carmassi et al., 2020). As such, there is a need to consider the impacts that COVID-19 has had on first responders' mental health.

1.2 Impact of Coronavirus Disease-2019 on Mental Health

Prior to the COVID-19 pandemic, firefighting, among other emergency occupations, faced several demanding challenges. Since the start of the pandemic in January 2020, firefighters, among many other emergency response personnel, have been part of the frontline workers serving and protecting communities during COVID-19 (Ruiz & Gibson, 2020). Firefighters are often the first on the scene during emergency response, and consequently, have the potential of direct exposure to COVID-19. As part of their responsibilities, firefighters often work in close proximity to potentially infected people (providing patient care) and/or their living quarters, increasing their risk of exposure to COVID-19 (Graham et al., 2021). During the initial wave in 2020, in comparison to the general public, firefighters and other first responders were 15 times more likely to be infected (Weiden et al., 2020). In a recent study by Graham et al. (2021), approximately 48% of firefighters were diagnosed with COVID-19, while 64% potentially encountered COVID-19-positive patients during emergency responses. Along with the increased

fear of contracting the virus, firefighters are also placed under a greater workload when their coworkers call in sick. This causes team members to work additional shifts and longer hours, further impacting their mental and physical health (Morren et al., 2007). As such, COVID-19 has exacerbated the required demands to be performed regularly and extensively. As a result, firefighters experience increased stress, anxiety, depression, and other related PTSD symptoms (Johnson et al., 2020; Vujanovic & Tran, 2021).

Carmassi et al. (2020) identified that the COVID-19 pandemic significantly impacted emergency response personnel's mental health, especially increasing the risk of PTSD. This trend was also identified in the 2003 SARS outbreak and the 2012 MERS outbreak. Among these outbreaks, including the current COVID-19 outbreak, the following factors increase the risk of PTSD: direct exposure, role, years of service, support availability, age, gender, marital status, quarantine, and coping styles (Carmassi et al., 2020). Johnson et al. (2020) identified that among a sample of healthcare workers and emergency response personnel during the COVID-19 pandemic, 28.9% were at risk for PTSD diagnosis, 21.2% experienced severe anxiety symptoms, and 20.5% experienced severe symptoms of depression. Ruiz and Gibson (2020) identified that Toronto emergency response personnel also experience an increased risk of trauma-related stress, occupational burnout, insomnia, and overall, greater emotional stress than they had prior to the pandemic. This may also affect the emotional impact that results from CI exposure, which may worsen the symptoms that a firefighter may be experiencing (Johnson et al., 2020). Johnson et al. (2020) identified that during the COVID-19 pandemic, CIs resulted in increased emotional exhaustion and depression. With the pandemic still underway, there is ample information about COVID-19 that is unknown that has also sparked a significant amount of fear and stress (Ruiz & Gibson, 2020). Firefighters experience an increased risk for mental health disorders, which can

further impact the physical, emotional, behavioural, and social components of health. In addition to the immediate impacts that COVID-19 has on mental health, it is also important to identify and understand how these impacts changed over time. While COVID-19 impacts emergency response personnel's mental health, several demographic factors increase/influence/predict the firefighter's risk of PTSD, including gender, years of service, and age.

1.3 Influencing Factors on Mental Health

1.3.1 Gender

Firefighting is prevalently gendered, appealing to male ideals as a masculine praised workplace (Thurnell-Read & Parker, 2008). As part of a nationwide survey, less than 4% of firefighters are female, increasing by only 0.2% each year (Hulett et al., 2008; Isaac & Buchanan, 2021). Tolin and Foa (2008) identified that among firefighters, females were more likely than males to meet the criteria for PTSD diagnosis. Females are also two to three times more at risk of developing PTSD due to the psychophysiological distress experienced from CI exposures (Olf, 2017). This may result from the stigma that lies as a significant barrier to accessing and/or receiving treatment and reporting (including self-reporting) to preserve their overall perception of health, specifically among male firefighters to continue their service (Isaac & Buchanan, 2021; Thurnell-Read & Parker, 2008). The type of CI exposure, emotional reactions, coping mechanisms, and psychobiological reactions impact the differences found between male and female responses to trauma and their risk of developing PTSD (Olf, 2017). When left untreated for a prolonged period of time prior to accessing help, the recovery time is also prolonged; therefore, early detection is critical within this population (Du et al., 2020). Consequently, it is important to identify the influence of gender when examining mental health among the TBFR.

1.3.2 Years of Service

Years of service is the number of years an individual has been employed, in this case, as a TBFR firefighter. With a high prevalence of CI exposure in firefighting, especially among TBFR firefighters, it can be hypothesized that years of service would be positively correlated with CI exposures (Sinden et al., 2020). Based on previous research of the relationship between CI exposure and PTSD risk, it can be hypothesized that the relationship between years of service and CI exposure also increases the risk of PTSD (Del Ben et al., 2006). More recently, firefighters with greater years of experience were experiencing higher degrees of occupational stress and an increased risk of PTSD (Isaac and Buchanan, 2021; Nydegger et al., 2011).

1.3.3 Age

Age also influences work-related disorders, including PTSD risk (Katsavouni et al., 2015; Obuobi-Donkor et al., 2022). It was identified that younger firefighters had a four times greater risk of developing PTSD due to the increased unpredictability of CI exposures and their reactions to them (Del Ben et al., 2006; Obuobi-Donkor et al., 2022; Tull & Block, 2020). Rates of mental health disorders, among other work-related disorders, also seem to increase with age (Harvey et al., 2016). Findings further identified that older firefighters were more frequently exposed to CIs over time, increasing their risk of developing PTSD (Obuobi-Donkor et al., 2022). As such, it is important to examine the relationship that age has with PTSD risk among the TBFR firefighters. Ultimately, while several factors impact the firefighter's risk of PTSD, it is also important to consider the TBFR service and their specific occupational demands and geographical context.

1.4 Thunder Bay Fire Rescue

TBFR is a professional fire service located in Thunder Bay, Ontario, that is responsible for several emergency responses across the city and is the largest professional service in Northwestern Ontario. Additionally, Thunder Bay is the most populated community in Northwestern Ontario, with an approximate population of 110,000. The service is comprised of eight different stations, and overall, employs professional firefighters ($n = 190$). Due to the geographical location, TBFR firefighters respond to urban and rural emergency responses equivalently (“Fire rescue”, 2018). The research being performed is part of an established research partnership and program with the TBFR service, which is aimed to improve firefighters’ health and well-being.

1.5 Research Purpose and Objectives

Consequently, the purpose of this thesis was to determine the mental health burden among TBFR firefighters in the context of the COVID-19 pandemic. The following research objectives were subsequently developed: 1) to identify the TBFR firefighter’s CI exposure in the context of COVID-19, 2) to identify the TBFR firefighter’s PTSD risk in the context of COVID-19, and 3) to identify which factors predict PTSD risk in the context of COVID-19.

Chapter 2: METHODOLOGY

2.1 Study Design

A longitudinal (cohort) study was conducted comparing measures at the following points in time: baseline (phase one) and during COVID-19 (phase two). This study encompassed a quantitative approach to identify and assess the TBFR firefighter's mental health in the context of COVID-19.

2.2 Participants

All active-duty career firefighters were eligible to participate. The term active indicates that the participants were engaged in their occupational duties by attending scheduled shifts. Exclusion criteria included inactive firefighters (on leave, amid return-to-work [RTW], or have been terminated). To compare measures across time, participants with repeated participation at baseline and during COVID-19 were included ($n = 78$; Sinden et al., 2020). Participants were provided with the following questionnaires: a demographic questionnaire, a 25-item version of the Critical Incident Inventory (CII-25), and the PTSD Checklist for the DSM-5 (PCL-5).

2.3 Instrumentation

2.3.1 Demographic Questionnaire

The demographic questionnaire was previously developed with the TBFR firefighters and the research team in phase one (see Appendix A). This questionnaire examined questions pertaining to the firefighter's previous participation (phase one), gender, and years of service. Participants were given the opportunity to report their gender, which was then separated as follows: male, female, and prefer something else/not to specify. This questionnaire also contained questions pertaining to the firefighter's age, years of service, job rank/title, and primary station assignment (Sinden et al., 2020).

2.3.2 Critical Incident Inventory

The 24-item CII (CII-24) is a self-reporting questionnaire utilized to identify the TBFR firefighter's CI exposure (Monnier et al., 2002). The CII-24 aimed to identify the types and frequency of CI exposures the firefighters experienced within the last two months. Each question provided a multiple-choice response, which allowed the participant to select the respective exposure with one of the following four options: one time, two times, three or more times, or none. The questionnaire was scored by allocating a score of one, two, three, or zero, respectively. The completed questionnaires were further assessed based on the six subscales (trauma to self, victims known to fire-emergency worker, multiple casualties, incidents involving children, unusual or problematic tactical operations, and exposure to severe medical trauma, numbered respectively) to further identify the general types and frequency of exposures experienced (Monnier et al., 2002). The CII was previously developed in correspondence to the experiences of the firefighting population and was anecdotally tested among the TBFR firefighters (including in phase one). The CII-24 was administered at baseline. Assessment of Cronbach's alpha for the CII-24 total scores indicated good reliability with values .77 and .86, respectively across time.

To capture the firefighter's exposure to COVID-19, Duivesteyn (2021) generated an additional question (25th item) to develop the CII-25, which was administered during COVID-19 (see Table 1). As per the overriding purpose, the administration of the modified version of the CII, which will be referred to as the CII-25, aimed to identify firefighter's exposure to COVID-19 as a CI and the influence this experience had on PTSD risk. As per Morren et al. (2007), since the participants selected the generated question when administered, it can be confirmed that this question has content validity. As with the CII, this study has anecdotally tested the psychometric

properties of this questionnaire among the TBFR firefighters. Within this study, Cronbach's alpha was .86 when assessing the CII-25 total scores, indicating excellent reliability.

