Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Generalized anxiety disorder during COVID-19 in Canada: Gender-specific association of COVID-19 misinformation exposure, precarious employment, and health behavior change

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ABSTRACT

Background: Growing evidence has demonstrated the mental health sequelae of the COVID-19 pandemic. Few studies have examined how pandemic-related stressors and resilience factors of anxiety affect women and men differently in Canada.

Methods: Population-based data from the Canadian Perspective Survey Series (CPSS-4: July 20 to 26, 2020) were analyzed to examine the relationship between Generalized Anxiety Disorder-7 scale (GAD-7) with COVID-19 misinformation exposure, precarious employment, and health behavior changes, after adjusting for socio-demographic variables. Stratified by gender, two multinomial logistic regression were conducted to calculate the likelihood of having minimal–mild anxiety ($1 \leq$ GAD score <10) and moderate–severe anxiety (GAD score ≥ 10), compared to no anxiety symptoms (GAD=0).

Results: Overall, respondents ($n = 3{,}779$) were mainly Canadian-born (76.3%), aged >25 years (85.4%) and high school graduate (87.9%). The population prevalence of moderate–severe GAD was 13.6%, with women significantly higher than men (17.2% vs. 9.9%, $p<0.001$). For women ($n = 2{,}016$), GAD was associated with being absent from work due to COVID-19 reasons (OR=3.52, 99% CI:1.12–11.04), younger age (ORs range from 2.19 to 11.01, p's<0.01), being single/widowed (OR=2.26, 99% CI 1.18–4.33), no past-week contacts outside household (OR=2.81, 99% CI:1.24–6.37), no outdoor exercise (OR=1.86, 99% CI:1.13–3.07). For men ($n = 1{,}753$), GAD was associated with frequent fake news exposure (dose-response relations: ORs range from 3.14 to 6.55, p's<0.01), increased time of watching TV (OR=2.62, 99% CI: 1.31 – 5.27), no indoor exercise (OR=1.91, 99% CI:1.07–3.42). For both genders, GAD was associated with increased intake of alcohol, cannabis, and junk/sweet food (p's<0.01).

Limitations: Cross-sectional data prohibits causal inferences; self-reporting biases of GAD symptoms requires confirmation with diagnostic records.

Conclusion: The gendered impact of the COVID-19 pandemic was observed in the associations between clinically significant anxiety with COVID-19 misinformation exposure, job precarity, and addictive behaviors in Canada. Mental health interventions need to be gender responsive and should tackle upstream social determinants of health in this public health emergency.

1. Introduction

The ongoing pandemic of COVID-19 has been causing unprecedented disruption, panic and stress in every aspect of human living condition (Bavel et al., 2020; Fancourt et al., 2021). Since March 11, 2020, the World Health Organization (WHO) proclaimed the new coronavirus (COVID-19) outbreak a worldwide pandemic (Cucinotta and Vanelli, 2020), governments have imposed travel restrictions, lockdowns, workplace closure, and stay-at-home orders to combat the spread of COVID-19 all over the world(Pierce et al., 2020; Turna et al., 2021). While these unprecedented measures have been successful in slowing the COVID-19 transmission, there have been widespread concerns about the mental health challenges escalated by the pandemic-rated stressors, such as mandatory quarantine (de Lima et al., 2020; Shi et al., 2020;

Abbreviations: GAD, Generalized anxiety disorder; CPSS, Canadian Perspective Survey Series.

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Wang et al., 2021), social distancing (Kämpfen et al., 2020; Marroquín et al., 2020; Zhao et al., 2020), unexpected job loss (Mazza et al., 2020; Xiong et al., 2020) and fear of COVID-19 infection and mortality (Elton-Marshall et al., 2021; Kämpfen et al., 2020; Shi et al., 2020). A recent systemic review has indicated that, as a result of this large-scale public health crisis, the general population are under tremendous stress and enduring elevated psychological symptoms, ranging from depression (14.6% to 48.3%), psychological distress (34.43% to 38%), post-traumatic stress disorder (7% to 53.8%) and anxiety (6.33% to 50.9%) in different regions of the world (Xiong et al., 2020).

Anxiety disorders are among the top ten causes of disability worldwide (Vos et al., 2016). In pre-pandemic times, mounting evidence has investigated genetic and environmental risk factors in their etiology of anxiety disorders (Hettema et al., 2001). For instance, females are more likely to be diagnosed with generalised anxiety disorders and these gender disparities appear to be shaped by both biological factors and socio-cultural forces (McLean et al., 2011). Previous research has shown that women are more prone to inflammation, autoimmune reactions (Quintero et al., 2012; Yang and Kozloski, 2011), which may lead to increased mental health burden. Since the COVID-19 outbreak, a burgeoning body of psychiatry research has focused on anxiety symptoms related to specific public health measures and pandemic disruptions. A Chinese study has found that participants who experienced quarantine procedures had greater rates of anxiety than those who were not quarantined (Wang et al., 2021). Another Chinese study has demonstrated that frequent social media exposure was positively associated with greater odds of anxiety during the pandemic (Gao et al., 2020). Spanish evidence has shown that both a healthy diet and not reading too much COVID-19 news were strongly linked to reduced levels of anxiety symptoms (Fullana et al., 2020a). Furthermore, being women, younger age, student status, unemployment, and past psychiatric history were all identified as risk factors for anxiety amidst this public health emergency (Solomou and Constantinidou, 2020).

Although gender-specific analyses of anxiety disorders were well documented before the pandemic (Boehlen et al., 2020; Brunes et al., 2015; Luo et al., 2019; Oshiyama et al., 2018), far less is known about the extent to which psychological consequences of the COVID-19 pandemic related to health information, labor market participation and health behaviours differ by the role of gender. In fact, since the onset of the COVID-19 pandemic, the gendered impact of this public health crisis has not been thoroughly addressed in research and policy response, as pointed out in a recent commentary from *The Lancet* (Wenham et al., 2020). Longitudinal data from eight Organization for Economic Co-operation and Development (OECD) countries have shown substantial gender differences in behavior and attitude towards the virus, where women had a higher propensity to perceive COVID-19 as a serious health threat and to comply with new restraining public health rules than men (Galasso et al., 2020). Considering such gendered differential susceptibility to COVID-19 pandemic, it is fundamental to ascertain how radically transformed social context of the disease outbreak affect mental health of women and men differently. Thus, sex-disaggregated analyses of anxiety prevalence and its social determinants are crucially warranted to inform gender-specific interventions and preventions.

1.1. Research gaps and study questions

The arrival of COVID-19 in Canada presents an unprecedented public health challenge, with over 2.9 million confirmed cases, 33 thousand deaths to date (Canada, Public Health Agency, 2020), and a crude case fatality rate of 4.9% on April 22, 2020 (Abdollahi et al., 2020), which is substantially greater than seasonal influenza death rate of approximately 0.1% (Jordan et al., 2020). Although scientists have been exploring the scale, the trends and the mechanisms of this traumatic event's impact on mental health in Canada (Bulloch et al., 2021; Findlay et al., 2020; Zajacova et al., 2020a), the current landscape of Canadian literature on anxiety prevalence during the COVID-19 pandemic has been constrained by several methodological limitations, such as the use of non-probability sampling (Elton-Marshall et al., 2021; Nwachukwu et al., 2020; Turna et al., 2021) and unvalidated measure of anxiety (Dozois et al., 2021; McCormack et al., 2021, 2020). While these early insights based on rapid approaches are valuable, high-quality population data on mental health needs arising from the pandemic are still needed to inform appropriate evidence-based health policies to mitigate mental health sequelae (Pierce et al., 2020). In addition, very few epidemiological studies have examined exposure to COVID-19 health information in relation to anxiety levels in Canada.

