



## Food insecurity, chronic pain, and use of prescription opioids

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### ARTICLE INFO

#### Keywords:

Socioeconomic status  
Pain management  
Opioid use disorder  
Opioid overdose  
Opioid dependence  
Health equity

### ABSTRACT

Chronic pain has been on the rise in recent decades in Canada. Accordingly, the use of prescription opioids (PO) in Canada increased drastically between 2005 and 2014, only starting to decrease in 2015. Both pain and PO use have serious public health repercussions, disproportionately affecting select socially disadvantaged populations. Food insecurity is a strong risk factor for mental disorders and suicidal outcomes, yet its relationship to chronic pain and PO use is largely unknown. Using two recent cycles from the population representative Canadian Community Health Survey (CCHS), we examined the association of household food insecurity status with chronic pain and PO use among Canadians 12 years and older, adjusting for health and sociodemographic characteristics. Compared to food-secure individuals, marginally, moderately, and severely food-insecure individuals had 1.31 (95% confidence interval [CI] 1.15–1.48), 1.89 (95% CI 1.71–2.08), and 3.29 (95% CI 2.90–3.74) times higher odds of experiencing chronic pain and 1.55 (95% CI 1.30–1.85), 1.77 (95% CI 1.54–2.04), and 2.65 (95% CI 2.27–3.09) times higher odds of using PO in the past year, respectively. The graded association with food insecurity severity was also found in severe pain experience and pain-induced activity limitations among chronic pain patients and, less consistently, in intensive, excess, and alternative use of PO and its acquisition through means other than medical prescription among past-year PO users. Food insecurity was a much more powerful predictor of chronic pain and PO use than other well-established social determinants of health like income and education. Policies reducing food insecurity may lower incidence of chronic pain and help contain the opioid crisis.

### Introduction

Chronic pain – pain that lasts for 3–6 months or beyond the normal healing time – has grown more prevalent in high income countries in the recent decades, with chronic pain reported by one in five Canadians in 2014 (Shupler et al., 2019). Women, older adults, and ethnic minorities are disproportionately affected by chronic pain (Mills et al., 2019; Reitsma et al., 2011); these findings have been associated with activity limitations (Reitsma et al., 2011), depression (Currie & Wang, 2004), anxiety (Fuller-Thomson et al., 2017), and suicidal ideation and attempts (Racine, 2018). Causes driving the demographic heterogeneity in

chronic pain are not well understood, though biological predisposition, susceptibility to pain-related diseases, and structural socioeconomic disadvantages are likely contributing factors (Mills et al., 2019). In Ontario, Canada, chronic pain management was associated with 51% higher per-person annual health care costs (Hogan et al., 2016).

Once mainly used on terminally ill patients, prescription opioids (PO) such as oxycodone, hydromorphone, and fentanyl have been increasingly dispensed to non-cancer patients for pain management over the past decades (Barbera et al., 2017; Fischer, Jones, et al., 2018). Canada's total dispensing of prescription opioids tripled from 2000 to 2012, rendering the country second in global opioid consumption after

*Abbreviations:* PO, prescription opioids; FI, food insecurity; CCHS, Canadian Community Health Survey.

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<https://doi.org/10.1016/j.ssmph.2021.100768>

Received 7 December 2020; Received in revised form 19 February 2021; Accepted 2 March 2021

Available online 9 March 2021

2352-8273/© 2021 The Author(s).

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the United States (US) (Fischer et al., 2016; Vojtila et al., 2020). Following a series of policy interventions, Canada's opioid consumption has somewhat shrunk, ranking just behind the US and some European countries in 2016–18 (International Narcotics Control Board, 2019). Even after substantial declines, about one-eighth of Canadians were dispensed PO in 2018, of which almost one-fifth were prescribed on a long-term basis (Canadian Institute for Health Information, 2019); the rates were even higher in the largest province (Ontario) (Gomes et al., 2017). While PO can be an effective tool for pain management when used appropriately, overprescription, non-medical use, and increasing proliferation of illicit/synthetic opioids have all contributed to high rates of opioid use disorder and opioid-related deaths in Canada (Fischer, 2018; Fischer et al., 2018b, 2020; Gomes, Khuu, et al., 2018; Vojtila et al., 2020). Over 17,000 opioid-related deaths and 21,000 opioid-related hospitalizations have occurred in Canada since 2016 (Special Advisory Committee on the Epidemic of Opioid Overdoses, 2020), disproportionately affecting men and young adults (Gomes, Greaves, et al., 2018; Lisa & Jessica, 2018). Opioids were estimated to cost Canada \$5.9 billion in 2017, representing 12.9% of total costs attributable to substance use (Canadian Substance Use Costs and Harms Scientific Working Group, 2020).

Both chronic pain and use of PO are more common in select socioeconomically disadvantaged populations (Currie & Wang, 2004; Fuller-Thomson et al., 2017; Grol-Prokopczyk, 2017; Hogan et al., 2016; Mills et al., 2019; Poleshuck & Green, 2008). Food insecurity – the inadequate or insecure access to food due to financial constraints – affects one in eight Canadian households (Tarasuk & Mitchell, 2020), most of who also experience other socioeconomic disadvantages (Tarasuk, Fafard St-Germain, & Mitchell, 2019). As a social determinant of health, food insecurity has been associated with multiple negative health outcomes, including mental disorders and suicidality (Jessiman-Perreault & McIntyre, 2017; Men et al., 2021; Men et al., 2020a, b; Men & Tarasuk, 2020; Tarasuk et al., 2018). Pain may be more prevalent, sustained, and severe among food-insecure versus food-secure people due to chronic stress (Blackburn-Munro & Blackburn-Munro, 2001; Martin et al., 2016), chronic physical and mental illnesses (Men et al., 2021; Men et al., 2020a, b; Tarasuk et al., 2018; Van Hecke et al., 2017), strenuous labour (McIntyre et al., 2012; Poleshuck & Green, 2008), nutrient inadequacy (Brain et al., 2019; Kirkpatrick et al., 2015), abnormal weight (Chin et al., 2020; Vozoris & Tarasuk, 2003), poor sleep (Arenas et al., 2019; Haack et al., 2020), cost-related non-adherence to prescription drugs (Kurlander et al., 2009; Men et al., 2019), and lack of social support (Martin et al., 2016; Poleshuck & Green, 2008). All of these health hazards have been more prevalent among food-insecure individuals than their food-secure counterparts (Arenas et al., 2019; Kirkpatrick et al., 2015; Martin et al., 2016; McIntyre et al., 2012; Men et al., 2021; Men et al., 2019, 2020a, b; Tarasuk et al., 2018; Vozoris & Tarasuk, 2003). Pain of longer duration and greater severity may in turn prompt food-insecure patients to use and possibly abuse PO for immediate symptom relief insofar as alternative pain management strategies are not as convenient, effective, or affordable (Bartram & Stewart, 2019; Longo et al., 2007).

