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Change in prevalence of smoking during the first year of the COVID-19 pandemic among middle-aged and older adults in Canada: a cohort study of the Canadian Longitudinal Study on Aging

Jayati Khattar,[1,2] Urun Erbas Oz,[1] Vanessa De Rubeis ,[1,2] Margaret de Groh,[2] Ying Jiang,[2] Lauren Griffith,[1] Laura N Anderson [1]

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[1]Health Research Methods, Evidence, and Impact, McMaster University, Hamilton, Ontario, Canada
[2]Public Health Agency of Canada, Ottawa, Ontario, Canada

Correspondence to
Dr Laura N Anderson;
LN.Anderson@mcmaster.ca

ABSTRACT

Objective The primary objective was to evaluate the change in the prevalence of daily or occasional tobacco smoking during the first year of the COVID-19 pandemic and to assess if socioeconomic factors were associated with changes in smoking. The secondary objective was to evaluate the association of smoking with adherence to public health measures.

Methods In this prospective cohort study, using Canadian Longitudinal Study on Aging data (44 139 middle-aged and older-aged adults), the prevalence of smoking during the COVID-19 pandemic (2020) and prepandemic (2011–2018) was estimated using weighted generalised estimating equations. ORs and 95% CIs for the association between smoking and adherence to public health measures (a derived score) were estimated using multinomial logistic regression.

Results Time (during vs prepandemic) was a significant predictor of smoking (adjusted OR (aOR) 1.12; 95% CI 1.07, 1.17). The adjusted prevalence of smoking during the beginning of the pandemic was 11.2% (95% CI 10.1%, 12.4%), compared with the prepandemic prevalence of 10.1% (95% CI 9.1%, 11.2%), with p<0.001. Factors associated with an increase in smoking were male sex, being aged 55 to 74 years, residing in Ontario or British Columbia, immigrant background, belonging to a racialised group, higher income and being married/common-law relationship. Smoking was associated with increased odds of high adherence to public health measures (aOR 1.53; 95% CI 1.31, 1.78).

Conclusion Among middle-aged and older adults in Canada, there was a small increase in the adjusted prevalence of smoking early in the pandemic. Daily or occasional smoking was associated with greater adherence to public health measures.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ There is mixed evidence for a change in the prevalence of smoking during the COVID-19 pandemic.
⇒ Previous work in Canada on this topic has not used a longitudinal study design or examined how the change varied by socioeconomic status.

WHAT THIS STUDY ADDS

⇒ This study was able to examine changes in smoking during the beginning of the COVID-19 pandemic in a national sample of middle-aged and older adults and identify characteristics associated with change while accounting for participants lost to follow-up.
⇒ Through development of a novel measure, we were able to examine how adults who smoked adhered to public health measures during the first year of the COVID-19 pandemic.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Support for cessation services is still required, knowing that tobacco smoking is a well-established risk factor for many chronic diseases. Any increase in the prevalence of tobacco smoking could have detrimental downstream effects.

INTRODUCTION

The COVID-19 pandemic brought significant changes to the daily lives of Canadians in 2020. As part of the response to the COVID-19 pandemic, governments and public health authorities implemented public health measures (PHMs) to promote physical distancing and reduce disease spread.[1 2] The pandemic and associated PHMs resulted in high levels of unemployment, challenges accessing healthcare services and worsened mental health.[3 4] These disruptions may have led to a change in the prevalence of tobacco smoking. Systematic reviews found a lack of strong evidence to indicate a change in smoking during the pandemic in the general population, although increases were observed in some subgroups, such as adults with mental health disorders.[5–7] Few studies have assessed how changes in smoking during the COVID-19

pandemic differed by socioeconomic characteristics.[8 9] According to the Canadian Tobacco and Nicotine Survey (CTNS), the prevalence of smoking in 2020 was 10.3% (95% CI 9.5%, 11.2%), while the prevalence of smoking in 2021 was 10.2% (95% CI 9.4%, 11.0%).[10 11] Evaluation of the CTNS data suggested that while a decrease in smoking was seen among females from 2019 to 2020, there was limited change in smoking overall from 2020 to 2021.[12] According to a survey conducted in the first two months of the pandemic, 3.3% of Canadians reported increasing their tobacco use.[13] Tobacco smoking is an established risk factor for numerous chronic diseases.[14] Through intensive policy and public health interventions, the prevalence of smoking has declined over recent decades,[15] but the prevalence remains higher among groups with lower education and income levels.[16] If the prevalence of smoking increased during the pandemic, and if the change was disproportionately distributed by socioeconomic factors, health inequalities could widen postpandemic.