The present study, therefore, examines the population-weighted prevalence of clinically significant anxiety by the standardized Generalized Anxiety Disorder-7 (GAD-7) scale based on a population-based sampling strategy in Canada and extends exiting literature by investigating its association with a wide range of socioecological factors. The COVID-19 pandemic is the first in human history to involve widespread use of social media that have facilitated unchecked misinformation (e.g., vaccine rumors, unproven treatments, trivializing the risks of COVID-19) with fatal consequences (Limaye et al., 2020; Loomba et al., 2021) and COVID-19 misinformation is reaching more people via online video sharing platforms in the digital era than in the past public health crises (Li et al., 2020). Given the context of COVID-19 "infodemic" as declared by the WHO (Galvão, 2021), we are particularly interested in how COVID-19-related stressors (i.e., exposure to COVID-19 misinformation online, precarious employment) and resilience factors (i.e., changes in health behaviours) are related to anxiety as well as the gender differences across these parameters.

Grounded in the socioecological paradigm (Davison et al., 2021; Kawachi et al., 2002; Lin, 2021) and the social determinants of health framework (Marmot, 2005) and fundamental social cause theory (Phelan and Link, 2005; Phelan et al., 2010), the present study hypothesizes that individuals who are affected by the disruptions from the COVID-19 pandemic at macro-, meso- and micro-levels of their ecosystems may be more susceptible to adverse mental health consequences (see Fig. 1 for the conceptual framework). Hence, to evaluate the psychosocial inequalities of the pandemic and identify gender-specific risk factors of anxiety symptoms, the present study examines the following three research questions:

***Q1 Health information impact (Macro-system)*:** If COVID-19 misinformation exposure (i.e., frequency of seeing suspected misleading information related to COVID-19 on the Internet) is associated with the probability of having anxiety symptoms for men and women, respectively?

Q2 Labour market impact (Meso-system): If COVID-19-related job precarity (i.e., being absent from work due to reasons related to COVID-19) is associated with the probability of having anxiety symptoms for men and women, respectively?

Q3 Health behaviors impact (Micro-system): If health behavior changes (i.e., lifestyle and coping behaviours) during the COVID-19 pandemic are associated with the probability of having anxiety symptoms for men and women, respectively?

2. Methods

2.1. Data source and study context

The data were drawn from the Canadian Perspective Survey Series – Information Sources Consulted During the Pandemic (CPSS4-COVID), an online survey conducted from July 20 to July 26 2020, that is around four months after the first provincial state of emergency was declared in Ontario (Canada) since the COVID-19 outbreak. 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

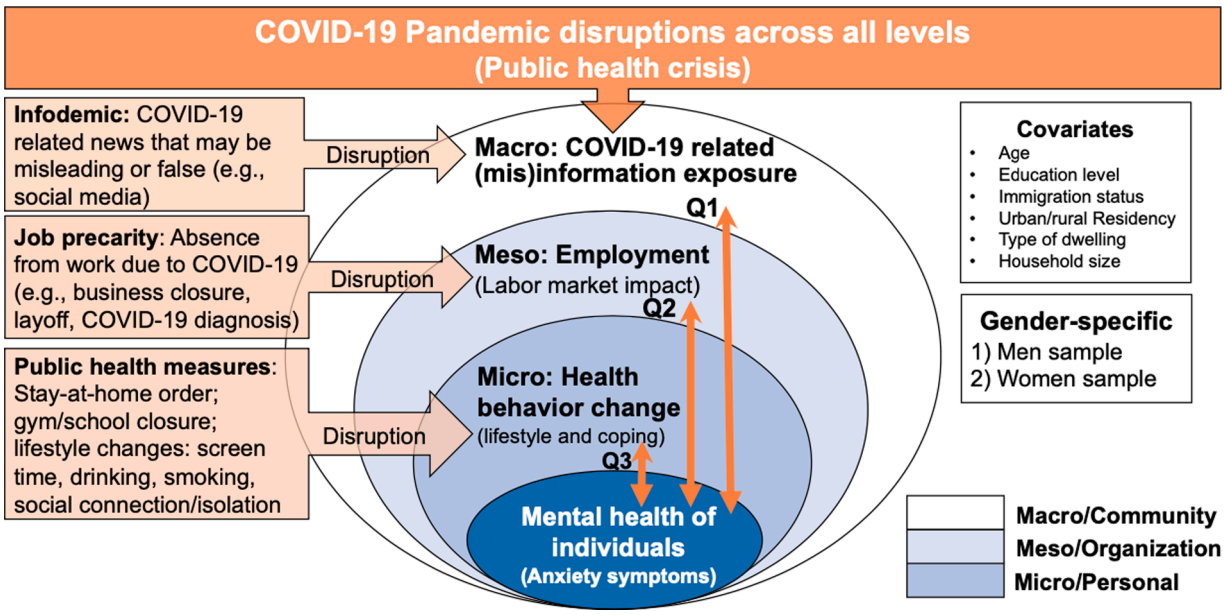

Fig. 1. Understanding COVID-19 pandemic's impact on anxiety symptoms: A socio-ecological framework.

March 2020 (Zajacova et al., 2020a). The CPSS4-COVID survey, in particular, aims to evaluate the ongoing impact of COVID-19 on Canadians' mental health and employment circumstances, with a special focus on the quantity and quality of COVID-19 information they received from multiple sources. 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 (Statistics Canada, 2020).

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 CPSS4 was 58.2% and may reflect a tight schedule for data collection and COVID-19-related fatigue during the pandemic. Among the total 4,218 respondents in the CPSS4, individuals with missing predictor values ($n = 318$) or with no valid anxiety data ($n = 131$) were excluded in this study ($n = 449$, 10.6% of the total), yielding an analytic sample of 3,769. Notably, the excluded subjects have statistically significant demographic differences from the included respondents, as tested by Chi-square statistics ($p<0.05$), with more females (57.5% vs 53.5%), rural individuals (25.4% vs 20.3%), immigrants (21.2% vs. 17.2%), unemployed residents (56.8% vs. 38.6%) and older persons aged >75 years (17.4% vs 6.5%) being excluded.

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. Outcome variable

Symptoms of generalized anxiety were assessed by the Generalized Anxiety Disorder-7 (GAD-7) scale (Spitzer et al., 2006). The GAD-7 is a 7-item standardized instrument and screening tool for anxiety disorders that evaluates symptoms such as feeling nervous, unable to control worrying, have trouble relaxing, and becoming easily annoyed in the past two weeks. This composite measure (range: 0–21) is a 4-point Likert scale with options ranging from "never" (=0) to "nearly every day" (=3). The GAD-7 has a strong test-retest reliability and criterion validity, highly correlated with the Medical Outcomes Study Short-Form General Health Survey (SF-20). A score of 10 or greater on the GAD-7 represents a reasonable cut point for identifying clinically significant cases of GAD (Spitzer et al., 2006), with a sensitivity of 89% and a specificity of 82%. The interpretation of GAD-7 scores is based on a 5-level categorization: 0 (no symptom); 1–4 (minimal anxiety symptoms); 5–9 (mild anxiety symptoms), 10–14 (moderate anxiety symptoms); and 15–21 (severe anxiety symptoms). Due to the small sample size and statistical power concerns, minimal and mild anxiety were grouped, and moderate and severe anxiety were combined. Therefore, in the analyses, anxiety was categorized into three levels: (1) no anxiety (GAD=0); (2) minimal/mild anxiety ($1 \leq$ GAD score <10); (3) moderate/severe distress (GAD score ≥ 10). In this CPSS-4 data, the seven items of the GAD-7 scale reported a good internal consistency (reliability), as determined by Cronbach's α: overall sample=0.922; male sample=0.915; female sample=0.926.