The relationship between food insecurity and chronic pain or PO use has not been examined in Canada; literature from the US is scant. One small-scale study on US food bank users found chronic pain associated with food insecurity independent of age and sex (Bigand et al., 2020). Some research has found higher prevalence of pain among lower income and less educated populations (Currie & Wang, 2004; Fuller-Thomson et al., 2017; Hogan et al., 2016); however, those socioeconomic indicators do not necessarily capture the material hardships denoted by food insecurity (Tarasuk, Fafard St-Germain, & Mitchell, 2019). Food insecurity has been associated with nonmedical use of PO among US young adults (Nagata et al., 2020) and with illicit opioid use among US adults with or at risk for HIV (Raja et al., 2020; Whittle et al., 2019). Neighborhood food insecurity rate predicted higher opioid-related mortality in the Massachusetts general population (Flores et al.,

2020), while county-level food insecurity rate was inversely associated with opioid-related mortality rate in the US general population (Langabeer et al., 2020). The few studies linking food insecurity with pain and opioid use have relied on small or special samples from the US and applied binary or aggregate measures of food insecurity. Knowledge is also lacking on the explanatory power of food insecurity relative to other socioeconomic determinants of pain and PO use.

In this context, examining Canadian population data with a validated food insecurity scale will help bridge those gaps and deepen our understanding on the relationship between food insecurity, pain, and PO usage. We used two unique annual cycles of the population representative Canadian Community Health Survey (CCHS) to assess the association of food insecurity with chronic pain in 2015 and PO use in 2018.

## Materials and methods

### Study population and sample

The CCHS is an annual cross-sectional survey of Canadians' health and health-related behaviours administered in person or via telephone to roughly 65,000 households in Canada. A probability sampling scheme is used to create representative samples for health regions within each province. One member 12 years or older is randomly selected per household to voluntarily answer the survey on behalf of the household. Interviews are conducted throughout a calendar year, known as a cycle. The sampled respondents generalize to 98% of the non-institutionalized population in the country. Questions on household food insecurity have been formally incorporated in the survey since 2005, though certain provinces and territories chose not to administer those when given the option.

We built two separate samples, one from CCHS 2015 for pain analysis and another from CCHS 2018 to study PO use. The two annual cycles contained the most recent data from all ten provinces on the two subjects, respectively; neither cycle contained pan-provincial data on both subjects. CCHS 2015 and 2018 contained 51,550 and 54,100 respondents 12 years and older, respectively. Of those, we excluded 1150 from 2015 and 850 from 2018 for having invalid food insecurity status. Another 50 from 2015 and 2150 from 2018 were excluded for their missing responses to questions used to construct the primary outcomes, which were presence of chronic pain and past-year PO use, respectively. We did not include territories because few had data on key variables. We further excluded from CCHS 2015 17,350 individuals in Ontario and Newfoundland and Labrador because the two provinces, representing one-third of the total sample, opted out of the food insecurity module during that cycle. The average household income, a previously demonstrated strong correlate of food insecurity (Tarasuk, Fafard St-Germain, & Mitchell, 2019), was similar in 2015 between the two excluded provinces (\$80,770) and the eight remaining provinces (\$80,180) while chronic pain was slightly more prevalent in the two provinces versus the other eight (25.8% vs 23.2%). The final samples for pain analysis consisted of 33,000 individuals from eight provinces in CCHS 2015 and 51,100 individuals from all ten provinces in CCHS 2018.

### Outcome measures

All outcome variables examined were dichotomized in this study.

The primary outcome for chronic pain was whether the respondent was "usually free of pain or discomfort". For those with pain or discomfort, we further investigated whether its "usual intensity" was severe (versus mild or moderate) and whether the pain or discomfort "prevented most activities" (versus some, a few, or none).

For PO analysis, the primary outcome of interest was whether the respondent has used any PO such as oxycodone, fentanyl, or others (e.g. hydromorphone, morphine) during the past 12 months. Each of these PO formulations are considered *strong* opioids based on the World Health Organization "pain ladder" (Anekar & Cascella, 2020) and available by

prescription only, as opposed to codeine, a *weak* opioid available in some over-the-counter formulations, and illicit non-prescription opioids like heroin. For those who used PO in the past year, we further examined whether there were signs of intensive use (daily or almost daily use), excess use (ever took more pills or more often than directed by a physician or pharmacist), alternative use (ever used PO for purposes other than pain relief such as stress coping or experience seeking), or acquisition through means other than medical prescription (having at least some PO not prescribed by doctors).

### Exposure

The key exposure was 12-month household food insecurity status, a four-level categorical variable built from the Household Food Security Survey Module. It was developed by US Department of Agriculture and later adapted by Health Canada (Health Canada, 2007). It includes ten questions on adults' access to food and eight questions concerning food access among children under 18 years in the past 12 months. A household is classified as food-secure or marginally, moderately, or severely food-insecure based on the number of affirmative answers (Health Canada, 2007).

