The “loneliness epidemic”, intersecting risk factors and relations to mental health help-seeking: a population-based study during COVID-19 lockdown in Canada

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Authors: Shen (Lamson) Lin, PhD ab*

a - Department of Social and Behavioural Sciences, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong SAR, China
b - Factor-Inwentash Faculty of Social Work, University of Toronto, 46 Bloor St W, Toronto, ON M5S 1V4, Canada
* - Corresponding author.

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Correspondence:
Dr. Shen (Lamson) Lin, Assistant Professor, Department of Social and Behavioural Sciences, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong SAR, China
E-mail addresses:
shenlin@cityu.edu.hk
lamsonlin.lin@mail.utoronto.ca

ORCID: https://orcid.org/0000-0002-9792-2372

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The “loneliness epidemic”, intersecting risk factors and relations to mental health help-seeking: a population-based study during COVID-19 lockdown in Canada

**Background:** Pandemic-induced social distancing and stay-at-home orders, while successful in decreasing the transmission of COVID-19, could exacerbate loneliness. Few studies have examined how pandemic-related social determinants intersect to shape pandemic loneliness and its relations to mental health care in Canada.

**Methods:** A population-representative sample of 3,772 adults from the Canadian Perspective Survey Series (CPSS-6; January 25 to 31, 2021) was analyzed. Gender-specific logistic regression was employed to investigate the association between three-item loneliness scale (UCLA-3) with socio-demographics, job precarity, health behaviours, social isolation indicators, and mental health help-seeking. Classification and Regression Tree (CART) modelling was also used to identify intersecting risk factors and the most important predictor of severe loneliness (UCLA-3 score ≥ 7).

**Results:** The estimated prevalence of severe loneliness was 34.7% in Canada, with women significantly higher than men (38.1% vs 31.3%, p<0.001). Pandemic loneliness were more prevalent in female (OR=1.53, 99% CI: 1.26 – 1.85), those who were younger (OR’s range 1.42 – 3.00), women without college degree (OR=1.44, 99% CI: 1.01 – 2.04), those living alone (OR=1.56, 99% CI: 1.09 – 2.23), immigrant men (OR=1.79, 99% CI: 1.23 – 2.60), those with small network (OR’s range: 1.73 – 3.26), those who were absent from work due to COVID-19 related reasons (OR=2.11, 99% CI: 1.04 – 4.28), past-month binge drinkers (OR’s range: 1.39 – 1.70) and cannabis user (OR=1.47, 99% CI: 1.12 – 1.93). The CART algorithm identifies that immigrants who experienced pandemic-triggered job insecurity were the most-at-risk group of severely loneliness. Loneliness was positively associated with formal help-seeking from mental health professionals (OR=1.71, 99% CI: 1.21 – 2.41), informal help-seeking from social circle (OR=1.51, 99% CI: 1.17 – 1.95), and unmet mental health needs (OR=1.78, 99% CI: 1.29 – 2.49).

**Limitations:** Cross-sectional data prohibits causal inferences.

**Conclusion:** The COVID-19 pandemic converges with loneliness epidemic in Canada. Prevention and intervention programs should target upstream social determinants of mental health, especially the intersection of migration status and job precarity, to eliminate loneliness during the pandemic.

**Key words:** Psychiatric epidemiology; General population; COVID-19; loneliness; Machine learning
The “loneliness epidemic”, intersecting risk factors and relations to mental health help-seeking: a population-based study during COVID-19 lockdown in Canada

1. Introduction

The COVID-19 pandemic has been causing disruption, unpredictability, and uncertainty in all aspects of human life (Bavel et al., 2020; Fancourt et al., 2021). Since the World Health Organization (WHO) declared that the new coronavirus (COVID-19) outbreak was a global pandemic on March 11, 2020 (Cucinotta & Vanelli, 2020), health authorities around the world have imposed various public health measures including societal lockdowns, flight restrictions, workplace closures, mandatory quarantine (de Lima, Carlos Victor Chaves et al., 2020; Shi et al., 2020; Wang et al., 2021), enforced social distancing (Kämpfen et al., 2020; Marroquín et al., 2020; Zhao et al., 2020) and stay-at-home orders (Pierce, Hope et al., 2020; Turna et al., 2021). While necessary in slowing the spread of the virus, there have been widespread concerns that these COVID-19 containment strategies could exacerbate pre-existing “loneliness epidemic” (Di Gessa & Price, 2021; O'Sullivan et al., 2021), since they are, by design, meant to keep individuals apart from person-to-person interactions and to curtail activities organized in community congregate settings, such as indoor recreational events, gymnastic exercises, and religious/spiritual coping groups (Bao et al., 2021), which could result in greater levels of social isolation and difficulties in maintaining social connections.

In pre-pandemic times, loneliness has already been recognised as one of the major public health concerns that could affect people of any age (Bao et al., 2021; Bu et al., 2020a; Bu et al., 2020b), considering that loneliness has been associated with a myriad of adverse psychological, physiological, and behavioural consequences, including depression, suicidal ideation, cardiovascular diseases, coronary heart disease, metabolic syndrome, and increased all-cause
mortality (Bu et al., 2020; Solmi et al., 2020; Steptoe et al., 2013). This recognition has led to the government’s appointment of the “Minister of Loneliness” to take concrete policy actions in the United Kingdom and Japan (Escalante et al., 2021). During the pandemic, a recent systemic review indicates that, as a result of this large-scale public health crisis, the general population are experiencing problematic levels of loneliness on a global scale (Loades et al., 2020). A burgeoning body of psychiatry research has found that women, youth, divorced individuals, low-income households, those living alone, students, people without large social networks, and those having intolerance of uncertainty were at elevated risks of loneliness amidst this public health emergency (Loades et al., 2020; McQuaid et al., 2021; Rumas et al., 2021).

Although scientists have been exploring the magnitude, the trends and the mechanisms of this traumatic event’s impact on mental health in Canada, the current landscape of Canadian literature on loneliness prevalence during the early stage of COVID-19 pandemic has been constrained by several methodological or theoretical limitations, such as the use of non-probability sampling (Lowe et al., 2022; McQuaid et al., 2021; Rumas et al., 2021; Wickens et al., 2021), single-item measure of loneliness (McDonald et al., 2022; Savage et al., 2021; Wickens et al., 2021), and the focus of a specific sub-population (Howden et al., 2022; Savage et al., 2021). While these early insights based on rapid approaches are valuable, high-quality population-representative data on loneliness arising from the pandemic are still needed to inform appropriate evidence-based health policies to mitigate mental health sequelae (Holmes et al., 2020; Pierce, McManus et al., 2020). Furthermore, although gender-specific differences in loneliness have been examined before the pandemic (Ernst et al., 2021), far less is known about the extent to which psychological consequences of the COVID-19 pandemic related to labour force participation and social isolation differ by the role of gender. In fact, a recent commentary from *The Lancet* pointed out that the
gendered impact of this public health crisis has not been thoroughly addressed in research and policy response (Wenham et al., 2020).