2.4. Main explanatory variables

COVID-19 misinformation exposure was a derived variable from three consecutive questions to evaluate respondents' reactions and frequency of seeking health information on the Internet since the beginning of the COVID-19 pandemic. First, respondents were first asked: "*What is your main source of information to find out about COVID-19?*". This information could include "*major symptoms, how and when to get tested, closures, travel restrictions and recommendations, maintaining good mental and physical health.*" Participants who reported "*I do not look for information about this*" were skipped to the end. Only those who look for COVID-19-related information from any of the sources were then asked if they use "the Internet" for searching COVID-19 information, and if so, whether (how often) and how they "*check the accuracy of information about COVID-19 on the Internet?*" (e.g., verified the author/date/URL address to check for credibility; cross-validation with other sources; consulted with friends/family/online network). Participants who "never" checked the accuracy of online information were skipped to the

end. Only those reported that they had "ever" checked the information accuracy were prompted with the last question regarding frequency: "*Since the beginning of the COVID-19 pandemic, how often have you seen information related to COVID-19 on the Internet that you suspected was misleading, false or inaccurate? (*i.e.*, fake news)"*. Therefore, the response options for were recoded as: 1=multiple times a day; 2=once a day; 3=at least once a week; 4=rarely/never; 5=inactive: do not look for information about COVID-19; and/or (if have information exposure) did not use the internet as the main source; and/or (if using the Internet) do not check the accuracy of information.

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., July 12 to July 18, 2020). 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 for precarious employment were aggregated and categorized into five groups: 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 behavior change was a cluster of 13 variables measured by two modules in the CPSS-4. In the module of "*Doing activities for health",* respondents were asked**:** *"Are you doing any of the following activities for your mental or physical health?"* These five health-promoting activities include:1) communication with friends and family; 2) meditation; 3) exercise outdoors; 4) exercise indoors; 5) changing food choices. The response options were aggregated into two levels: 1=yes for physical and/or mental health; 0=no. In the module of "*Change in weekly habits*", respondents were asked: "*Have your weekly habit changed for any of the following activities*?" These seven health-compromising and leisure activities may potentially serve as coping during the pandemic and include: 1) consuming alcohol; 2) using tobacco products; 3) consuming cannabis; 4) eating junk food or sweets; 5) watching television; 6) spending time on the internet; 7) playing video games. The response options were coded as: 0=no change (reference), 1=increased, and 2=decreased. In line with previous studies (Luk et al., 2021; Zajacova et al., 2020b), "no change" was chosen as the reference group because the data specifically aimed to capture self-reported changes in health behaviours rather than actual consumption levels. In addition, past-week social contact, as an indicator of social circle, was measured by a survey question asking: "*Excluding members of your household, how many people in total did you come in close contact (i.e., within 2 meters) with during the last 7 days?"* It could include any people such as "*co-workers, relatives, neighbours, delivery workers, other shoppers, health professionals and restaurant employees*." The response options were coded as: 0 = 0 person (no contact with people outside one's household); 1=between 1 and 3 persons; and 3=more than 3 persons.

2.5. Potential confounders

To reduce the possibility of spurious associations between key explanatory variables and mental health symptoms, control variables were included in the statistical model. These covariates include age groups, gender, highest educational attainment (<high school diploma, high school graduate/college diploma, ≥ bachelor's degree), migration status (Canadian-born residents versus migrants), residency (urban or rural), marital status (single/widowed or married), type of dwelling (single-detached house, low-rise apartment with less than five stories, high-rise apartment with five or more stories, other types) and household size (1/2/≥ 3 persons).

2.6. 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. The present study adopted normalizing weights, whereby the original survey weight of each unit in the subpopulation being analysed is divided by the mean of the survey weights for all sampled units in the subpopulation. This is a commonly accepted practice that have been reported in prior studies using Statistic Canada's probability-based survey (Baiden et al., 2014, 2015). Second, stratified by gender, cross-tabulation analyses were generated by Chi-square tests (χ^2) using weighted percentages to compare between-group differences by anxiety levels. Third, gender-specific multinomial logistic regression was conducted to examine associations between key explanatory variables and severity of anxiety symptoms while adjusting for covariates.

To account for multiple testing of a large set of independent variables, a more stringent criterion was employed for the interpretation of p-values. A significance level of 0.01 ($p < 0.01$) was considered statistically significant and 99% confidence intervals (99% CI) were used in the multinomial logistic regression. Model performance was assessed by the Nagelkerke R^2 statistic (a pseudo R-squared measure of the proportion of explained variation in the logistic model). Initially, a backward elimination approach was applied to select variables based on the Wald test for individual parameters to achieve a parsimonious model in the process of statistical model building. The procedure began with all candidate predictors in the model, and the variable with the least significant effect that did not satisfy the 0.05 significance threshold was deleted. However, the reduced models with backward elimination procedure only excluded two variables (i.e., indoor exercise and tobacco consumption) for the women sample and three variables (i.e., food choices, outdoor exercise, and residency status) for the men sample, while the estimates of all retained variables did not change substantially compared to the original models. As such, to facilitate comparisons between men and women, full models with all *à priori* variables were presented for both sub-samples.

3. Results

3.1. Sample characteristics and prevalence of anxiety

Table 1 summarizes the unweighted sample size and weighted percentages by anxiety levels for all variables. The weighted overall sample (n = 3,769) mainly consisted of respondents who were Canadian-born (76.3%), aged >25 years (85.4%), high school graduate (87.9%), urban residents (85%), in a relationship (60.4%), living in a single-detached house (62.3%), 2-person households (52.6%). The sex distribution was even (men: 49.3%; women: 50.7%). With reference to variables of interest, around a quarter of respondents saw suspected misleading information related to COVID-19 multiple times a day (22%). More than half of respondents were employed and at work (51.9%) while only 2.6% were absent from work due to COVID-19 related reasons. The majority of respondents tended to report no change in their consumption of alcohol (72.3%), tobacco (94%), cannabis (91.9%), junk food/sweets (57.6%). Almost half of the respondents reported an increase in screen-time activities, including watching TV (46.6%) and using the Internet (57.1%). Most respondents

Table 1
Sample characteristics: unweighted sample size and weighted percentages (%) of generalized anxiety disorder (GAD) stratified by gender-by-GAD severity levels in the CPSS4-COVID (July 20–26, 2020).