In Canada, the most restrictive PHMs were in place from March to May 2020 with a relaxation of restrictions over the summer and then reinstatement in November 2020.[17] Adherence to PHM varies due to individual behaviour (eg, preference) and structural factors (eg, employment, housing).[18 19] As noted earlier, smoking has been associated with lower socioeconomic status (SES). Adults with lower SES were more likely to experience challenges physical distancing because of shared living situations, employment as an essential worker and lack of paid sick leave.[20–22] Understanding the association of smoking with adherence to PHM is important since adults who smoke are at increased risk of adverse COVID-19 outcomes.

The primary objective of this study was to evaluate the change in the prevalence of daily or occasional tobacco smoking during the beginning of the COVID-19 pandemic and to investigate the socioeconomic factors associated with change in smoking. The secondary objective was to evaluate the association of tobacco smoking with adherence to PHMs.

MATERIALS AND METHODS

Study design and data source

A prospective cohort study was conducted using data from the Canadian Longitudinal Study on Aging (CLSA). The CLSA is a national cohort study that collects data on the health of Canadian adults every 3 years.[23 24] Baseline data collection was completed from 2011 to 2015, with the participation of 51 338 community-dwelling adults between the ages of 45 and 85. Follow-up 1 (FUP1) data collection was completed from 2015 to 2018, with 44 817 adults participating (response rate=87%). At baseline, participants were required to independently complete the surveys, reside in 1 of the 10 provinces and respond in French or English. Individuals who were residing in the Canadian territories and some remote regions, First Nations reserves and other First Nations settlements in the provinces or institutions at the time of recruitment were excluded. Additionally, full-time members of the armed forces and individuals with cognitive impairment at time of recruitment were excluded. Detailed information on the CLSA is available at https://www.clsa-elcv.ca/data-collection.

In April 2020, the CLSA launched the COVID-19 Study. All pre-existing CLSA participants with valid contact information who could independently complete the surveys (N=42 511) were invited to participate by email (N=34 428) or telephone (N=8083). Of the eligible participants, 28 559 completed the COVID-19 baseline survey from 15 April 2020 to 30 May 2020 (response rate=67%). Afterwards, two biweekly (if participating via telephone) or four weekly (if participating via web) surveys were administered. Participants continued to complete the surveys via telephone or web on a monthly basis in July, August and September 2020 before completing the final COVID-19 exit survey from 29 September to 30 December 2020 (N=24 114).

Patient and public involvement

There was no patient or public involvement at any stage of this study. Participants were required to provide informed consent prior to participation in the CLSA.

Exposures and covariates

For the primary objective, the main exposure was the period of time: prepandemic (2011–2018) versus during the pandemic (2020). In the regression models, the prepandemic period was treated as the reference group. The following covariates were selected for inclusion in the models *a priori* based on commonly identified smoking risk factors: age group, sex, region of residence, urban or rural residence, immigrant background, racial background, marital status, household income and education level.[25–27] All covariate data were taken from the CLSA baseline to be able to compare the prevalence of smoking while holding all other characteristics constant, with the exception of age. Age was included as a time-varying covariate and imputed for individuals with missing data. Region of residence was determined by asking participants what province they resided in, which were categorised as Ontario, Quebec, British Columbia, Atlantic (Newfoundland, Nova Scotia, New Brunswick, Prince Edward Island), Prairies (Alberta, Manitoba, Saskatchewan). Participants were categorised as residing in an urban or rural area based on postal code linkage with the Statistics Canada Postal Code Conversion File. Participants were categorised as immigrants if they indicated they were not born in Canada. Racial background was measured by asking participants what racial or cultural background they best identified with. All non-white participants were grouped together, due to small sample sizes. For marital status, participants were categorised into the following groups: single/never married/never lived with a partner, married/in a common-law relationship, widowed/divorced/separated. For education,