Emerging studies have linked feeling lonely to reduced odds of COVID-19 preventive behaviours such as mask wearing and hands sanitizing (Kang et al., 2021; Stickley et al., 2021) and increased propensity to health care utilization (Bao et al., 2021; Gerst-Emerson & Jayawardhana, 2015). Studies also revealed that efforts have been made to adapt the provision of mental health services to the pandemic response by modifying access to diagnosis, support, and treatment such as the delivery of tele-mental health and remote therapy (Ashcroft et al., 2021; Moreno et al., 2020); yet many questions remain about whether this rapid transition to virtual care could be responsive to the immediate mental health needs of Canadians so as to address pandemic-induced loneliness symptoms. Given that the COVID-19 pandemic is constantly evolving and that pandemic-related stressors could impose an enduring impact, it is essential to assess the causes and consequences of loneliness symptoms during the second wave of COVID-19 infection in Canada. This timely surveillance could not only inform targeted interventions to address pandemic-related mental health problems but also be conducive to the continuous assessment of mental health care system. Therefore, guided by the pandemic-specific conceptual framework (see Figure 1), the present study aims to examine the following three research questions:

(1) What are risk and resilience factors of loneliness symptoms and how does these factors differ between men and women in the general population?

(2) How do risk factors intersect to affect loneliness symptoms and which is the most important determinant during the pandemic?

(3) Is loneliness a robust indicator associated with greater likelihood of mental health help-seeking after controlling for other mental health conditions?
2. Methods

2.1 Data source and study context

The data were drawn from the Canadian Perspective Survey Series – Substance Use and Stigma during the Pandemic (CPSS6-COVID), a sixth online survey, conducted during January 25 to January 31, 2021. This timing was at the larger second wave of the pandemic in Canada (778,972 confirmed cases and 20,032 deaths as of January 31, 2021) and only around 1.5 month after the first COVID-19 vaccine was officially authorized with most Canadians unvaccinated. The purpose of the cross-sectional CPSS survey series is a multi-wave effort to evaluate the health and socioeconomic consequences of the COVID-19 pandemic among Canadians aged 15 years or older in 10 provinces, starting from March 2020 (Lin, 2022). The CPSS6-COVID survey, in particular, aims to evaluate the ongoing impact of COVID-19 on Canadians’ mental health and substance use, with a special focus on the social stigma of addiction. The sampling frame of CPSS is a probabilistic panel (i.e., four rotation groups) from the Labour Force Survey (LFS) created by a stratified multi-stage sampling. Participants answering the LFS for the last time in April, May, June and July of 2019 was selected at random to participate in the CPSS and received emailed survey invitations with a link for online self-completion. Details of the survey methodology regarding the sampling frame and data collection are available elsewhere. The CPSS represents 98% of the national populations and excludes persons living on First Nations reserves; the institutionalized population, and households in remote areas. The collection response rate of the CPSS6 was 54.4% and may reflect a tight schedule for data collection and COVID-19-related fatigue during the pandemic. Among the total 3941 respondents in the CPSS6, individuals
with missing values were excluded in this study (n= 169, 4.3% of the total), yielding an analytic sample of 3,772.

2.2 Ethical considerations

The analyses were based on the public-use microdata files (PUMF) available to both Canadian and international researchers via Statistics Canada’s Data Liberation Initiative. The public-use data are completely de-identified with necessary suppression methods to protect confidentiality; thus, according to the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans – TCPS 2 (2018), this study is considered as non-human subject research that does not require institutional ethics review.

2.3 Measurements

**Pandemic loneliness symptoms** were assessed by the widely used three-item loneliness scale (UCLA-3) (Hughes et al., 2004), a validated short version derived from the 20-item Revised University of California at Los Angeles Loneliness Scale (R-UCLA). Questions were re-designed in the pandemic context: “In general, how often have you felt the following since the start of the COVID-19 pandemic?” . The UCLA-3 evaluates three symptoms: feelings of lacking companionship, feeling left out of life, and feeling isolated from others. The response option in the CPSS-6 survey was rated on a five-point Likert scale; and to be consistent with prior literature (Gyasi et al., 2022; Polenick et al., 2019; Varga et al., 2021) and original UCLA-3 scale’s coding approach (Hughes et al., 2004), we converted it back into a three-point Likert scale: 1 = never or hardly ever; 2 = some of the time; 3 = often or always. First, ratings were summed to generate a composite measure (ranging: 3–9), with higher scores indicating greater loneliness. Second, to produce a binary measure, we used a cut-off score of 7 or greater on the UCLA-3 to classify
respondents: 3–6 (not severely lonely); 7–9 (severely lonely). These cut-off points have been applied in previous studies (Gyasi et al., 2022; Polenick et al., 2019; Varga et al., 2021). In this CPSS-6 data, the UCLA-3 has a Cronbach’s alpha of 0.804 ($M = 5.64$, $SD = 1.90$) in the overall sample. Third, for sensitivity analytical purposes, three loneliness symptom items were coded as three binary variables (0=never/hardly ever/some of the time; 1=often/always).

**Other mental health conditions.** Self-rated mental health (Chiu et al., 2020; Islam et al., 2014), perceived life stress (Ahmad et al., 2014; Villatoro et al., 2018) and mental health change compared to pre-pandemic were ascertained three single-item questions as covariates to predict mental health help-seeking. SRMH was assessed by a question asking, “In general, how would you describe your mental health?” and binary coded (0=excellent/very good/good; 1=fair/poor). Life stress was assessed by a question asking, “In general, how would you describe the amount of stress in your life, since the start of the COVID-19 pandemic?” (0= Not at all stressful/A little stressful; 1=stressful/very stressful/extremely stressful). MH change (vs pre-pandemic) was examined by the item: “Compared to before the COVID-19 pandemic, how would you say your mental health is now?” (0=about the same; 1=much/somewhat better; 2=somewhat worse now; 3=much worse now).

**Social determinants of mental health.** Social demographics, that signify conditions where people are born, grow, live, and work (McQuaid et al., 2021), were collected in the CPSS-6. These included (1) age groups, (2) gender, (3) highest educational attainment, (4) migration status (Canadian-born residents versus migrants), (5) residency (urban or rural), (6) housing type, (7) precarious employment status, and (8) health behaviors. *Precarious employment* was a derived variable to investigate the pandemic's impact on labor market participation (worked at least one
hour for pay, including self-employment) in the past 7 days prior to the survey (i.e., January 18 to 22, 2021). Respondents were first asked: “Did you work (at least one hour) at a job or business?” for the designated week and, if so, “Did you have a job or business from which you were absent (for the entire week)?”. To measure the direct disruption from the COVID-19 pandemic, respondents who had a casual job with no work available at the week were not considered as absent from work. Those who replied affirmatively were asked: “What was the main reason you were absent from work that week?” The response options were categorized into five levels: 1=employed and at work for at least part of the week (including work from home); 2=employed but absent for the entire week due to COVID-19 (e.g., business closure, layoff or personal circumstances including “personal safety, own or household member's diagnosis, self-isolation after recent travel, taking care of children due to school closure”); 3=employed but absent for the entire week due to other reasons not related to COVID-19, including planned absence (e.g., “vacation, work schedule, maternity or parental leave, seasonal business”) and unplanned absence (e.g., “illness other than COVID-19, caring for children or elder relative for non-COVID-19 reasons”); 4= not employed; 5=not stated. Health behaviors during the pandemic such as binge drinking (i.e., consuming five or more drinks on one occasion), cannabis use, and opioid use were also ascertained.