	Full sample	Male Sample (n = 1,753)				Female Sample (n = 2,016)			
	Unweighted size	GAD=0	1≤GAD<10	GAD≥10	χ2	GAD=0	1≤GAD<10	GAD≥10	χ2
Variables	n = 3,769	n = 671	n = 945	n = 137	Sig.	n = 607	n = 1,136	n = 273	Sig.
Age					<0.001				<0.001
15–25	159	18.5%	64.9%	16.6%		9.2%	61.6%	29.1%	
25–44	1145	25.4%	63.5%	11.2%		19.5%	58.4%	22.1%	
45–64	1472	35.6%	56.5%	7.9%		31.7%	55.6%	12.7%	
≥65	993	46.5%	48.1%	5.4%		40.9%	52.2%	6.9%	
Education					0.003				0.026
< High school	192	24.9%	58.7%	16.4%		26.1%	55.3%	18.7%	
High school graduate to college	2066	33.6%	57.3%	9.2%		26.8%	54.6%	18.6%	
≥ Bachelor's degree	1511	29.3%	61.8%	8.9%		24.5%	62.0%	13.5%	
Immigration status					0.005				0.002
Canadian-born	3122	31.4%	59.9%	8.7%		26.4%	54.9%	18.7%	
Migrants	647	31.0%	55%	14%		24.7%	62.9%	12.4%	
Residency					0.021				<0.001
Urban	764	30.6%	58.7%	10.7%		24.3%	57.8%	17.9%	
Rural	3005	35.7%	59.0%	5.3.0%		35%	51.4%	13.6%	
Marriage					<0.001				<0.001
Married/common law	2334	35.2%	56.7%	8.1%%		29.8%	57.7%	12.6%	
Single/widowed	1435	24.9%	62.1%	13.0%		20.7%	55.6%	23.7%	
Type of dwelling					<0.001				<0.001
Single detached house	2517	34.2%	58.4%	7.3%		26.7%	57.3%	16.0%	
Low-rise apartment	419	19.1%	58.5%	22.4%		20.3%	53.9%	25.9%	
High-rise apartment	250	22.6%	66.7%	10.7%		25.5%	65.5%	9.1%	
Other	583	32.4%	55.8%	11.9%		27.6%	53.7%	18.8%	
Household size					0.001				<0.001
1 person	1080	34.8%	52.4%	12.8%		30.4%	54.2%	15.4%	
2 persons	2155	30.2%	62.4%%	7.5%		27.8%	57.3%	14.9%	
≥ 3 persons	534	31.7%	55.6%	12.7%		20.7%	57.4%	21.9%	
COVID-19 misinformation exposure					<0.001				<0.001
Multiple times a day	800	23.7%	61.0%	15.3%		18.1%	53.7%	28.3%	
Once a day	430	30.9%	57.5%	11.6%		20.9%	60.3%	18.8%	
At least once a week	979	31.0%	58.4%	10.7%		23.3%	63.8%	12.9%	
Rarely/Never	1031	32.9%	63%%	4.1%		29.2%	57.3%	13.5%	
Inactive	529	44.9%	46.4%	8.7%		41.4%	43.7%	14.8%	
Pandemic-related job precarity					0.026				<0.001
Employed	1912	32.0%	58.1%	9.9%		20.8%	65.0%	14.1%	
Absent, not COVID-19 related	252	40.0%	52.3%	7.7%		43.5%	37.0%	19.5%	
Absent, COVID-19 related	79	NA	NA	NA		15.1%	41.1%	43.8%	
Not employed	1453	31.5%	59.1%	9.4%		29.5%	54.1%	16.4%	
Not stated	73	NA	NA	NA		NA	NA	NA	
Change in weekly habits									
Consuming alcohol					<0.001				<0.001
Increased	590	13.0%	73.0%	14.0%		12.5%	58.6%	28.9%	
Decreased	335	17.7%	71.6%	10.7%		11.1%	68.1%	20.8%	
No change	2844	37.8%	53.3%	8.9%		31.2%	54.8%	14.0%	
Using tobacco products					<0.001				0.002
Increased	144	12.2%	56.1%	31.7%		13.0%	63.6%	23.4%	
Decreased	63	NA	NA	NA		NA	NA	NA	
No change	3562	32.2%	58.9%	8.8%		26.7%	56.7%	16.6%	
Consuming cannabis					<0.001				<0.001
Increased	197	3.2%	75.4%	21.4%		5.5%	55.0%	39.4%	
Decreased	67	NA	NA	NA		NA	NA	NA	
No change	3505	33.3%	57.6%	9.1%		27.5%	57.1%	15.4%	
Eating junk food/sweets					<0.001				<0.001
Increased	979	13.0%	65.9%	21.1%		13.0%	61.8%	25.2%	
Decreased	490	23.4%	63.1%	13.4%		14.7%	65.1%	20.2%	
No change	2300	39.9%	55.1%	5.0%		36.8%	51.7%	11.6%	
Watching television					<0.001				<0.001
Increased	1638	18.3%	66.5%	15.2%		21.5%	56.6%	22.0%	
Decreased	321	32.3%	63.8%	3.9%		21.9%	62.7%	15.4%	
No change	1810	43.5%	50.7%	5.9%		31.7%	56.0%	12.3%	
Using internet					<0.001				<0.001
Increased	1910	20.3%	66.6%	13.1%		18.9%	60.1%	21.0%	
Decreased	140	21.4%	60.7%	17.9%		32.3%	59.7%	8.1%	
No change	1719	46.2%	48.6%	5.2%		37.0%	51.3%	11.7%	
Playing video games					<0.001				<0.001
Increased	527	14.6%	70.3%	15.1%		14.7%	63.8%	21.5%	
Decreased	107	20.3%	67.2%	12.5%		13.6%	53.0%	33.3%	
No change	3135	37.7%	54.4%	7.9%		28.5%	55.8%	15.8%	
Doing activities for health									
Chat with friends					<0.001				<0.001
No	323	53.8%	38.7%	7.5%		34.5%	33.1%	32.4%	

(*continued on next page*)

Table 1 (*continued*)

Variables	Full sample Unweighted size n = 3,769	Male Sample (n = 1,753) GAD=0 n = 671	1≤GAD<10 n = 945	GAD≥10 n = 137	χ2 Sig.	Female Sample (n = 2,016) GAD=0 n = 607	1≤GAD<10 n = 1,136	GAD≥10 n = 273	χ2 Sig.
Yes	3446	28.7%	61.1%	10.2%		25.3%	58.7%	16.0%	
Past-week contact					0.025				0.09
0 person	238	31.8%	57.6%	10.6%		26.7%	49.3%	24.0%	
1–3 persons	809	33.2%	53.1%	13.7%		28.3%	55.0%	16.7%	
>3 persons	2722	30.7%	60.6%	8.7%		25.1%	58.2%	16.7%	
Meditation					0.026				<0.001
No	2812	32.4%	58.6%	9.0%		26.7%	58.2%	15.1%	
Yes	957	27.6%	59.4%	13%		24.1%	53.0%	22.8%	
Exercise outdoors					0.167				<0.001
No	774	30.7%	57.1%	12.2%		23.4%	51.4%	25.2%	
Yes	2995	31.5%	59.3%	9.1%		27.0%	58.8%	14.2%	
Exercise Indoors					0.938				0.23
No	1825	31.4%	58.4%	10.2%		27.8%	55.2%	17.0%	
Yes	1944	31.2%	59.1%	9.7%		24.5%	58.1%	17.4%	
Changing food choices					<0.001				<0.001
No	2148	36.1%	55.8%	8.1%		30.2%	56.4%	13.5%	
Yes	1621	25.5%	62.4%	12.2%		21.2%	57.3%	21.5%	

Notes: Sample size was presented as unweighted data while the percentages were based on weighted data to reflect population-based national estimates. NA=not available (unweighted cell count, $n \leq 40$, therefore, estimates based on such data were not shown for quality control). CPSS4=Canadian Perspective Survey Series 4 (Online nationwide survey).

were proactively doing outdoor sports (73.3%) and chatting with friends for health (91.1%). Chi-square statistics also revealed that most variables were significantly linked to anxiety for both men and women samples, except for social circle, exercise outdoors, and exercise indoors (p>0.05). The estimated overall prevalence of generalized anxiety disorders (GAD score ≥10) was 13.6% during the first wave of COVID-19 outbreak in Canada, with women's GAD prevalence significantly higher than men's (17.2% vs. 9.9%, χ 2=46.7, p<0.001). Fig. 2 depicts the prevalence of 4-level GAD severity in the general populations (32.4% minimal, 25.3% mild, 9.1% moderate, 4.5% severe) and stratified by genders.