Table 2.1

CII-25

Included Question(s)	Generated Question(s)
- Direct exposure to extremely hazardous materials (22)	- Direct exposure to a life-threatening virus (i.e., COVID-19; 25)
- Direct exposure to blood and bodily fluids (23)	

Note. This table identifies the included questions in the CII pertaining to exposure (hazardous materials, blood, and other bodily fluids). It further provides the generated question identifying recent exposure to COVID-19. The numbers included reflect the item number in which the questions were presented in the administered CII.

2.3.3 Posttraumatic Stress Disorder Checklist for the DSM-5

The PCL-5 was developed to determine the risk of PTSD based on the symptoms the individual is experiencing with respect to the criteria of the DSM-5 (Weathers et al., 2013). As such, the PCL-5 was administered to determine the TBFR firefighter's risk of PTSD (see Appendix C). The PCL-5 is a 20-item self-report questionnaire based on the symptoms as per the DSM-5 (Weathers et al., 2013). Each of the 20 questions comprised a five-point Likert scale, rating their symptom severity in the previous month from zero (not at all) to four (extremely). The questionnaire was scored by summing the resulting 20 Likert scores, providing a numerical score for the participants' PTSD risk (ranging between 0 to 80; Weathers et al., 2013). The greater the score achieved, the greater the risk is of developing PTSD; those exceeding a score of 39 are at high risk and likely to be diagnosed with PTSD (in clinical settings; Chiu et al., 2011). Blevins et al. (2015) and Bressler et al. (2018) reported that the questionnaire has strong

test-retest reliability, convergent validity, and discriminant validity. Cronbach's alpha values of .92 and .93 indicated excellent reliability within the PCL-5 total scores over time.

2.4 Data Collection

Data collection was organized with TBFR's management, union, and primary knowledge user to minimize the impact on operations. As per previous studies with the TBFR, participants were provided with the opportunity to participate while on- or off-duty (Sinden et al., 2020). All participating and active-duty firefighters completed the demographic questionnaire, CII-25, and PCL-5. Several data collection sessions were held to ensure that all shifts (platoons) and stations had the opportunity to participate.

2.5 Data Preparation

The data collected in December 2019 and January 2020 (prior to the COVID-19 pandemic) was defined as baseline data (phase one), while the data collected for the purpose of this study in April 2022 was defined as during COVID-19 data (phase two). During COVID-19, participant responses were recorded in Microsoft© Excel (2022). Each participant was evaluated individually, and each questionnaire item was recorded. The item was left blank if a question was unanswered in either the CII-25 or PCL-5 (missing data). Each questionnaire and their respective Excel sheets were re-examined to ensure that all the respondent and recorded values were the same. With respect to the questionnaire, the individual responses of each participant were then summated to identify their CII-24, CII-25, and PCL-5 total scores. Additionally, the respective items in the CII-24 were summated to identify each subscale score. Participation in both phase one (baseline) and phase two (during COVID-19) was then identified through cross-referencing participant ID, which provided a subsample that was utilized for pre- and post-analysis ($n = 78$).

2.6 Statistical Analysis

Data analysis was completed using Microsoft© Excel (2022) and IBM© SPSS Statistics (2022) 28 for macOS. The descriptive statistics were determined for the TBFR firefighter's age, years of service, CI exposure, and PTSD risk. Inferential statistical analyses performed in this study included the following non-parametric tests to test for the medians: Wilcoxon Signed Rank Tests, Spearman correlations, and a Mann-Whitney *U* Test. Inferential statistics also included the development of linear stepwise regression models. Each analysis utilized the 95% rule, setting the alpha level to .05 (Pallant, 2020). With respect to the first and second objectives, a series of Wilcoxon Signed Rank Tests were performed to compare CI exposure and PTSD risk (respectively) over time (baseline and during COVID-19). Additional Wilcoxon Signed Rank Tests were conducted to determine the changes in the types and frequency of CI exposures experienced over time. Further analysis was conducted utilizing the during COVID-19 data set, which included a series of Spearman correlations to compare the CII-24 to the CII-25 and their relationship with the PCL-5 scores (PTSD risk). To further determine the influence that COVID-19 exposure had on PTSD risk, a Mann-Whitney *U* Test was conducted, comparing the firefighter's PTSD risk with low and high exposure to COVID-19. To address the third objective of this study, linear stepwise regression models were developed for each phase (baseline and during COVID-19) to identify the best predictors of PTSD risk and were compared to determine how these predictors changed over time. Lastly, based on the sample size ($n = 78$), an alpha level of .05, and moderate effect size, a post-hoc analysis was conducted utilizing G*Power 3.1 (Faul et al., 2009), which identified an achieved power of 85% (.85) within this study.

Chapter 3: RESULTS

3.1 Demographic Characteristics Across Participation

This study was conducted to assess the TBFR male firefighter's ($n = 78$) mental health over time. Participants at baseline were 38.21 years old ($SD = 7.73$ years) with an average of 9.77 years of service ($SD = 6.46$ years). During COVID-19, participants were 40.31 years old ($SD = 7.51$ years) and their average years of service was 12.15 ($SD = 6.48$ years). See Table 1 for a summary of the demographic characteristics over time.

Table 3.1

Demographic Descriptive Statistics

	<i>M</i>	<i>SD</i>	Minimum	Maximum	Range
Baseline					
Age	38.21	7.73	21.00	57.00	36.00
Years of service	9.77	6.46	1.00	28.00	27.00
During COVID-19					
Age	40.31	7.51	23.00	60.00	37.00
Years of service	12.15	6.48	3.00	30.00	27.00

Note. This table summarizes the demographic characteristics gathered over time.

3.2 Objective 1: Change in Critical Incident Exposures

With respect to the first objective of this study, the TBFR firefighter's CI exposure were quantified to identify overall exposure and how their exposure has changed over time (baseline and during COVID-19). Overall, findings identified that the number of CI exposures at both points in time remained the same, where firefighters experienced seven CIs within two months. Though, the maximum/range of exposures has changed over time, having increased during the COVID-19 pandemic (see Table 2).

Table 3.2*CII-24 Descriptive Statistics*

	Median	Minimum	Maximum	Range
Baseline	7	0	27	27
During COVID-19	7	0	44	44

Note. This table depicts the frequency on the number of CI experienced within two months among the TBFR firefighters over time.

Firefighters are frequently exposed to several demanding challenges, often including CIs. To determine TBFR firefighter's overall CI exposure, the following tables provide further analysis of the data collected. The firefighter's CI exposures were assessed to determine the types and frequency of exposures. See Table 3 for the descriptive statistics on the frequency and the types of CIs (represented by the respective subscale) that the firefighters were exposed to within the last two months. Table 4 reports the overall experiences of the TBFR firefighters. Specifically, the table highlights the percentage of firefighters that experienced each respective CI exposure (in the CII-24) within the last two months and the frequency (one time, two times, three or more times, or not at all) with comparison over time (baseline and during COVID-19). Lastly, Figure 1 identifies the percentage of firefighters exposed to at least one CI within two months, including exposure to each subscale.

Table 3.3*Summary of CII-24 Subscale Scores Over Time*

	Trauma to self	Victims known to fire- emergency worker	Multiple casualties	Incidents involving children	Unusual or problematic tactical operations	Severe medical trauma
Baseline						
Median	1	1	2	0	2	0
Range	8	6	6	4	11	5
During COVID- 19						
Median	2	0	2	0	1	0
Range	9	5	7	5	14	8

Note. This table provides the frequency of exposure to each CII-24 subscale over time. In all cases, the minimum value achieved was zero; therefore, the range depicts the maximum exposure to each type of CI exposure.

Table 3.4*Overall Assessment of the CII-24 by Determining the Firefighter's Overall Critical Incident**Exposure*

CII-24 Item	One time	Two times	Three + times	None
	A; B	A; B	A; B	A; B
Trauma to Self				
1. Serious line of duty injury to self.	1%; 3%	0%; 0%	0%; 0%	99%; 97%
2. Threat of serious line of duty injury or threat of death to self (that did not result in actual serious injury).	12%; 15%	3%; 4%	3%; 5%	82%; 76%
19. Incident necessitating search or rescue involving serious risk to yourself.	12%; 14%	1%; 4%	0%; 3%	87%; 79%
22. Direct exposure to extremely hazardous materials.	9%; 5%	3%; 3%	0%; 5%	88%; 87%
23. Direct exposure to blood and bodily fluids	27%; 26%	12%; 17%	22%; 29%	40%; 28%
Victims Known to Fire-Emergency Worker				
3. Line of duty death of fellow emergency worker.	1%; 0%	0%; 0%	0%; 0%	99%; 100%
4. Serious line of duty injury to fellow emergency worker (that did not result in death).	4%; 8%	0%; 3%	0%; 0%	96%; 90%
5. Threat of serious line of duty injury or threat of death to fellow emergency worker (that did not result in actual serious injury or death).	13%; 26%	0%; 4%	3%; 4%	85%; 67%
6. Suicide or attempted suicide by fellow emergency worker.	36%; 10%	1%; 1%	0%; 0%	63%; 88%
14. Victim(s) known to you.	21%; 14%	3%; 0%	1%; 3%	76%; 85%
Multiple Casualties				
7. Responded to incident involving three or more deaths.	1%; 3%	0%; 0%	1%; 0%	97%; 97%
8. Responded to incident involving one or two deaths.	26%; 17%	23%; 28%	27%; 33%	24%; 22%
9. Responded to incident involving multiple serious injuries (three or more victims sustained serious injuries).	22%; 17%	6%; 1%	3%; 6%	69%; 76%
Incidents Involving Children				
12. Incident involving serious injury or death to children.	10%; 4%	3%; 1%	0%; 1%	87%; 94%
13. Incident involving severe threat to children (that did not result in actual serious injury or death to children).	10%; 9%	1%; 1%	0%; 4%	88%; 86%