**Social isolation component** was assessed by four separated indicators of social integration collected in the CPSS-6 demographic questions: (1) marital status, (2) living arrangements measured by household size, (3) social network size, and (4) social participation, in consistent with prior research (Steptoe et al., 2013). **Social network size** was measured by the question: “Approximately how many relatives and friends do you have who you feel close to, that is, who you feel at ease with and can talk to about what is on your mind?”. The response was coded as: 0=no person; 1=one to two persons; 2=three persons or more. **Social participation** was measured
by the question: “In the past 12 months, were you a member or participant in the following groups, organizations, or associations (include groups you are active in online)?” Respondents could choose from a multiple response set of options, such as recreational, cultural, educational, political, religious, or hobby organization, civic or community (youth/senior) association, immigrant, or ethnic groups and/or others. These groups could be formally organized or informal groups of people who get together regularly to do an activity or talk about things. The response was aggregated as: 0=no group; 1=at least one group.

**Mental health help-seeking during COVID-19.** We examined four binary variables (yes/no) to capture the full spectrum of mental health (MH) support and treatment during the pandemic. Professional MH care was assessed by the question: “Since the beginning of the COVID-19 pandemic, have you seen, or talked on the telephone to, any of the following people about problems with your emotions, mental health or use of alcohol or drugs?” Options included psychiatrist; family doctor or general practitioner; psychologist; nurse; social worker, counsellor, or psychotherapist. Informal MH support was assessed by the same question and was flagged if respondents selected any of the options, including family member, friend, co-worker, supervisor, boss, teacher, school principal, or other persons. Unmet MH need was measured by the question (Urbanoski et al., 2008): “Since the beginning of the COVID-19 pandemic, was there ever a time when you felt that you needed help for your emotions, mental health or use of alcohol or (prescribed and non-prescribed) drugs, but you didn’t receive it?”. Psychiatric medication use was assessed by the question: “Since the beginning of the COVID-19 pandemic, have you taken any prescribed medication to help you with problems with your emotions, mental health or use of alcohol or drugs?”. 
2.4 Statistical analysis

Statistical analyses and data management were performed using the SPSS software package, Version 26 (IBM Corp., Armonk, N.Y., USA). First, unweighted statistics were used to describe the overall sample characteristics, while a normalized weight was applied to calculate weighted percentages that represent the national estimates. Stratified by gender, cross-tabulation analyses were generated by Chi-square tests ($\chi^2$) using weighted percentages to compare between-group differences by loneliness. Second, binary logistic regression was conducted to examine associations between explanatory variables and the probability of severe loneliness in the general sample as well as gender-specific samples. Due to multiple comparisons, a more stringent criterion was employed for the statistical significance ($p < 0.01$). Third, the Classification and Regression Tree (CART) was performed to identify intersecting risk factors of severe loneliness. Lastly, another series of logistic regression analyses were conducted to evaluate the robustness of the association between loneliness and mental health help-seeking after controlling for all covariates including other mental health conditions.

As a machine learning approach, the CART algorithm is binary decision tree that allows identifying complex interactions between variables across the measurement space (Smits et al., 2008); and the strongest predictor from the root node by splitting the data into child nodes repeatedly (Lemon et al., 2003). Because decision tree modelling could detect meaningful intersections and split branches based on heterogeneity, this approach was considered a promising data-driven explorative tool for quantitative intersectionality research (Bauer & Scheim, 2019; Evans, 2019) and for the identification of at-risk populations in public health science (Lemon et al., 2003). In this study, cases with severe loneliness were assigned a value of ‘1’, and others were assigned a value of ‘0’. The CART model selected variables with close associations with loneliness.
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from all influencing factors and visually displayed their interactions in the form of a tree diagram. Categories of each predictor were merged if they are deemed as homogenous with respect to loneliness. To avoid overfitting (Kreatsoulas & Subramanian, 2018), we set the stopping rules to require each child node with a minimum sample size of \( n = 50 \) and branching limited to five levels. We used cross-validation with 10 sample folds to calculate misclassification risk (Rhodes et al., 2011).

3. Results

3.1 Sample characteristics and prevalence of loneliness

Table 1 summarizes weighted percentages of all variables stratified by severe loneliness. The overall sample (\( n=3,772 \)) mainly consisted of respondents who were Canadian-born (75.6%), aged >25 years (87.2%), college degree or above (62.1%), urban residents (85.6%), and living in a single-detached house (60.9%). The sex distribution was even (men: 49.9%; women: 50.1%). More than half of respondents were employed and at work (54.2%) while only 1.7% were absent from work due to COVID-19 related reasons. Most respondents tended to report moderate-to-good social integration: married (61.8%), cohabitating (83.9%), size of social network >2 persons (58.5%). Most had healthy habits: no past-month binge drinking (70.8%) and never use cannabis (71%). The estimated prevalence of severe loneliness (UCLA-3 score ≥7) was 34.7% since the pandemic (feeling isolated from others: 41.9%; lacking companionship: 23.4%; feeling left out of life: 17%), while women sample had significantly higher rate of severe loneliness than male sample (38.1% vs 31.3%, \( p<0.001 \)). In the entire sample, 13.6% reported seeking professional consultation for mental health, 9.9% of respondents reported prescribed medication use, 23.9% of respondents reported seeking informal support, and 13.4% of respondents reported unmet mental
health needs. Chi-square statistics revealed that most variables were significantly linked to loneliness in the overall sample, except for urban-rural residency (p>0.05). There were gender-specific risk factors for loneliness: lower educational attainment was correlated with loneliness only among women while urban residency and living alone were stood out only among men.

[Editor: please insert Table 1 from the Appendix]

3.2 Logistic regression predicting severe loneliness

Table 2 presents the multivariable-adjusted associations between major risk factors and severe loneliness in the general sample and stratified by gender. Logistic regression analysis revealed that young age (15–24 years) (OR = 3.00, 99% CI: 1.85 – 4.87), female (OR=1.53, 99% CI: 1.26 – 1.85), absence from work due to COVID-19 reasons (OR=2.11, 99% CI: 1.04 – 4.28), living alone (OR=1.56, 99% CI: 1.09 – 2.23), cannabis use in the past month (OR=1.52) were significantly associated with severe loneliness. There were also gradient effects between severe loneliness with diminished size of social circle (OR’s range:1.73 – 3.26) and frequency of binge drinking (OR’s range: 1.39 – 1.70). For sex-specific analysis, one the one hand, immigrant status (OR=1.79, 99% CI: 1.23 – 2.60), living alone (OR=2.03, 99% CI: 1.09 – 3.75) and opioids use (OR’s range: 1.81 – 2.85) were uniquely associated with severe loneliness in the male sample, but they did not come through in the female sample; on the other hand, lower educational attainment (OR=1.44, 99% CI: 1.01 – 2.04), absence from work due to COVID-19 reasons (OR=2.48, 99% CI: 1.05 – 5.86) and past-month cannabis use (OR=1.59, 99% CI: 1.08 – 2.33) were three risk factors of severe loneliness mainly driven by the female sample but not by male sample.