3.2. Multivariable logistic regression

Table 2 contain the multivariable-adjusted logistic regression analysis of major socio-ecological factors on the severity levels of anxiety symptoms for men (Model A) and women (Model B), respectively. After full adjustment, the associations between certain socio-ecological factors and anxiety were very robust that the linkages were not attenuated by known confounders. Notably, the Nagelkerke R^2 statistics indicate that the established model could explain 30.3% variance of anxiety prevalence for the overall sample, 35.1% for the men sample and 34.7% variance for the women sample. In the whole sample model with full adjustment (data not shown but available upon request), women double the odds of moderate/severe anxiety than men (OR=2.00, 99% CI: 1.42–2.81). Besides gender inequalities, there were other risk factors of moderate/severe anxiety, including younger age (ORs range from 2.26 – 5.03), living in low-rise apartment (OR=3.11, 99% CI: 3.11 – 5.37), had ≥ one exposure to fake news per day (ORs range from 2.23 – 2.74), absent from work due to COVID-19 reasons (OR=3.27, 99% CI:

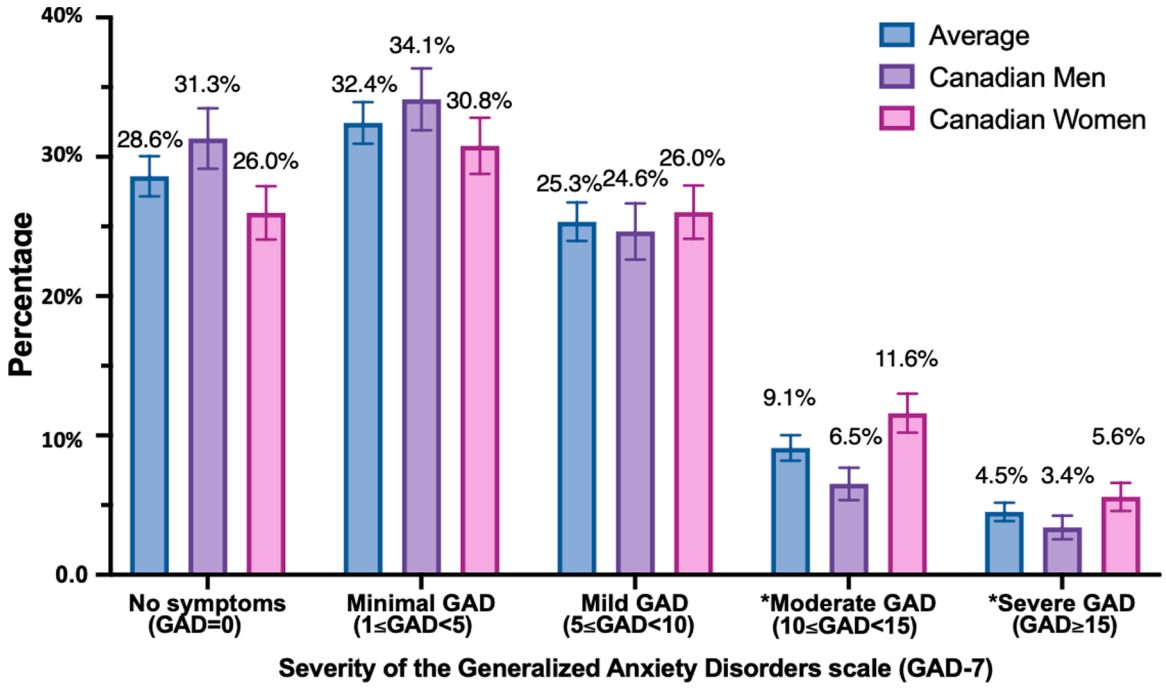

Fig. 2. Prevalence of generalized anxiety disorder (GAD) by gender in CPSS4-COVID (July 20–26, 2020), persons aged ≥15 (N = 3,769)
Note: *indicates clinically significant cases of anxiety disorders.

Table 2
Multivariable-adjusted odds ratios of generalized anxiety disorder (GAD) by misinformation exposure, precarious employment, and health behavior change among men (Model A) and women (Model B), CPSS4-COVID (July 20–26, 2020).

	Model A: Male Sample (n = 1753)								Model B: Female Sample (n = 2016)							
	Mini/Mild: 1≤GAD<10 (vs. no anxiety: GAD=0) n = 1,030				Moderate/severe: GAD≥10 (vs. no anxiety: GAD=0) n = 174				Mini/Mild: 1≤GAD<10 (vs. no anxiety: GAD=0) n = 1,145				Moderate/severe: GAD≥10 (vs. no anxiety, GAD=0) n = 347			
Explanatory variables	aOR	99%CI		Sig.	aOR	99%CI		Sig.	aOR	99%CI		Sig.	aOR	99%CI		Sig.
Socio-demographics																
Age (Ref. ≥65)																
15–25	1.56	0.68	3.58	0.167	2.30	0.56	9.45	0.130	**3.17**	**1.29**	**7.80**	**0.001**	**11.01**	**3.45**	**35.13**	**<0.001**
25–44	**1.80**	**1.02**	**3.17**	**0.007**	1.80	0.63	5.17	0.152	1.48	0.89	2.45	0.045	**4.85**	**2.19**	**10.71**	**<0.001**
45–64	**1.82**	**1.11**	**2.99**	**0.002**	1.66	0.64	4.31	0.174	1.12	0.71	1.76	0.519	**2.19**	**1.02**	**4.71**	**0.008**
Education (Ref. ≥ Bachelor's degree)																
< High school	1.39	0.70	2.74	0.213	2.78	0.95	8.19	0.014	0.53	0.28	1.02	0.013	0.52	0.21	1.28	0.061
High school graduate	0.82	0.57	1.19	0.178	0.86	0.44	1.68	0.562	0.89	0.62	1.27	0.386	1.30	0.77	2.19	0.198
Migration status (Ref. Canadian-born)																
Migrants	0.86	0.57	1.29	0.327	1.76	0.89	3.47	0.033	1.23	0.83	1.81	0.182	**0.49**	**0.27**	**0.90**	**0.002**
Residency (Ref. Urban)																
Rural	1.13	0.71	1.79	0.508	0.94	0.35	2.53	0.880	0.74	0.49	1.12	0.059	0.54	0.28	1.02	0.013
Marriage (Ref. Married)																
Single/widowed	1.74	0.99	3.07	0.012	0.91	0.34	2.48	0.816	1.19	0.72	1.97	0.372	**2.26**	**1.18**	**4.33**	**0.001**
Type of dwelling (Ref. Detached house)																
Low-rise apartment	1.68	0.90	3.16	0.033	**4.95**	**1.99**	**12.36**	**<0.001**	1.49	0.84	2.62	0.071	2.06	0.98	4.32	0.012
High-rise apartment	1.50	0.80	2.83	0.098	1.40	0.47	4.13	0.429	1.12	0.62	2.05	0.619	0.74	0.28	2.00	0.437
Others	0.91	0.58	1.43	0.581	1.24	0.57	2.74	0.476	0.81	0.54	1.23	0.198	0.73	0.41	1.30	0.160
Household size (Ref. 2 persons)																
1 person	**0.36**	**0.18**	**0.72**	**<0.001**	0.86	0.25	2.92	0.746	0.72	0.40	1.28	0.139	0.48	0.22	1.04	0.015
≥ 3 persons	**0.59**	**0.39**	**0.88**	**0.001**	1.38	0.68	2.80	0.248	0.89	0.59	1.35	0.466	0.86	0.47	1.54	0.495
Macro-level stressor																
COVID-19 misinformation exposure (Ref. Rarely/Never)																
Multiple times a day	1.30	0.81	2.08	0.151	**6.55**	**2.67**	**16.09**	**<0.001**	1.22	0.76	1.95	0.278	**1.88**	**1.01**	**3.53**	**0.009**
Once a day	1.19	0.71	2.01	0.386	**5.34**	**1.89**	**15.10**	**<0.001**	1.24	0.72	2.14	0.318	1.43	0.66	3.09	0.236
At least once a week	0.98	0.63	1.52	0.899	**3.14**	**1.29**	**7.68**	**0.001**	1.39	0.92	2.08	0.039	1.08	0.58	2.01	0.737
Inactive	0.99	0.57	1.71	0.963	**5.24**	**1.74**	**15.80**	**<0.001**	0.85	0.53	1.39	0.399	1.10	0.52	2.31	0.744
Meso-level stressor																
Job precarity (Ref. Employed)																
Absent, not COVID-19 related	**0.44**	**0.20**	**0.99**	**0.009**	0.51	0.12	2.16	0.225	**0.29**	**0.16**	**0.51**	**<0.001**	1.00	0.48	2.10	1.000
Absent, COVID-19 related	NA	NA	NA	0.116	NA	NA	NA	0.909	0.68	0.25	1.89	0.336	**3.52**	**1.12**	**11.04**	**0.005**
Not employed	1.53	0.99	2.36	0.012	1.41	0.68	2.91	0.227	0.85	0.59	1.25	0.279	1.42	0.84	2.42	0.089
Not stated	NA	NA	NA	0.124	NA	NA	NA	0.615	NA	NA	NA	0.907	NA	NA	NA	0.010
Micro-level health behavior changes																
Consuming alcohol (Ref. No change)																
Increased	**2.98**	**1.72**	**5.14**	**<0.001**	**3.01**	**1.35**	**6.70**	**<0.001**	**1.80**	**1.08**	**3.01**	**0.003**	**3.08**	**1.67**	**5.68**	**<0.001**
Decreased	**2.58**	**1.38**	**4.81**	**<0.001**	1.88	0.72	4.94	0.093	**2.17**	**1.12**	**4.22**	**0.003**	2.03	0.86	4.76	0.033
Using tobacco products (Ref. No change)																
Increased	1.03	0.37	2.85	0.951	1.87	0.55	6.38	0.186	1.73	0.63	4.73	0.160	1.21	0.36	4.10	0.683
Decreased	NA	NA	NA	0.073	NA	NA	NA	0.747	NA	NA	NA	0.520	NA	NA	NA	0.759
Consuming cannabis (Ref. No change)																
Increased	**5.36**	**1.39**	**20.63**	**0.001**	**5.38**	**1.18**	**24.54**	**0.004**	**3.31**	**0.96**	**11.40**	**0.013**	**6.20**	**1.68**	**22.92**	**<0.001**
Decreased	NA	NA	NA	0.219	NA	NA	NA	0.158	NA	NA	NA	0.508	NA	NA	NA	0.869
Eating junk food/sweets (Ref. No change)																
Increased	**1.88**	**1.13**	**3.11**	**0.001**	**7.11**	**3.42**	**14.79**	**<0.001**	**2.72**	**1.83**	**4.05**	**<0.001**	**3.41**	**2.02**	**5.75**	**<0.001**
Decreased	1.32	0.80	2.16	0.151	**2.92**	**1.30**	**6.56**	**0.001**	**2.35**	**1.35**	**4.08**	**<0.001**	1.70	0.81	3.54	0.065
Watching television (Ref. No change)																
Increased	**1.65**	**1.11**	**2.47**	**0.001**	**2.62**	**1.31**	**5.27**	**<0.001**	0.85	0.58	1.23	0.259	1.68	0.98	2.88	0.013
Decreased	0.96	0.51	1.78	0.852	0.32	0.07	1.42	0.049	1.02	0.53	1.95	0.950	1.32	0.52	3.38	0.440

