

**EFFECTS OF THE INFECTION PREVENTION AND CONTROL MEASURES ON THE  
MENTAL HEALTH OF HEALTHCARE WORKERS IN CANADA**

by

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## **Abstract**

**BACKGROUND:** Healthcare workers (HCWs) are vulnerable to infection and emotional distress when providing treatment during a pandemic. The safety of healthcare workers (HCWs) is of the utmost significance. The pandemic of COVID-19 has significantly altered the global workplace environment and healthcare work routines. Appropriate infection prevention and control (IPC) methods and sufficient personal protective equipment (PPE) may increase HCWs' mental well-being. In contrast, insufficient IPC practices and PPE supply at the workplace may result in negative psychological consequences.

**OBJECTIVE:** The purpose of the proposed study was to clarify the psychological impacts of IPC methods during the pervasiveness of COVID-19 on healthcare workers across Canada and examine the relationship between PPE and the impact on the mental health of HCWs.

**METHODS:** From November 2020 to December 2020, a web-based survey published by Statistics Canada was conducted to collect data from approximately 18,000 healthcare workers in 34 sites across Canada. A cross-sectional study targeting nationwide healthcare workers in Canada was conducted based on the national survey above. Bivariable analyses examined the association between mental health outcomes and exposure variables among healthcare workers, while regression analyses measured the strength of associations.

**RESULTS:** HCWs that reported having more than three inadequate PPE items from their workplace were more likely to report fair or poor perceived mental health (OR 2.39, 95% CI 1.79, 3.19;  $P < 0.001$ ), somewhat or much worse now compared to before the pandemic (OR 2.16, 95% CI 1.48, 3.19;  $P < 0.001$ ) and quite a bit or extremely stress (OR 2.47, 95% CI 1.18, 6.42;  $P = 0.05$ ). HCWs having "masks for patients" introduced were less likely to report worse mental health compared to before the pandemic (OR 0.81, 95% CI 0.74, 0.90;  $P < 0.001$ ) and HCWs having "masks for patients" introduced were less likely to report stress (OR 0.69, 95% CI 0.50, 0.93;  $P = 0.02$ ).

**CONCLUSION:** COVID-19 infection prevention and control measures and personal protective equipment supply can significantly impact healthcare workers' mental health. As the pandemic

continues, healthcare institutions and organizations should recognize the significance of providing HCWs with appropriate IPC measures and adequate PPE.

## **Lay Summary**

The current outbreak of the novel Coronavirus Disease (COVID-19) has posed a significant risk to healthcare personnel's physical and emotional health. This cross-sectional study aimed to determine the immediate relationship between infection control practices and mental health symptoms among Canadian healthcare professionals.

To secure the health and safety of the healthcare workforce, better policies and practices addressing workplace conditions are critically needed, specifically during the COVID-19 crisis. Evidence-based strategies and policy changes are critically important to protect the mental health and well-being of health workers in Canada, especially considering their prolonged exposure to chronic stress resulting from the COVID-19 pandemic. These strategies have also informed ongoing pandemic preparedness measures. The project may contribute to the evidence informing such strategies and interventions.

## **Preface**

This dissertation is an original, unpublished, independent work by the author, Yike Huang.

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## **List of Abbreviations**

CI

Confidence Interval

CIHI

Canadian Institute for Health Information

COVID-19

Coronavirus disease of 2019

GOF

Goodness of Fit

HCWs

Healthcare Workers

IPC

Infection Control Procedures

ICU

Intensive Care Unit

LTC

Long-Term Care

MHA

Mental Health America

OLR

Ordinal Logistic Regression

ONS

Office for National Statistics

OR

Odds Ratio

PHAC

Public Health Agency of Canada

PPE

Personal Protective Equipment

PTSD

Post-Traumatic Stress Disorder

SMD

Standardized Mean Difference

SRs

Systematic Reviews

VIF

Variance Inflation Factor

WHO

World Health Organization

## **Glossary**

### Systematic review

Research that summarizes the evidence on a clearly formulated question according to a pre-defined protocol using systematic and explicit methods to identify, select and appraise relevant studies, and to extract, collate and report their findings. It may or may not use statistical meta-analysis.

## **Acknowledgements**

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Lastly, I would like to mention my parents, who have been there for me during my academic career, lending me their moral and financial support.



## **Dedication**

My dissertation is dedicated to the members of my family and many close friends. I want to express my sincere gratitude to my devoted parents, whose words of wisdom and insistence on perseverance still ring in my ears. My little brother has always been there for me and is extremely important to me.

## **Chapter One: Introduction**

Wuhan, China, reported the discovery of a new Coronavirus pulmonary disease at the end of 2019. The virus' strong contagiousness resulted in global dissemination. The novel Coronavirus disease "COVID-19" was issued by the World Health Organization (WHO) on February 11, 2020, and declared a pandemic by the WHO on March 11, 2020. The pandemic was responsible for 680,728,329 confirmed cases and 6,805,545 deaths in 228 countries and territories by March, 2023 [1]. In Canada, an individual who had recently traveled to Wuhan, China, tested positive for the first time on January 27, 2020, and the first confirmed case of community transmission was reported in British Columbia on March 5 [2]. The COVID-19 pandemic in Canada is part of a more significant global pandemic. As of March 2023, 4,600,615 COVID-19 cases have been confirmed in Canada. More than half of the reported cases (54.8%) were female and around a third (34.8%) involved those aged 20 to 39. The COVID-19 vaccination campaign was promoted on December 14, 2020 according to Statistic Canada. It is suggested that the vaccines used in Canada are highly effective at preventing COVID-19-related severe illness, hospitalization, and death. So far, 80.7% of the population has received at least one dose of vaccination [3].

Since healthcare professionals play such a vital role in the battle against COVID-19 on a national scale, they also face an extraordinarily high risk of infection. Over 150,000 healthcare workers (HCWs) in Canada have been infected with COVID-19 since the start of the pandemic, which accounted for approximately 18.9% of the workforce and approximately 5.8% of all reported cases, and 46 have died from the disease as of January 14, 2022. Given that definitions of HCWs vary across provinces and territories and may include volunteers, HCW counts here are based on their commonly used and standard definitions [4].

The importance of mental health and well-being is precisely equivalent to that of physical health. The pandemic has adversely affected many people's mental health concerns, particularly among healthcare workers, since they have been brought face-to-face with COVID-19. Severe work pressure, rapid adaptations to intensive care situations, unanticipated numbers of detrimentally critical patients, countless patient deaths, and infection threats have significantly contributed to deteriorating mental health outcomes among the healthcare workforce [5]. In light of this public health crisis, various studies have been conducted at the national level on the far-reaching psychological effects on the health workforce [6][7][8]. Additionally, previous studies have

revealed that healthcare staff in Canada have sustained extraordinary levels of depressive symptomatology when treating COVID-19 patients[9].

According to a report released by Statistics Canada based on a crowdsourced questionnaire — “Impacts of COVID-19 on Health Care Workers: Infection Prevention and Control (ICHCWIPC), 2020”, there are 33% of healthcare workers, who work in healthcare settings, reported having fair to poor mental health, and 56% reported that most days were moderately or severely stressful. When compared to before the COVID-19 pandemic, among those working in close contact with confirmed or suspected COVID-19 cases, more than three-quarters (77%) of respondents expressed worsening mental health. It was also reported that self-reported mental health and stress levels are improved when workers have access to the proper personal protective equipment (PPE) [10].

The primary method used to safeguard healthcare workers (HCWs) against infection in healthcare settings is the implementation of reliable infection prevention control (IPC) practices and use of personal protective equipment (PPE). When it comes to the hierarchy of controls, PPE and IPC occupy different positions. PPE refers to the clothing or equipment worn by HCWs to safeguard them from infection, while IPC is about the adjustments made to the way those workers carry out their duties or the implementation of work equipment. IPC relies heavily on the use of proper PPE.

In Canada, Infection Prevention and Control (IPC) methods against COVID-19 guidelines developed by Public Health Agency of Canada (PHAC) were initiated in February 2020. With the current COVID-19 pandemic situation in mind, aggressive IPC measures have been proven to be efficient in reducing or stopping the transmission of infection in healthcare settings.

However, the restrictive IPC measures might have unintended effects. A previous study showed that healthcare workers in Japanese care home settings were more likely to get exhausted from the COVID-19 infection control measures. This exhaustion of healthcare professionals may result in physical and psychological harm, as well as a decrease in the quality of care [11].

This study aimed to examine the relationship between IPC practices during COVID-19 and the mental health of Canadian HCWs. This research would be able to inform institutions and health facilities to make improvements to IPC guidelines to the local needs as well as provide support services at a time when HCWs are a population at high risk for negative mental health outcomes.

## **Goals & Objective**

The purpose of this study is to understand the strength of the relationship between IPC, other potential covariates, and mental health status among HCWs during COVID-19 in Canada.

The first goal of the proposed study is to measure the differential effect of COVID-19 on healthcare workers' mental health with a specific focus on workplace IPC methods and access to PPE. The second goal is to identify other factors that may influence the association between IPC methods and the mental health of HCWs.

## **Chapter Two: Literature Review**

### **Mental Health Symptoms in HCWs**

Mental Health America (MHA) has observed an increase in anxiety, depression, helplessness, and other mental health issues throughout the COVID-19 pandemic. COVID-19 has had a profoundly devastating impact on the nation's mental health, particularly among those who must confront the virus. According to Vizheh et al, among health care employees, the lowest prevalence rates were 24.1% for anxiety, 12.1% for depression, and 29.8% for stress among health care workers. In addition, the maximum values that were achieved for the aforesaid parameters were 67.55%, 55.89%, and 62.99%, separately [12]. Using national data, Kapetanos et al. examined the prevalence of stress, anxiety, depression, and burnout among health care personnel in Cyprus who manage COVID-19 patients. The prevalence rates of anxiety, stress, depression and burnout in the sample population were, respectively, 28.6%, 18.11%, 15 % and 12.3% [13]. Parchani et al. reported that the resulting mental health problems affect not only the patients and their relatives/friends, but also healthcare workers (HCWs) in north India[14]. The study demonstrated that there was an increase in anxiety, stress and depression among hospital staff working in COVID-19-designated locations [14]. Through an online survey, Vicentini et al. investigated “helplessness (40.94%); sadness (36.56%) and frustration (32.66%)” among front liners and non-front liners in a province of Italy which was not massively affected by the pandemic [15]. Thatrimontrichai et al. conducted a systematic search in PUBMED for articles reporting on the mental health of HCWs in Asia between December 1, 2019, and September 20, 2020. The pooled mean rates of anxiety, sleep problem, depression and dread in Asian HCWs were 25.9%, 35.0%, 27.2% and 77.1% [16].

By surveying among Canadian HCWs during the COVID-19 pandemic, Wilbiks et al. revealed an increased severity and symptoms of clinical depression within this cohort [9]. A recently published study in JAMA Psychiatry discovered that during the first year of the pandemic, Ontario physicians have seen a 27% increase in the number of yearly clinic visits for mental health and substance addiction. The investigation found that doctors experience high rates of anxiety and sadness, and polls show that the COVID-19 pandemic has only made things worse [17]. According to a study “Mental Disorder Symptoms Among Nurses in Canada”, a large portion of the sample of Canadian nurses reported symptoms of Major Depressive Disorder

(36.4%), and many reported clinically significant symptoms of anxiety (26.1%), burnout (29.3%) and PTSD (23.0%) in 2019 [18]. In June and July of 2020, a cross-sectional study was conducted among nurses in British Columbia, Canada. Significant prevalence rates for PTSD (47%), depression (41%), anxiety (38%), and extreme emotional tiredness (60%) were discovered [19].

## **Infection Prevention and Control**

### **Definition**

WHO defines infection prevention and control (IPC) as “a practical, evidence-based approach which prevents patients and health workers from being harmed by avoidable infection and as a result of antimicrobial resistance.”

In the context of COVID-19, to provide guidelines and assist HCWs in the prevention and control of infections among their patients, the Public Health Agency of Canada (PHAC) has published guidance "Infection Prevention and Control Measures for Healthcare Workers in Acute Care and Long-term Care Settings.", which includes but is not limited to surveillance, screening, hand hygiene, accommodation, personal protective equipment (PPE), environmental cleaning, management of visitors and so on [20].