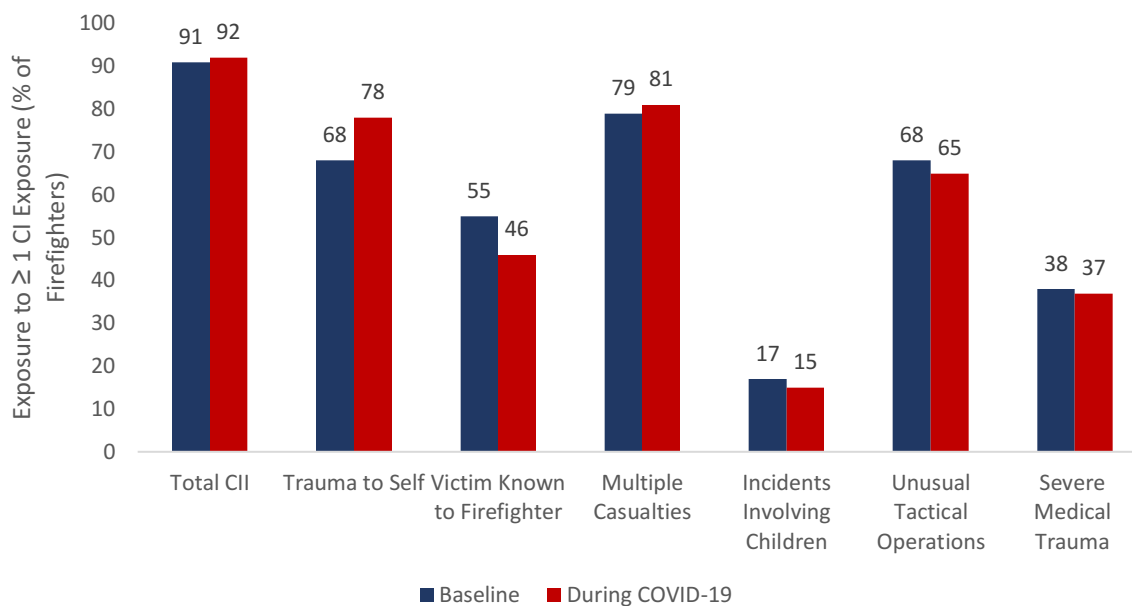
Unusual or Problematic Tactical Operations				
10. Incident requiring police protection while on duty.	18%; 18%	8%; 9%	4%; 4%	71%; 69%
11. Verbal or physical threat by public while on duty (that did not result in police protection).	13%; 29%	13%; 6%	3%; 8%	72%; 56%
15. Failed mission after extensive effort.	19%; 13%	1%; 9%	4%; 4%	76%; 74%
16. Critical (negative) media attention.	9%; 19%	15%; 8%	27%; 6%	49%; 67%
21. Use of deadly force by police at an incident.	0%; 3%	0%; 0%	0%; 0%	99%; 97%
24. Critical equipment failure or lack of equipment in any of the above situations.	1%; 14%	0%; 0%	0%; 0%	99%; 86%
Severe Medical Trauma				
17. Close contact with burned or mutilated victim.	6%; 5%	1%; 1%	0%; 1%	92%; 92%
18. Removing dead body or bodies.	24%; 17%	5%; 5%	1%; 10%	69; 68
20. Prolonged extrication of trapped victim with life-threatening injuries.	0%; 6%	1%; 1%	1%; 0%	97; 92

A = Baseline; *B* = During COVID-19

Note. This table identifies the percentage of firefighters that experienced each included CI exposure (concerning the CII-24 questions) at the following frequencies: one time, two times, three or more times, or not at all at each point in time.

Figure 3.1

Percentage of Firefighter's Total and Subscale CI Exposure Over Time



Note. This figure presents the percentage of firefighters exposed to at least one CI within two months at each point in time, which further highlights the overall frequency of the types of CI exposures.

The Wilcoxon Signed Rank Test identified no statistically significant difference in the firefighter's overall exposure to CIs from baseline to during COVID-19, $z = 1.02$, $n = 78$, $p = .307$, indicating there was no statistically significant change over time (Pallant, 2020).

Furthermore, a series of Wilcoxon Signed Rank Tests were conducted to assess whether there were any changes in the CII-24 subscales. Statistical significance was identified in exposure to trauma to self over time, $z = 2.61$, $n = 78$, $p = .009$, where trauma exposure to self increased from baseline ($Md = 1$) to COVID-19 exposure ($Md = 2$) with a medium effect size ($r = .30$; Pallant, 2020). See Table 5 for a summary of the findings.

Table 3.5*Wilcoxon Signed Rank Test Analysis on Firefighter CI Exposure*

	<i>n</i>	Baseline <i>Md</i>	During COVID- 19 <i>Md</i>	Standardized Test Statistic (<i>z</i>)	<i>p</i>	<i>r</i>
Total CI Exposure	78	7	7	1.02	.307	
Trauma to Self	78	1	2	2.61	.009*	.30
Victim Known to Fire- Emergency Worker	78	1	0	-.47	.641	
Multiple Casualties	78	2	2	.71	.476	
Incidents Involving Children Unusual or Problematic	78	0	0	.73	.734	
Tactical Operations	78	2	1	-1.01	.311	
Severe Medical Trauma	78	0	0	1.31	.192	

**p* < .05

Note. This table identifies the findings from a series of Wilcoxon Signed Rank Tests assessing the firefighter's total exposure and subscale exposure to CIs.

3.3 Objective 2: Change in Posttraumatic Stress Disorder Risk

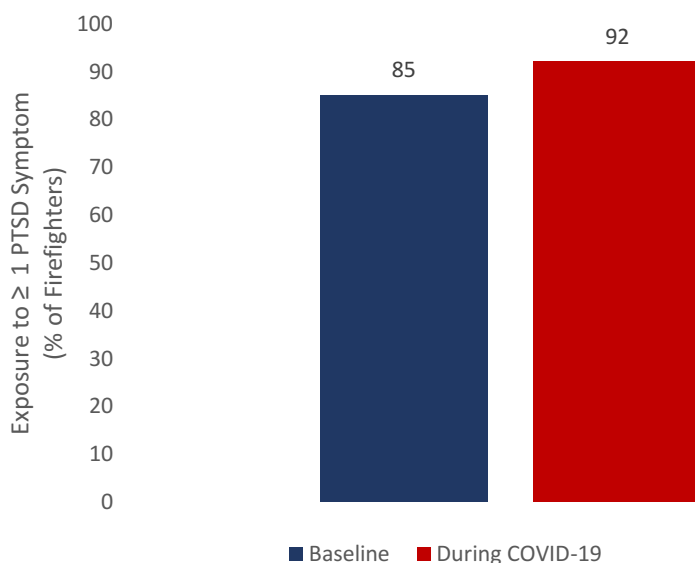
The PCL-5 was administered, scored, and summated to identify the TBFR firefighter's PTSD risk. Descriptive statistics over time identified that there was an overall change in PTSD symptoms. It was identified that within the previous month, the TBFR firefighter's overall total of PTSD symptoms experiences increased from baseline (*Md* = 6) to during COVID-19 (*Md* = 8). Please see Table 6 for a summary of the changes in the firefighter's PCL-5 scores compared across the different cohorts and subsets over time.

Table 3.6*Descriptive Statistics of PCL-5 Scores*

	Median	Minimum	Maximum	Range
Baseline	6	0	54	54
During COVID-19	8	0	53	53

Note. This table identifies the frequency of PTSD symptoms experienced among the TBFR firefighters over time.

While it was previously identified that the majority of the TBFR firefighters were exposed to at least one CI within the previous two months, the majority also experienced at least one PTSD symptom within the previous month. Figure 2 compares the baseline and the COVID-19 samples, which identified an increase in the number of firefighters who experienced at least one PTSD symptom by 7% over time.

Figure 3.2*Frequency of Firefighter PTSD Symptom Experiences*

Note. Percentage of firefighters who experienced a minimum of one PTSD symptom.

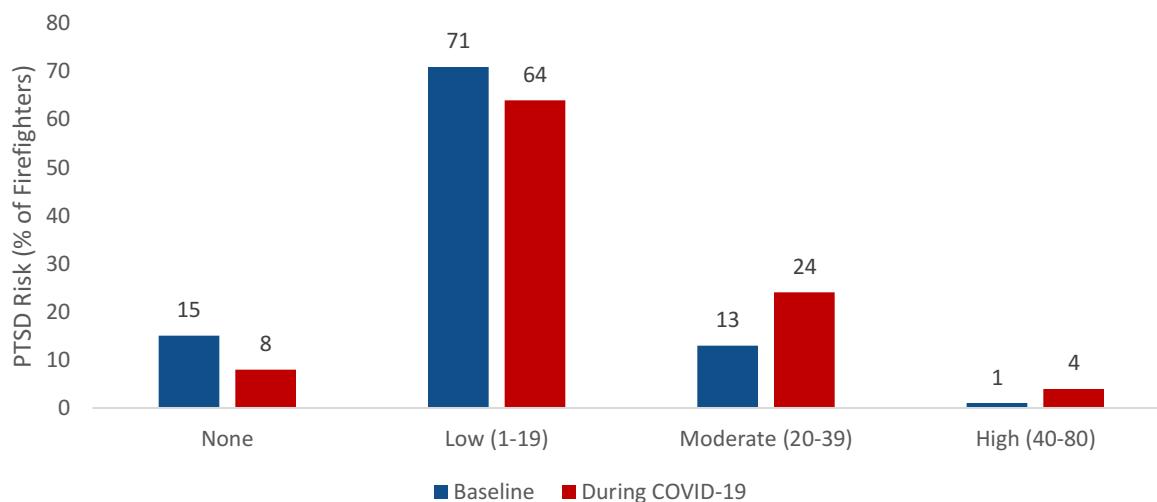
To fully assess the firefighter's PTSD symptom experiences, their PCL-5 scores were segregated into the following classifications: no risk (0), low risk (1-19), moderate risk (20-39), and high risk (40-80). See Table 7 for a summary of the TBFR firefighters' overall risk of PTSD, including how the range of symptom experiences changed over time. While the majority experienced a low risk of PTSD, it is important to highlight that the number of firefighters experiencing moderate-to-high PTSD risk has increased over time (Figure 3).