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Table 2 (*continued*)

	Model A: Male Sample (n = 1753)								**Model B: Female Sample (n = 2016)**							
	Mini/Mild: 1≤GAD<10 (vs. no anxiety: GAD=0) n = 1,030				**Moderate/severe: GAD≥10 (vs. no anxiety: GAD=0)** n = 174				**Mini/Mild: 1≤GAD<10 (vs. no anxiety: GAD=0)** n = 1,145				**Moderate/severe: GAD≥10 (vs. no anxiety, GAD=0)** n = 347			
Explanatory variables	aOR	99%CI		Sig.	aOR	99%CI		Sig.	aOR	99%CI		Sig.	aOR	99%CI		Sig.
Using internet (Ref. No change)																
Increased	**1.49**	**1.02**	**2.18**	**0.007**	1.90	0.91	3.93	0.024	**1.70**	**1.17**	**2.47**	**<0.001**	1.65	0.95	2.86	0.020
Decreased	1.65	0.60	4.52	0.200	**5.47**	**1.27**	**23.63**	**0.003**	0.87	0.35	2.15	0.691	0.42	0.09	1.97	0.149
Playing video games (Ref. No change)																
Increased	**1.63**	**1.01**	**2.65**	**0.009**	1.95	0.92	4.12	0.021	1.28	0.76	2.17	0.228	1.04	0.54	2.01	0.885
Decreased	1.27	0.48	3.38	0.534	1.24	0.27	5.69	0.718	1.29	0.42	3.94	0.554	2.09	0.55	7.96	0.154
Past-week contact (Ref. >3 persons)																
0 person	0.91	0.49	1.67	0.676	1.66	0.60	4.59	0.196	1.33	0.73	2.42	0.226	**2.81**	**1.24**	**6.37**	**0.001**
1–3 persons	0.76	0.51	1.14	0.078	1.09	0.57	2.10	0.725	1.05	0.73	1.51	0.732	1.40	0.84	2.33	0.089
Chat with friends for health (Ref. Yes)																
Did not chat with friends	**0.40**	**0.24**	**0.68**	**<0.001**	0.67	0.25	1.75	0.280	**0.43**	**0.23**	**0.80**	**0.001**	1.70	0.77	3.76	0.085
Meditation for health (Ref. Yes)																
Did not do meditation	0.87	0.58	1.31	0.395	0.71	0.37	1.37	0.178	0.90	0.63	1.29	0.438	**0.43**	**0.27**	**0.71**	**<0.001**
Outdoor sports for health (Ref. Yes)																
Did not do outdoor sports	1.19	0.80	1.77	0.268	1.18	0.63	2.23	0.503	1.06	0.72	1.55	0.714	**1.86**	**1.13**	**3.07**	**0.001**
Indoor sports for health (Ref. Yes)																
Did not do indoor sports	1.24	0.89	1.73	0.102	**1.91**	**1.07**	**3.42**	**0.004**	0.97	0.70	1.33	0.780	1.02	0.64	1.62	0.917
Food choice for health (Ref. Yes)																
Did not change food choice	0.88	0.62	1.26	0.373	0.99	0.53	1.85	0.975	1.08	0.78	1.50	0.545	0.68	0.43	1.09	0.037

Note: To account for multiple testing of a large set of independent variables, a more stringent criterion was adopted: a significance level of 0.01 ($p < 0.01$) was considered statistically significant (bolded) and 99% confidence intervals (99% CI) were used in the multinomial logistic regression. Model performance: Nagelkerke R^2=35.1% (Male sample). Nagelkerke R^2=34.7% (Female sample). Sig.= significance level. aOR=adjusted odds ratio. CPSS4=Canadian Perspective Survey Series 4. The reference time frame of the employment status: July 12 to July 18, 2020. NA=not available (unweighted cell count, $n \leq 40$, therefore, estimates based on such data were not shown for quality control).

1.17 – 9.14), increased intake of alcohol (OR=3.24, 99% CI: 2.02 – 5.19), cannabis (OR=7.06, 99% CI: 2.70 – 18.49), junk food/sweets (OR=3.90, 99%CI: 2.90 – 5.58), increased screen time of television (OR=2.03, 99% CI: 1.35 – 3.04) and no past-week contact outside household (OR=1.83, 99% CI: 1.01 – 3.34). For sex-specific analysis, the odds of moderate/severe anxiety were associated with younger age (ORs range from 2.19 to 11.01, p's<0.01) and being single (OR=2.26, 99% CI: 1.18–4.33) among women, while men living in a low-rise apartment were close to five times more likely to develop moderate/severe anxiety than men living in a single-detached house (OR=4.95, 99% CI: 1.99–12.36).