### **Association between IPC and Mental Health**

During the COVID-19 pandemic, European hospital HCWs reported low mental well-being when delivering hospital care and in accordance with local IPC requirements [21]. The shortage of protective equipment was associated with increased levels of mental symptoms in Ethiopia [22]. Khajuria et al. conducted an international cross-sectional study and found that workplace characteristics, such as the accessibility of personal protective equipment, adequate training for personnel who are reassigned, and the availability of wellness and mental health assistance, are strongly correlated with the risk that employees would develop depressive symptoms [23]. The author Monica et al. attached much importance to the mandated use of invasive personal protection equipment which can lead to stress [24]. Thatrimontrichai et al. stated that appropriate IPC such as strict hand washing, wearing masks and gloves was positively associated with better mental status. Adherence to IPC, IPC’s knowledge, dependable IPC education and frequency of IPC practices such as wearing PPE and physical distancing were mentioned in the review [16].

Among workers not specifically working in healthcare settings in Canada, the effectiveness of infection control procedures (ICP), and availability of personal protective equipment (PPE) were associated with anxiety and depression symptoms [25]. For those who work in healthcare settings, the relationship also exists. Eight types of PPE and the implementation of ten ICPs were included in the study. The percentage of PPE and IPC requirements that were fulfilled was associated with anxiety symptoms. IPC guidelines are designed to safeguard patients, HCWs, and the health system, they must guarantee that HCWs feel protected while performing their duties and are supposed to be beneficial to healthcare workers' mental health. However, IPC practices that lead to increased workloads are also possibly associated with negative psychological outcomes [26].

### **Sociodemographic Factors and Work-related Factors**

It was found that age, gender, and occupation were the most common sociodemographic variables influencing the development of psychiatric symptoms during the pandemic. The female sex was the strongest predictor of psychological consequences. Correspondingly, age was a determinant of the psychological impacts of the pandemic, and younger age was a risk factor for adverse psychological features [22]. Thatrimontrichai et al. in contrast observed that older age was the primary variable associated with increased suicide risk among healthcare workers in China [16]. Nurses have a higher chance of developing serious mental health issues compared to doctors [24]. Longer working hours, insufficient rest time, fewer years of experience and direct contact with suspected or confirmed patients were also identified as risk factors [16].

At the apex of the pandemic in Canada, a sample of HCWs revealed a connection between their work in long-term care (LTC) settings, their gender, their age, and their direct exposure to COVID-19 patients, and the development of anxiety [26].

### **Conceptual Framework**

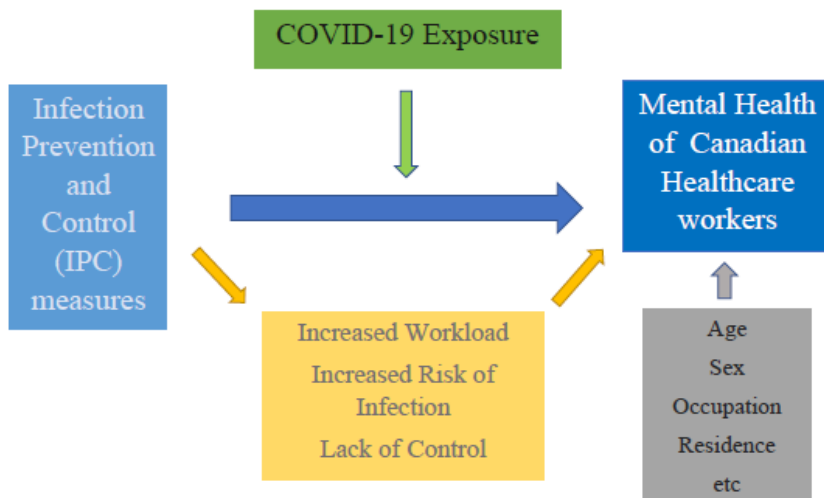
During the pandemic, IPC practices may be associated with healthcare workers' psychological situations in Canada.

Pathways connecting inadequate PPE and inappropriate IPC to negative mental health in a healthcare setting include increased workload and work pressure due to an increase in infection among colleagues and patients, lack of information about a potentially fatal illness, the impersonal nature of protective gears worn by healthcare workers, and corresponding influences

on the risk of infection for close family members [5][26]. This may explain why some IPC practices and insufficient PPE supply lead to negative emotions. The implementation of visitor management can be helpful to reduce the spread of the infectious agents and decrease the risk of infection, however, strict management policies may possibly increase HCWs' workload and result in exhaustion.

Nurses' perceptions of security in relation to their own, their patients', and their loved ones' mental well-being may be improved by the use of appropriate PPE, hence reducing the potential detrimental consequences of coronavirus exposure on mental health [28]. According to Sanghera et al, direct exposure to SARS-CoV-2 cases was identified as the most prevalent risk factor for five mental health outcomes among healthcare workers. When PPE is lacking, HCWs' risk of infection considerably rises [29]. Thus, for HCWs who have direct exposure to SARS-COV-2 patients, insufficient PPE supply may cause a worsening of HCWs' mental health status. On the contrary, no contact with COVID-19 patients may possibly assist in mitigating the potential negative effects of PPE shortages on the mental health of HCWs. To summarize, direct exposure to COVID-19 can conceivably influence the strength of the association between the PPE supply and mental health outcomes during the pandemic.

Demographic variables (such as age, gender, residence, occupation, job setting type, etc.) may be confounders of the relationships.



**Figure 1 Conceptual Framework**



## **Gap in the Literature**

To date, several studies have investigated the prevalence of psychological problems as well as identified several factors associated with the mental health among HCWs. Mental health disorders like anxiety, depression and stress were commonly reported and may be predicted by risk factors such as female, young age, nurse, unsafe work environment, high workloads, and insufficient PPE. However, the gaps still remain.

First, current studies published were conducted in different countries worldwide, the majority of studies were from China, where the disease was discovered. A lack of studies was found in Canada. There is evidence that the prevalence of mental health outcomes differs by country, implying that different cultural contexts may produce different results [27]. Thus, there is a necessity to summarize findings among HCWs in Canada.

Second, there was strong evidence that inadequate PPE was found to be a significant risk factor for negative mental health consequences. To our knowledge, however, few studies have yet evaluated how the number of COVID-19 infection prevention and control efforts affects healthcare workers' mental health.

Third, there is also a scarcity of research diving into the effectiveness of various types of PPE and specific recommended IPC measures. Understanding these relationships is essential for efficient IPC management among HCWs at the risk of COVID-19 infection in the Canadian context.

## **Hypotheses**

- The number of IPC measures may be associated with the mental health of HCWs. The more infection control measures newly introduced or increased, the better the HCWs' mental health condition.
- The number of inadequate PPE item may be associated with the mental health of HCWs. The more items in short, the worse the HCWs' mental health condition.
- Different types of infection control practices produce both positive and negative consequences.
- The associations between PPE supply and mental health outcomes differ between HCWs who have been exposed to COVID-19 and those who were not.

## **Chapter Three: Methodology**

### **Study Design and Data Source**

In this thesis, I conducted a secondary analysis using data from a survey conducted by Statistics Canada — “Impacts of COVID-19 on Health Care Workers: Infection Prevention and Control (ICHCWIPC), 2020.” By using this crowdsourced data, this thesis was able to conduct a cross-sectional study targeting healthcare workers and individuals working in medical settings in Canada during the pandemic.

### **Questionnaire Design**

Stakeholders and consultants from Statistics Canada, Health Canada, the Public Health Agency of Canada (PHAC), the Canadian Institutes for Health Information (CIHI), and other ministries participated in working groups to design the questionnaire's questions and answer options.

Within the context of computer-assisted interviewing, the questionnaire contains phrasing and techniques that are considered to be conventional. The data collection of computer applications was thoroughly tested. The questionnaire was available in both HTML and PDF formats [30].

### **Participants and Study population**

Approximately 18,000 healthcare workers or those working in healthcare settings in one of the ten provinces or three territories participated in the survey. Professional healthcare providers (e.g., nurses, physicians, therapists, dentists, nutritionists), technical assistance providers (e.g., technicians and other support staff), and those who offer support services in a healthcare context (e.g., food and cleaning services staff, security personnel) were all eligible. The proposed study based on the same dataset focused on the immediate mental health outcomes among Canadian HCWs, while the lasting psychological effects of the COVID-19 pandemic still remain to be seen. To gain a better understanding of healthcare workers' experiences during the early stages of the COVID-19 pandemic, I included those who had worked at all since March 2020 as the study population. Of this sample, the observations with missing information were removed if the frequencies of “Not Stated” were less than ten percent (Whenever a question was omitted, but one could have been asked, the “Not Stated” was used) [30].

## **Potential Associated Factors**

### **Covariates**

#### **Demographic Variables**

Participants also provided sociodemographic data, including age, gender, occupation, region of residence, visible minority, indigenous identity, and immigration status [31].

#### **Work-related Variables**

Work-related factors include direct exposure to suspected or confirmed cases, number of locations worked since March 2020, job setting type, region of work, and years of experience [31]. The potential role of COVID-19 exposure as an effect modifier in the relationship between the main independent and dependent variables was of interest [28].

#### **Main Independent Variables**

For the purpose of avoiding recall bias and keeping up with the mental health outcome, which measured the current mental health compared to before the COVID-19 pandemic, the variables which measured "Access to PPE – since March" were not chosen, and those counterparts targeting "past month" were reserved. The variables which measured "Access to other PPE" were also dropped due to the high frequencies of "Not Stated" and vague descriptions.

There were ten new or increased IPC methods in the workplace, including screening patient or staff, mask for patients, hand hygiene, PPE practice, management flow of patient, environmental cleaning and disinfection, management of health care worker exposure, visitor management, handling of deceased and reduction/suspension in-person contact.

The access to PPE contained 7 PPE items which included gloves, masks, respirators, gowns, face shields or visors, eye protection or goggles, and hand sanitizer or other handwashing facilities [31].

#### **Reducing the Answer Categories**

The questions would not apply to the participants if they report "NO" to a certain previous question, for example, regarding the question "Since March 2020, were there new IPC protocols introduced or an increase in the IPC protocols and practices for your position?", if the answer was "No", the participant would not answer PPE\_15A ~ PPE\_15J. Thus, the "valid skip" in the answer categories of "new or increased practices" can be explained as "None of the practices were introduced". Similarly, for "access to PPE past month", the "valid skip" can be combined

with "Not needed for the job". Further, I combined "Sometimes available when needed" and "Never available when needed" to be "Shortage"; the rest of the answer categories would be "Not needed or available".

### **Sum Variables**

Seventeen variables were merged into two overarching variables: "the number of new or increased practices" and "access to PPE past month". Since participants reported at least one practice was newly introduced in the workplace, the number of measures was classified and started with "1 practice". "The number of new or increased practices" had four levels: (1) 1-2 practices were newly introduced or increased;(2) 3-4 practices were newly introduced or increased;(3) 5-6 practices were newly introduced or increased;(4) more than 6 practices were newly introduced or increased. "Access to PPE past month" had three levels: (1) 0-1 PPE items were inadequate;(2) 2-3 PPE items were inadequate;(3) more than 3 PPE items were inadequate.

### **Dependent Variables**

The outcome measures are perceived mental health, perceived life stress, and mental health compared to before the pandemic measured by a single item, respectively. There are five answer categories in each item. To explain the presence of the mental health outcomes, I decided to conduct binary logistic regression first. Thus, I recode these ordinal variables and convert them to dummy variables.

#### **Perceived mental health**

Participants were asked to report how they would describe their mental health. I coded "Poor" and "Fair" as 1; "Good", "Very good" and "Excellent" as 0.

#### **Mental health compared to before pandemic**

Participants were asked how they would report their mental health is now compared to before the COVID-19 pandemic. I coded "Somewhat worse now" and "Much worse now" as 1; "About the same", "Somewhat better now," and "Much better now" as 0.

#### **Perceived life stress**

Participants were asked how they would describe most of their days thinking about the amount of stress in their life. I coded "A bit stressful", "Quite a bit stressful" and "Extremely stressful" as 1; "Not very stressful" and "Not at all stressful" as 0.