### Covariates

We adjusted for individual and household characteristics associated with pain and opioid use that could potentially affect those outcomes independent of food insecurity status (Bigand et al., 2020; Grol-Prokopycz, 2017; Mills et al., 2019; Nagata et al., 2020; Poleshuck & Green, 2008; Raja et al., 2020; Whittle et al., 2019). The individual risk factors included sex (female, male), age (continuous), race-ethnicity (white, Black, Indigenous, others), and immigrant status (Canadian-born, immigrant) which have all been related to pain and opioid use (Lisa & Jessica, 2018; Mills et al., 2019; Reitsma et al., 2011). We also adjusted for household characteristics such as household income, highest education in the household (high school incomplete, high school, college degree), housing status (renter, homeowner), household type (couple with children, couple without children, lone parents, others), and urbanicity (urban, rural). These household circumstances proxy for budget for and availability of pain management services and other resources accessible to a household that may moderate household members' susceptibility to pain and PO use (Fischer, Vojtila, & Rehm, 2018; Poleshuck & Green, 2008). Roughly one-quarter of the CCHS 2015 sample and one-tenth of the CCHS 2018 sample did not report household income due to refusal, lack of knowledge, or failed linkage to tax records; Statistics Canada imputed their income using an algorithm based on neighbor-based information and a prediction model (Statistics Canada, 2020). We included a covariate to denote imputed incomes. We also adjusted for individual prescription insurance coverage (uninsured, at least partial coverage on prescription medications by any sponsor), tobacco smoking status (non-smoker, former smoker, current smoker), and past-year alcohol consumption (none, up to once a week, twice or more a week), which may affect our outcomes independent of food insecurity. Alcohol use and smoking are both common but often ineffective coping strategies for chronic pain (Mills et al., 2019). In fact, alcohol intoxication, smoking, and their withdrawal may trigger or exacerbate chronic pain (Egli et al., 2012; Zale et al., 2016), heightening the risk of PO use. Operating in parallel to the universal health care system, prescription drug insurance in Canada comprises a patchwork of private and public insurance plans. Out-of-pocket expenses are common for insured patients and even higher for the uninsured, restricting low-resource patients' access to pain relieving medications including PO (Law et al., 2018; Martins et al., 2019). Missing values from the controlled covariates were coded into separate dummies and kept in the analyses.

### Statistical analyses

We first described sample characteristics by pain and PO use status and tabulated outcomes' prevalence by food insecurity levels. T-test was used to make comparisons of mean values across categories. We then fitted logistic models on the binary outcomes while adjusting for the confounding factors. Given the heterogeneity observed in populations affected by pain and opioid use (Lisa & Jessica, 2018; Mills et al., 2019; Reitsma et al., 2011), we further stratified our samples by sex and age to test their potential interaction with food insecurity status. We estimated two-sided robust confidence intervals for adjusted odds ratios (aOR) and average predicted probabilities. We also conducted domain analysis to determine the relative contribution of food insecurity and other predictors in explaining any chronic pain and any PO use in multivariate analyses (Luchman, 2015). The Stata program *DOMIN* was used to compare *McFadden R-squared* of all possible subsets of covariates; the method has been widely applied in prior health research (Kang et al., 2018; Lazarević & Brandt, 2020). *P*-value less than 0.05 was deemed statistically significant. All analyses were done unweighted in *Stata SE* 15.1. Numbers of observations were rounded to protect respondents' identity pursuant to Statistics Canada's guidelines. Ethics approval for the present study came from the Health Sciences Research Ethics Board, University of Toronto, under protocol number 34032.

### Results

A total of 4.0%, 5.7%, and 3.0% of the sampled individuals lived in marginally, moderately, and severely food-insecure households in CCHS 2015, respectively; the comparable figures for CCHS 2018 were 3.5%, 5.4%, and 3.1%, respectively (Table 1). Compared to respondents reporting pain or PO use, those without pain or PO use had greater socioeconomic disadvantages (e.g. lower income, less education).

An estimated 23.2% of the 2015 sample had pain while 6.2% of the 2018 sample used PO (Table 2). The share of severely food-insecure people with pain was more than double that of food-secure ones (47.4% vs 21.5%); the corresponding gap for PO use was over threefold (16.8% vs 5.4%). The differences in outcomes' prevalence by food insecurity status were graded and substantial (S1 Table).

We continued to observe a graded association between food insecurity status and chronic pain after adjusting for confounding factors (Table 3; S2 Table for all covariates' coefficients). Marginal, moderate, and severe food insecurity were associated with 1.31 (95% confidence interval [CI] 1.15–1.48), 1.89 (95% CI 1.71–2.08), and 3.29 (95% CI 2.90–3.74) times higher odds of experiencing chronic pain, respectively. The predicted probability of pain ranged from 0.214 (95% CI 0.210–0.219) among food-secure people to 0.450 (95% CI 0.420–0.481) among severely food-insecure ones (Fig. 1).

The association was significant and similar across sex and age subsamples except that moderate food insecurity had a stronger association with pain among seniors versus non-senior adults (Table 4, interaction aOR 1.51,  $p = 0.007$ ). The probability of pain was generally higher among females versus males and among older versus younger people with the same food insecurity status (Fig. 2). Among those with chronic pain, severity of food insecurity was associated with 1.40–2.88 times higher likelihood of having severe pain and 1.43–3.19 times higher odds of having most activities prevented by pain, respectively ( $p < 0.05$ ).

We also found a dose-response association between food insecurity status and PO use net of confounding effects. Marginal, moderate, and severe food insecurity were associated with 1.55 (95% CI 1.30–1.85), 1.77 (95% CI 1.54–2.04), and 2.65 (95% CI 2.27–3.09) times higher odds of using any PO in the past year, respectively. The dose-response association with food insecurity status was observed for oxycodone, fentanyl, and other POs. The probability of any PO use varied from 0.055 (95% CI 0.053–0.058) among food-secure people to 0.133 (95% CI 0.116–0.149) among their severely food-insecure counterparts. The associations were significant and similar in magnitude across sex and age

**Table 1**  
Sample characteristics (proportions unless specified otherwise) by chronic pain in CCHS 2015 and PO use status in CCHS 2018.