3.2.1. The gendered impact of COVID-19 misinformation exposure on anxiety (Q1)

The associations between COVID-19 misinformation exposure and anxiety were more salient among men than women. As shown in Table 2 Model A, in the multivariable model, there was a dose-response relationship between the frequency of seeing suspected misleading information related to COVID-19 and moderate/severe anxiety symptoms among men. In other words, with increasing exposure to misleading COVID-19 news, the odds of having moderate/severe anxiety significantly escalated among men, ranging from men in the lowest exposure bracket (i.e., at least once a week) with more than triple the odds (OR=3.14, 99% CI:1.29–7.68) to men in the highest exposure bracket (i.e., multiple times a day) having six-and-a-half greater odds (OR=6.55, 99% CI:2.67–16.09), compared to men who never or rarely saw misleading COVID-19 information. Men who were inactive in seeking and/or validating COVID-19 information also reported higher odds (OR=5.24, 99% CI:1.74–15.80). For women (see Table 2 Model B), compared to women who never saw misinformation, only respondents in the highest exposure bracket experienced moderate/severe anxiety (OR=1.88, 99% CI:1.01–3.53), while other women with different levels of misinformation exposure had a comparable pattern.

3.2.2. The gendered impact of pandemic-related job precarity on anxiety (Q2)

On the other hand, the COVID-19 disruptions on employment were only observed among Canadian women but not among men. As shown in Table 2 Model B, the odds of experiencing moderate/severe anxiety for women who were absent from work due to COVID-19 reasons were 3.52 times higher than women who were employed and at work (OR=3.53, 99% CI:1.12–11.04). For both men and women (see Model A & Model B), individuals who were employed and absent from work due to other reasons not related to COVID-19 (e.g., vacation, parental leave) reported decreased odds of experiencing mild anxiety (men: OR=0.44, 99% CI:0.20–0.99; women: OR=0.29, 99% CI:0.16–0.51) than their peers who were at work during the past seven days. For both genders, the odds of anxiety among respondents who were not employed in the labor market did not differ from their employed counterparts (p's>0.01). This suggests that it was the job precarity stemming from the COVID-19 pandemic, rather than the employment status itself, leading to respondents' elevated anxious feeling.

3.2.3. The gendered impact of health behavior changes on anxiety (Q3)

There were several gender-specific disparities in the relationship between health behavior changes and different levels of anxiety. Men who increased their time in watching TV on a weekly basis tended to have mild to severe anxiety (ORs range from 1.65 to 2.62, p's<0.01) while such linkage was not significant among women. Compared to men who exercised indoors for health, non-exercisers had close to double the odds of having moderate/severe anxiety (OR=1.91, 99% CI:1.07–3.42). Interestingly, men with reduced time on Internet were positively correlated to moderate/severe anxiety (OR=5.47, 99% CI:1.27–23.63), compared to users whose time remained the same. Women with no contacts outside the household around triple the odds of moderate/severe anxiety (OR=2.81, 99% CI:1.24–6.37) while this pattern did not stand out among men. Outdoor sports for health were uniquely linked with anxiety among women (OR=1.86, 99% CI:1.13–3.07) but not for men.

In addition, several consistent patterns were observed across both genders. For both men and women (see Table 2, Model A & Model B, respectively), there were strong linkages between increased alcohol use and moderate/severe anxiety (men: OR=3.01, 99% CI:1.35–6.70; women: OR=3.08, 99% CI:1.67–5.68) and minimal/mild anxiety (men: OR=2.98, 99% CI:1.72–5.14; women: OR=1.80, 99% CI:1.08–3.01). Similarly, for individuals who reported increasing their cannabis consumption, the odds of having mild to severe anxiety symptoms ranged from 5.36 to 5.38 for men and ranged from 3.31 to 6.20 for women (p's<0.01). The associations with mild to severe anxiety were also observed among both genders with increased intake of junk/sweet food (men: ORs range from 1.88 to 7.11, p's<0.01; women: ORs range from 2.72 to 3.41, p's<0.001). Interestingly, men and women who did not chat with friends/family for health tended to report lower odds of minimal/mild anxiety. Likewise, women who did not practice meditation for health reported decreased odds of moderate/severe anxiety (OR=0.43, 99% CI:0.27–0.71). These counterintuitive directions may reflect that chatting with friends and meditation both served as adaptive coping behaviors after individuals developinganxiety symptoms.

4. Discussion

This nationwide study is among the first to estimate the gender-specific population prevalence of anxiety based on the GAD-7 validated scale and its risk factors during early COVID-19 pandemic in Canada. The finding revealed that approximately one out of seven Canadians (13.6%) was at risk of experiencing clinically significant levels of generalized anxiety disorders (GAD), with women's GAD prevalence significantly higher than men's (17.2% vs. 9.9%). This overall estimate by relying on probability sampling was similar to previous COVID-19 psychiatry research (13.7%) among teachers in China (Li et al., 2020) and slightly higher than a German study (9.6%) (Bäuerle et al., 2020), but substantially lower than other Canadian studies sampling (25.5%–30.2%) based on non-probability (Elton-Marshall et al., 2021; Turna et al., 2021). Higher prevalence of GAD among women (vs. men) during early COVID-19 outbreak was also observed in a UK study (25.1% vs. 17.9%) using quota sampling (Shevlin et al., 2020). In addition, the current investigation concurrently examined three levels of COVID-19-related socioecological factors (i.e., fake news exposure, job precarity and behavioural alterations) and their relationships with generalized anxiety disorder among community-dwelling Canadians aged 15 years and older.

4.1. Main findings and implications for practice

4.1.1. COVID-19 infodemic management to reduce men's anxiety (Q1)

There was a clear gradient effect by the frequency of seeing suspected COVID-19 misinformation on the probability of developing moderate to severe anxiety symptoms, especially among men, which persisted regardless of demographic, socioeconomic, and behavioural health factors (Research question 1). A recent Chinese study revealed that increased time spent on information (≥ 3 h) related to COVID-19 was associated with GAD (Huang and Zhao, 2020). Another Chinese study further illustrated that learning COVID-19 information from mixed sources, including both public service announcements and social media, was linked to decreased odds of GAD, compared to individuals who only learned information from social media (Li et al., 2020), which implies that cross-referencing COVID-19 information with credible sources would prevent anxious feeling. Our nuanced assessment extends this line of inquiry by quantifying the dose-response relationship underlying the mechanism between COVID-19 misinformation exposure and anxiety for men who saw fake news online: the more frequent misleading information being exposed, the higher likelihood of

experiencing panic mood. However, this dose-response association were only observed among men but not among women.

The gender difference may be attributable to the "gender gap in news consumption" (Melki et al., 2021) - a phenomenon where women tend to consume less news due to caretaking responsibilities (Benesch, 2012; Toff and Palmer, 2019). This evidence of COVID-19 misinformation' harmful impact on mental health is particularly relevant to the infodemic management. Given the COVID-19 infodemic continues to jeopardize public health measures and ignite mistrust in health authorities (WHO, 2020), the finding illuminates the importance of conveying accurate health information to the public via health care professionals as trusted sources (Garfin et al., 2020) and leverage health communication strategies as well as infodemic-surveillance systems in the battle against COVID-19 (Mheidly and Fares, 2020; Scales et al., 2021). Taking breaks from receiving COVID-19 news and choosing trusted sources are recommended to mitigate anxiety symptoms, particularly among men who may have higher news consumption.