## Statistical Analyses

Critical data analysis methods included descriptive statistical procedures, bivariable analyses, and multivariable logistic regression. The data were exported to RStudio [32] for analysis. For categorical data, descriptive statistics were produced using frequencies and percentages. The significance level was set at  $\alpha = 0.05$ , and all tests were 2-tailed for all analyses.

## Missing Data

Figure 2 depicts the procedure for handling missing data. There were complete data on all variables I used in my study for 13,251 healthcare workers (73.1%). In total, 4484 participants, or 24.7% of the original sample, were excluded because they were missing responses to at least one variable-related survey item (demographic variables, work-related variables, IPC and PPE-related variables, and mental health outcomes). Confounding variables and mental health outcomes were compared between respondents with complete information on the major variables of interest and those with missing information on at least one major variable of interest.

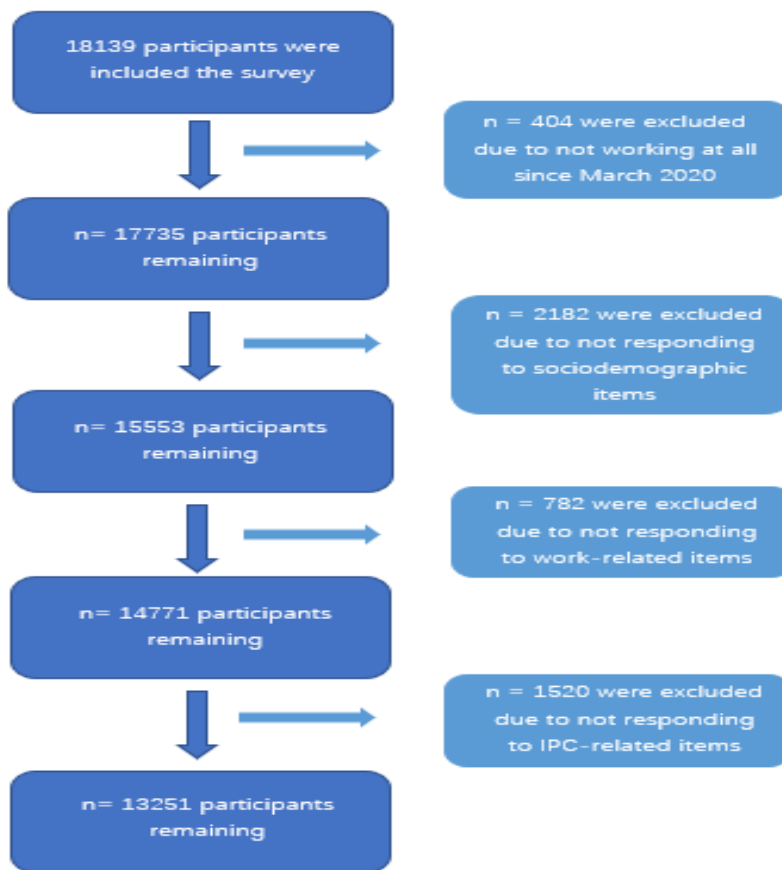


Figure 2 Flow chart for handling missing data

## **Bivariable Analyses**

The Chi-square or Fisher's exact test for categorical data to determine the differences in mental health outcomes for covariates. It is also a necessity to explore the relationship between demographic characteristics or other covariates and the primary independent variables of interest to gain an understanding of what factors are associated with IPC methods and PPE supply among HCWs in the survey, specifically. The chi-square test was then used to investigate differences in symptoms of mental health according to the number of new or expanded practices and the number of PPE items supply in short.

## **Multiple Logistic Regression Model**

Then multivariable logistic regression was performed to identify confirmed associations while adjusting for a range of covariates. And the associations between the main independent variable of interest (namely IPC and PPE-related variables) and outcomes were presented as odds ratios (ORs) and 95% Confidence Interval [33]. Several multivariable models were built separately, and forward selection was used. The ideal and most widely used method for analyzing ordinal dependent variables is ordinal logistic regression (OLS). To begin with, the mental health outcomes were handled as dichotomous variables and separate binary logistic regression was used to make the model building and interpretation easier [34]. Later, the effects of each IPC measure and each item of PPE were also detected. OLS was further conducted by keeping them as three categorical variables to maintain more information. Brant test was conducted to check if the proportional odds assumption is violated [35].

## **Selection of Confounders**

It has been recommended to include covariates that may be associated with the main exposure, a risk factor for the outcome, or both [36]. In this analysis, the main exposure of interest was IPC measures, and the primary outcomes were self-reported mental health conditions. The covariates that met the criteria were selected for mental health outcomes in participants.

## **Interactions among Predictors**

In this step, potential interactions between predictors were investigated. An interaction between two variables indicates that the effect of one variable on the response variable depends on the other variable. To begin with, interaction pairs from a clinical perspective are feasible. It was assumed that there was an interaction between COVID-19 exposure and PPE shortage in the

study. In other words, the effect of insufficient PPE on the seriousness of negative mental health consequences was moderated by direct exposure to COVID-19 cases. The model with the interaction term was compared to the preliminary multivariable logistic model using a partial likelihood ratio test to decide whether to drop the interaction term.

### **Multicollinearity**

When two or more independent variables in a model are highly correlated, collinearity is considered to exist. Regression models were assessed for multicollinearity between variables. The Variance Inflation Factor (VIF) for each independent measure was used to check multicollinearity. Typically, a VIF greater than 10 indicates a multicollinearity issue.

### **Assessing Fit of the Model**

Hosmer-Lemeshow tests were used to measure the goodness of fit (GOF) for logistic regression. The *P* value indicated whether there was a significant difference between observed and predicted values. Furthermore, Pulkstenis-Robinson (PR) test and Lipsitz goodness-of-fit test were performed to calculate goodness of fit chi-squared and deviance for ordinal logistic regression models. If the *P*-value is greater than the 5% threshold, we cannot reject the null hypothesis that the fitted model meets the likelihood ratio assumption. In other words, the specifications for the model are satisfactory.

## **Chapter Four: Results**

### **Missing Data**

Non-complete observations (people who participated with at least one missing item in any of the main variables of interest) were more likely to be visible minorities, immigrants, or permanent residents, less likely to be experienced (<10 years), have contacted suspected or confirmed cases of COVID-19 and had higher proportions of reporting poor perceived mental health and extremely stressed compared to complete observations (people who participated with no missing data on the main variables of interest) (see Appendix A). The comparison indicated that young people (<35 years), females, nurses, those who reside or work in Ontario, and those who work in acute care, outpatient, and ambulatory care were more likely to participate in the study.

### **Characteristics of Study Participants**

#### **Demographic Characteristics**

There are 18,139 respondents in total from the result published by Statistic Canada, of which 17,735 respondents have worked at all since March 2020. After deleting observations with missing values and dropping meaningless variables, there were 13,251 rows left in the data set. Of this sample, the majority of respondents were female (91%), worked as allied health professionals (40.4%) and nurses (33.0%), and were from the province of Ontario (47.8%), 16.8% of the participants were older than 55.

#### **Work-related Characteristics**

Over 40% of participants had contact with suspected or confirmed cases of COVID-19. A total of 44.5% of the participants worked in acute care facilities, and 29% had more than 20 years of work experience. The frequency distributions between the "Region of primary job location" and "Region of residence" were almost the same. Thus, only "Region of primary job location" was reported in the following results. Detailed descriptive data on work-related factors are provided in the tables below.

#### **Key Explanatory Characteristics**

Table 3 shows the number of new or increased practices and the details of each IPC method. The most implemented infection control measures were "screening patient or staff" (94.8%), "Masks for patients" (92.4%), and "PPE practices" (92.1%). In contrast, relatively few participants reported that "handling of deceased" (17.8%) and "reduction/suspension in-person contact"



(55.5%) were newly introduced. According to the Table 3 which aims to provide information about the details of the number of IPC measures put in place, the overarching variable is meaningful, but the analyses of each IPC measure and PPE item are also necessary. Table 4 shows that the shortage was highest for respirators (10.5%) or eye protection or goggles (8.4%).

**Table 1 Distribution of sociodemographic variables in study populations**

	N (%)		N (%)
<b>Age</b>		<b>Visible minority</b>	
<35 years	4043 (30.5)	Yes	1274 (9.6)
35-44 years	3754 (28.3)	<b>Indigenous identity</b>	
45-54 years	3226 (24.3)	Yes	214 (1.6)
>54 years	2228 (16.8)	<b>Immigration status</b>	
<b>Gender</b>		Immigrant or permanent resident	1346 (10.2)
Male	1183 (8.9)	<b>Region of residence</b>	
Female	12068 (91.1)	Atlantic provinces	1918 (14.5)
<b>Occupation</b>		Quebec	780 (5.9)
Physician	355 (2.7)	Ontario	6334 (47.8)
Nurse	4375 (33.0)	Manitoba and Saskatchewan	1214 (9.2)
Personal support worker or care aide	398 (3.0)	Alberta	1910 (14.4)
Emergency medical personnel	200 (1.5)	British Columbia	1074 (8.1)
Allied health professional	5354 (40.4)	Territories	21 (0.2)
Laboratory worker	1200 (9.1)		
Pharmacist	147 (1.1)		
Dental professional	1222 (9.2)		

**Table 2 Distribution of work-related variables in study populations**

	N (%)		N (%)
<b>Direct exposure to suspected or confirmed cases</b>		<b>Region of work</b>	
No	7883 (59.5)	Atlantic provinces	1918 (14.5)
Yes	5368 (40.5)	Quebec	780 (5.9)
<b>Number of locations worked since March 2020</b>		Ontario	6443 (47.8)
1-2	12181 (91.8)	Manitoba and	1214 (9.2)
>=3	1070 (8.1)	Saskatchewan	
<b>Job setting type</b>		Alberta	1910 (14.4)
Acute care	5866 (44.3)	British Columbia	1074 (8.1)
Long-term care	1180 (8.9)	Territories	21 (0.2)
Outpatient and ambulatory care	4257 (32.1)	<b>Years of experience</b>	
Community/home care	518 (3.9)	<10 years	4227 (32.3)
Congregate living	74 (0.6)	10-19 years	2447 (26.0)
Other	1356 (10.2)	>20 years	3847 (26.0)
		Not stated	1680 (12.7)

**Table 3 The number of newly introduced or increased IPC practices and the detail of each effort**

<b>Practice</b>	<b>Number of newly introduced or increased IPC practices</b>				
	<b>1-2 (n=495)</b>	<b>3-4 (n=1743)</b>	<b>5-6 (n=3936)</b>	<b>&gt;=7 (n=7077)</b>	<b>Total (N=13251)</b>
Screening patient or staff	299 (60.4)	1497 (85.9)	3752 (95.1)	7026 (99.3)	12564 (94.8)
Masks for patients	274 (55.4)	1413 (81.1)	3660 (93.0)	6930 (97.5)	12250 (92.4)
Hand hygiene	121 (24.4)	876 (50.3)	2812 (74.1)	6652 (94.0)	10461 (78.9)
PPE practices	268 (54.1)	1321 (75.8)	3591 (91.2)	7029 (99.3)	12209 (92.1)
Management flow of patients	52 (10.5)	679 (39.0)	3021 (76.8)	6871 (97.1)	10623 (80.2)
Environmental cleaning and disinfection	71 (14.3)	833 (47.8)	3241 (82.3)	6942 (98.1)	11087 (83.7)
Management of healthcare worker exposure	27 (5.5)	243 (13.9)	1468 (37.3)	647804 (91.5)	8216 (62.0)
Visitor management	105 (21.2)	820 (47.0)	2616 (66.5)	6848 (96.8)	10389 (78.4)
Handling of deceased	6 (1.2)	57 (3.3)	270 (6.9)	2021 (28.6)	2354 (17.8)
Reduction/suspension in-person contact	53 (10.7)	345 (19.8)	1434 (36.4)	5522 (78.0)	7354 (55.5)