3.3 Decision tree model predicting severe loneliness
Figure 2 provides the dendrogram of how CART algorithm identifies risk factors for severe loneliness (benchmark rate: 34.7%). The loneliness rate ranged from 19.7% to 86.2% across 11 terminal nodes. The performance of the CART tree as a classifier was moderate, with an overall classification agreement of 67.7%. The cross-validation estimate for risk of misclassification was low at 0.33. As shown in the top parent branch, job precarity due to COVID-19 reasons (and not stated) was the strongest predictor of severe loneliness (64.1% vs 33.0%). Among those experienced pandemic-related job precarity, nativity status provided the most significant split for loneliness with immigrants substantially higher than Canadian-born residents (86.2% vs. 48.7%). Besides this crucial interaction, the CART tree elucidates how risk profiles intersect in more complex way to shape loneliness such as four-order intersection (job precarity × social network size × cannabis use × marital status) and five-order intersection (job precarity × social network size × age × binge drinking × education level). Notably, the absence of five risk factors sequentially were the most protective from developing loneliness when respondents did not experience pandemic-related job precarity, have larger social circle (> 2 persons), older age (> 24 years), no past-month binge drinking and with higher educational attainment (≥ college degree).

3.4 Logistic regression predicting mental health help-seeking

Table 3 shows three panels of multiple logistic regression models to test the association between loneliness and mental health help-seeking (full statistics available upon request). After adjusting for covariates and mental health conditions including SRMH and perceived life stress, severe loneliness was positively associated with professional care for MH (OR=1.71, 99% CI: 1.21 – 2.41), informal support for MH (OR=1.51, 99% CI: 1.17 – 1.95), and unmet MH needs (OR=1.78, 99% CI: 1.29 – 2.49), whereas there was no significant correlation between loneliness and
psychiatric medication use (OR=0.76, p=0.132, not shown in Table 3). Loneliness composite scores and the same covariates were added into models to illustrate the robustness of these associations (all p’s <0.001). In addition, loneliness symptoms were entered into the identical models to provide more nuanced insights: respondents with feeling often left out of life (OR=1.64, 99% CI: 1.10 – 2.43) was more likely to have unmet MH needs; respondents who often felt lacking companionship (OR=1.59, 99% CI: 1.09 – 2.33) and left out of life (OR=1.69, 99% CI: 1.09 – 2.63) were more likely to seek professional consultation for MH; respondents who often felt isolated from others had two-fold greater odds of seeking informal support for MH (OR=2.24, 99% CI: 1.71 – 2.93).

4. Discussion

To our best knowledge, this is the first large-scale study to estimate the population prevalence of severe loneliness based on the UCLA-3 validated scale, its intersecting risk factors, and health care consequences during the COVID-19 pandemic in Canada. The finding revealed that, in the times of pandemic lockdown, approximately one-in-three Canadians (34.7%) was at risk of experiencing severe loneliness, with women’s prevalence significantly higher than men’s (38.1% vs 31.3%, p<0.001). This Canadian national estimate of loneliness based on a probabilistic sample was substantially higher than those statistics using an identical measure of loneliness (UCLA-3) reported in other regions during the pandemic, including the prevalence (24.2 %) from China (Bao et al., 2021), the proportion (14% - 27%) from UK (Bu et al., 2020; Groarke et al., 2020), as well as the percentages (7% - 18%) from other Western and Northern European countries (Varga et al., 2021). In addition, youth and adolescent, women, people with lower educational background, people living alone, and people with limited social circle had an elevated risk of
developing severe loneliness during the pandemic. These at-risk groups are consistent with psychiatric literature on loneliness during ordinary times (Lim et al., 2020) as well as the pandemic period (Bao et al., 2021; Bu et al., 2020; Bu et al., 2020). The observed gender disparities in loneliness in this study were consistent with other epidemiological studies since the onset of COVID-19, as the intense isolation may impose a greater disruption on women who may be more prone to inflammation under stressful situations (Lin, 2022) and tend to depend more heavily than men on social connections (McQuaid et al., 2021).

The concerning population prevalence implies that, at the second larger wave of COVID-19 infections, severe loneliness was ubiquitous among general Canadian residents (Detsky & Bogoch, 2021), probably due to the pandemic-induced disruption of habitual stress-coping mechanisms caused by the lockdown measures. Since the data collection period (January 25 to 31, 2021) was at the third week following the New Year's Day, being unable to participate in this annual ritual of national celebration with friends and families, for the first time, may exacerbate the feeling of loneliness (Bu et al., 2020). Also, it is possible that the lockdown-related fatigue as well as the fluctuations in COVID-19 restrictions may have aggravated the sensations of loneliness at the second wave. For example, the Ontario’s government paused the 3-stage re-opening plan (since July 17, 2020) by implementing a province-wide shut down on December 26, 2020, further initiated a Stay-at-Home order and Declaration of Emergency on January 14, 2021, and subsequently extended it for another 30 days until February 19, 2021, in light of the emerging COVID-19 variants (Public Health Ontario, 2021). According to the Canadian Medical Association, constant changes in public health restrictive measures across the country had led to confusion and frustration in the public (The Canadian Press, 2021). As such, it may speak to why “feeling isolated from others” became the major source of the “loneliness epidemic”, as its
prevalence (41.9%) was considerably higher than the other two symptoms (lacking companionship: 23.4%; left out of life: 17%), reflecting the repercussion of enforced social distancing, lockdowns and self-isolation. These preventative measures also entailed daily adjustments and multiple waves of losses in many areas of life (i.e., economic security, personal freedom), leading to feelings of loss to grief. Therefore, this abnormal phenomenon has been termed as the “lockdown loneliness” across the globe (Shah et al., 2020)

Our research is novel because the decision tree analysis highlights that COVID-19-related job insecurity was the strongest determinant for severe loneliness among many other social factors and that immigrants who experienced job insecurity because of a business closure/layoff or personal circumstances related to COVID-19 were the most-at-risk group of developing severely loneliness during the pandemic in Canada. A recent Canadian study supports that precarious employment during the pandemic is associated with compromised mental health conditions including generalized anxiety disorders (Lin, 2022). Moreover, the pandemic-triggered job insecurity and its intersecting impact with immigration status on severe loneliness have not, to our knowledge, been reported elsewhere. This intersection may reflect the fact that immigrants to Canada are over-represented in low-paid, low-skilled precarious work such as retail positions, cleaners, or cashiers that require extensive interaction with the public (Hira-Friesen, 2018); and thus, at greater occupational risk of COVID-19 infections and consequential employment insecurity (McNamara et al., 2021). Immigrants are especially vulnerable to isolation and loneliness, in pre-pandemic times, because of their resettlement in a new environment where they may face a variety of post-migration stressors such as language obstacles, reduced social networks, a diminished sense of community belonging, racial discrimination, and poverty (Lin, 2021; Lin, et al., 2020). The COVID-19 pandemic has amplified immigrants’ susceptibility to loneliness as one
third of them were fear of being stigmatized as risky others in Canada (Lin, 2022). This may be due to the framing of COVID-19 as “foreign virus” that fuels otherness, xenophobia, and anti-immigrant sentiment. Longitudinal research has found the relationship between job loss and loneliness may be bi-directional and self-reinforcing (Morrish & Medina-Lara, 2021), suggesting that interventions addressing both job precarity and loneliness are crucial for immigrants in the public health crisis. As some racialized immigrant communities may have a culture of mental illness stigma, the 3-item UCLA loneliness scale could be used as a brief community screening tool for depressive symptoms to enable early detection of mental health problems that may be under-recognized among marginalized populations (Liu et al., 2020).