Table 3.7

Firefighter Risk of PTSD

	None (0)	Low (1-19)	Moderate (20-39)	High (40-80)
Baseline				
<i>n</i>	12	55	10	1
Median	0	6	27	54
Minimum	0	1	21	54
Maximum	0	19	35	54
Range	0	18	14	0
During COVID-19				
<i>n</i>	6	50	19	3
Median	0	6	26	45
Minimum	0	1	21	42
Maximum	0	19	32	53
Range	0	18	11	11

Note. This table provides the frequency of each respective classification of PTSD risk (none, low, moderate, and high risk).

Figure 3.3*Firefighter's Risk of PTSD by Percentage*

Note. This table depicts the number of participants experiencing no, low, moderate, or high risk of PTSD as a percentage of firefighters in the baseline and during COVID-19 samples.

To determine whether there was a change in PTSD risk, a Wilcoxon Signed Rank Test was performed, which indicated a statistically significant difference in PTSD risk over time, $z = 2.94$, $n = 78$, $p = .003$, with a medium effect size ($r = .33$; Pallant, 2020). Specifically, TBFR firefighters experienced an increase in PTSD risk during COVID-19 ($Md = 8$) compared to the start of the COVID-19 pandemic ($Md = 6$; see Table 8).

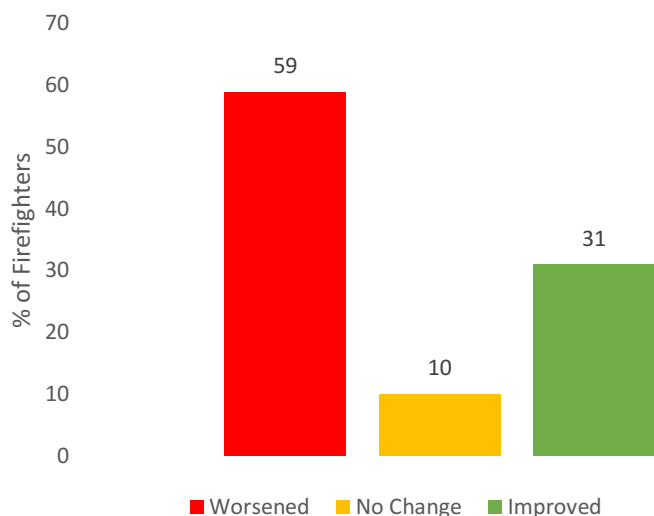
Table 3.8*Wilcoxon Signed Rank Test Analysis on Firefighter PTSD Risk*

	<i>Md</i>	Standardized Test Statistic (<i>z</i>)	<i>N</i>	<i>p</i>	<i>r</i>
Baseline	6	2.94	78	.003*	.33
During COVID-19	8				

**p* < .05

Note. This table identifies the findings from a Wilcoxon Signed Rank Test assessing the firefighter's PTSD risk over time.

Since there was a statistically significant change in PTSD risk over time, the baseline and during-COVID-19 data were compared to determine the percentage of firefighters that experienced worsened, no change, and improved PTSD symptoms. Specifically, as depicted in Figure 4, 59% experienced worsened PTSD symptoms, meaning they experienced an increase in PTSD symptoms compared to their pre-COVID-19 scores. Over time, 10% experienced no change in their PTSD symptom experiences, meaning they scored the same at baseline and during COVID-19. While 31% experienced improved PTSD symptoms, indicating a decrease in PTSD symptoms from baseline to during COVID-19.

Figure 3.4*Firefighter's Change in PTSD Risk Over Time*

Note. This figure further compares the firefighter's PCL-5 scores between the pre-COVID-19 and during-COVID-19 samples, identifying whether the firefighters experienced worsened, no change, or improved PTSD symptoms.

Lastly, PTSD risk was assessed among those previously (baseline) and currently (during COVID-19) identified as having moderate-to-high PTSD risk. Since their previous participation ($n = 11$), 9% of the firefighters experienced no change in PTSD risk. Furthermore, 55% experienced a reduced risk, while 36% experienced increased risk. In the firefighters currently identified to have moderate-to-high PTSD risk ($n = 22$), it was identified that 90% experienced increased risk, 5% had no change in risk, and 5% experienced a reduction in their PTSD risk since their previous participation.

3.3.1 Mental Health in the Context of COVID-19

During COVID-19 (phase two), the CII-25 was administered, which included a 25-item to determine the firefighters' exposure frequency to COVID-19 within two months. When

examining only the 25th item, it was identified that 26% of the firefighters were not exposed to COVID-19, whereas 24% were exposed once, 10% were exposed twice, and 40% were exposed three or more times within the last two months. Initial assessment of the descriptive statistics identified that increased COVID-19 exposure increased PTSD risk. Specifically, the comparison identified that the firefighters that were exposed to COVID-19 three or more times experienced the most PTSD symptoms ($Md = 12, n = 31$), followed by one exposure ($Md = 9, n = 19$), no exposure ($Md = 6, n = 20$), and lastly, with two exposures ($Md = 4, n = 8$) experiencing the least number of PTSD symptoms within the last two months. COVID-19 exposure was compared to those experiencing no, low, moderate, and high PTSD risk to further assess this relationship. Please see Table 9 for a summary of the descriptive statistics comparing COVID-19 exposure and PTSD risk. Firefighters exposed to COVID-19 at least three or more times reported experiencing PTSD symptoms. Additionally, only those exposed to COVID-19 three or more times had a high PTSD risk ($n = 3$). Lastly, most firefighters who experienced PTSD symptoms also experienced increased COVID-19 exposure (primarily three or more exposures).

Table 3.9*PTSD Risk Based on COVID-19 Exposure*

	No exposure	One exposure	Two exposures	Three or more exposures	Total COVID-19 exposure
None (0)					
<i>n</i>	3	1	2	0	6
Median	0	0	0	0	0
Minimum	0	0	0	0	0
Maximum	0	0	0	0	0
Range	0	0	0	0	0
Low (1-19)					
<i>n</i>	13	15	4	18	50
Median	6	8	4	6	6
Minimum	1	1	3	3	1
Maximum	15	19	8	19	19
Range	14	18	5	16	18
Moderate (20-39)					
<i>n</i>	4	3	2	10	19
Median	23	4	32	26	26
Minimum	21	21	31	21	21
Maximum	28	30	33	32	32
Range	7	9	1	11	11
High (40-80)					
<i>n</i>	0	0	0	3	3
Median	0	0	0	45	45
Minimum	0	0	0	42	42
Maximum	0	0	0	53	53
Range	0	0	0	11	11
Total PTSD risk					
<i>n</i>	20	19	8	31	78
Median	6	6	9	24	8
Minimum	0	0	0	3	0
Maximum	28	30	32	53	53
Range	28	30	32	50	53

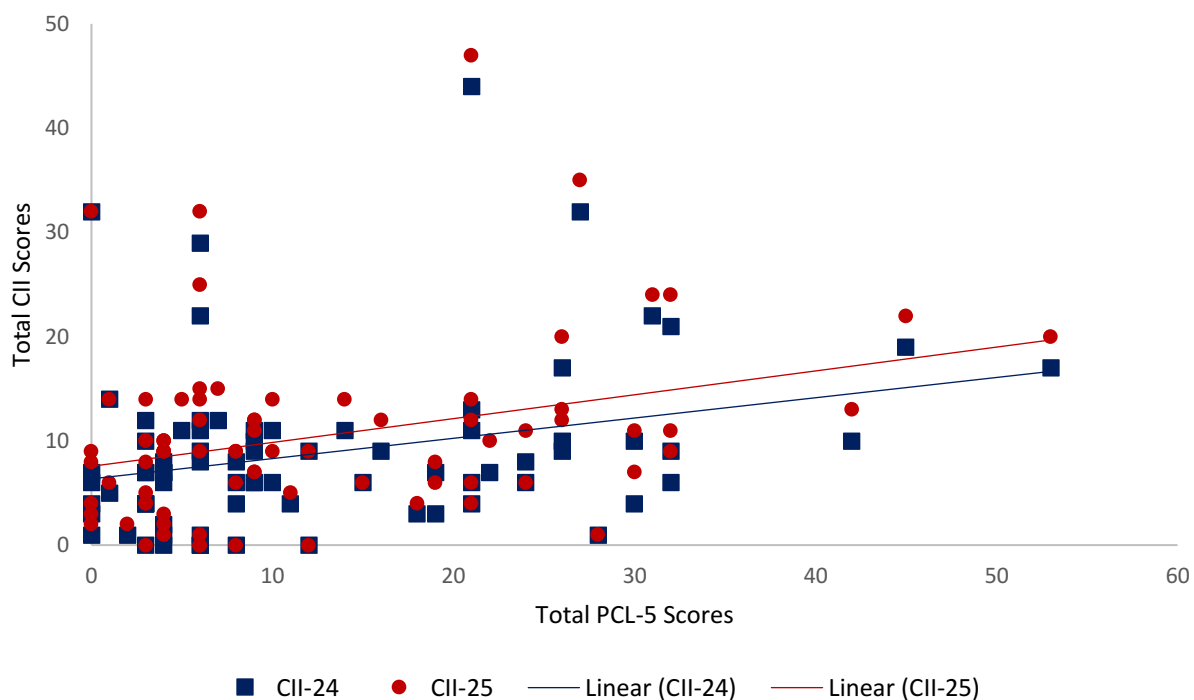
Note. This table provides the frequencies concerning COVID-19 exposure (none, one, two, three or more, and total) within the last two months.