4.1.2. Occupational justice and income replacement for precarious women workers (Q2)

The elevated burden of anxiety among women who were absent from work due to COVID-19 reasons (e.g., business closure, layoff, COVID-19 diagnosis) confirms the hypothesis of labor market impact (Research question 2). This finding is consistent with previous studies which found perceived high risk of job loss and job insecurity associated with a greater risk of GAD (Fullana et al., 2020b; Ganson et al., 2021). However, in the present study, this pattern was not observed among men largely due to limited statistical power, because the unweighted cell size ($n = 27$) of this category ("absent from work due to COVID-19 reasons") was so small that a possible association could not be detected among men. This finding highlights another worrying situation that women were disproportionately influenced by the precarious employment disrupted by the pandemic than men in this sample (72.2% vs. 27.8%, $p<0.001$). It resonates with existing evidence on gender inequalities in job loss related to the COVID-19 pandemic (Dang and Viet Nguyen, 2021; Matilla-Santander et al., 2021).

Gender-based occupational segregation is the fundamental cause, by which women were overrepresented in the health and social care workforce (e.g., nurse aides and personal support workers) that are often underpaid and at higher risk of exposure to COVID-19 pathogens as well as in accommodations and foodservice sectors that are hardest hit by the COVID-19 crisis(King et al., 2020). As such, occupational justice is needed to confront the longstanding gender discrimination and the gendered nature of precarious labor underlying job precariousness. Moreover, considering that higher burden of anxiety was observed among jobless women as a consequence of COVID-19, primary care teams should expand access to virtual mental health care and recourses (Ashcroft et al., 2021), such as Internet-delivered cognitive behavioral therapy, tailored to women coping with precarious employment. Social policies that redistribute resources could address upstream social determinants of health, particularly among women workers with precarious job (Phelan et al., 2010). For example, the Canada Emergency Response Benefit, a temporary cash transfer program, is an excellent example in responding to the escalated precariousness of employment during this turbulent time, which could be beneficial in reducing financial hardship for Canadians (Zajacova et al., 2020a).

4.1.3. Prevention for co-occurring anxiety and addictive behaviours in both genders (Q3)

Lastly, GAD was positively linked with certain sedentary and addictive behaviours for men and women, which validate the health behavior impact hypothesis (Research question 3). Without longitudinal data, it is difficult to determine the direction of the association and the relationship may be bidirectional. The result demonstrates that increased intake of alcohol and cannabis were strongly associated with GAD for both men and women during the pandemic, possibly because of the avoidance coping strategy for grappling with the COVID-19-related stressors (Rodriguez et al., 2020; Taylor et al., 2021). Such causal patten could be explained by prior meta-analysis and knowledge synthesis in pre-pandemic times (DeMartini and Carey, 2011; Kedzior and Laeber, 2014). Previous prospective analyses revealed that baseline cannabis use was associated with increased anxiety at the follow-up assessment among young adults (Wittchen et al., 2007). In addition, studies found that persons with higher anxiety sensitivity - the fear of arousal-related bodily sensations- had more risky drinking motives that were correlated with drinking frequency (Stewart et al., 2001). More importantly, the present study implies that the COVID-19 pandemic may contribute to the new onset of concurrent disorders (i.e., co-occurring addiction and mental health problems) or relapse of pre-existing dual disorders for both genders (Volkow, 2020). Given anxious individuals may start using cannabis and alcohol as anti-anxiety remedies to mitigate negative emotions (e.g., fear, tension or even grief) during the pandemic, continued monitoring should be employed to prevent new cases of addiction problems, including alcohol abuse and sedative/hypnotic dependence (Du et al., 2020).

The present study also found a linkage between increased junk food consumption and anxiety amid COVID-19 outbreak in Canada for both men and women. This was consistent with recent dietary research in Chile, which documented the pattern of anxiety levels associated with sugar-sweetened beverages, fast food, and pastry consumption during the pandemic (Landaeta-Díaz et al., 2021). Our findings corroborate existing work on social isolation's effect on anxiety (Boehlen et al., 2020; Wu et al., 2021) and illustrate that women whose social circles were only within the household in the past seven days were at greater risk of experiencing anxiety in COVID-19 times. Furthermore, the finding identifying an association between a decrease in internet screen time and anxiety for men has not, to our knowledge, been reported elsewhere. In line with prior research (Hu et al., 2020), the beneficial influence of indoor exercise for men and outdoor exercise for women on anxiety reduction was observed in this study. It may be plausible that exercise could improve the expression of brain-derived neurotrophic factors, affect synaptic transmission, and therefore exert a neuroprotective effect (Sleiman et al., 2016).

4.2. Strength and limitations

By using population-based data, this study illuminates the unique role of gender, suspected fake news, job precarity and health behaviours in the association with anxiety disorders during the first wave of COVID-19 outbreak in Canada. 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. For example, the variable of COVID-19 misinformation exposure was based on subjective perceptions and evaluation of respondents themselves; thus, those who believe in conspiracy theory may assess misinformation as trustworthy. Yet, questions of information validation may have prevented such possible misclassification because those who never validate COVID-19 information were skipped from reporting exposure frequency. Second, the cross-sectional nature of the data prohibits the examination of causality. For instance, some individuals consume junk food and sweets because of their self-soothing qualities when facing mental health challenges.

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 survey did not capture pre-existing mental health conditions or history of psychiatric diagnoses as these confounders were proved to impact anxiety symptoms at a later stage (Fancourt et al., 2021). There are many psychopathological processes that are involved in anxiety and thus it was impossible to account for all health determinants. 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). Due to relatively small sample size, some estimates may contain large variance, thus caution should be given to interpret these estimates. Lastly, despite the CPSS is a nationwide survey, the online survey method of CPSS-4 excludes individuals without Internet access and is subjective to potential nonresponse bias, resulting in an overrepresentation of individuals with a post-secondary certification, Canadian-born residents and two-person households as well as an underrepresentation of people without a high school diploma.

5. Conclusion

Amidst the turbulent time of the COVID-19 pandemic, this nationwide study has evaluated the psychological impact of this unprecedented public health emergency, by documenting the estimated population prevalence of generalized anxiety and its associations with COVID-19 misinformation exposure, precarious employment, and health behavior changes, after adjusting for various socio-demographic measurements in Canada. At the practice level for clinicians, these identified associations could shed light on the gender-specific case identification of vulnerable populations: men were more susceptible to anxiety resulting from COVID-19-related misinformation exposure; whereas women were more prone to anxiety caused by the pandemic-related job precarity. As such, it is vital to implement gender-specific interventions for an equitable pandemic response, whereby COVID-19 infodemic management would be more beneficial for men while income replacement programs for precarious workers are expected to have a stronger anxiety-reducing effect on women. For both men and women, as the pandemic evolves, continued monitoring of sedentary and addictive behaviours are necessary to prevent new cases of addictions and/or onset of concurrent disorders among anxious individuals. On a broader scale, these empirical findings could contribute to the formulation of mental health policies and targeted evidence-based interventions that are responsive to the immediate mental health needs of Canadians during a public health crisis.

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Ethical approval and data availability statement

The public use microdata file of the Canadian Perspectives Survey Series is available to Canadian researchers via Statistics Canada's Data Liberation Initiative and to international researchers by request at dli-idd@statcan.gc.ca from Statistics Canada. The public-use data are completely de-identified and publicly available 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 relied solely on Statistics Canada's publicly avaliable data could be deemed as non-human subjects research and does not require institutional ethics review. TCPS Article 2.2 allows exemption of research based exclusively on publicly available data from reasech ethics board review. This exemption is based on the presence of a legally designated custodian who protects privacy.

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The opinions expressed in this manuscript are the author's own and do not reflect the views of Statistics Canada.

CRediT authorship contribution statement

Shen (Lamson) Lin: Conceptualization, Methodology, Writing – original draft, Formal analysis, Writing – review & editing.

Declaration of Competing Interest

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