	CCHS 2015			CCHS 2018		
	No pain	Any pain	Total	No PO use	Any PO use	Total
Household food insecurity						
Food-secure	0.892	0.810	0.873	0.887	0.778	0.880
Marginally food-insecure	0.038	0.046	0.040	0.034	0.049	0.035
Moderately food-insecure	0.049	0.084	0.057	0.052	0.090	0.054
Severely food-insecure	0.020	0.061	0.030	0.027	0.083	0.031
Sex						
Male	0.478	0.411	0.462	0.462	0.406	0.458
Female	0.522	0.589	0.538	0.538	0.594	0.542
Mean age (years)	46.8	56.2	49.0	50.0	52.1	50.1
Mean age SD	(20.6)	(17.6)	(20.3)	(20.3)	(17.1)	(20.2)
Mean household income (Canadian dollars)	85,800	66,600	81,300	92,600	79,300	91,800
Mean household income SD	(69,378)	(58,197)	(67,440)	(76,619)	(70,953)	(76,348)
Income imputed by Statistics Canada	0.252	0.275	0.258	0.090	0.095	0.090
Race-ethnicity						
White	0.839	0.870	0.846	0.819	0.868	0.822
Black	0.015	0.007	0.013	0.017	0.008	0.016
Indigenous	0.048	0.060	0.051	0.049	0.079	0.051
Others	0.096	0.059	0.087	0.111	0.045	0.106
Not stated	0.003	0.003	0.003	na	na	0.005
Highest education in household						
High school incomplete	0.089	0.139	0.100	0.088	0.088	0.088
High school diploma	0.159	0.187	0.166	0.164	0.193	0.165
College degree	0.722	0.641	0.704	0.722	0.689	0.720
Not stated	0.030	0.032	0.030	0.026	0.030	0.027
Housing status						
Renter	0.247	0.310	0.261	0.262	0.348	0.266
Homeowner	0.753	0.690	0.736	0.738	0.652	0.731
Not stated	na	na	0.003	na	na	0.003
Household type						
Couple with children	0.337	0.191	0.302	0.289	0.220	0.285
Couple without children	0.288	0.352	0.302	0.299	0.302	0.298
Lone parents	0.087	0.080	0.085	0.086	0.097	0.087
Others	0.289	0.377	0.309	0.326	0.380	0.329
Not stated	na	na	0.002	na	na	0.001
Smoking status						
Never smoked	0.425	0.282	0.392	0.426	0.269	0.415
Former smoker	0.407	0.482	0.425	0.410	0.445	0.411
Current smoker	0.165	0.233	0.181	0.165	0.286	0.172
Not stated	0.003	0.003	0.003	na	na	0.003
Past-year alcohol consumption						
None	0.229	0.253	0.235	0.236	0.227	0.234
Any, up to once a week	0.476	0.480	0.477	0.485	0.517	0.486
Twice or more a week	0.291	0.263	0.285	0.279	0.256	0.277
Not stated	0.004	0.004	0.004	na	na	0.004
Medication insurance coverage						
No	0.183	0.195	0.186	0.197	0.169	0.194
Yes	0.809	0.800	0.807	0.803	0.831	0.800
Not stated	0.008	0.005	0.007	na	na	0.006
Immigrant status						
Canadian-born	0.848	0.878	0.854	0.824	0.881	0.826
Immigrant	0.152	0.122	0.145	0.176	0.119	0.172
Not stated	na	na	0.001	na	na	0.002
Residence location						
Urban	0.726	0.717	0.724	0.726	0.722	0.726
Rural	0.274	0.283	0.276	0.274	0.278	0.274
Number of respondents	25,300	7600	33,000	48,000	3100	51,100

Notes: “PO” = prescription opioid. “na” denotes cells with few respondents, which were undisclosed for identity protection purpose. Household income is in Canadian dollar and rounded to \$100. Numbers of respondents are rounded to the nearest 100, thus overall sample size may not match the sum of subsamples’ sizes. The prevalence differs across pain status for all covariates except “lone parents”, “with medication insurance”, and “rural residence” ( $p > 0.05$ ). The prevalence differs across PO use status for all covariates except “income imputation status”, “high school diploma”, “couple without children”, “no alcohol last year”, and “rural residence” ( $p > 0.05$ ).

groups except that marginal and severe food insecurity were not significant among those under age 30 and had magnitudes smaller than those of the 30-64-year-olds (interactions  $p < 0.05$ ). The probability of PO use was mostly similar for men and women with the same food insecurity status. Severely food-insecure individuals 30–64 years old had the highest probability of PO use across age-food-insecurity groups, at 0.151 (95% CI 0.130–0.172). Among PO users, severe food insecurity

was associated with 2.29 (95% CI 1.75–2.99) times higher odds of daily or near daily PO use. Moderate food insecurity predicted 1.55 (95% CI 1.04–2.33) times higher odds of using more PO than instructed. Marginal, moderate and severe food insecurity were associated with 1.75 (95% CI 1.11–2.73), 1.75 (95% CI 1.11–2.73), and 2.20 (95% CI 1.35–3.61) times higher likelihood of using PO for purposes other than pain relief, respectively. PO users in marginally food-insecure