To identify the overall impact that COVID-19 had on PTSD risk, the CII-24 and the CII-25 scores were compared to the firefighter's PCL-5 scores through a series of Spearman correlations. These comparisons helped to determine the relationship that COVID-19 exposure had as a traumatic experience on PTSD risk, in addition to other CI exposures. The Spearman

correlations identified a moderate positive relationship, where the scores of the CII-25, $\rho = .32$, $n = 78$, $p = .004$, had a stronger relationship with PTSD risk than the scores from the CII-24, $\rho = .30$, $n = 78$, $p = .007$, respectively (Pallant, 2020). These relationships are depicted in Figure 5, which includes a scatterplot comparing the firefighter's CII-24 (red) and CII-25 (blue) scores to their PCL-5 scores. Furthermore, the linear trend line for each respective relationship was also depicted. Lastly, please see Table 10 for a summary of the relationships.

Figure 3.5

Scatterplot Examining the Relationships Between the CII-24 and CII-25 on PCL-5 Scores



Note. Relationship between CI exposures and PTSD risk. Specifically, it compares the firefighter's CII-24 scores and the CII-25 scores to their PCL-5 scores. Linear trendlines for each relationship have been included for easy reference.

Table 3.10*Spearman Correlations Between the CII-24 and CII-25 CII Scores on PCL-5 Scores*

	<i>rho</i>	<i>p</i>	<i>n</i>
CII-24 scores	.30	.007*	78
PCL-5 scores			
CII-25 scores	.32	.004*	78
PCL-5 scores			

* $p < .05$

Note. Relationship between the firefighter's CII-24 scores and their PCL-5 scores, and the relationship between the CII-25 scores and PCL-5 scores.

These relationships demonstrated a slightly stronger relationship between CI exposures and PTSD risk with the inclusion of COVID-19 exposure. Subsequently, a Mann-Whitney *U* Test was performed to determine the impact that exposure level has on PTSD risk. Specifically, the different exposure levels of COVID-19 (no exposure, one time, two times, and three or more times) were further segregated into the following two levels: low exposure (no exposure and exposure one time) and high exposure (two times and three or more times). Initial analysis and mean rank order identified that those with high COVID-19 exposure experienced an increased PTSD risk ($Md = 10, n = 39$) than those with low exposure ($Md = 6, n = 39$). This was supported by the Mann-Whitney *U* Test, which identified a statistically significant difference between low and high COVID-19 exposure on PTSD risk, $U = 997, z = 2.37, p = .018, r = .27$. Therefore, it was determined that exposure to COVID-19 increases PTSD risk with a small effect size (Pallant, 2020). Please see Table 11 for a summary of the results.

Table 3.11*Mann-Whitney U Test Analysis Comparing COVID-19 Exposure*

	<i>n</i>	<i>Md</i>	<i>U</i>	<i>z</i>	<i>p</i>	<i>r</i>
Low exposure -	39	6	997	2.37	.02*	.27
High exposure	39	10				

* $p < .05$

Note. This table includes the findings from a Mann-Whitney *U* Test assessing the firefighter's COVID-19 exposure (low versus high) on their PCL-5 scores (risk of PTSD).

3.4 Objective 3: Identifying Influencing Factors on PTSD Risk Over Time

With respect to the third objective, the literature review highlighted that CI exposure, age, and years of service also impact and influence the risk of PTSD. As such, a series of linear stepwise regression models were developed to determine which variable(s) were the best predictors of PTSD risk among the TBFR firefighters at baseline and during COVID-19 to determine how these relationships changed over time.

3.4.1 Baseline Predictors

Within this model, since the probability of the F_{change} would not be statistically significant ($p > .100$) with the inclusion of all the predictors, the stepwise linear regression model removed years of service and identified CI exposure and age as statistically significant predictors of PTSD risk. The Pearson correlations identified statistically significant relationships between age and CI exposure on PTSD risk. In both relationships, a weak correlation was identified between age and PTSD risk, $r = .20$, $p = .038$, $n = 78$, and a moderate correlation between CI exposures and PTSD risk, $r = .31$, $p = .003$, $n = 78$. Additionally, a one-way analysis of variance (ANOVA) was conducted (see Table 12) to assess whether the regression model was statistically significant. The

analysis identified that the model does account for the predicted variance, $F(2, 75) = 6.80$, $p = .003$, $n = 78$.

Table 3.12

Results of the One-way ANOVA to Assess for Predicted Variance

	Sum of squares	<i>df</i>	Mean square	<i>F</i>	<i>p</i>
Regression	1124.49	2	562.25	6.38	.003*
Residual	6609.73	75	88.13		
Total	7734.22	77			

* $p < .05$

To further assess the model, the coefficient of determination identified a moderate correlation between the predictors and PTSD risk (Table 13). Additionally, the coefficient of determination identified that 15% of the variance was accounted for by the predictors, while the r^2_{change} identified that years of service accounted for 5% of the variance. Therefore, 80% of the variance was left unaccounted for by this model. Additionally, while the model did not account for most of the variance, the F_{change} ($p = .046$) identified significance. The Durbin-Watson, tolerance, and variance inflation factor (VIF) were assessed, which did not reveal significance (see Tables 13 and 14). This identified that the assumption of multicollinearity was not violated. In doing so, it was confirmed that CI exposure and age were not related within this model.

Table 3.13*Model Summary*

	<i>r</i>	<i>r</i> ²	<i>S_e</i>	Change statistics					Durbin-Watson
				<i>r</i> ² _{change}	<i>F</i> _{change}	<i>df</i> ₁	<i>df</i> ₂	<i>p</i>	
CII-24 scores and age	.38	.15	9.39	.05	4.12	1	75	.046*	1.92

**p* < .05

Note. This table was generated to provide an overall summary of the strength of the selected model, which includes CI exposure and age as predictors of PTSD risk.

Table 3.14*Statistical Coefficients for Explaining the Model*

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	<i>B</i>	Std. Error	<i>Beta</i>	<i>t</i>	<i>p</i>	Tolerance	VIF
Constant	-5.37	5.66		-.95	.345		
CII-24 scores	.54	.18	.32	3.03	.003*	1.00	1.00
Age	.28	.14	.22	2.03	.046*	1.00	1.00

**p* < .05

Note. This table identifies the coefficients utilized to determine the equations to explain the model generated to predict PTSD at baseline.

Lastly, as identified in Table 14, since the constant was identified not to be statistically significant and the predictors' slopes were identified as statistically significant, the standardized coefficients were utilized to construct the following model that would explain the impact that the predictors had on PTSD risk: $y = .32*CI\ exposure + .22*age$. Therefore, PTSD risk increases by a unit of .32 CI exposures and/or .22 years of age.

3.4.2 During COVID-19 Predictors

Similar to the baseline model, since the probability of the F_{change} would not be statistically significant ($p > .100$) with the inclusion of all the predictors, the stepwise linear regression model removed years of service, identifying CI exposure and age as significant predictors of PTSD risk during COVID-19. Initial analysis indicated a weak, but statistically significant Pearson correlation between CI exposure and age on the risk of PTSD, $r = .29, p = .005, n = 78$ and $r = .24, p = .018, n = 78$, respectively. Furthermore, as depicted in Table 15, a one-way ANOVA was performed to assess whether the regression model was statistically significant, which identified that the model accounts for the predicted variance, $F(2, 75) = 6.30, p = .003, n = 78$.

Table 3.15

Results of the One-way ANOVA to Assess for Predicted Variance

	Sum of squares	<i>df</i>	Mean square	<i>F</i>	<i>p</i>
Regression	1545.52	2	772.76	6.30	.003*
Residual	9197.36	75	122.63		
Total	10742.87	77			

* $p < .05$

Since CI exposure and age were identified as significant predictors of PTSD risk, the model was further assessed to determine statistically significant coefficients that help identify how much variance was accounted for. Overall, the coefficient of determination determined a moderate correlation between the predictors in the model and PTSD risk. Furthermore, the coefficient of determination identified that only 14% of the variance was accounted for by the predictors (CI exposure and age). As such, the r^2_{change} identified that years of service accounted for 6% of the variance, meaning that overall, 80% of the variance is unaccounted for. See Table 16 for a summary of these reported findings.

Table 3.16*Model Summary*

	<i>r</i>	<i>r</i> ²	<i>S_e</i>	Change statistics					Durbin-Watson
				<i>r</i> ² _{change}	<i>F</i> _{change}	<i>df</i> ₁	<i>df</i> ₂	<i>p</i>	
CII-24 scores and age	.38	.14	11.07	.06	5.17	1	75	.026*	2.18

**p* < .05

Note. This table was generated to provide an overall summary of the strength of the selected model, which includes CI exposure and age as predictors of PTSD risk.

While it is also important to highlight that this model did not account for most of the variance, the *F*_{change} (*p* = .026) and Durbin-Watson (2.18) identified significance, indicating potential concerns surrounding multicollinearity. Therefore, an assessment on multicollinearity was performed to ensure the assumption was not violated. Specifically, each predictor's evaluation of the tolerance and VIF was identified to be less than five (see Table 17). Therefore, it was concluded that CI exposure and age were not related to one another, and that this model's assumption of multicollinearity was not violated.

Table 3.17*Statistical Coefficients for Explaining the Model*

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	<i>B</i>	Std. Error	<i>Beta</i>	<i>t</i>	<i>p</i>	Tolerance	VIF
Constant	-6.56	7.06		-.93	.355		
CII-24 scores	.44	.16	.30	2.77	.007*	1.00	1.00
Age	.38	.17	.24	2.28	.026*	1.00	1.00

**p* < .05

Note. This table identifies the coefficients utilized to determine the equations to explain the model identifying predictors of PTSD risk during COVID-19.