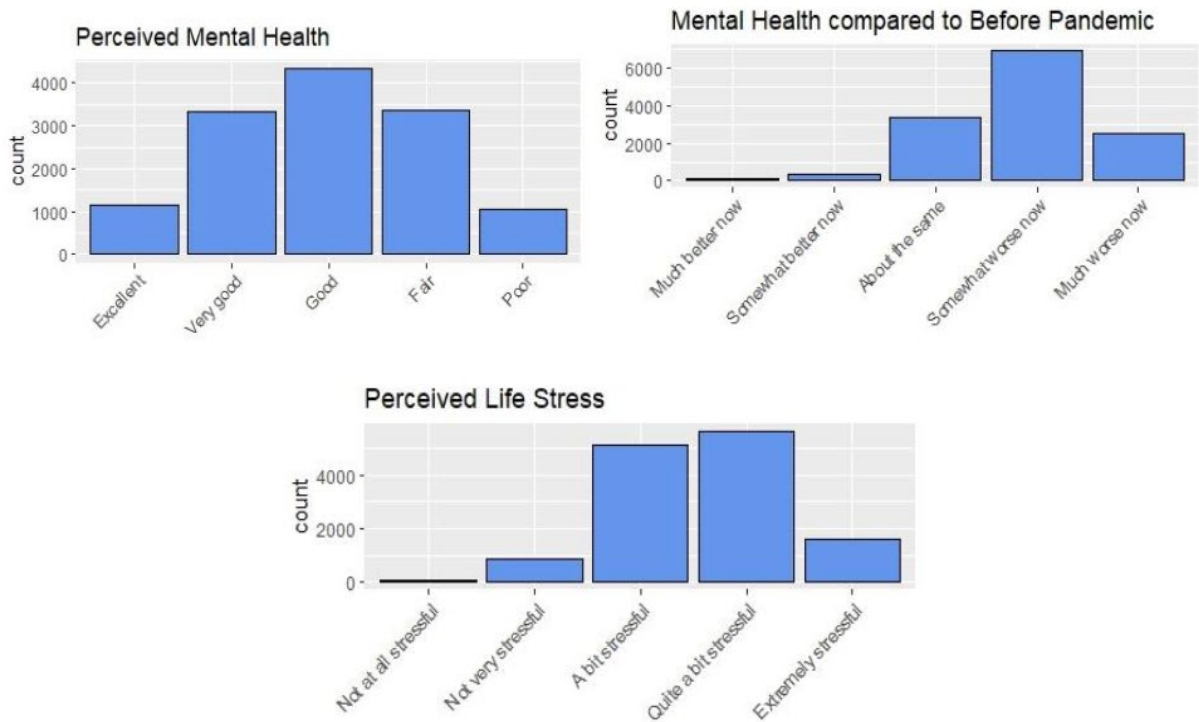
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**Table 4 The number of PPE items that are in short supply and details of each item**

<b>Item</b>	<b>Number of PPE items that are in short supply</b>			
	<b>0-1 (n=12235)</b>	<b>2-3 (n=811)</b>	<b>&gt;=4 (n=205)</b>	<b>Total (N=13251)</b>
Gloves	42 (0.3)	62 (7.6)	89 (43.4)	193 (1.5)
Mask	33 (0.3)	70 (8.6)	108 (52.7)	211 (1.6)
Respirator	723 (5.9)	485 (59.8)	180 (87.8)	1388 (10.5)
Gown	72 (0.6)	188 (23.2)	162 (79.0)	422 (3.2)
Face shield or visor	221 (1.8)	489 (60.3)	186 (90.7)	896 (6.8)
Eye protection or goggles	447 (3.7)	478 (58.9)	185 (90.2)	1110 (8.4)
Hand sanitizer/other handwashing facilities	68 (0.6)	86 (10.6)	99 (48.3)	253 (1.9)

## Outcome Variables

Regarding the outcome data (details see Appendix B), more than one third (33.5%) of participants reported fair or poor perceived mental health; 71.2% of participants stated that their mental health was worse than before the pandemic, nine-tenths (92.7%) of participants described most of their days as stressful.



**Figure 3 Distribution of perceived mental health, mental health compared before pandemic, and perceived life stress among Canadian healthcare workers (N=13251)**

## Bivariable Analyses

In bivariable analyses, age, gender, occupation, visible minority, immigration status, direct exposure to suspected or confirmed cases, job setting type, region of primary job location, and years of experience were the demographic and work-related variables significantly associated with the three mental health outcomes. Meanwhile, age, occupation, direct exposure to suspected or confirmed cases, job setting type, region of primary job location, number of locations worked

since March 2020, and years of experience were associated with both the number of new increased practices and the number of PPE items in short. Based on conceptual knowledge and empirical information, age, gender, occupation, visible minority, direct exposure to suspected or confirmed cases, job setting type, region of primary job location, and years of experience were included as potential confounding factors. The detail for chi square analyses between covariates and mental health outcomes were present in Appendix C.

Table 7 shows the basic characteristics according to the number of infection prevention and control measures newly implemented at the workplace as well as the number of PPE items in short. Compared to the HCWs working in healthcare settings with fewer IPC measures, the participants working with more IPC measures tended to be older ( $\geq 55$  years old), work as physicians and allied health professionals, work in long-term care and outpatient and ambulatory care settings, work in Ontario and have more years of experience. Moreover, HCWs having more insufficient PPE items were observed to be more likely to be younger ( $< 35$  years old), nurses, personal support worker or care aides, and emergency medical personnel, who have contacted with suspected or confirmed cases of COVID-19, work in home care settings, work in Ontario and British Columbia, and have fewer years of experience to those having more adequate PPE. In Table 7, a degraded trend was detected for the adverse mental health results based on the number of inadequate PPE items. For participants with no or only 1 item in short supply, 7.1% had poor perceived mental health, 17.8% indicated much worse mental health compared to before the pandemic, and 11.0% were extremely stressed. These increased to 22.0%, 43.4%, and 30.7%, respectively, for those with four or more insufficient items. Conversely, a graded relationship between the number of newly introduced IPC practices with a decreasing proportion of respondents reporting negative mental health outcomes was also observed in the same table. Among the sample with 1-2 practice was increased, 10.1% had poor perceived mental health, 19.8% reported much worse mental health compared to before the pandemic, and 13.7% were extremely stressed. These decreased to 7.2%, 18.4%, and 12.4%, respectively for those with more than six practices introduced.

**Table 5 Association of covariates and ordinal mental health outcomes (*P* value)**

	<b>Perceived mental health</b>	<b>Mental health compared to before pandemic</b>	<b>Perceived life stress</b>
Age	<0.001	<0.001	<0.001
Gender	<0.001	<0.001	<0.001
Occupation	<0.001	<0.001	<0.001
Visible minority	<0.001	<0.001	<0.001
Indigenous identity	0.004	<b>0.08</b>	<b>0.23</b>
Immigration status	<0.001	<0.001	<0.001
Direct exposure to suspected or confirmed cases	<0.001	<0.001	<0.001
Number of locations worked since March 2020	<b>0.06</b>	<b>0.15</b>	0.0076
Job setting type	<0.001	<0.001	<0.001
Region of primary job location	<0.001	<0.001	<0.001
Years of experience	<0.001	<0.001	<0.001

**Table 6 Association of covariates and IPC-related variables (*P* value)**

	<b>Number of newly introduced practices</b>	<b>Number of PPE items in short</b>
Age	<0.001	<0.001
Gender	<b>0.23</b>	<b>0.69</b>
Occupation	<0.001	<0.001
Visible minority	0.0214	<b>0.32</b>
Indigenous identity	<b>0.98</b>	<b>0.24</b>
Immigration status	0.0081	<b>0.69</b>
Direct exposure to suspected or confirmed cases	<0.001	<0.001
Number of locations worked since March 2020	<0.001	<0.001
Job setting type	<0.001	<0.001
Region of primary job location	<0.001	<0.001
Years of experience	<0.001	<0.001



**Table 7 Characteristics of the participants according to infection prevention and control measures and personal protective equipment**

	The number of newly introduced practices				The number of PPE shortage		
	1-2	3-4	5-6	>=7	0-1	2-3	>=4
<b>Age</b>							
<35 years	160(32.3)	597(34.3)	1297(33.0)	1989(28.1)	3665(30.0)	296(36.5)	82(40.0)
35-44 years	160(32.3)	499(28.6)	1142(29.0)	1953(27.6)	3480(28.4)	219(27.0)	55(26.8)
45-54 years	107(21.6)	415(23.8)	899(22.8)	1805(25.5)	3027(24.7)	164(20.2)	35(17.1)
>=55 years	68(13.7)	232(13.3)	598(15.2)	1330(18.8)	2063(16.9)	132(16.3)	33(16.1)
<b>Gender, female</b>	452(91.3)	1599(91.7)	3606(91.6)	6411(90.6)	11141(91.1)	743(91.6)	184(89.8)
<b>Occupation</b>							
Physician	6(1.2)	14(0.8)	60(1.5)	275(3.9)	319(2.6)	29(3.6)	7(3.4)
Nurse	155(31.3)	596(34.2)	1212(30.8)	2412(34.1)	3874(31.7)	389(48.0)	112(54.6)
Personal support worker or care aide	29(5.9)	75(4.3)	99(2.5)	195(2.8)	353(2.9)	32(3.9)	13(6.3)
Emergency medical personnel	11(2.2)	44(2.5)	61(1.5)	84(1.2)	189(1.5)	7(0.9)	4(2.0)
Allied health professional	142(28.7)	618(35.5)	1676(42.6)	2918(41.2)	5070(41.4)	235(29.0)	49(23.9)
Laboratory worker	93(18.8)	176(10.1)	357(9.1)	574(8.1)	1136(9.3)	56(6.9)	8(3.9)
Pharmacist	6(1.2)	20(1.1)	54(1.4)	67(0.9)	134(1.1)	12(1.5)	1(0.5)
Dental professional	53(10.7)	200(11.5)	417(10.6)	552(7.8)	1160(9.5)	51(6.3)	11(5.4)
<b>Population group flag, visible minority</b>	452(91.3)	1588(91.1)	3593(91.3)	6344(89.6)	11066(90.4)	732(90.3)	179(87.3)
<b>Immigration status, immigrant</b>	50(10.1)	172(9.9)	350(8.9)	774(10.9)	1236(10.1)	86(10.6)	24(11.7)

	The number of newly introduced practices				The number of PPE shortage		
	1-2	3-4	5-6	>=7	0-1	2-3	>=4
<b>Contact with COVID-19 cases</b>	206(41.6)	697(40.0)	1489(37.8)	2976(42.1)	4825(39.4)	438(54.0)	105(51.2)
<b>Job setting type</b>							
Acute care	250(50.5)	772(44.3)	1621(41.2)	3223(45.5)	5348(43.7)	421(51.9)	97(47.3)
Long-term care	32(6.5)	109(6.3)	249(6.3)	790(11.2)	1076(8.8)	85(10.5)	19(9.3)
Outpatient and ambulatory care	90(18.2)	481(27.6)	1427(36.3)	2259(31.9)	4029(32.9)	186(22.9)	42(20.5)
Community/home care	65(13.1)	151(8.7)	162(4.1)	140(2.0)	463(3.8)	34(4.2)	21(10.2)
Congregate living	2(0.4)	13(0.7)	25(0.6)	34(0.5)	63(0.5)	9(1.1)	2(1.0)
Other	56(11.3)	217(12.4)	452(11.5)	631(8.9)	1256(10.3)	76(9.4)	24(11.7)
<b>Region of work</b>							
Atlantic provinces	60(12.1)	253(14.5)	561(14.3)	1044(14.8)	1802(14.7)	92(11.3)	24(11.7)
Quebec	64(12.9)	131(7.5)	268(6.8)	317(4.5)	753(6.2)	22(2.7)	5(2.4)
Ontario	194(39.2)	740(42.5)	1814(46.1)	3586(50.7)	5861(47.9)	361(44.5)	112(54.6)
Manitoba and Saskatchewan	52(10.5)	169(9.7)	394(10.0)	599(8.5)	1098(9.0)	108(13.3)	8(3.9)
Alberta	71(14.3)	278(15.9)	584(14.8)	977(13.8)	1750(14.3)	137(16.9)	23(11.2)
British Columbia	54(10.9)	169(9.7)	310(7.9)	541(7.6)	952(7.8)	89(11.0)	33(16.1)
Territories	0(0.0)	3(0.2)	5(0.1)	13(0.2)	19(0.2)	2(0.2)	0(0.0)
<b>Year of experience</b>							
Not stated	71(14.3)	275(15.8)	488(12.4)	846(12.0)	1517(12.4)	124(15.3)	39(19.0)
<10 years	158(31.9)	605(34.7)	1347(34.2)	2167(30.6)	3906(31.9)	294(36.3)	77(37.6)