**Table 2**  
Prevalence of chronic pain in CCHS 2015 and PO use in CCHS 2018 by food insecurity status.

	Food-secure	Marginal FI	Moderate FI	Severe FI	Total
CCHS 2015					
Any pain (n = 33,000)	0.215 (0.002)	0.264 (0.012)	0.340 (0.011)	0.474 (0.016)	0.232 (0.002)
Severe pain if any pain (n = 7600)	0.134 (0.004)	0.179 (0.021)	0.214 (0.016)	0.309 (0.022)	0.153 (0.004)
Pain prevents most activity if any pain (n = 7600)	0.145 (0.004)	0.195 (0.021)	0.221 (0.016)	0.351 (0.022)	0.166 (0.004)
Number of respondents	28,800	1300	1900	1000	33,000
CCHS 2018					
Oxycodone (n = 51,100)	0.021 (0.001)	0.035 (0.004)	0.039 (0.004)	0.087 (0.007)	0.025 (0.001)
Fentanyl (n = 51,100)	0.006 (0.0004)	0.011 (0.002)	0.012 (0.002)	0.027 (0.004)	0.007 (0.0004)
Other POs (n = 51,100)	0.036 (0.001)	0.053 (0.005)	0.074 (0.005)	0.107 (0.008)	0.041 (0.001)
Any PO (n = 51,100)	0.054 (0.001)	0.085 (0.007)	0.102 (0.006)	0.168 (0.009)	0.062 (0.001)
Daily or near daily PO use if any PO (n = 6900)	0.098 (0.004)	0.141 (0.020)	0.128 (0.014)	0.244 (0.020)	0.113 (0.004)
Excess PO dose if any PO (n = 5900)	0.033 (0.003)	0.062 (0.015)	0.068 (0.011)	0.080 (0.014)	0.040 (0.003)
Alternative PO use if any PO (n = 6900)	0.013 (0.001)	0.040 (0.007)	0.040 (0.007)	0.066 (0.011)	0.020 (0.002)
Some PO not prescribed if any PO (n = 6900)	0.036 (0.002)	0.075 (0.015)	0.051 (0.009)	0.079 (0.012)	0.042 (0.002)
Number of respondents	45,000	1800	2800	1600	51,100

Notes: "FI" = food insecurity. "PO" = prescription opioid. Marginal and moderate food insecurity are collapsed for "alternative use if any PO" to conform to Statistics Canada's confidentiality requirement. Robust standard error is shown in parentheses.

households were 1.64 (95% CI 1.03–2.62) times more likely to have at least some of their opioids not prescribed by doctors.

Dominance analyses showed that food insecurity status accounted for 16.5% of the variation in any pain explained by all independent variables and 25.5% of the explained variation in any PO use (Table 5). Food insecurity ranked second among the fourteen variables adjusted in both models. Only age (36.2%) explained more of chronic pain than food insecurity did (16.5%), while smoking status (31.9%) was the only factor explaining more of PO use than food insecurity (25.5%). Income and education among other socioeconomic indicators had significantly lower power than food insecurity in explaining pain and PO use.

### Discussion

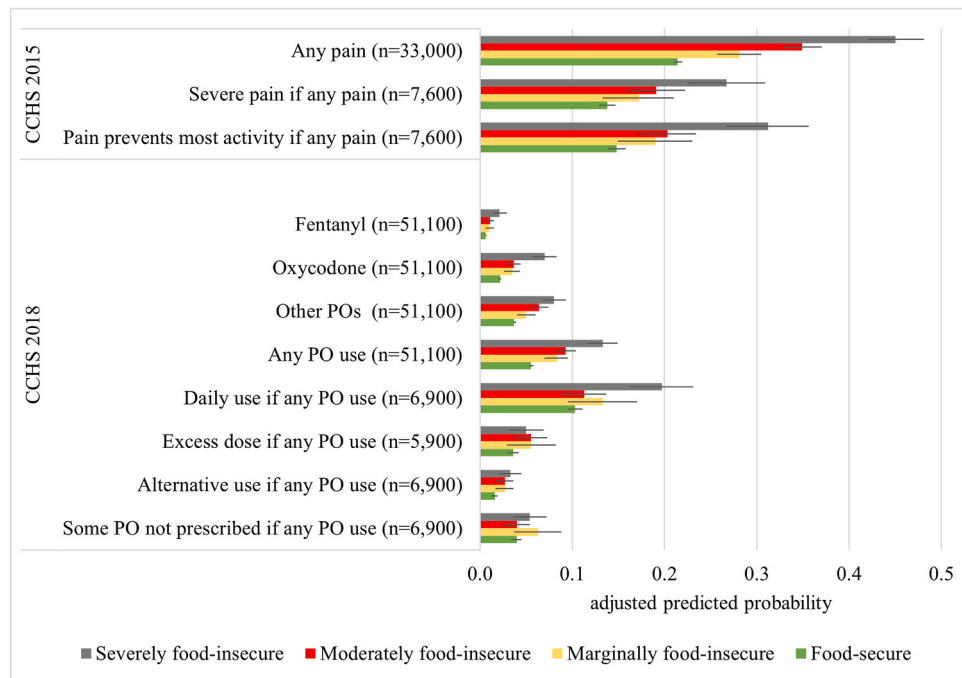
Using population survey data from 2015 and 2018, we found that household food insecurity was associated with greater likelihood of reporting chronic pain and PO use in a dose-response fashion among pan-provincial samples of Canadians. Compared to food-secure individuals with chronic pain, those who had more severe food insecurity were more likely to experience severe pain and pain-induced activity limitations. Some food-insecure PO users were more likely than their food-secure counterparts to show signs of intensive, excess, and alternative PO use and acquire opioids through means other than medical prescription. Food insecurity was one of the most powerful social determinant-type variable associated with chronic pain and PO use in the study sample.