More importantly, severely lonely individuals in Canada were 1.7-fold more likely to seek treatment from mental health professionals, 1.5-fold more likely to seek informal support for mental health concerns and 1.8-fold more likely to have unmet mental health needs. The present study finds that these robust associations between loneliness and mental health help-seeking were independent and not attenuated by other mental health conditions including self-rated mental health, perceived life stress and mental health change. A similar pattern was observed in China (Bao et al., 2021). This suggests that severe loneliness should be considered an important mental health concern and determinant of mental health service use during the COVID-19 pandemic. Although Canada’s mental health care have been transitioned to telehealth services since the outbreak (Ashcroft et al., 2021), vulnerable populations, such as homeless people, low-income households, people with low technological literacy and asylum seekers, who find remote communication more challenging than face-to-face interactions might disengage from remote psychotherapies, and their loneliness could be exacerbated in the absence of in-person contact (Moreno et al., 2020). This may partly explain why severe loneliness was positively correlated
with unmet MH needs even after MH care-seeking was taken into account. Against this backdrop of “digital health inequity”, the Canadian government has implemented the Connecting Families Initiative 2.0 to provide affordable high-speed Internet ($20/monthly) for low-income individuals and seniors, which could potentially mitigate barriers to digital health care. Another critical initiative is to provide free refurbished smartphones for low-income and homeless individuals (i.e., Homelessness Community Action program in British Colombia, PHONE-CONNECT program in Ontario) to increase their smartphone ownership and to narrow the gap in access to telemedicine (Kazevman et al., 2021).

5. Strength and Limitations

This study has a number of strengths including its use of a nationally representative sample for the general population across all age groups, its validated measurement tool of loneliness adapted for pandemic times as well as its application of machine learning to detect high-order interactions among risk factors. However, several methodological flaws and biases limited the generalisability. First, this study relied on self-reported survey data and therefore is susceptible to recall bias, misreporting and misclassification. Second, the cross-sectional nature of the data prohibits the examination of causality. Without longitudinal data, it is difficult to determine the direction of the association and it may be bidirectional. For example, unhealthy behaviors (e.g., binge drinking, cannabis use, and opioid use) could be consequences of severe loneliness as well as its risk factors. Third, the statistical models will always have the risk of ‘residual confounding’, resulting from unobserved characteristics that are not included in the analyses. For example, the CPSS-6 survey did not capture pre-existing mental health conditions or history of psychiatric diagnoses. Yet, change of mental health status was controlled in the model. We were unable to
control for financial resources (e.g., household income) due to a lack of relevant information in the CPSS-6, and alternatively, housing type was treated as a rough proxy. In addition, because CPSS adopts a complex sample design, a bootstrap variance estimation would have been preferable. Unfortunately, given the public use data set without bootstrap weights and the limitation of SPSS, the estimated variability measures produced by the normalized weight approach in the current study may differ from a full design-based approach, normally an underestimation of true variance of the estimates (Statistics Canada, 2014). Lastly, the online survey method of CPSS-6 is subjective to high nonresponse bias, resulting in an overrepresentation of individuals with post-secondary education, Canadian-born residents and two-person households.

6. Conclusion

The COVID-19 pandemic converges with “loneliness epidemic” in Canada, given that one-in-three Canadians (34.7%) experienced severe loneliness in the general population. This nationwide study not only evaluates how risk factors of loneliness stratify by genders and intersect with each other, but also examines loneliness’ association with mental health care-seeking during the unprecedented public health crisis. As the pandemic continues to evolve with the spread of more transmissible COVID-19 variants, there is an urgent need for health authorities to address the concurrent loneliness epidemic while balancing public health measures. To combat the pervasive lockdown loneliness, a national multi-level multi-agency strategy could be adopted: at the clinical settings, primary care providers and mental health clinicians should assess loneliness symptoms in their routine patient examinations. At the community level, social care organizations should develop early prevention and intervention programs (e.g., digital literacy training, accessible digital technology tools, and psychoeducation) targeting high-risk groups with greater
burden of loneliness, including those who experience employment uncertainty caused by the pandemic, immigrant men, women with lower educational level, persons living alone, individuals with a limited social network (< 3 persons), past-month binge drinkers, past-month cannabis users and men who had ever used opioids in Canada. These equity-driven efforts are crucial to foster social connectedness in a digital era, considering that severe loneliness could exacerbate psychological impact from the COVID-19 pandemic and lead to increased mental health expenditure.
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Appendix: Figures and Tables

Figure 1 Conceptual framework: Understanding COVID-19 pandemic's impact on loneliness symptoms

**COVID-19-related Job precarity**
- Absence from work due to COVID-19 (e.g., business closure, layoff, COVID-19 diagnosis)

**COVID-19 restrictions**
- Stay-at-home order; Lockdown; Gym/school closure; Social isolation

**Risk factors**
- Urban/rural residency; Housing type
- Education; Employment; Migration
- **Health behaviors**: Drinking; Cannabis and opioid use
- **Social isolation component**: 1) Marital status; 2) Live alone; 3) Social network size 4) Social participation

**Disruptions**

**Mental Wellbeing**

**Pandemic Loneliness**
(UCLA 3-item loneliness scale)
- Lacking companionship
- Feeling left out of life
- Feeling isolated from others

**Covariates**
- SRMH
- Life Stress
- MH Change

**Mental health help-seeking**
- **Professional care** (e.g., family doctors)
- **Informal support** (e.g., friends/relatives)
- Unmet mental health needs
- Psychiatric medication use

Notes: SRMH=Self-rated mental health; MH change=Changes in mental health status compared to pre-pandemic.
Figure 2 Machine learning prediction (classification and regression tree) for severe loneliness and its intersecting risk factors during COVID-19 pandemic in Canada (n=3,772), CPSS6-COVID (January 25–31, 2021).