	The number of newly introduced practices				The number of PPE shortage		
	1-2	3-4	5-6	>=7	0-1	2-3	>=4
10-19 years	132(26.7)	420(24.1)	1053(26.8)	1842(26.0)	3197(26.1)	205(25.3)	45(22.0)
>20 years	134(27.1)	443(25.4)	1048(26.6)	2222(31.4)	3615(29.5)	188(23.2)	44(21.5)
<b>Perceived mental health</b>	No. (%)						
Excellent	37(7.5)	118(6.8)	283(7.2)	720(10.2)	1103(9.0)	41(5.1)	14(6.8)
Very good	109(22.0)	407(23.4)	953(24.2)	1864(26.3)	3171(25.9)	126(15.5)	36(17.6)
Good	166(33.5)	579(33.2)	1288(32.7)	2292(32.4)	4042(33.0)	243(30.0)	40(19.5)
Fair	133(26.9)	480(27.5)	1075(27.3)	1690(23.9)	3050(24.9)	258(31.8)	70(34.1)
Poor	50(10.1)	159(9.1)	337(8.6)	511(7.2)	869(7.1)	143(17.6)	45(22.0)
Chi-square test	chi-squared = 74, $P < 0.001$				chi-squared = 242, $P < 0.001$		
<b>Mental health compared to before pandemic</b>	No. (%)						
Much better now	3(0.6)	15(0.9)	22(0.6)	78(1.1)	108(0.9)	7(0.9)	3(1.5)
Somewhat better now	7(1.4)	40(2.3)	84(2.1)	196(2.8)	309(2.5)	14(1.7)	4(2.0)
About the same	126(25.5)	404(23.2)	999(25.4)	1847(26.1)	3229(26.4)	123(15.2)	24(11.7)
Somewhat worse now	261(52.7)	898(51.5)	2081(52.9)	3655(51.6)	6416(52.4)	394(48.6)	85(41.5)
Much worse now	98(19.8)	386(22.1)	750(19.1)	1301(18.4)	2173(17.8)	273(33.7)	89(43.4)
Chi-square test	chi-squared = 32, $P = 0.002$				chi-squared = 227, $P < 0.001$		
<b>Perceived life stress</b>	No. (%)						
Not at all stressful	2(0.4)	14(0.8)	23(0.6)	50(0.7)	88(0.7)	1(0.1)	0(0.0)

	The number of newly introduced practices				The number of PPE shortage		
	1-2	3-4	5-6	>=7	0-1	2-3	>=4
Not very stressful	32(6.5)	104(6.0)	259(6.6)	479(6.8)	843(6.9)	25(3.1)	6(2.9)
A bit stressful	185(37.4)	657(37.7)	1557(39.6)	2683(37.9)	4824(39.4)	222(27.4)	36(17.6)
Quite a bit stressful	208(42.0)	738(42.3)	1696(43.1)	2984(42.2)	5133(42.0)	393(48.5)	100(48.8)
Extremely stressful	68(13.7)	230(13.2)	401(10.2)	881(12.4)	1347(11.0)	170(21.0)	63(30.7)
Chi-square test	chi-squared = 21, $P=0.051$				chi-squared = 213, $P<0.001$		

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## Multiple Logistic Regression Models

After adjustment for demographic characteristics and work-related conditions, the number of PPE items in short was significantly associated with three mental health outcomes (Table 8). As the number of inadequate PPE items increased, the OR for negative mental health outcomes also increased. HCWs that reported having more than three inadequate PPE items from their workplace were more likely to report fair or poor perceived mental health (OR 2.39, 95% CI 1.79, 3.19;  $P < 0.001$ ), somewhat or much worse now compared to before the pandemic (OR 2.16, 95% CI 1.48, 3.27;  $P < 0.001$ ) and quite a bit or extremely stressed (OR 2.47, 95% CI 1.18, 6.42;  $P = 0.03$ ). In comparison, the opposite trend was not applicable to the number of IPC measures. Table 9 shows the association between each infection prevention and control measure and mental health. Most practices were significantly associated with perceived mental health. Only four practices were associated with mental health compared to before the pandemic, and three were associated with perceived life stress after adjusting for covariates. The implementation of “Environmental cleaning and disinfection” was associated with all three mental health outcomes, and “masks for patients”, “hand hygiene”, “management of health care worker exposure” and “reduction/suspension in-person contact” were associated with more than one psychological outcome with statistical significance. In particular, those who had “masks for patients” introduced in the workplace were less likely to report stress (OR 0.69, 95% CI 0.50, 0.93;  $P = 0.02$ ). By contrast, “screening patient or staff” (OR 1.20, 95% CI 1.01, 1.42;  $P = 0.04$ ) and “Reduction/suspension in-person contact” (OR 1.14, 95% CI 1.00, 1.31;  $P = 0.04$ ) were positively associated with mental health compared to before the pandemic.

Most of the individual PPE item supplies were significantly associated with psychological consequences, with ORs ranging from approximately 1.37 to 2.23. In particular, the shortage of masks (OR = 2.23, 95% CI: 1.12-5.28,  $P = 0.04$ ) and gown and hand sanitizer or other handwashing facilities (OR = 2.03, 95% CI: 1.06-4.52,  $P = 0.05$ ) were associated with an increased risk for negative psychological outcomes.

For the purpose of detecting the potential moderating effect of exposure to confirmed or suspected COVID-19 cases, the interaction term (contact with COVID-19 patients: the number

of PPE items in short) was used. As a result, I did not observe any significant interactive relationship between the PPE shortage and any of the three mental health outcomes.

I draw the conclusion that there was no multicollinearity as none of the VIF values were greater than 10 according to the output from RStudio (not even close).

**Table 8 Adjusted association between the main exposure of interest and mental health outcomes (binary outcomes yes / no)**

	Perceived mental health		Mental health compared to before pandemic		Perceived life stress	
	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>
<b>The number of newly introduced practices</b>						
1-2	1.00		1.00		1.00	
3-4	0.95 (0.79-1.22)	0.66	1.06 (0.84-1.33)	0.43	1.01 (0.67-1.48)	0.66
5-6	0.94 (0.77-1.20)	0.56	0.98 (0.79-1.21)	0.70	0.96 (0.65-1.37)	0.65
>=7	0.79 (0.67-0.99)	0.02	0.95 (0.77-1.17)	0.65	0.98 (0.81-1.18)	0.88
<b>The number of PPE shortage</b>						
0-1	1.00		1.00		1.00	
2-3	1.88 (1.62-2.18)	<0.001	1.72 (1.42-2.08)	<0.001	2.10 (1.43-3.21)	<0.001
>=4	2.39 (1.79-3.19)	<0.001	2.16 (1.48-3.27)	<0.001	2.47 (1.18-6.42)	0.03

The multivariable models were adjusted for age, gender, occupation, visible minority, direct exposure to suspected or confirmed cases, job setting type, region of work, and years of experience.

**Table 9 Binary logistic regression for the effect of each IPC measures on mental health outcomes**

Practice	Perceived mental health		Mental health compared to before pandemic		Perceived life stress	
	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>
Screening patient or staff	1.18 (0.97-1.40)	0.06	1.20 (1.01-1.42)	0.04	1.18 (0.97-1.56)	0.28
Masks for patients	0.83 (0.72-0.95)	0.01	0.85 (0.73-0.99)	0.04	0.69 (0.50-0.93)	0.02
Hand hygiene	0.89 (0.82-0.98)	0.01	0.81 (0.74-0.90)	<0.001	0.92 (0.77-1.09)	0.35
PPE practices	0.88 (0.77-1.00)	0.08	0.89 (0.77-1.02)	0.09	0.85 (0.65-1.11)	0.25
Management flow of patients	0.85 (0.76-0.91)	<0.001	0.93 (0.84-1.04)	0.19	0.98 (0.81-1.17)	0.33
Environmental cleaning and disinfection	0.83 (0.76-0.92)	0.002	0.86 (0.77-0.96)	<0.001	0.80 (0.66-0.98)	0.04
Management of healthcare worker exposure	0.87 (0.80-0.94)	<0.001	0.89 (0.82-0.97)	0.03	0.96 (0.84-1.10)	0.57
Visitor management	0.92 (0.84-1.01)	0.08	1.10 (1.00-1.21)	0.05	1.14 (0.98-1.33)	0.09
Handling of deceased	1.07 (0.97-1.19)	0.35	1.07 (0.84-1.20)	0.27	0.95 (0.77-1.20)	0.07
Reduction/suspension in-person contact	0.91 (0.84-0.98)	0.01	1.00 (0.94-1.11)	0.65	1.14 (1.00-1.31)	0.04

The multivariable models were adjusted for age, gender, occupation, visible minority, direct exposure to suspected or confirmed cases, job setting type, region of work, and years of experience.



**Table 10 Binary logistic regression for the effect of each PPE item on mental health outcomes**

PPE item	Perceived mental health		Mental health compared to before pandemic		Perceived life stress	
	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>
Gloves	1.56 (1.16-2.10)	0.003	1.78 (1.25-2.62)	0.002	1.37 (0.77-2.70)	0.11
Mask	1.78 (1.35-2.36)	<0.001	1.58 (1.13-2.27)	0.01	2.23 (1.12-5.28)	0.04
Respirator	1.60 (1.42-1.80)	<0.001	1.61 (1.40-1.86)	<0.001	1.73 (1.31-2.33)	<0.001
Gown	1.98 (1.62-2.42)	<0.001	1.98 (1.53-2.60)	<0.001	1.57 (1.01-2.60)	0.06
Face shield or visor	1.68 (1.45-1.93)	<0.001	1.49 (1.25-1.78)	<0.001	1.83 (1.29-2.69)	<0.001
Eye protection or goggles	1.67 (1.47-1.91)	<0.001	1.57 (1.34-1.86)	<0.001	1.91 (1.38-2.71)	<0.001
Hand sanitizer/other handwashing facilities	1.85 (1.43-2.40)	<0.001	1.58 (1.14-2.25)	0.008	2.03 (1.06-4.52)	0.05

The multivariable models were adjusted for age, gender, occupation, visible minority, direct exposure to suspected or confirmed cases, job setting type, region of work, and years of experience.

## Ordinal Logistic Regression Models

The definition of proportional odd assumption implies that the effect of an independent variable remains constant across two response variable levels. The results of brant test for the proportional odds assumption were statistically insignificant, indicating that the key assumption of OLS was valid. According to Table 11, the number of inadequate PPE supplies had a statistically significant association with the three ordinal mental health outcomes. Participants who reported more than four PPE items in short supply were 2.28 times more likely to have worse perceived mental health (i.e., poor or fair versus good), 2.86 times more likely to have worse mental health compared to before the pandemic (much worse now or somewhat worse now versus about the same), and 3.36 times more likely to have worse perceived life stress (i.e., extremely stressful or quite a bit stressful versus a bit stressful in most of their days) compared to those who have almost all PPE needs met.

The results in Tables 12 and 13 were quite similar to that in previous binary logistic regression models. Each of the IPC measures was associated with at least one mental health outcome, and most of them reported significant  $p$  values for two psychological consequences. There were statistically meaningful associations between "environmental cleaning and disinfection" and the three psychological outcomes. Each of the PPE item shortage was significantly associated with a promotion in the odds of the psychological outcomes, with ORs ranging from approximately 1.69 to 3.02, with statistical significance.

Exceptionally, if considering the age-sex adjusted OR (details were present in Appendix D), the instruction for "visitor management" and "handling of deceased" had a significantly opposite effect on HCWS' mental health compared to other IPC practices. The implementation of "visitor management" was a risk factor for both worse mental health compared to before the pandemic and worse perceived life stress. The other two were risk factors for the three mental health outcomes. For instance, participants who answered "Yes" to the question about "Handling of deceased" were also more likely to report worse mental health compared to before the pandemic (OR 1.28, 95% CI 1.17, 1.40;  $P < 0.001$ ).