**Table 3**  
Adjusted odds ratios of food insecurity status on chronic pain in CCHS 2015 and PO use in 2018.

	Food-secure	Marginal FI	Moderate FI	Severe FI
CCHS 2015				
Any pain (n = 33,000)	reference	1.31 (1.15–1.48)	1.89 (1.71–2.08)	3.29 (2.90–3.74)
Severe pain if any pain (n = 7600)	reference	1.40 (1.06–1.87)	1.76 (1.44–2.16)	2.88 (2.33–3.56)
Pain prevents most activity if any pain (n = 7600)	reference	1.43 (1.08–1.88)	1.67 (1.37–2.05)	3.19 (2.60–3.91)
CCHS 2018				
Oxycodone (n = 51,100)	reference	1.64 (1.25–2.14)	1.74 (1.40–2.17)	3.43 (2.76–4.25)
Fentanyl (n = 51,100)	reference	1.66 (1.03–2.69)	1.75 (1.18–2.59)	3.45 (2.36–5.03)
Other POs (n = 51,100)	reference	1.36 (1.09–1.69)	1.79 (1.52–2.10)	2.26 (1.88–2.72)
Any PO (n = 51,100)	reference	1.55 (1.30–1.85)	1.77 (1.54–2.04)	2.65 (2.27–3.09)
Daily PO use if any PO (n = 6900)	reference	1.36 (0.94–1.97)	1.11 (0.84–1.48)	2.29 (1.75–2.99)
Excess PO dose if any PO (n = 5900)	reference	1.56 (0.89–2.73)	1.55 (1.04–2.33)	1.42 (0.90–2.23)
Alternative PO use if any PO (n = 6900)	reference	1.75 (1.11–2.73)	1.75 (1.11–2.73)	2.20 (1.35–3.61)
Some PO not prescribed if any PO (n = 6900)	reference	1.64 (1.03–2.62)	1.01 (0.67–1.51)	1.40 (0.95–2.08)

Notes: "FI" = food insecurity. "PO" = prescription opioid. All models adjusted for sex, age, race-ethnicity, household income, income imputation status, household highest education, housing status, household type, immigrant status, urbanicity, smoking status, past-year alcohol consumption, and prescription medication insurance status. Marginal and moderate food insecurity are collapsed for "alternative use if any PO" to conform to Statistics Canada's confidentiality requirement. Robust 95% confidence intervals are shown in parentheses.

The results on pain were consistent with the earlier Canadian studies showing higher risk of chronic pain among socioeconomically disadvantaged individuals (Bigand et al., 2020; Currie & Wang, 2004; Fuller-Thomson et al., 2017; Grol-Prokopczyk, 2017; Hogan et al., 2016; Mills et al., 2019; Poleshuck & Green, 2008). The findings are as expected given the many health and socioeconomic adversities underlying food insecurity (Arenas et al., 2019; Kirkpatrick et al., 2015; Martin et al., 2016; McIntyre et al., 2012; Men et al., 2021; Men et al., 2019, 2020a, b; Tarasuk et al., 2018; Vozoris & Tarasuk, 2003), many of which either precede or co-occur with chronic pain (Blackburn-Munro & Blackburn-Munro, 2001; Brain et al., 2019; Chin et al., 2020; Haack et al., 2020; Poleshuck & Green, 2008; Van Hecke et al., 2017). The fact that food insecurity was a much more powerful predictor of pain than income or education may be explained by its greater sensitivity as a marker of multiple structural disadvantages. This highlights the importance of examining food insecurity as an independent social determinant of health. As an experience-based measure of material deprivation, food insecurity captured availability of household resources more directly than income or education. It is disturbing that over one-fifth of the population and nearly half of severely food-insecure people reported chronic pain, especially in a wealthy nation with universal health care (Currie & Wang, 2004; Fuller-Thomson et al., 2017; Hogan et al., 2016; Reitsma et al., 2011). Of equally great concern is the association of food insecurity with severe pain and functional limitations, known risk factors for opioid overdose and suicide (Webster, 2017). The associated activity constraints could further restrict the food-insecure people's income earning potential, reducing their chance of achieving food security and health (Schwartz et al., 2019; Vozoris & Tarasuk, 2003). Food insecurity has soared during the ongoing



**Fig. 1.** Adjusted average predicted probability of chronic pain (CCHS 2015) and past-year PO use (CCHS 2018) by food insecurity status. “PO” denotes prescription opioids. Estimated from adjusted Poisson regressions. Black lines represent the 95% confidence interval.

**Table 4**  
Adjusted odds ratios of food insecurity status on any chronic pain in CCHS 2015 and any PO use in 2018, by sex and age.

	Food-secure	Marginal FI	Moderate FI	Severe FI
<b>CCHS 2015: Any pain</b>				
Male (n = 15,200)	reference	1.37 (1.11–1.69)	2.20 (1.86–2.61)	2.95 (2.39–3.64)
Female (n = 17,700)	reference	1.56 (1.32–1.85)	2.02 (1.76–2.32)	3.60 (2.98–4.35)
12–29 years old (n = 6900)	reference	1.41 (1.02–1.95)	1.58 (1.21–2.07)	3.05 (2.20–4.23)
30–64 years old (n = 17,400)	reference	1.36 (1.14–1.63)	2.00 (1.74–2.30)	3.20 (2.68–3.81)
65+ years old (n = 8700)	reference	1.74 (1.32–2.29)	2.76 (2.10–3.61)	2.38 (1.56–3.62)
<b>CCHS 2018: Any PO use</b>				
Male (n = 23,400)	reference	1.68 (1.28–2.19)	1.57 (1.24–2.00)	2.55 (1.99–3.27)
Female (n = 27,700)	reference	1.45 (1.15–1.84)	1.88 (1.58–2.24)	2.70 (2.21–3.29)
12–29 years old (n = 9700)	reference	0.97 (0.60–1.55)	1.47 (1.05–2.04)	1.49 (0.97–2.28)
30–64 years old (n = 26,700)	reference	1.64 (1.32–2.04)	1.76 (1.48–2.08)	2.65 (2.21–3.18)
65+ years old (n = 14,600)	reference	1.63 (1.09–2.45)	1.52 (1.02–2.25)	2.08 (1.21–3.57)