When further examining Table 17, the constant was not statistically significant, while the slopes were statistically significant. The standardized coefficients were utilized to construct the following model explaining the predictors' effects on PTSD risk: $y = .30*CI\ exposure + .24*age$. This indicated that exposure to a CI and/or aging causes PTSD risk to increase by a unit of .30 exposures and .24 years, respectively.

Chapter 4: DISCUSSION

4.1 Summary of the Findings

This study aimed to identify the TBFR firefighter's mental health burden by assessing their CI exposures and PTSD risk in the context of COVID-19. By capturing the firefighter's CI exposure and PTSD risk over two years, the data can be utilized to determine the impact of longitudinal and repeated exposures, as well as the potential impacts resulting from a global pandemic on the firefighters' mental health. To do so, a demographic questionnaire and the PCL-5 were administered at two points in time: baseline (December 2019/January 2020) and during COVID-19 (April 2022). For the purpose of this study, the CII-24 was administered at baseline to assess the firefighter's CI exposure, while the CII-25 was administered during COVID-19 to assess their CI and COVID-19 exposure. While exposure to CIs in both phases remained high, the number of exposures the firefighters experienced increased with time. Additionally, exposure to PTSD symptoms and PTSD risk also increased over time. Within this study, 92% ($n = 72$) of the TBFR firefighters were exposed to a CI, and 92% ($n = 72$) of the firefighters experienced at least one symptom of PTSD within the last month. Over time, these exposures increased by 1% and 7%, respectively. This assessment identified that the TBFR firefighters experienced worsened mental health outcomes, suggesting that COVID-19 has impacted their CI exposures and PTSD risk.

4.2 Discussion

4.2.1 Objective 1: Change in Critical Incident Exposures

With respect to other Canadian firefighter samples, the TBFR firefighters comparatively experience a high risk of exposure, with an overall increased frequency of exposures within the previous two months (MacDermid et al., 2019; Sinden et al., 2020). While previous findings

identified that 92% of firefighters will experience a CI exposure within their career, 92% of the TBFR firefighters experienced a CI within the previous two months (Nazari et al., 2020). Overall, there was no significant change in CI exposures in the context of COVID-19, with common exposure to seven CIs within two months of active service. While there was no significant change in exposures over time, probable changes resulting from the COVID-19 pandemic impacted the types of CIs the firefighters were exposed to. While it cannot be determined why this change occurred within this study, TBFR firefighters experienced increased exposure to the CII-24 subscales trauma to self (10%) and multiple casualties (2%). Additionally, the firefighters experienced a reduction in exposure to victims known to the firefighter (9%), incidents involving children (2%), unusual and problematic tactical operations (3%), and severe medical trauma (1%). As such, a series of analyses were conducted to determine the strength of change in the types of CI exposures, which identified a significant change in exposures to trauma to self over time. This suggested that firefighters experienced a significant increase in exposures to a serious line of duty injury to self, a threat to serious line of duty injury or threat of death to self (that did not result in actual serious injury), an incident necessitating search or rescue involving serious risk to yourself, direct exposure to extremely hazardous material, and lastly, direct exposure to blood and bodily fluids, over time.

With repeated and continued exposure to CIs, identification of these changes over time increases the TBFRs awareness of their current exposures (including specific types identified by the subscales), how these exposures have changed over time, the potential sources that may have inflicted this change (i.e., the COVID-19 pandemic), and the potential impacts that the exposures have on the firefighters' mental health. Therefore, these changes should also be utilized to develop targeted strategies to mitigate the impacts when these exposures occur, as well as

specific preventative strategies/training that could potentially reduce the risk of specific exposures. Overall, understanding what exposures the TBFR firefighters are at an increased or decreased risk of experiencing should be incorporated into resiliency training. Overall, consideration for the sources of change, as well as the identification of frequently experienced CIs, should each be considered in order to reduce the TBFR firefighters' exposures and subsequently, their risk of PTSD.

4.2.2 Objective 2: Change in Posttraumatic Stress Disorder Risk

With the high prevalence and repeated exposure to CIs among TBFR firefighters, the risk of PTSD has also increased (Kehl et al., 2014). The number of firefighters experiencing at least one symptom of PTSD and the overall risk of PTSD increased. Comparison identified that TBFR firefighters have continuously been experiencing a high risk of PTSD, where it is common for them to experience upwards of eight symptoms within a month. When examining the samples, the frequency of symptom experiences increased from six to eight within a month. Overall, there was a significant difference in the TBFR firefighter's PTSD risk over time. Study findings identified that 4% of the firefighters were at a high risk of PTSD, 24% were experiencing moderate risk of PTSD, 64% were at low risk of PTSD, and 8% of the firefighters were experiencing no risk of PTSD. Since baseline, the number of individuals experiencing no/little PTSD risk decreased, while there was an increase in those experiencing moderate/high risk. Overall, the findings suggest occurrences of increased and higher PTSD risk over time. Further comparison across time identified that 59% of the firefighters experienced worsened/increased PTSD risk, 10% experienced no change in their risk, and 31% experienced improvement/decreased PTSD risk. Since the previous evaluation (at baseline), of those who were identified to be experiencing moderate-to-high risk of PTSD, 55% improved, 9% had no

change, and 36% worsened. Of those identified as experiencing moderate-to-high PTSD risk during COVID-19, 5% improved, 5% had no change, and 90% worsened since baseline. Due to the prevalence of PTSD symptom experiences and the TBFR firefighter's overall increased risk, a significant number of the firefighters are at an increased risk of developing PTSD (Carleton et al., 2019; Wagner et al., 1998).

To identify the impact of COVID-19 exposure on PTSD risk, the 25th item included in the CII-25 was developed to assess exposure to COVID-19 as a CI. When this item was assessed, it was identified that within two months of service, 74% of the TBFR firefighters were exposed to COVID-19. More specifically, 24% were exposed once, 10% were exposed twice, 40% were exposed three or more times, and 26% were not exposed to COVID-19. Therefore, the findings suggested that the TBFR firefighters experienced a high prevalence of COVID-19 exposure. When not exposed to COVID-19, 4% of firefighters had no PTSD risk, 17% experienced low risk, 5% experienced moderate risk, and 0% experienced high PTSD risk. In contrast, 4% of the firefighters experienced no PTSD risk, 47% experienced low risk, 19% experienced moderate risk, and 4% experienced high risk when exposed to COVID-19 at least once. This finding suggested that with increased COVID-19 exposure, the firefighters experienced increased PTSD risk. Similar to the impacts of CI exposures, this further suggests that repeated and prolonged COVID-19 exposure increased the TBFR firefighter's risk of PTSD. As such, further analysis comparing low and high COVID-19 exposure identified a significant relationship between exposure and PTSD risk, supporting study findings. Lastly, comparison of the CII-24 and the CII-25 to PTSD risk (respectively) determined that the inclusion of COVID-19 as a CI had a stronger relationship with PTSD risk than without, concluding that exposure is a better predictor of PTSD risk.

Study findings have shown that overall PTSD risk has changed over time, which suggests that TBFR's current intervention program may not be effectively mitigating known risk, may only be effective for some individuals, and is likely not effectively preventing PTSD risk within the overall service. Since treatment can be highly individualized, programming should be developed which encompasses several interventive/preventative therapy and treatment options (i.e., Cognitive Behavioural Therapy, Cognitive Processing Therapy, Cognitive Therapy, and Prolonged Exposure) that would collectively meet the TBFR firefighters' needs to effectively reduce their risk of PTSD ("PTSD treatment", 2020). Previous research also suggests that frequent and repeated occupational screening procedures should incorporate both physical and mental components of health to help facilitate the promotion of multidimensional health within the workplace (Wagner et al., 2016). Studies also suggest the incorporation and development of disability management programming/policies surrounding physical and mental health to encourage and support those who develop mental health disorders, as well as promote treatment accessibility (Coduti et al., 2016; Wagner et al., 2016).

4.2.2.1 Mental Health in the Context of COVID-19. While this study cannot determine whether the pandemic directly caused the change in PTSD risk, COVID-19 exposure was a significant predictor and can be considered a CI exposure, impacting firefighter mental health. Similar impacts on firefighters were previously seen in the 2003 SARS and 2012 MERS outbreaks, suggesting that the COVID-19 pandemic did impact the TBFR firefighter's PTSD risk (Carmassi et al., 2020). With respect to other firefighting samples, previous literature identified that 64% were exposed to COVID-19, while 74% of the TBFR firefighters were exposed to COVID-19 (Graham et al., 2021). Although the TBFR firefighters were exposed to COVID-19 at an increased rate, they experienced a lower risk of developing PTSD (4%) than other firefighting

cohorts (28.9%) during the COVID-19 pandemic (Johnson et al., 2020). Overall, due to the high prevalence of COVID-19 exposure, study findings and previous literature suggest that the pandemic has influenced the TBFR firefighter's mental health, specifically in terms of their PTSD risk (Johnson et al., 2020). The exacerbation of the firefighter's job demands during the COVID-19 may have also influenced and impacted the TBFR firefighter's mental health over time (Johnson et al., 2020). It is also important to highlight that the findings within this study include known COVID-19 exposure within the last two months. As such, it can be hypothesized that the TBFR firefighter's COVID-19 exposure could be greater (under-reported). As such, the increased rate of exposure impacts the firefighters' overall mental health and increases their susceptibility and risk of developing PTSD (Johnson et al., 2020).