**Table 11 Adjusted association between the main exposure of interest and mental health outcomes (ordinal outcomes)**

	Perceived mental health		Mental health compared to before pandemic		Perceived life stress	
	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>
<b>The number of newly introduced practices</b>						
1-2	1.00		1.00		1.00	
3-4	0.98 (0.81-1.16)	0.76	1.10 (0.92-1.35)	0.28	1.02 (0.84-1.23)	0.11
5-6	0.94 (0.80-1.12)	0.49	1.00 (0.85-1.21)	0.74	0.92 (0.77-1.10)	0.19
>=7	0.78 (0.67-0.92)	0.004	0.94 (0.79-1.12)	0.51	0.97 (0.82-1.15)	0.07
<b>The number of PPE shortage</b>						
0-1	1.00		1.00		1.00	
2-3	1.98 (1.74-2.26)	<0.001	1.91 (1.66-2.19)	<0.001	1.91 (1.67-2.18)	<0.001
>=4	2.28 (1.74-2.97)	<0.001	2.86 (2.18-3.77)	<0.001	3.36 (2.58-4.37)	<0.001

The multivariable models were adjusted for age, gender, occupation, visible minority, direct exposure to suspected or confirmed cases, job setting type, region of work, and years of experience.

**Table 12 Ordered logistic regression for the adjusted effect of each IPC measures on mental health outcomes.**

Practice	Perceived mental health		Mental health compared to before pandemic		Perceived life stress	
	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>
Screening patient or staff	1.16 (1.01-1.37)	0.03	1.16 (1.00-1.35)	0.05	1.17 (1.00-1.37)	0.05
Masks for patients	0.88 (0.78-1.00)	0.04	0.86 (0.77-1.01)	0.08	0.94 (0.83-1.06)	0.40
Hand hygiene	0.86 (0.80-0.93)	<0.001	0.86 (0.80-0.94)	<0.001	1.04 (0.96-1.13)	0.06
PPE practices	0.85 (0.76-0.95)	0.003	0.86(0.80-1.05)	0.21	0.97 (0.86-1.12)	0.63
Management flow of patients	0.83 (0.77-0.89)	<0.001	0.93 (0.85-1.01)	0.09	0.90 (0.83-0.98)	0.02
Environmental cleaning and disinfection	0.82 (0.75-0.89)	<0.001	0.84 (0.77-0.92)	<0.001	0.88 (0.81-0.96)	<0.001
Management of healthcare worker exposure	0.86 (0.81-0.92)	<0.001	0.87 (0.82-0.93)	<0.001	1.03 (0.97-1.11)	0.32
Visitor management	0.91 (0.84-0.98)	0.02	1.08 (0.99-1.17)	0.09	1.12 (1.03-1.21)	0.01
Handling of deceased	1.02 (0.94-1.12)	0.06	1.12 (1.03-1.23)	0.02	1.28 (1.17-1.40)	<0.001
Reduction/suspension in-person contact	0.90 (0.84-0.95)	<0.001	0.94 (0.87-1.03)	0.25	1.03 (0.97-1.10)	0.31

The multivariable models were adjusted for age, gender, occupation, visible minority, direct exposure to suspected or confirmed cases, job setting type, region of work, and years of experience.

**Table 13 Ordered logistic regression for the effect of each PPE item on mental health outcomes**

<b>PPE item</b>	<b>Perceived mental health</b>		<b>Mental health compared to before pandemic</b>		<b>Perceived life stress</b>	
	<b>OR (95% CI)</b>	<b><i>P</i></b>	<b>OR (95% CI)</b>	<b><i>P</i></b>	<b>OR (95% CI)</b>	<b><i>P</i></b>
Gloves	1.63 (1.25-2.13)	<0.001	2.21 (1.66-2.92)	<0.001	2.75 (2.09-3.61)	<0.001
Mask	1.72 (1.33-2.22)	<0.001	1.86 (1.42-2.44)	<0.001	2.71 (2.08-3.52)	<0.001
Respirator	1.57 (1.41-1.74)	<0.001	1.76 (1.58-1.97)	<0.001	1.90 (1.71-2.12)	<0.001
Gown	2.02 (1.68-2.43)	<0.001	2.34 (1.93-2.84)	<0.001	2.33 (1.93-2.81)	<0.001
Face shield or visor	1.74 (1.54-1.98)	<0.001	1.84 (1.60-2.10)	<0.001	1.65 (1.45-1.88)	<0.001
Eye protection or goggles	1.70 (1.52-1.91)	<0.001	1.70 (1.50-1.91)	<0.001	1.66 (1.47-1.87)	<0.001
Hand sanitizer/other handwashing facilities	1.79 (1.42-2.26)	<0.001	2.04 (1.59-2.62)	<0.001	2.57 (2.04-3.24)	<0.001

The multivariable models were adjusted for age, gender, occupation, visible minority, direct exposure to suspected or confirmed cases, job setting type, region of work, and years of experience.

## **Chapter Five: Discussion**

### **Conclusion**

Globally, the pandemic of COVID-19 is putting significant pressure on healthcare workers. Recognizing and tackling the mental health of the healthcare workforce is an essential element of the COVID-19 response. The objective of implementing IPC measures in healthcare organizations is to instruct HCWs on how to prevent the transmission of SARS-CoV-2 in healthcare settings which is essential for their sense of security. Thus, it is crucial in this context to identify modifiable IPC-related factors in the workplace that are associated with mental health outcomes.

In this sample of HCWs in Canada, I examined the impact of infection prevention and control (IPC) measures and access to personal protective equipment (PPE) in the workplace during the pandemic. As hypothesized, there were associations between mental health outcomes and the implementation of ten COVID-19 infection prevention and control practices as well as seven personal protective equipment recommended in the healthcare settings. It worth noting that some IPC practices were negatively associated with the mental health reported by the participants, this explained why more increased practices did not result in better mental health outcomes.

In comparison, the study revealed that increased number of inadequate PPE items was associated with worse mental health of HCWs. Although I cannot demonstrate causal relationships between access to PPE and mental health outcomes, the previous finding suggests a causal mechanism. Consistent with a recent convenience-based online survey of Canadian healthcare workers, these findings indicate a graded association between perceived adequacy of PPE availability and symptoms of anxiety and depression, with fewer symptoms among survey participants whose PPE requirements were being met [26]. Besides, the associations between PPE supply and mental health outcomes do not differ between HCWs who have been exposed to COVID-19 and those who did not since interaction effect was not statistically significant.

Surprisingly, the implementation of “screening of patient and staff”, “visitor management”, “handling of deceased” and “reduction/suspension in-person contact” were not protective factors for mental health. These practices, like screening of patients or clients or staff, provide the

utmost protection from infection. However, it may increase the HCWs' workload and consequently result in worse mental health outcomes.

There was not enough detail about "visitor management" in the data dictionary. Currently, digital visitor management systems are widely used in Canada, which enables healthcare institutions to deliver the necessary knowledge and transparency - a foundational component for safety, adherence, patient and staff security, medical care quality, and patient engagement [37]. I assumed that the practice of "visitor management" added additional burdens to the already overworked healthcare staff at the onset of the pandemic due to traditional security management, with which healthcare workers were left to start enforcing unfavorable visitation restrictions and policies among patients and visitors, resulting in excessive pressure on medical personnel. Apparently, risks of infection from handling dead bodies with COVID-19 is a big challenge for healthcare workers. Besides, reducing person-to-person contact is part of the social distancing practice, this restricts healthcare workers' social interactions and can exacerbate feelings of loneliness and negative emotions. Significantly higher mean PHQ-9 and GAD-7 scores were associated with the tight lockdown restrictions among healthcare workers [38].

The results above suggest that the implementation of appropriate and reliable IPC practices is associated with the mental health status reported in healthcare workers. Furthermore, reliable IPC education on virus transmission and prevention during COVID-19 outbreaks is recommended to reduce HCW fear and anxiety, while the safety culture within the healthcare settings plays a crucial role in HCWs' conformance with IPC guidelines during pandemics. Individual factors, including HCW compliance to IPC guidelines for respiratory infectious diseases, are also meaningful. HCW believed they abided to IPC rules when they saw the value associated with the practices [16]. The findings from previous research also indicate that reinforcing IPC strategies could have profound consequences for the mental health symptoms of healthcare workers [26].

Each PPE item was found to be associated with worse psychological consequences if not available. In particular, the shortage of gloves, masks, and hand sanitizer/other handwashing facilities remarkably increased the severity of perceived life stress. Since feelings of hopelessness and helplessness have been linked to depression, and the importance of personal protective equipment in keeping workers safe, particularly those in high-risk situations, such as

healthcare workers, is emphasized. This can be considered as the reason why lack of adequate PPE was significantly associated with negative mental health status [28].

It should be recognized that these analyses compared individuals with and without access to a specific PPE item; however, individuals without access to this item may have access to other items. Therefore, it does not evaluate the effectiveness of a single piece of protective equipment in isolation. Similarly, Participants who took a particular infection control measure are compared to those who did not, but those who did not may also take other IPC measures.

The current study uncovered considerable variation in COVID-19 infection control measures and PPE supply across territories and healthcare facilities. These differences depended on the level of local COVID-19 transmission. These should be designed and constructed to achieve a healthy balance between the spread of infectious diseases and the promotion of patient outcomes and primary care. Future research should indeed investigate professional discretion regarding the clinical circumstance as well as prevailing information on how the specific healthcare facility has tailored and implemented technical and administrative control systems, including the proper use of personal protective equipment (PPE) using the same data source which also provides restricted access PPE (e. g. reuse own PPE w/out decon, extended use, use wrong type PPE, etc.) [31].

### **Implications and Limitations of the Study**

Health care workers' mental health may deteriorate as a result of increased workloads brought about by strict infection control policies. Thus, policymakers should take into account how to balance the infection management and mental health needs of HCWs in the future. Some social and financial support can make the implementation of strict IPC measure more friendly, such as active psychological intervention and additional subsidy. In the fight against present and future pandemics, the mental health of healthcare personnel is a crucial component that will impact their productivity, attitudes regarding patients, and likelihood of quitting their jobs.

Since the study was an observational cross-sectional design, it is not possible to make the assumption that a causal relationship existed between exposures of interest and mental health outcomes. It will be better to use cohort design to assess causality using longitudinal, weighted data in the future study. The results may more accurately represent the impact of IPC measures



on mental health of HCWs. Long-term effects of IPC practices on healthcare workers' mental well-being may also be obtained from follow-up study.

This study has some other limits. First, the snowball sampling method was used in the data source, with survey respondents encouraged to participate by enrolled respondents [30]. As a non-probability sampling technique and may result in selection bias. The results can be unrepresentative and lack generalizability. There are restrictions that must be accounted for when interpreting the data. Thus, despite the fact that the survey included information on how healthcare workers have responded to the pandemic in a variety of contexts, it was not supposed to be representative of HCWs. In addition, due to the online invitation structure of the survey, the response rate could not be calculated. Furthermore, Self-selection bias might well have affected the findings, as it is entirely feasible that HCWs with mental health symptoms were more likely to participate in the survey. The effect of this bias is that it causes us to overestimate the severity of the mental health problems among HCWs.

Secondly, the survey was conducted from November 24 to December 13, 2020, during the second wave of COVID-19 in Canada. However, the effects of the COVID-19 pandemic on mental health may have fluctuated over time. Hence, it may not accurately reflect the impact of infection control on the mental health of HCWs during the current pandemic. Besides, the three mental health outcomes were measured using three simple questions asking healthcare workers how they describe their mental health and the amount of stress in their life. Accordingly, participants' self-report responses did not correspond to formal clinical diagnostic procedures of mental health status, and information bias may occur. This type of bias can either under- or overestimate the true association.

The third limitation is that the criteria were employed to set categories for some of the variables in order to obtain groups with fewer variables. This gives concision, but it might be perplexing due to the atypical classification, which can lead to a degree of measurement bias. Finally, I simply deleted the observations with missing values in specified variables of interest in the dataset, as I supposed that there were enough observations left. This quick but dirty method may result in the deletion of meaningful information from the data source and the reduction of the

statistical power of the analysis, also, selection bias arises. This form of bias can also lead to both an underestimation and an overestimation of the actual association.