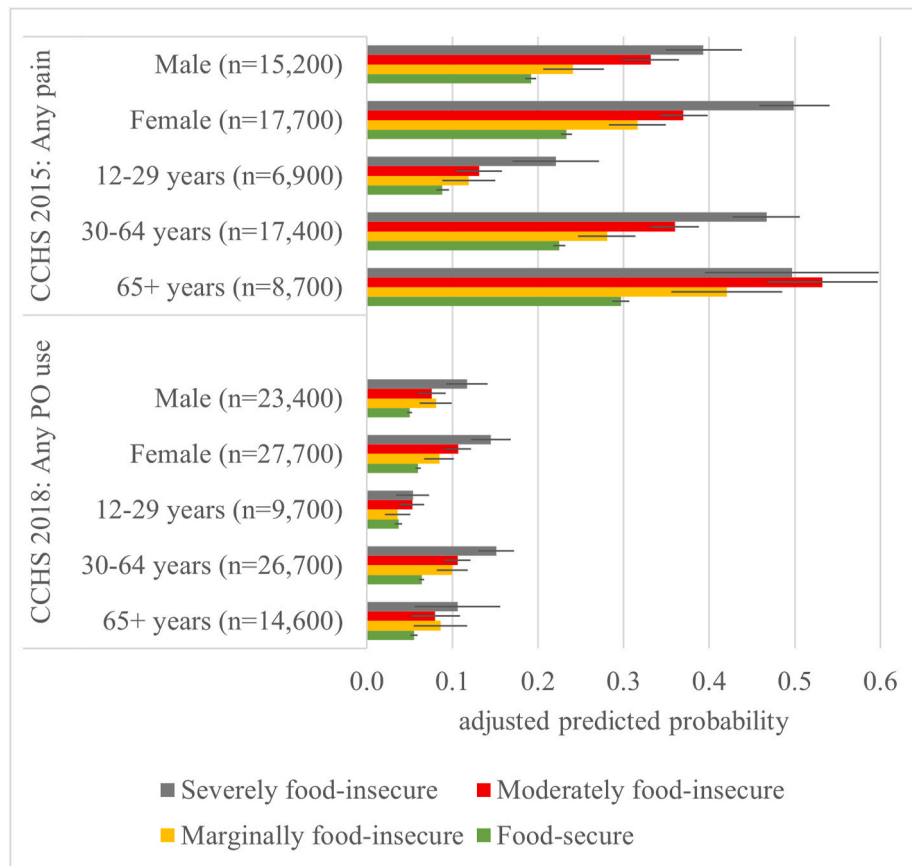
Notes: “FI” = food insecurity. “PO” = prescription opioid. All models adjusted for sex, age, race-ethnicity, household income, income imputation status, household highest education, housing status, household type, immigrant status, urbanicity, smoking status, past-year alcohol consumption, and prescription medication insurance status. Robust 95% confidence intervals are shown in parentheses.

COVID-19 pandemic (Men & Tarasuk, 2021). While data are absent, the material hardship and associated social disadvantages can only render chronic pain more prevalent and less manageable in the present time (Karos et al., 2020).

In line with prior US studies (Nagata et al., 2020; Raja et al., 2020; Whittle et al., 2019), our findings established the graded association

between food insecurity status and PO use in Canada and further illustrated the importance of food insecurity as an independent correlate of PO use above and beyond other socioeconomic characteristics. This also accords with our finding of higher incidence of severe pain among food-insecure people, laying the foundation for future studies to examine food insecurity as a potential cause of pain and PO use. Physicians may overprescribe PO disproportionately to food-insecure patients to abate their pain symptom when PO medications are covered by public insurance (Fischer et al., 2014; Martins et al., 2019). Moreover, strong opioid formulations – fentanyl in particular – have been proliferating on the illegal market (Jones et al., 2020; Special Advisory Committee on the Epidemic of Opioid Overdoses, 2020), potentially exposing food-insecure people to even greater risk of opioid-related harms (Gomes et al., 2017). Indeed, one-quarter of severely food-insecure individuals reported daily or near-daily PO use, a plausible symptom of opioid use disorder (e.g. opioid dependence), which may involve or lead to drug tolerance, overdose, and suicide if managed improperly (Ballantyne, 2018). Our findings on excess and alternative PO usage and opioid acquisition through means other than medical prescription indicate high-risk drug use behaviours that could compound the existing economic and health vulnerabilities of food-insecure individuals, such as injection needle sharing and unprotected sex, magnifying the risk exposure to HIV and other communicable diseases (Nagata et al., 2020; Raja et al., 2020; Whittle et al., 2019). As a result of recent policy restrictions on PO dispensing, population-level opioid prescribing has dropped substantially in Canada, up to 50% in some provinces from peak values (Canadian Institute for Health Information, 2019; Fischer et al., 2016; Jones et al., 2020). Protecting existing PO users from overdose and other harms of opioids has become the new public health priority.

Effective solutions are needed to alleviate food-insecure individuals’ multiple burdens of fighting food hardship, managing pain, and minimizing side effects from PO use. Several studies have found reductions in food insecurity associated with greater income supports (Brown & Tarasuk, 2019; Li et al., 2016; Loopstra et al., 2015; Tarasuk, Li, et al., 2019). Future studies may examine whether supplementing incomes of low-resource households attenuates the relationship between food



**Fig. 2.** Adjusted average predicted probability of any chronic pain (CCHS 2015) and any past-year PO use (CCHS 2018) by food insecurity status, stratified by sex and age. “PO” denotes prescription opioids. Estimated from adjusted Poisson regressions. Black lines represent the 95% confidence interval.

**Table 5**

Dominance analysis of covariates from fully adjusted logistic models on any chronic pain in CCHS 2015 and any PO use in CCHS 2018.