Rate of loneliness
- <28% (Protective factors)
- 28% - 34.8% (Protective factors)
- 34.9% - 39.9% (保护性因素)
- 40% - 60% (Risk factors)
- > 60% (Risk factors)

Low loneliness rate
- Larger size of social network ≥ 3 persons 28.1%
- Aged >24 years 25.8%
- Not binge drinking (30 days) 22.0%
- College degree and above 19.7%

High loneliness rate
- Small size of social network 0; 1-2 person(s) 40.3%
- Aged 15-24 years 43.6%
- Binge drinking monthly 34.8%
- Without a college degree 27.3%

Prediction for severe loneliness during COVID-19 pandemic
(Benchmark rate: 34.7%; UCLA-3 score ≥ 7)
- Did not absent from work due to COVID-19 reasons (i.e., at work; absence from work for other reasons; not employed) 33.0%
- Unplanned absence from work due to COVID-19 reason; and/or not stated for employment status 64.1%
- Canadian-born residents 48.7%
- Immigrants and migrants 86.2%
- Cannabis use in the past month 53.7%
- Married 44%
- Not married 63.6%
- Never or not use cannabis in the past month 37.7%
- Not single 34.9%
- Single 46.2%

Notes: Decision tree is based on the CART growing method to maximize within-node homogeneity (Overall classification: 67.7%; sensitivity of 11.3% and specificity of 97.8%). Growing criteria: Minimum sample size: Child node (n= 50); parent node (n=100), branching depth was limited to five levels. Nine variables were inputted into CART analysis software to identify intersecting risk factors of loneliness. At each binary split, the parental node branches off into two directions: the right-hand side (proportion at risk is more prevalent) whereas the left-hand side (less prevalent). Each node displays the splitting variable and the percent of those participants with the outcome of interest (severe loneliness). 10-fold cross-validation was applied to generate misclassification risk.
Table 1. Sample characteristics: unweighted sample size and weighted percentages (%) of severe loneliness (UCLA-3 score ≥ 7) among full, male, and female samples, CPSS6-COVID (January 25–31, 2021).

| Variables                          | Full sample (n=3,772) | Male (n=1,744) | Female (n=2,028) |
|------------------------------------|-----------------------|----------------|------------------|
|                                    | Unw. | Sev. | Sig. | Sev. | Sig. | Sev. | Sig. |
| **Loneliness symptoms**            |       |      |     |      |      |      |      |
| Isolated from others (often)       | 1431  | ---  | 41.9% | ---  | 40.0% | ---  | 43.9% | <0.001 |
| Lacking companionship (often)      | 903   | ---  | 23.4% | ---  | 20.6% | ---  | 26.3% | <0.001 |
| Feeling left out (often)           | 596   | ---  | 17.0% | ---  | 15.1% | ---  | 19.0% | <0.001 |
| **Age**                            |       |      |     |      |      |      |      |
| 15-24                              | 138   | 50.5% | 49.5% | 44.9% | 55.1% | 56.4% | 43.6% | <0.001 |
| 25-44                              | 1085  | 61.3% | 38.7% | 68.0% | 32.0% | 54.2% | 45.8% | <0.001 |
| 45-64                              | 1521  | 71.3% | 28.7% | 72.8% | 27.2% | 70.0% | 30.0% | <0.001 |
| ≥ 65                               | 1028  | 71.4% | 28.6% | 79.0% | 21.0% | 64.6% | 35.4% | <0.001 |
| **Sex**                            |       |      |     |      |      |      |      |
| Male                               | 1744  | 68.7% | 31.3% |       |      |      |      | <0.001 |
| Female                             | 2028  | 61.9% | 38.1% |       |      |      |      | <0.001 |
| **Education**                      | 0.001 | 0.12  |      | 0.002 | 0.035 | 0.45  |
| High school grad                   | 884   | 61.8% | 38.2% | 67.1% | 32.9% | 57.2% | 42.8% |      |
| College degree                     | 1362  | 66.2% | 33.8% | 67.3% | 32.7% | 65.0% | 35.0% |      |
| University                         | 1526  | 68.6% | 31.4% | 72.2% | 27.8% | 65.1% | 34.9% |      |
| **Immigrant status**               | 0.046 | <0.001 | 0.035 |       |      |      |      |
| Canadian-born residents             | 3122  | 66.2% | 33.8% | 71.6% | 28.4% | 60.6% | 39.4% |      |
| Immigrants                          | 650   | 62.6% | 37.4% | 59.1% | 40.9% | 65.8% | 34.2% |      |
| **Pandemic Job precarity**         | <0.001 | <0.001 | <0.001 |       |      |      |      |
| Employed; & At work                 | 2095  | 67.2% | 32.8% | 70.4% | 29.6% | 63.3% | 36.7% |      |
| Absent; not COVID-19-related        | 84    | 63.4% | 36.6% | 83.3% | 16.7% | 51.0% | 49.0% |      |
| Absent; COVID-19-related            | 59    | 42.2% | 57.8% | 50.0% | 50.0% | 38.3% | 61.7% |      |
| Not employed                        | 1452  | 66.7% | 33.3% | 70.1% | 29.9% | 64.1% | 35.9% |      |
| Not stated                          | 82    | 35.0% | 65.0% | 32.9% | 67.1% | 37.7% | 62.3% |      |
| **Residency**                       | 0.403 | 0.031 | 0.45  |       |      |      |      |
| Rural                              | 778   | 66.9% | 33.1% | 74.8% | 25.2% | 59.9% | 40.1% |      |
| Urban                              | 2994  | 65.0% | 35.0% | 67.8% | 32.2% | 62.2% | 37.8% |      |
| **Housing type**                   | <0.001 | <0.001 | 0.001 |       |      |      |      |
| Single detached house              | 2517  | 68.6% | 31.4% | 72.3% | 27.7% | 64.9% | 35.1% |      |
| Low-rise apartment                  | 413   | 60.0% | 40.0% | 59.0% | 41.0% | 60.9% | 39.1% |      |
| High-rise apartment                 | 253   | 58.5% | 41.5% | 57.5% | 42.5% | 59.3% | 40.7% |      |
| Others                             | 589   | 61.0% | 39.0% | 69.5% | 30.5% | 53.7% | 46.3% |      |
| **Social isolation indicators**    |       |      |     |      |      |      |      |
| Married                            | 2379  | 69.2% | 30.8% | 74.4% | 25.6% | 63.4% | 36.6% | <0.001 |
| Widow/separated                    | 635   | 66.4% | 33.6% | 66.2% | 33.8% | 66.5% | 33.5% | <0.001 |
| Single/never married               | 758   | 55.6% | 44.4% | 55.5% | 44.5% | 55.7% | 44.3% | <0.001 |
| **Live alone**                     | <0.001 | <0.001 | 0.214 |       |      |      |      |
| Not alone                          | 2702  | 66.7% | 33.3% | 70.8% | 29.2% | 62.5% | 37.5% |      |
| Alone                              | 1070  | 58.1% | 41.9% | 57.0% | 43.0% | 58.9% | 41.1% |      |
| **Social network size**            | <0.001 | <0.001 | <0.001 |       |      |      |      |
| 0 friend/relative                  | 165   | 39.9% | 60.1% | 37.9% | 62.1% | 42.0% | 58.0% |      |
| 1 to 2 friends/relatives           | 1370  | 58.6% | 41.4% | 64.2% | 35.8% | 52.3% | 47.7% |      |
| ≥ 3 friends/relatives              | 2237  | 71.3% | 28.7% | 74.1% | 25.9% | 68.8% | 31.2% |      |
| **Social participation**           | <0.001 | <0.001 | <0.001 |       |      |      |      |
| No group                           | 1646  | 63.5% | 36.5% | 69.7% | 30.3% | 57.3% | 42.7% |      |
| 1 or more social groups            | 2085  | 68.5% | 31.5% | 71.7% | 28.3% | 65.3% | 34.7% |      |
### Health behaviours

#### Binge drinking

|                          | Not stated | At least once a week | At least once a month | Not in the past month |
|--------------------------|------------|----------------------|-----------------------|-----------------------|
| Health behaviours        |            | <0.001               | <0.001                | <0.001                |
|                          | 41         | 55.0%                | 40.7%                 | 68.8%                 |
|                          | 45.0%      | 59.3%                | 45.5%                 | 31.2%                 |
| **<0.001**               |            |                      |                       |                       |