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## **Appendices**

### **Appendix A: Comparison for complete cases and non-complete cases.**

**Table 14 Comparison for covariates and mental health outcomes for complete cases and non-complete cases.**



	Complete N=13251	Non-complete N=4484	$\chi^2/P$ value
<b>Age</b>			193.8, $p<0.001$
<35 years	4043(30.5)	1039(23.4)	
35-44 years	3754(28.3)	1140(25.6)	
45-54 years	3226(24.3)	1151(25.9)	
$\geq 55$ years	2228(16.8)	1119(25.2)	
<b>Gender</b>			371.6, $p<0.001$
Male	1183(8.9)	868(19.7)	
Female	12068(91.1)	3543(80.3)	
<b>Occupation group of participants</b>			366.0, $p<0.001$
Physician	355(2.7)	205(6.1)	
Nurse	4375(33.0)	939(27.7)	
Personal support worker or care aide	398(3.0)	232(6.8)	
Emergency medical personnel	200(1.5)	65(1.9)	
Allied health professional	5354(40.4)	1264(37.3)	
Laboratory worker	1200(9.1)	322(9.5)	
Pharmacist	147(1.1)	129(3.8)	
Dental professional	1222(9.2)	232(6.8)	
<b>Indigenous identity flag</b>			5.3, $p=0.02$
Indigenous identity	214(1.6)	46(1.1)	
<b>Population group flag</b>			42.0, $p<0.001$
Visible minority	1274(9.6)	490(12.6)	
<b>Participant's immigration status</b>			28.2, $p<0.001$
Immigrant or permanent resident	1346(10.2)	561(13.8)	
<b>Province or region of residence</b>			291.9, $p<0.001$
Atlantic provinces	1918(14.5)	615(13.7)	
Quebec	780(5.9)	351(7.8)	
Ontario	6334(47.8)	1769(39.5)	
Manitoba and Saskatchewan	1214(9.2)	460(10.3)	

	Complete N=13251	Non-complete N=4484	$\chi^2/P$ value
Alberta	1910(14.4)	643(14.3)	
British Columbia	1074(8.1)	573(12.8)	
Territories	21(0.2)	73(1.6)	
<b>Number of locations worked since March 2020</b>			16.5, $p<0.001$
1	9703(73.2)	3226(72.4)	
2	2478(18.7)	787(17.7)	
$\geq 3$	1070(8.1)	445(10.0)	
<b>Job setting type</b>			381.9, $p<0.001$
Acute care	5866 (44.3)	1513 (33.7)	
Long-term care	1180 (8.9)	568 (12.7)	
Outpatient and ambulatory care	4257 (32.1)	960 (21.4)	
Community/home care	518 (3.9)	124 (2.7)	
Congregate living	74 (0.6)	28 (0.6)	
other	1235 (10.2)	759 (16.9)	
<b>Number of years worked in current occupation</b>			83.1, $p<0.001$
Not stated	1680(12.7)	792(17.7)	
<10 years	4277(32.3)	1486(33.1)	
10-19 years	3447(26.0)	1005(22.4)	
>20 years	3847(29.0)	1201(26.8)	
<b>Contact with suspected or confirmed cases of COVID-19</b>			
Yes	5368(40.5)	1198(26.7)	1325.2, $p<0.001$
<b>Province or region of primary job location</b>			278.6, $p<0.001$
Atlantic provinces	1918(14.5)	603(13.8)	
Quebec	780(5.9)	293(6.7)	
Ontario	6334(47.8)	1748(40.0)	
Manitoba and Saskatchewan	1214(9.2)	453(10.4)	
Alberta	1910(14.4)	631(14.4)	
British Columbia	1074(8.1)	568(13.0)	

	Complete N=13251	Non-complete N=4484	$\chi^2/P$ value
Territories	21(0.2)	73(1.7)	
<b>Perceived mental health</b>			26.2, $p < 0.001$
Under cut-off (0)	8816(66.5)	3044 (67.9)	3.4, $p = 0.07^a$
Excellent	1158(8.7)	486(10.9)	
Very good	3333(25.2)	1146(25.6)	
Good	4325(32.6)	1412(31.6)	
Met cut-off (1)	4435(33.5)	1430 (31.9)	
Fair	3378(25.5)	1042(23.3)	
Poor	1057(8.0)	388(8.7)	
<b>Mental health compared to before the pandemic</b>			47.9, $p < 0.001$
Under cut-off (0)	3821(28.8)	1496 (33.4)	34.9, $p < 0.001^a$
Much better now	118(0.9)	75(1.7)	
Somewhat better now	327(2.5)	129(2.9)	
About the same	3376(25.5)	1292(29.0)	
Met cut-off (1)	9430(71.2)	2965 (66.1)	
Somewhat worse now	6895(52.0)	2188(49.0)	
Much worse now	2535(19.1)	777(17.4)	
<b>Perceived life stress</b>			29.0, $p < 0.001$
Under cut-off (0)	963(7.3)	363 (8.1)	4.2, $p = 0.04^a$
Not at all stressful	89(0.7)	60(1.4)	
Not very stressful	874(6.6)	303(6.9)	
Met cut-off (1)	12288(92.7)	4055 (90.4)	
A bit stressful	5082(38.4)	1687(38.2)	
Quite a bit stressful	5626(42.5)	1775(40.2)	
Extremely stressful	1580(11.9)	593(13.4)	

<sup>a</sup> chi square test result for binary outcome variable.

## Appendix B Descriptive Data for Outcome Variables

Table 15 Distribution of outcome variables in study populations

	N (%)		N (%)
<b>Perceived mental health</b>		<b>Perceived life stress</b>	
Under cutoff (0)	8816 (66.5)	Under cutoff (0)	963 (7.3)
Excellent	1158 (8.7)	Not at all stressful	89 (0.7)
Very good	3333 (23.2)	Not very stressful	874 (6.6)
Good	4325 (32.6)	Met cutoff (1)	12288 (92.7)
Met cutoff (1)	4435 (33.5)	A bit stressful	5082 (38.4)
Fair	3378 (25.5)	Quite a bit stressful	5626 (42.5)
Poor	1057 (8.0)	Extremely stressful	1580 (11.9)
<b>Mental health compared to before pandemic</b>			
Under cutoff (0)	3821 (28.8)		
Much better now	118 (0.9)		
Somewhat better now	327 (2.5)		
About the same	3376 (25.5)		
Met cutoff (1)	9430 (71.2)		
Somewhat worse now	6895 (52.0)		
Much worse now	2535 (19.1)		

## **Appendix C Chi Square Tests of Association**

**Table 16 Associations between baseline variables and perceived mental health**

	Perceived mental health					$\chi^2$	P value
	Excellent	Very good	Good	Fair	Poor		
	N (%)						
<b>Age</b>						568.2	<0.001
<35 years	221(19.1)	791(23.7)	1294(29.9)	1227(36.3)	510(48.2)		
35-44 years	270(23.3)	922(27.7)	1227(28.4)	1027(30.4)	308(29.1)		
45-54 years	357(30.8)	886(26.6)	1100(25.4)	715(21.2)	168(15.9)		
>=55 years	310(26.8)	734(22.0)	704(16.3)	409(12.1)	71(6.7)		
<b>Gender, female</b>	940(81.2)	2995(89.9)	4018(92.9)	3141(93.0)	974(92.1)	180.1	<0.001
<b>Occupation</b>						251.4	<0.001
Physician	42(3.6)	102(3.1)	99(2.3)	85(2.5)	27(2.6)		
Nurse	286(24.7)	945(28.4)	1428(33.0)	1282(38.0)	434(41.1)		
Personal support worker or care aide	28(2.4)	88(2.6)	132(3.1)	104(3.1)	46(4.4)		
Emergency medical personnel	14(1.2)	46(1.4)	56(1.3)	61(1.8)	23(2.2)		
Allied health professional	590(50.9)	1508(45.2)	1752(40.5)	1176(34.8)	328(31.0)		
Laboratory worker	92(7.9)	274(8.2)	400(9.2)	307(9.1)	127(12.0)		
Pharmacist	10(0.9)	38(1.1)	46(1.1)	41(1.2)	12(1.1)		
Dental professional	96(8.3)	332(10.0)	412(9.5)	322(9.5)	60(5.7)		
<b>Indigenous identity</b>	1148(99.1)	3287(98.6)	4254(98.4)	3321(98.3)	1027(97.2)	15.4	0.004
<b>Visible minority</b>	995(85.9)	2999(90.0)	3950(91.3)	3086(91.4)	947(89.6)	36.0	<0.001
<b>Immigrant or permanent resident</b>	205(17.7)	360(10.8)	395(9.1)	293(8.7)	93(8.8)	89.0	<0.001

	Perceived mental health					$\chi^2$	P value
	Excellent	Very good	Good	Fair	Poor		
	N (%)						
<b>Year of experience</b>						358.8	<0.001
Not stated	130(11.2)	380(11.4)	487(11.3)	502(14.9)	181(17.1)		
<10 years	294(25.4)	903(27.1)	1392(32.2)	1206(35.7)	482(45.6)		
10-19 years	270(23.3)	894(26.8)	1176(27.2)	878(26.0)	229(21.7)		
>20 years	464(40.1)	1156(34.7)	1270(29.4)	792(23.4)	165(15.6)		
<b>Contact with COVID-19 cases</b>	347(30.0)	1134(34.0)	1716(39.7)	1579(46.7)	592(56.0)	272.7	<0.001
<b>Job setting type</b>						220.7	<0.001
Acute care	391(33.8)	1329(39.9)	1925(44.5)	1629(48.2)	592(56.0)		
Long-term care	104(9.0)	273(8.2)	402(9.3)	300(8.9)	101(9.6)		
Outpatient and ambulatory care	476(41.1)	1213(36.4)	1372(31.7)	985(29.2)	211(20.0)		
Community/home care	32(2.8)	136(4.1)	173(4.0)	140(4.1)	37(3.5)		
Congregate living	5(0.4)	16(0.5)	27(0.6)	17(0.5)	9(0.9)		
Other	150(13.0)	366(11.0)	426(9.8)	307(9.1)	107(10.1)		
<b>Region of work</b>						64.6	<0.001
Atlantic provinces	151(13.0)	506(15.2)	640(14.8)	494(14.6)	127(12.0)		
Quebec	82(7.1)	220(6.6)	270(6.2)	164(4.9)	44(4.2)		
Ontario	591(51.0)	1561(46.8)	2064(47.7)	1614(47.8)	504(47.7)		
Manitoba and Saskatchewan	91(7.9)	312(9.4)	437(10.1)	279(8.3)	95(9.0)		

	Perceived mental health					$\chi^2$	P value
	Excellent	Very good	Good	Fair	Poor		
	N (%)						
Alberta	154(13.3)	464(13.9)	573(13.2)	524(15.5)	195(18.4)		
British Columbia	86(7.4)	267(8.0)	335(7.7)	296(8.8)	90(8.5)		
Territories	3(0.3)	3(0.1)	6(0.1)	7(0.2)	2(0.2)		
<b>Number of locations</b>						15.0	0.059
1	873(75.4)	2460(73.8)	3206(74.1)	2402(71.1)	762(72.1)		
2	205(17.7)	616(18.5)	778(18.0)	671(19.9)	208(19.7)		
3 or more	80(6.9)	257(7.7)	341(7.9)	305(9.0)	87(8.2)		