Predictor	Any pain (n = 32,000)			Any PO use (n = 51,100)		
	Dominance statistic	Percentage	Rank	Dominance statistic	Percentage	Rank
Total dominance statistic:	0.0687			0.0408		
Age	0.0249	36.23%	1	0.0010	2.48%	10
Food insecurity	0.0113	16.45%	2	0.0104	25.54%	2
Smoking status	0.0098	14.16%	3	0.0130	31.86%	1
Household type	0.0077	11.17%	4	0.0011	2.72%	9
Household income	0.0057	8.30%	5	0.0015	3.72%	5
Sex	0.0023	3.37%	6	0.0014	3.49%	6
Race-ethnicity	0.0019	2.82%	7	0.0058	14.32%	3
Education	0.0016	2.34%	8	0.0009	2.25%	11
Housing status	0.0013	1.84%	9	0.0024	5.88%	4
Alcohol consumption	0.0012	1.79%	10	0.0006	1.59%	12
Immigrant status	0.0006	0.80%	11	0.0012	3.07%	7
Insurance status	0.0003	0.38%	12	0.0012	2.93%	8
Income imputed	0.0002	0.29%	13	<0.0001	0.06%	14
Urbanicity	<0.0001	0.06%	14	<0.0001	0.10%	13

Notes: “PO” = prescription opioid. Food insecurity ranks second in both models. Food insecurity is dominated by “age” in the “any pain” model and “smoking status” in the “any PO use” model. Food insecurity had statistically indistinguishable dominance as smoking status and household type in the pain model. Food insecurity dominated other variables in the two models. Dominance statistics are estimated through Luchman’s method based on fully adjusted logistic models on any pain and any PO use.

insecurity and chronic pain or PO use. Enhancing access to alternative pain managements and mental health supports is key to preventing acute mild pain from evolving into chronic severe pain (Furlan & Williamson, 2017). We recently reported a strong relationship between food insecurity status and cost-related prescription drug nonadherence (Men et al., 2019). Reducing or waiving out-of-pocket charges may improve accessibility of non-opioid prescriptions and the associated pain

management among food-insecure patients (Kurlander et al., 2009; Men et al., 2019). The affordability of pain-managing physiotherapy and psychotherapy requires critical assessment; the limited coverage and non-trivial out-of-pocket charges on these services may prevent food-insecure patients from accessing timely treatment (Bartram & Stewart, 2019; Longo et al., 2007). For the existing opioid users with limited resources, free distribution of opioid antagonists may reduce

deaths by overdose (Irvine et al., 2018). There is also evidence that delisting high-strength PO such as fentanyl from public insurance formulary may reduce dispensing of publicly funded PO (Martins et al., 2019). However, access to alternative pain management should be facilitated to discourage food-insecure patients from seeking replacement drugs on illegal markets.

### Limitations

Our findings need to be interpreted in light of several caveats. The cross-sectional study design precluded determination of causality since we could not determine the time order of food insecurity experiences, pain, and PO use; neither do we know their duration. Future research could use longitudinal data with repeated measurements of key variables to capture the timing and chronicity of pain and PO use and assess their causal relationship with food insecurity. We were unable to examine pain and PO use using a same sample due to data limitations. Since both sampled cycles asked about presence of arthritis, a common illness accompanied by chronic pain (correlation coefficient of arthritis and chronic pain in CCHS 2015 equals 0.37,  $p < 0.0001$ ), we compared its adjusted correlation with food insecurity status in 2015 to that in 2018 through a sensitivity test. The similar associations across cycles suggested that the association between food insecurity and pain from arthritis did not change from 2015 to 2018 (S3 Table), thus mitigating the concern over change in the pain outcome from 2015 to 2018. Even though we referred to our outcome as prescription opioids, the CCHS questionnaire acknowledged that certain opioids based on codeine did not require a prescription for purchase. Since we disregarded codeine in our analysis, such ambiguity in term definition should not have affected our results. Use of heroin and other illicit non-prescription opioids was not a survey subject in CCHS 2018 despite its potential linkage to food insecurity, therefore it is not accounted for by the present data and its association with food insecurity warrants further research. Ontario and Newfoundland and Labrador were excluded from the 2015 sample due to lack of food insecurity measurement, limiting the generalisability of the findings on pain to the eight other provinces. However, the similar income level and prevalence of outcomes between the two dropped provinces and the remaining eight suggest that the results on pain would likely have been similar had the two provinces participated in the food security assessment. Last, since the sample was restricted to the provinces in Canada, our results are not generalisable to the territories.

### Conclusions

Based on analysis of recent population health surveys, we found that severity of food insecurity was significantly associated with chronic pain and PO use in large parts of the Canadian population. Narrowing the socioeconomic gap in chronic pain and PO use is a necessary step towards achieving health equity. Clinicians need to acknowledge the multiple barriers to pain relief facing food-insecure individuals and facilitate their access to non-opioid pain management services. For patients with regular PO use, preventive measures need to be in place to minimize harm and risk of death from the drugs. Policymakers need to take action to reduce the prevalence and severity of food insecurity, which may lower incidence of chronic pain and help contain the opioid crisis.

### Author statement

**Fei Men:** Conceptualization, Methodology, Software, Formal analysis, Investigation, Writing – Original draft, Writing – Review & Editing, Visualization. **Benedikt Fischer:** Validation, Investigation, Writing – Review & Editing, Funding acquisition. **Marcelo L. Urquia:** Validation, Writing – Review & Editing, Funding acquisition. **Valerie Tarasuk:** Validation, Investigation, Resources, Writing – Review & Editing, Supervision, Funding acquisition.

### Funding statement

This work was supported by Canadian Institutes of Health Research [grants PJT-153260 and SAF-94814]. The funder had no role in the design and conduct of the study; collection, analysis, and interpretation of data; writing of the article; or decision to submit the article for publication.

### Conflict of interest

None from any and all authors.

### Ethics

Ethics approval for the present study came from the Health Sciences Research Ethics Board, University of Toronto, under protocol number 34032.

### Declaration of competing interest

The authors declared no competing interests.

### Acknowledgement

This research was conducted at RDC Toronto, a part of the Canadian Research Data Centre Network (CRDCN). This service is provided through the support of the University of Toronto, the Canadian Foundation for Innovation, the Canadian Institutes of Health Research, the Social Science and Humanity Research Council, and Statistics Canada. We thank Canadian Institutes of Health Research [grants PJT-153260 and SAF-94814] for their funding. Dr. Fischer acknowledges support from the endowed Hugh Green Foundation Chair in Addiction Research, Faculty of Medical and Health Sciences, University of Auckland. The authors thank the two anonymous reviewers for their constructive feedback.

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