Overall, study findings support previous findings suggesting that pandemics (i.e., COVID-19, SARS, and MERS) impact firefighters' PTSD risk (Carmassi et al., 2020). While firefighters experience several occupational challenges that increase their risk of mental health disorders, these findings highlight the importance of considering and evaluating the impact that pandemics have on emergency response personnel. These findings should also be incorporated in the development of programming and policies to identify the risk of exposure and the impacts experienced by the service (i.e., absenteeism, infection rates, and other mental health disorders) to mitigate them. To do so, mental health reevaluation, therapies/treatments, and education/training should also consider pandemic-related exposures and their impact on firefighters' mental health.

4.2.3 Objective 3: Identifying Influencing Factors on PTSD Risk Over Time

Lastly, in order to identify predictors of PTSD risk, modelling was developed to determine the cumulative relationship on the TBFR firefighter's PTSD risk. Years of service,

age, and CI exposure were each assessed to determine which factor(s) were the best predictors of PTSD risk at each point in time (baseline and during COVID-19). The models identified CI exposures and age to be the best predictors, where years of service did account for some of the variance within each. Overall, it was also identified that both models accounted for similar amounts of variance, whereas neither of them accounted for 80% of the variance. This finding suggests that there are other influencing factors on PTSD risk that were not assessed within this study, including but not limited to gender, stress, burnout, coping styles, marital status, social support, and support availability (Carmassi et al., 2020; Serrano-Ibáñez et al., 2022).

Individually, when comparing the predictors included in this study, it was further identified that over time the strength of a CI exposure as a predictor of PTSD risk decreased, where exposures may have been influenced by the COVID-19 pandemic, reducing the firefighters' risk of PTSD. Whereas the strength of age as a predictor of PTSD risk increased from baseline to during COVID-19, suggesting that the aging population increases the firefighters' risk of PTSD. Lastly, both models identified that years of service was not a significant predictor of PTSD risk. These findings suggest that in addition to the CI exposures, the aging TBFR firefighter population is also important to consider (Del Ben et al., 2007; Obuobi-Donkor et al., 2022; Sinden et al., 2020). Study findings identified that these factors had a cumulative influence on PTSD risk, further suggesting that the firefighters are not hardened over time by repeated exposure to CIs, increasing their risk of PTSD and other mental health disorders. Additionally, future research should evaluate additional factors that have been identified to influence PTSD risk to further develop the knowledge and awareness surrounding TBFRs exposures and needs in order to mitigate and prevent their risk of mental health disorders.

4.2.4 Study Implications

Study objectives were developed to address the purpose of this study, which identified how measures of mental health have changed over time among TBFR firefighters. Additionally, this research is one of the only studies with an established research partnership which has the ability to conduct longitudinal studies on measures of firefighter mental health. While this study was not comprehensive, the PCL-5 provided a complex examination of the PTSD symptoms experienced by the TBFR firefighters. Findings have also been utilized to inform and increase the TBFR's awareness of the work-related risks that their firefighters are experiencing. Therefore, the identified significant changes should be utilized in the development of interventive and preventative strategies to improve their overall mental health.

Continuous and promotional education/training related to mental health disorder reduction and prevention should address stigma reduction, CI exposure prevention/resiliency, the impacts of the COVID-19 pandemic, and the components included in the developed programming/policies (as previously discussed). Previous research identified that addressing each of these components has promoted a psychologically healthy workplace (Coduti et al., 2016; Wagner et al., 2016). Additional promotion of workplace practices such as employee involvement, work-life balance, employee growth and development, psychological health and safety, and employee recognition have also been identified to promote a psychologically healthy workplace (Coduti et al., 2016). Subsequently, addressing each of these components can improve productivity, reduce absenteeism, reduce overall injury rates, and reduce related costs (i.e., lost-time and workplace disability claims; Coduti et al., 2016; Ramsden et al., 2018; Wagner et al., 2016). As such, each of these components should be continuously reviewed and assessed to continue the development of a psychologically healthy workplace for the TBFR firefighters.

4.3 Limitations

As a result of the ongoing COVID-19 pandemic, the progression of this project has faced several challenges and limitations that may have impacted the findings of this study. Due to COVID-19, there were several challenges with recruitment that were not previously experienced during previous data collections with TBFR. While it was anticipated that in-person data collection improved participation and firefighters were eligible to participate both on- and off-duty, there were fewer participants with previous participation ($n = 78$). It was hypothesized that along with reasons for exclusion (i.e., on leave, among RTW, or were terminated), absenteeism resulted from general availability, sickness/illnesses (COVID-19 related and non-related), vacations, and retirement since previous participation. As such, only 56% of the TBFR firefighters participated during COVID-19 (phase two), while previous participation rates were at upwards of 75-80% (i.e., including baseline/phase one; Sayed et al., 2019; Sinden et al., 2020).

Previous findings among the TBFR firefighters indicated that throughout the year, they may have been exposed to different types of emergency response calls, as well as experiencing different volumes of calls on a monthly and/or seasonal basis (Sayed et al., 2019). As part of the TBFR firefighter's responsibilities, they are expected to participate in several training sessions on a monthly/seasonal basis. Additionally, due to COVID-19, the challenges surrounding the implementation of this project (i.e., continuous restrictions, lockdowns, and other COVID-19-related impacts) may have also impacted the results due to the period of time at which the data was collected (i.e., December 2019/January 2020 versus April 2022). Therefore, in addition to the potential impacts of COVID-19, this study may also incorporate potential monthly and/or seasonal influences on the firefighter's CI exposures, further impacting their mental health.

Due to the firefighter's responsibilities and duties (i.e., calls and training), each data collection period was extended in order to provide all the firefighters with an opportunity to participate. In doing so, the additional days between data collection periods allowed for the reporting and inclusion of more recent CI exposures that other firefighters with recent participation may have also experienced. The findings could reflect a series of additional CI exposures experienced by a subset of the firefighters, which may have also influenced their PTSD risk.

When examining the time frames in which the questionnaires identified exposures and experiences, it is important to highlight that there is only some overlap. Specifically, the CII-24 and CII-25 identified CI exposures and COVID-19 exposure within the previous two months, while the PCL-5 identified PTSD symptoms experienced within the previous month (as per the DSM-5; APA, 2020). Due to the repetitive nature of exposures, it is important to highlight that due to the lack of overlap, it may become difficult for participants to remember incidents and symptoms on varying timelines. As a result of the prevalence of CI exposures, COVID-19 exposures, and PTSD symptom experiences, it may be hard for them to recall upwards of two months of CI/COVID-19 exposures. Therefore, the findings may include over- and/or under-reporting due to the cumulative exposure/experiences that the TBFR firefighters experience.

Within this study, the mental health burden was specifically assessed by determining the TBFR firefighter's PTSD risk (Carleton et al., 2019; Haugen et al., 2012). Firefighters are also at risk of developing several other mental health disorders, including major depressive disorder, alcohol abuse disorder, and generalized anxiety disorder (Carleton et al., 2019; Haugen et al., 2012; Johnson et al, 2020; Vujanovic & Tran, 2021). To identify TBFR's true mental health burden, future studies should incorporate the evaluation of other mental health concerns

commonly experienced by firefighters. Additionally, this study only assessed the influence that CI exposures, age, and years of service had on PTSD risk. As study findings highlighted, these variables only accounted for 20% of the variance within the modelling, meaning several additional variables influence the TBFR firefighter's PTSD risk that were not assessed within this study. These variables should also be evaluated and considered to identify the firefighter's mental health burden.

While the TBFR firefighters are also at an increased risk of developing other mental health disorders, it is also important to identify that some PTSD symptoms (i.e., anxiety, depression, mood changes, and sleep disturbances) co-occur with other mental health disorders (Brady et al., 2000). Additionally, these symptoms are immediate reactions to traumatic events, such as a CIs. While these reactions are common, when these symptoms persist, the risk of developing PTSD also increases. Therefore, to be diagnosed with PTSD, the individual must experience a series of diagnostic symptoms (previously discussed) for at least a month (APA, 2020). Rather than assessing the frequency of symptoms, the PCL-5 only addresses the severity of PTSD symptoms experienced within the previous month (Weathers et al., 2013). As such, this study assessed the TBFR firefighter's PTSD risk based on symptom severity, which could have been inflicted by their continued and repeated exposure to CIs.

Lastly, in Thunder Bay, firefighting remains a severely gendered occupation, where recent data collection identified that 0% of the TBFR firefighters were female ($n = 78$ males). Stigma still lies as a significant barrier to receiving and accessing treatment/reporting, further lying as a barrier to improving the firefighter's mental health (Isaac & Buchanan, 2021; Thurnell-Read & Parker, 2008). Increased discussion surrounding mental health among the TBFR firefighters as part of the research partnership, as well as the change in the Workplace

Safety and Insurance Board legislation which presumes PTSD development and diagnosis to be work-related among first responders, may have both increased reporting within the current phase of data collection (“Posttraumatic stress disorder in first responders and other designated workers”, 2018). Stigma likely remains a significant barrier in a masculine praised workplace. It is also important to highlight that as a result of the repeated and prolonged exposure to CIs and the prolonged period of time prior to accessing and receiving treatment, the firefighter’s PTSD risk has worsened, which may also impact the findings within this study.

Chapter 5: KNOWLEDGE TRANSLATION STRATEGY

The overall knowledge translation (KT) strategy aimed to identify the most effective way to transfer findings into practice and to ensure that the partner is able to obtain quick uptake and implementation of findings. Consequently, this will also facilitate the development of evidence-informed programming surrounding the reduction and prevention of mental health disorders. As previously mentioned, the research team has developed a partnership with the TBFR service, which aims to improve the firefighter's overall health and well-being. Within this partnership, integrative knowledge translation (iKT) facilitated active dissemination of the research conducted and findings with key stakeholders from the TBFR service, including the firefighters, primary knowledge user, management, and union. To help facilitate active dissemination and guide the implementation of this process, the knowledge-to-action (KTA) framework developed by Graham et al. (2006) was utilized. The KTA framework is a fundamental framework utilized in health research to help facilitate knowledge development and application (see Appendix D). With respect to this study and as part of the framework, the tailoring/creating knowledge phase includes a series of steps concerning the synthesis of knowledge and the development of tools/products that make the knowledge readily available for uptake (Graham et al., 2006). Within this study, an infographic reporting the preliminary findings of this study was developed alongside the primary knowledge user and was further provided to the stakeholders within the TBFR service (Appendix E). Overall, the infographic was developed to address the TBFR firefighter's current mental health burden (including type and frequency of CI exposures and PTSD risk). Study findings will be utilized to address and support the need for continued development of evidence-informed programming surrounding mental health disorder reduction and prevention that is effective for the TBFR firefighters.