#### Cannabis use

|                          | Used; in the past month | Used; not in the past month | Never use |
|--------------------------|-------------------------|-----------------------------|-----------|
| **<0.001**               | 465                     | 45.8%                       | 41.8%     |
|                          | 56.8%                   | 43.2%                       | 45.5%     |
| **<0.001**               | 587                     | 43.2%                       | 45.5%     |
|                          | 58.7%                   | 41.3%                       | 49.6%     |
| **<0.001**               | 2720                    | 58.2%                       | 31.2%     |
|                          | 40.7%                   | 60.4%                       | 35.2%     |

#### Opioids use

|                          | Used; in the past month | Used; not in the past month | Never use |
|--------------------------|-------------------------|-----------------------------|-----------|
| **0.015**                | 594                     | 54.8%                       | 41.8%     |
|                          | 56.8%                   | 43.2%                       | 39.0%     |
| **<0.001**               | 496                     | 61.4%                       | 38.6%     |
|                          | 67.9%                   | 32.1%                       | 22.8%     |
| **<0.001**               | 2682                    | 67.7%                       | 32.3%     |
|                          | 60.7%                   | 39.3%                       | 28.9%     |

#### Mental health care seeking during pandemic

|                          | No                      | Sought support             | Professional MH care |
|--------------------------|-------------------------|---------------------------|----------------------|
| **<0.001**               | 2884                    | 70.7%                     | 68.9%                |
|                          | 73.7%                   | 29.3%                     | 31.1%                |
| **<0.001**               | 73.7%                   | 26.3%                     | 28.4%                |
|                          | 67.3%                   | 32.7%                     | 46.4%                |
| **<0.001**               | 888                     | 48.0%                     | 52.0%                |
|                          | 46.4%                   | 53.6%                     | 44.1%                |
| **<0.001**               | 493                     | 42.2%                     | 57.8%                |
|                          | 44.1%                   | 55.9%                     | 40.9%                |

### Other mental health conditions

|                          | Self-rated Mental health | Perceived life stress | Mental health change |
|--------------------------|--------------------------|-----------------------|----------------------|
| **<0.001**               | 2932                     | 74.4%                 | 72.7%                |
|                          | 25.6%                   | 24.0%                 | 27.3%                |
| **<0.001**               | 840                      | 39.5%                 | 36.0%                |
|                          | 60.5%                   | 55.8%                 | 64.0%                |
| **<0.001**               | 3147                     | 71.7%                 | 69.1%                |
|                          | 28.3%                   | 25.9%                 | 30.9%                |
| **<0.001**               | 625                      | 38.5%                 | 37.6%                |
|                          | 61.5%                   | 60.2%                 | 62.4%                |

**Notes:** Sample size was presented as unweighted data while the percentages were based on weighted data to reflect population-based national estimate. CPSS6=Canadian Perspective Survey Series 6 (Online nationwide survey).
Table 2. Multivariable logistic regression predicting loneliness (UCLA-3 score ≥ 7) by risk factors (e.g., employment, social isolation and health behaviors) among full, male, and female samples, CPSS6-COVID (January 25–31, 2021).

| Variables                          | Full sample (n=3,772) | Male Sample (n=1,744) | Female sample (n=2,028) |
|-----------------------------------|-----------------------|-----------------------|-------------------------|
|                                   | Nagelkerke R²=13.0%   | Nagelkerke R²=20.3%   | Nagelkerke R²=13.4%     |
|                                   | OR 99% CI Sig.        | OR 99% CI Sig.        | OR 99% CI Sig.          |
| Age (Ref. 45-64)                  |                       |                       |                         |
| 15-24                             | 3.00 1.85 4.87 <0.001 | 3.63 1.68 7.86 <0.001 | 2.22 1.15 4.27 0.002    |
| 25-44                             | 1.42 1.11 1.81 <0.001 | 1.19 0.81 1.74 0.252  | 1.67 1.20 2.32 <0.001   |
| ≥ 65                              | 0.97 0.72 1.31 0.822  | 0.62 0.38 1.00 0.011  | 1.37 0.92 2.03 0.041    |
| Female (Ref. Male)                | 1.53 1.26 1.85 <0.001 | ----- ----- -----     | ----- ----- -----        |
| Education (Ref. University)       |                       |                       |                         |
| High school grad or below         | 1.13 0.87 1.48 0.226  | 0.99 0.64 1.52 0.932  | 1.44 1.01 2.04 0.008    |
| College degree                    | 1.06 0.83 1.36 0.557  | 1.42 0.97 2.10 0.019  | 0.94 0.67 1.32 0.620    |
| Immigrants (Ref. Canada-born)     | 1.08 0.85 1.37 0.424  | 1.79 1.23 2.60 <0.001 | 0.79 0.57 1.11 0.072    |
| Pandemic Job precarity (Ref. At work) |                  |                       |                         |
| Absent; not COVID-19-related      | 1.04 0.53 2.06 0.870  | 0.43 0.10 1.94 0.151  | 1.36 0.60 3.07 0.327    |
| Absent; COVID-19-related          | 2.11 1.04 4.28 0.007  | 1.79 0.49 6.57 0.250  | 2.48 1.05 5.86 0.007    |
| Not employed                      | 1.11 0.88 1.40 0.234  | 1.40 0.97 2.01 0.019  | 1.04 0.76 1.42 0.763    |
| Not stated                         | 3.47 2.09 5.77 <0.001 | 3.04 1.37 6.73 <0.001 | 2.32 1.12 4.79 0.003    |
| Urban residency (Ref. Rural)      | 1.04 0.78 1.37 0.735  | 1.30 0.81 2.07 0.150  | 0.95 0.66 1.36 0.698    |
| Housing type (Ref. Detached house) |                       |                       |                         |
| Low-rise apartment                 | 1.14 0.83 1.55 0.291  | 1.18 0.73 1.90 0.380  | 0.88 0.57 1.35 0.432    |
| High-rise apartment                | 1.40 0.99 1.98 0.012  | 1.60 0.95 2.71 0.021  | 1.25 0.76 2.05 0.254    |
| Others                            | 1.26 0.97 1.64 0.025  | 1.10 0.72 1.67 0.572  | 1.35 0.94 1.92 0.032    |
| Social isolation indicators        |                       |                       |                         |
| Relationship (Ref. Married)       |                       |                       |                         |
| Widow/separated                   | 0.73 0.50 1.06 0.031  | 0.78 0.39 1.57 0.366  | 0.73 0.46 1.17 0.084    |
| Single/never married              | 0.98 0.70 1.36 0.854  | 0.84 0.48 1.49 0.445  | 1.13 0.74 1.74 0.447    |
| Live alone (Ref. Not live alone)   | 1.56 1.09 2.23 0.001  | 2.03 1.09 3.75 0.003  | 1.20 0.77 1.89 0.289    |
| Social network size (Ref. ≥ 3 persons) |     |                       |                         |
| 0 person                          | 3.26 2.03 5.24 <0.001 | 3.63 1.71 7.69 <0.001 | 2.85 1.51 5.38 <0.001   |
| 1 to 2 persons                    | 1.73 1.42 2.10 <0.001 | 1.41 1.04 1.92 0.004  | 1.96 1.50 2.55 <0.001   |
| Social participation (Ref. No group) |            |                       |                         |
| 1 or more social groups           | 1.10 0.90 1.34 0.222  | 1.00 0.73 1.36 0.973  | 1.20 0.92 1.57 0.074    |
| Not stated                        | 0.83 0.50 1.40 0.362  | 2.15 0.97 4.76 0.013  | 0.43 0.20 0.89 0.003    |
| Binge drinking (Ref. not in past month) |    |                       |                         |
| At least once a week              | 1.70 1.27 2.27 <0.001 | 2.34 1.54 3.56 <0.001 | 1.32 0.85 2.04 0.103    |
| At least once a month             | 1.39 1.08 1.80 0.001  | 1.32 0.90 1.93 0.060  | 1.45 1.00 2.09 0.009    |
| Cannabis use (Ref. Never)         |                       |                       |                         |
| Ever used; not in the past month  | 0.95 0.71 1.27 0.651  | 0.67 0.43 1.05 0.022  | 1.39 0.92 2.09 0.041    |
| Ever used; in the past month      | 1.47 1.12 1.93 <0.001 | 1.33 0.88 2.00 0.079  | 1.59 1.08 2.33 0.002    |
| Opioids use (Ref. Never)          |                       |                       |                         |
| Ever used; in the past month      | 1.51 1.00 2.28 0.010  | 2.85 1.46 5.58 <0.001 | 0.97 0.57 1.67 0.886    |
| Ever used; not in the past month  | 1.25 0.95 1.64 0.040  | 1.61 1.05 2.44 0.004  | 1.00 0.68 1.46 0.999    |