**Table 17 Associations between baseline variables and mental health compared to before pandemic**



	<b>Mental health compared to before pandemic</b>					$\chi^2$	P value
	Much better now	Somewhat better now	About the same	Somewhat worse now	Much worse now		
	N (%)						
<b>Age</b>						495.3	<0.001
<35 years	26(22.0)	98(30.0)	739(21.9)	2143(31.1)	1037(40.9)		
35-44 years	37(31.4)	85(26.0)	828(24.5)	1997(29.0)	807(31.8)		
45-54 years	31(26.3)	91(27.8)	982(29.1)	1652(24.0)	470(18.5)		
>=55 years	24(20.3)	53(16.2)	827(24.5)	1103(16.0)	221(8.7)		
<b>Gender, female</b>	106(89.8)	279(85.3)	2996(88.7)	6345(92.0)	2342(92.4)	49.1	<0.001
<b>Occupation</b>						339.2	<0.001
Physician	2(1.7)	9(2.8)	94(2.8)	182(2.6)	68(2.7)		
Nurse	24(20.3)	68(20.8)	856(25.4)	2325(33.7)	1102(43.5)		
Personal support worker or care aide	14(11.9)	17(5.2)	108(3.2)	184(2.7)	75(3.0)		
Emergency medical personnel	2(1.7)	6(1.8)	51(1.5)	101(1.5)	40(1.6)		
Allied health professional	56(47.5)	178(54.4)	1535(45.5)	2765(40.1)	820(32.3)		
Laboratory worker	3(2.5)	16(4.9)	327(9.7)	609(8.8)	245(9.7)		
Pharmacist	3(2.5)	5(1.5)	34(1.0)	85(1.2)	20(0.8)		
Dental professional	14(11.9)	28(8.6)	371(11.0)	644(9.3)	165(6.5)		
<b>Indigenous identity</b>	117(99.2)	319(97.6)	3333(98.7)	6787(98.4)	2481(97.9)	8.7	0.07
<b>Visible minority</b>	85(72.0)	273(83.5)	2992(88.6)	6316(91.6)	2311(91.2)	89.2	<0.001

	<b>Mental health compared to before pandemic</b>					$\chi^2$	P value
	Much better now	Somewhat better now	About the same	Somewhat worse now	Much worse now		
	N (%)						
<b>Immigrant or permanent resident</b>	37(31.4)	50(15.3)	458(13.6)	593(8.6)	208(8.2)	139.4	<0.001
<b>Year of experience</b>						285.6	<0.001
Not stated	18(15.3)	43(13.1)	375(11.1)	842(12.2)	402(15.9)		
<10 years	40(33.9)	129(39.4)	887(26.3)	2235(32.4)	986(38.9)		
10-19 years	31(26.3)	77(23.5)	844(25.0)	1831(26.6)	664(26.2)		
>20 years	29(24.6)	78(23.9)	1270(37.6)	1987(28.8)	483(19.1)		
<b>Contact with COVID-19 cases</b>	28(23.7)	87(26.6)	1002(29.7)	2858(41.5)	1393(55.0)	426.2	<0.001
<b>Job setting type</b>						335.2	<0.001
Acute care	23(19.5)	92(28.1)	1203(35.6)	3150(45.7)	1398(55.1)		
Long-term care	16(13.6)	24(7.3)	302(8.9)	605(8.8)	233(9.2)		
Outpatient and ambulatory care	50(42.4)	147(45.0)	1303(38.6)	2156(31.3)	601(23.7)		
Community/home care	10(8.5)	14(4.3)	133(3.9)	277(4.0)	84(3.3)		
Congregate living	1(0.8)	3(0.9)	20(0.6)	36(0.5)	14(0.6)		
Other	18(15.3)	47(14.4)	415(12.3)	671(9.7)	205(8.1)		
<b>Region of work</b>						113.3	<0.001
Atlantic provinces	12(10.2)	38(11.6)	556(16.5)	1014(14.7)	298(11.8)		
Quebec	10(8.5)	20(6.1)	212(6.3)	370(5.4)	168(6.6)		

	<b>Mental health compared to before pandemic</b>					$\chi^2$	<i>P</i> value
	Much better now	Somewhat better now	About the same	Somewhat worse now	Much worse now		
	N (%)						
Ontario	62(52.5)	190(58.1)	1665(49.3)	3244(47.0)	1173(46.3)		
Manitoba and Saskatchewan	5(4.2)	21(6.4)	283(8.4)	679(9.8)	226(8.9)		
Alberta	21(17.8)	25(7.6)	395(11.7)	1014(14.7)	455(17.9)		
British Columbia	8(6.8)	33(10.1)	257(7.6)	565(8.2)	211(8.3)		
Territories	0(0.0)	0(0.0)	8(0.2)	9(0.1)	4(0.2)		
<b>Number of locations</b>						11.9	0.154
1	78(66.1)	225(68.8)	2504(74.2)	5062(73.4)	1834(72.3)		
2	27(22.9)	75(22.9)	622(18.4)	1260(18.3)	494(19.5)		
3 or more	13(11.0)	27(8.3)	250(7.4)	573(8.3)	207(8.2)		

**Table 18 Associations between baseline variables and perceived life stress**

	Perceived life stress					$\chi^2$	P value
	Not at all stressful	Not very stressful	A bit stressful	Quite a bit stressful	Extremely stressful		
	N (%)						
<b>Age</b>						99.1	<0.001
<35 years	12(13.5)	229(26.2)	1560(30.7)	1787(31.8)	455(28.8)		
35-44 years	20(22.5)	211(24.1)	1414(27.8)	1621(28.8)	488(30.9)		
45-54 years	30(33.7)	214(24.5)	1202(23.7)	1376(24.5)	404(25.6)		
>=55 years	27(30.3)	220(25.2)	906(17.8)	842(15.0)	233(14.7)		
<b>Gender, female</b>	70(78.7)	745(85.2)	4591(90.3)	5214(92.7)	1448(91.6)	75.3	<0.001
<b>Occupation</b>						361.6	<0.001
Physician	1(1.1)	16(1.8)	113(2.2)	155(2.8)	70(4.4)		
Nurse	15(16.9)	185(21.2)	1428(28.1)	2087(37.1)	660(41.8)		
Personal support worker or care aide	7(7.9)	21(2.4)	150(3.0)	157(2.8)	63(4.0)		
Emergency medical personnel	0(0.0)	24(2.7)	87(1.7)	70(1.2)	19(1.2)		
Allied health professional	56(62.9)	473(54.1)	2300(45.3)	2067(36.7)	458(29.0)		
Laboratory worker	4(4.5)	74(8.5)	457(9.0)	520(9.2)	145(9.2)		
Pharmacist	1(1.1)	4(0.5)	56(1.1)	67(1.2)	19(1.2)		
Dental professional	5(5.6)	77(8.8)	491(9.7)	503(8.9)	146(9.2)		
<b>Indigenous identity</b>	88(98.9)	863(98.7)	5011(98.6)	5529(98.3)	1546(97.8)	5.6	0.228
<b>Visible minority</b>	71(79.8)	785(89.8)	4566(89.8)	5150(91.5)	1405(88.9)	26.1	<0.001

	Perceived life stress					$\chi^2$	P value
	Not at all stressful	Not very stressful	A bit stressful	Quite a bit stressful	Extremely stressful		
	N (%)						
<b>Immigrant or permanent resident</b>	26(29.2)	114(13.0)	532(10.5)	486(8.6)	188(11.9)	63.4	<0.001
<b>Year of experience</b>						42.1	<0.001
Not stated	7(7.9)	95(10.9)	580(11.4)	754(13.4)	244(15.4)		
<10 years	27(30.3)	268(30.7)	1648(32.4)	1851(32.9)	483(30.6)		
10-19 years	25(28.1)	207(23.7)	1364(26.8)	1436(25.5)	415(26.3)		
>20 years	30(33.7)	304(34.8)	1490(29.3)	1585(28.2)	438(27.7)		
<b>Contact with COVID-19 cases</b>	13(14.6)	218(24.9)	1747(34.4)	2549(45.3)	841(53.2)	351.8	<0.001
<b>Job setting type</b>						279.9	<0.001
Acute care	19(21.3)	280(32.0)	2097(41.3)	2685(47.7)	785(49.7)		
Long-term care	15(16.9)	58(6.6)	373(7.3)	533(9.5)	201(12.7)		
Outpatient and ambulatory care	35(39.3)	359(41.1)	1823(35.9)	1653(29.4)	387(24.5)		
Community/home care	0(0.0)	32(3.7)	201(4.0)	225(4.0)	60(3.8)		
Congregate living	1(1.1)	5(0.6)	24(0.5)	35(0.6)	9(0.6)		
Other	19(21.3)	140(16.0)	564(11.1)	495(8.8)	138(8.7)		
<b>Region of work</b>						92.0	<0.001
Atlantic provinces	13(14.6)	131(15.0)	836(16.5)	775(13.8)	163(10.3)		
Quebec	6(6.7)	62(7.1)	262(5.2)	384(6.8)	66(4.2)		

	Perceived life stress					$\chi^2$	P value
	Not at all stressful	Not very stressful	A bit stressful	Quite a bit stressful	Extremely stressful		
	N (%)						
Ontario	47(52.8)	454(51.9)	2393(47.1)	2632(46.8)	808(51.1)		
Manitoba and Saskatchewan	4(4.5)	59(6.8)	474(9.3)	524(9.3)	153(9.7)		
Alberta	11(12.4)	101(11.6)	706(13.9)	841(14.9)	251(15.9)		
British Columbia	7(7.9)	65(7.4)	403(7.9)	462(8.2)	137(8.7)		
Territories	1(1.1)	2(0.2)	8(0.2)	8(0.1)	2(0.1)		
<b>Number of locations</b>						20.8	0.008
1	69(77.5)	634(72.5)	3672(72.3)	4172(74.2)	1156(73.2)		
2	14(15.7)	185(21.2)	1009(19.9)	996(17.7)	274(17.3)		
3 or more	6(6.7)	55(6.3)	401(7.9)	458(8.1)	150(9.5)		

## Appendix D: Unadjusted, age- and multivariable adjusted results

Table 19 Unadjusted, age- and multivariable adjusted associations of three IPC measures with binary outcomes

	Perceived mental health		Mental health compared to before pandemic		Perceived life stress	
	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>
<b>Visitor management</b>						
Unadjusted	1.05 (0.96-1.15)	0.29	1.24 (1.13-1.36)	<0.001	1.31 (1.13-1.52)	<0.05
Age-sex adjusted	1.04 (0.95-1.14)	0.39	1.24 (1.13-1.35)	<0.001	1.31 (1.12-1.52)	<0.001
Multivariable adjusted <sup>a</sup>	0.92 (0.84-1.01)	0.08	1.10 (1.00-1.21)	0.05	1.14 (0.98-1.33)	0.09
<b>Handling of deceases</b>						
Unadjusted	1.27 (1.15-1.39)	<0.001	1.35 (1.21-1.49)	<0.001	1.46 (1.21-1.77)	<0.001
Age-sex adjusted	1.21 (1.10-1.33)	<0.001	1.29 (1.16-1.43)	<0.001	1.40 (1.16-1.71)	<0.001
Multivariable adjusted <sup>a</sup>	1.07 (0.97-1.19)	0.35	1.07 (0.84-1.20)	0.27	0.95 (0.77-1.20)	0.07

The multivariable models were adjusted for age, gender, occupation, visible minority, direct exposure to suspected or confirmed cases, job setting type, region of work, and years of experience.

**Table 20 Unadjusted, age- and multivariable adjusted associations of three IPC measures with ordinal outcomes**

	Perceived mental health		Mental health compared to before pandemic		Perceived life stress	
	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>
<b>Visitor management</b>						
Unadjusted	1.04 (0.96-1.12)	0.29	1.27 (1.18-1.38)	<0.001	1.28 (1.19-1.39)	<0.05
Age-sex adjusted	1.03 (0.96-1.11)	0.39	1.27 (1.17-1.37)	<0.001	1.30 (1.19-1.39)	<0.001
Multivariable adjusted <sup>a</sup>	0.91 (0.84-0.98)	0.02	1.08 (0.99-1.17)	0.09	1.12 (1.03-1.21)	0.01
<b>Handling of deceases</b>						
Unadjusted	1.25 (1.15-1.35)	<0.001	1.42 (1.30-1.54)	<0.001	1.55 (1.43-1.69)	<0.001
Age-sex adjusted	1.18 (1.09-1.28)	<0.001	1.35 (1.24-1.47)	<0.001	1.54 (1.41-1.67)	<0.001
Multivariable adjusted <sup>a</sup>	1.02 (0.94-1.12)	0.06	1.12 (1.03-1.23)	0.02	1.28 (1.17-1.40)	<0.001

The multivariable models were adjusted for age, gender, occupation, visible minority, direct exposure to suspected or confirmed cases, job setting type, region of work, and years of experience.



**Appendix E: Impacts of COVID-19 on Health Care Workers: Infection  
Prevention and Control – 2020 Public Use Microdata File (PUMF) –  
Crowdsource May 2021**