Chapter 6: CONCLUSION

Over time, the TBFR firefighters have continued to experience a mental health burden, specifically influenced by CI exposures and risk of PTSD. Considering the impacts of CI exposures on mental health, the continued high frequency and rate of CI exposures within two months have played a significant role in the firefighter's mental health. Findings identified that the firefighters experienced a significant increase in PTSD risk. Within the context of COVID-19, while exposure to COVID-19 was identified as a significant predictor, a relationship was also identified between the rate of exposure (i.e., low versus high) and PTSD risk. Due to these relationships, it is evident that there is a need for mental health education/training, accessible resources, and interventive programming with effective treatments suited to the firefighters. When developing these, the impacts of pandemics on mental health should also be considered. Overall, it is evident that the firefighter's overall health and well-being have been implicated and must be addressed to develop and improve their health and well-being. To do so, the KT tool was developed to inform the key stakeholders within the TBFR service about the firefighter's current mental health burden with respect to their CI exposures and PTSD risk. As part of the research program, as well as the programming surrounding applied ergonomics and occupational health and safety, study findings will be utilized to inform and support the development of a psychologically healthy workplace for the TBFR firefighters.

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Appendix B

Conceptualized Critical Incident Inventory (CII)

Date: ___/___/___ dd/mm/yyyy

ID Code: _____

Critical Incident Inventory (CII)

Instructions: Indicate the number of times each event has occurred in the **past 2 months**.

Questions	One time	Two Times	Three or more times	None
1. Serious line of duty injury to self.				
2. Threat of serious line of duty injury or threat of death to self (that did not result in actual serious injury).				
3. Line of duty death of a fellow emergency worker.				
4. Serious line of duty injury to fellow emergency worker (that did not result in death).				
5. Threat of serious line of duty injury or threat of death to fellow emergency worker (that did not result in actual serious injury or death).				
6. Suicide or attempted suicide by fellow emergency worker.				
7. Responded to incident involving three or more deaths.				
8. Responded to incident involving one or two deaths.				
9. Responded to incident involving multiple serious injuries (three or more victims sustained serious injuries).				
10. Incident requiring police protection while on duty.				
11. Verbal or physical threat by public while on duty (that did not result in police protection).				
12. Incident involving serious injury or death to children.				
13. Incident involving severe threat to children (that did not result in actual serious injury or death to children)				
14. Victim(s) known to you.				
15. Failed mission after extensive effort.				
16. Critical (negative) media interest.				
17. Close contact with burned or mutilated victim.				
18. Removing dead body or bodies.				
19. Incident necessitating search or rescue involving serious risk to yourself.				
20. Prolonged extrication of trapped victim with life- threatening injuries.				
21. Use of deadly force by police at an incident.				
22. Direct exposure to extremely hazardous materials.				
23. Direct exposure to blood and body fluids.				
24. Critical equipment failure or lack of equipment in any of the above situations.				
25. Direct exposure to a life-threatening virus (i.e., COVID-19)				

Appendix C

Posttraumatic Stress Disorder Checklist for the DSM-5 (PCL-5)

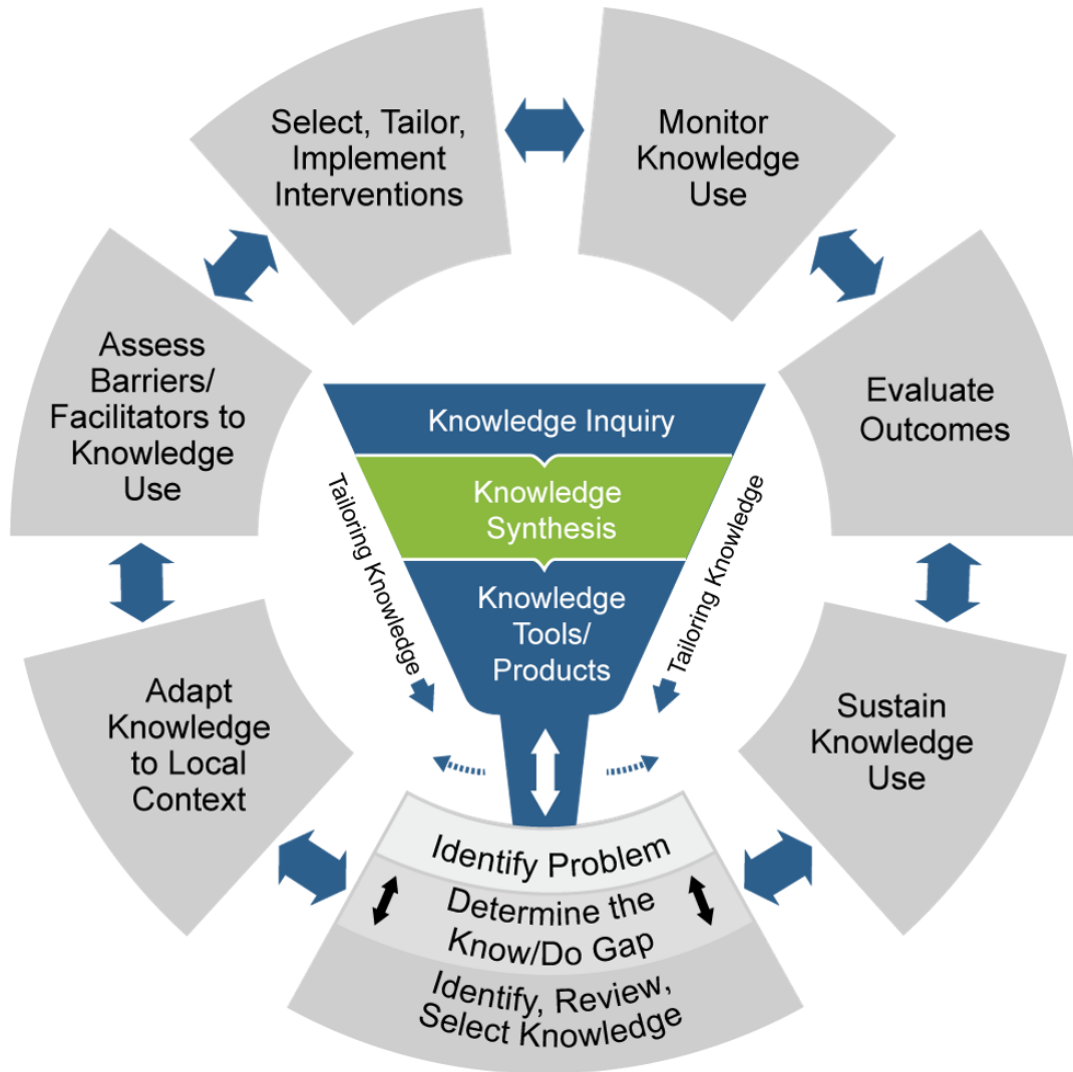
PCL-5

Instructions: Below is a list of problems that people sometimes have in response to a very stressful experience. Please read each problem carefully and then circle one of the numbers to the right to indicate how much you have been bothered by that problem in the past month.

In the past month, how much were you bothered by:	Not at all	A little bit	Moderately	Quite a bit	Extremely
1. Repeated, disturbing, and unwanted memories of the stressful experience?	0	1	2	3	4
2. Repeated, disturbing dreams of the stressful experience?	0	1	2	3	4
3. Suddenly feeling or acting as if the stressful experience were actually happening again (as if you were actually back there reliving it)?	0	1	2	3	4
4. Feeling very upset when something reminded you of the stressful experience?	0	1	2	3	4
5. Having strong physical reactions when something reminded you of the stressful experience (for example, heart pounding, trouble breathing, sweating)?	0	1	2	3	4
6. Avoiding memories, thoughts, or feelings related to the stressful experience?	0	1	2	3	4
7. Avoiding external reminders of the stressful experience (for example, people, places, conversations, activities, objects, or situations)?	0	1	2	3	4
8. Trouble remembering important parts of the stressful experience?	0	1	2	3	4
9. Having strong negative beliefs about yourself, other people, or the world (for example, having thoughts such as: I am bad, there is something seriously wrong with me, no one can be trusted, the world is completely dangerous)?	0	1	2	3	4
10. Blaming yourself or someone else for the stressful experience or what happened after it?	0	1	2	3	4
11. Having strong negative feelings such as fear, horror, anger, guilt, or shame?	0	1	2	3	4
12. Loss of interest in activities that you used to enjoy?	0	1	2	3	4
13. Feeling distant or cut off from other people?	0	1	2	3	4
14. Trouble experiencing positive feelings (for example, being unable to feel happiness or have loving feelings for people close to you)?	0	1	2	3	4
15. Irritable behavior, angry outbursts, or acting aggressively?	0	1	2	3	4
16. Taking too many risks or doing things that could cause you harm?	0	1	2	3	4
17. Being "superalert" or watchful or on guard?	0	1	2	3	4
18. Feeling jumpy or easily startled?	0	1	2	3	4
19. Having difficulty concentrating?	0	1	2	3	4
20. Trouble falling or staying asleep?	0	1	2	3	4

Appendix D

Knowledge-to-Action (KTA) Framework



Appendix E

Infographic on Preliminary Findings