Notes: To account for multiple testing, a more stringent criterion for statistically significance (p < 0.01) was applied (bolded) and 99% confidence intervals (99% CI) was used. Sig.= significance level. OR= odds ratio. CPSS6=Canadian Perspective Survey Series 6 (Online nationwide survey). The reference time frame of the employment status: January 18 to 22, 2021.
Table 3 Multivariable logistic regression predicting mental health help-seeking by loneliness after controlling for mental health conditions and other covariates in the full sample (N=3,772), CPSS6-COVID (January 25–31, 2021).

| Model 1 Binary Loneliness | OR 99% CI Sig. | OR 99% CI | OR 99% CI | OR 99% CI |
|---------------------------|----------------|------------|------------|------------|
| Severe Lonely (Ref. not lonely) | 1.78 1.29 2.46 <0.001 | 1.71 1.21 2.41 <0.001 | 1.51 1.17 1.95 <0.001 |
| Poor/fair SRMH (Ref. good) | 2.94 2.06 4.18 <0.001 | 1.64 1.12 2.41 <0.001 | 2.05 1.53 2.75 <0.001 |
| High Stress (Ref. low) | 1.59 1.11 2.26 0.001 | 1.17 0.79 1.73 0.298 | 1.58 1.17 2.12 <0.001 |
| MH vs. pre-pandemic (Ref. same) | | | |
| MH Better | 1.94 1.07 3.51 0.004 | 4.86 2.79 8.44 <0.001 | 1.39 0.91 2.14 0.048 |
| MH somewhat worse | 1.57 1.03 2.39 0.006 | 1.96 1.28 2.99 <0.001 | 1.23 0.92 1.64 0.064 |
| MH much worse | 2.27 1.27 4.06 <0.001 | 1.51 0.78 2.92 0.108 | 1.39 0.85 2.28 0.084 |
| Nagelkerke R² | R²=39.4% | R²=44.4% | R²=30.7% |

| Model 2 Loneliness scale | OR 99% CI Sig. | OR 99% CI | OR 99% CI |
|--------------------------|----------------|------------|------------|
| Loneliness scale (range: 3-15) | 1.22 1.13 1.31 <0.001 | 1.13 1.05 1.21 <0.001 | 1.14 1.08 1.20 <0.001 |
| Poor/fair SRMH (Ref. good) | 2.80 1.96 3.99 <0.001 | 1.62 1.11 2.37 0.001 | 1.96 1.46 2.62 <0.001 |
| High Stress (Ref. low) | 1.42 0.99 2.04 0.012 | 1.12 0.76 1.65 0.468 | 1.45 1.08 1.96 0.001 |
| MH vs. pre-pandemic (Ref. same) | | | |
| MH Better | 2.02 1.11 3.69 0.003 | 5.08 2.92 8.85 <0.001 | 1.46 0.95 2.25 0.025 |
| MH somewhat worse | 1.43 0.93 2.18 0.031 | 1.92 1.26 2.93 <0.001 | 1.16 0.87 1.54 0.198 |
| MH much worse | 1.87 1.03 3.39 0.007 | 1.41 0.73 2.75 0.180 | 1.25 0.76 2.06 0.248 |
| Nagelkerke R² | R²=40.5% | R²=44.4% | R²=31.4% |

| Model 3 Loneliness symptoms | OR 99% CI Sig. | OR 99% CI | OR 99% CI |
|-----------------------------|----------------|------------|------------|
| Isolated from others (Ref No) | 1.23 0.85 1.78 0.160 | 0.83 0.56 1.23 0.216 | 2.24 1.71 2.93 <0.001 |
| Lacking companionship (Ref No) | 1.29 0.91 1.84 0.063 | 1.59 1.09 2.33 0.002 | 0.86 0.64 1.16 0.196 |
| Feeling left out (Ref No) | 1.64 1.10 2.43 0.001 | 1.69 1.09 2.63 0.002 | 0.90 0.65 1.27 0.443 |
| Poor/fair SRMH (Ref. good) | 2.93 2.06 4.18 <0.001 | 1.63 1.11 2.39 0.001 | 2.07 1.54 2.77 <0.001 |
| High Stress (Ref. low) | 1.51 1.06 2.17 0.003 | 1.15 0.78 1.70 0.363 | 1.50 1.11 2.02 0.001 |
| MH vs. pre-pandemic (Ref. same) | | | |
| MH Better | 1.93 1.06 3.49 0.004 | 4.84 2.78 8.43 <0.001 | 1.43 0.92 2.20 0.035 |
| MH somewhat worse | 1.54 1.01 2.35 0.009 | 2.00 1.31 3.05 <0.001 | 1.20 0.90 1.61 0.099 |
| MH much worse | 2.09 1.16 3.76 0.001 | 1.45 0.74 2.81 0.153 | 1.36 0.82 2.24 0.117 |
| Nagelkerke R² | R²=39.2% | R²=44.7% | R²=32.1% |

Notes: To account for multiple testing, a more stringent criterion for statistically significance (p < 0.01) was applied (bolded) and 99% confidence intervals (99% CI) was used. Sig.= significance level. OR= odds ratio. CPSS6=Canadian Perspective Survey Series 6 (Online nationwide survey). Panel A: Models were controlled for all covariates including professional care and informal support. Panel B: Models were controlled for all covariates including unmet needs and informal support. Panel C: Models were controlled for all covariates including unmet needs and professional care.