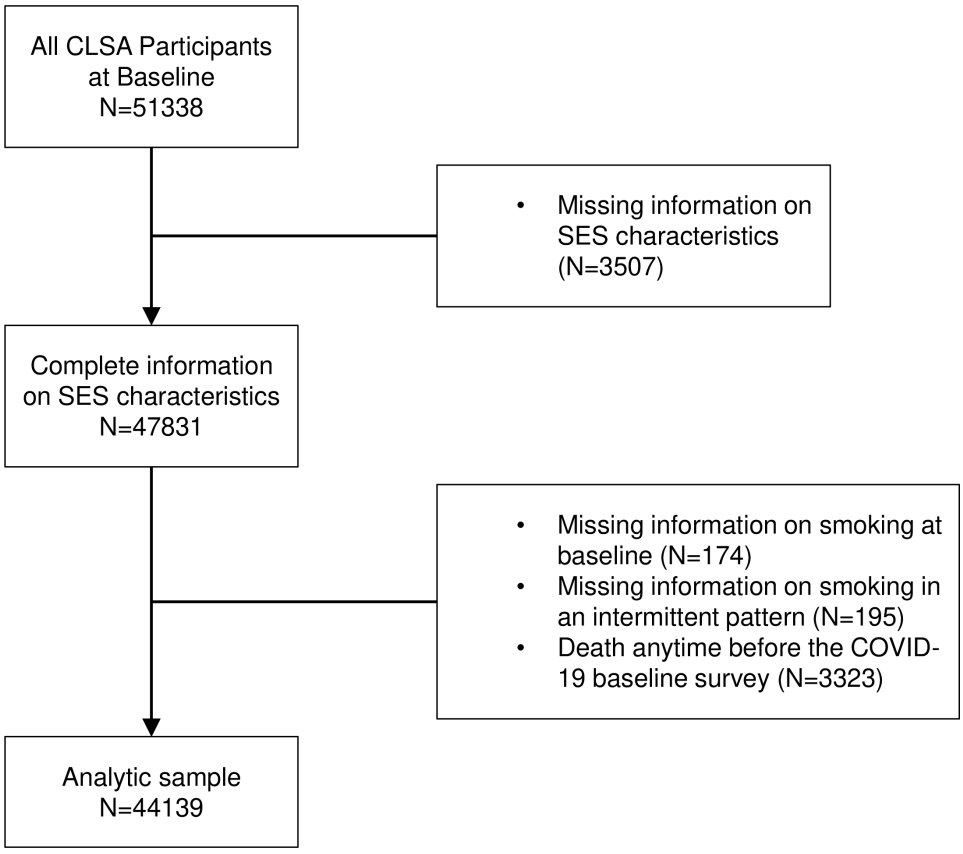

Figure 1 Flow chart showing the selection of Canadian Longitudinal Study on Aging (CLSA) participants for the weighted generalised estimating equation models. SES, socioeconomic status.

participants were categorised into the following groups: less than secondary school, secondary school graduation, some postsecondary (eg, started but did not graduate) and postsecondary.

For the secondary objective, we considered tobacco smoking during the COVID-19 pandemic as the main exposure. Data on tobacco smoking during the pandemic were collected in the CLSA COVID-19 baseline survey (15 Apr 2020–30 May 2020). Participants were first asked if they had ever smoked in their lifetime. If participants indicated that they had, they were asked if they currently smoked daily, occasionally or not at all. For our analysis, participants who reported not currently smoking (formerly smoked) and participants who had never smoked in their lifetime (never smoked) were grouped together as not smoking. Participants who smoked daily or occasionally were grouped together, due to the small number of participants who reported occasional smoking. The original proportions are displayed in online supplemental figure 1.

Outcomes

For the primary objective, the outcome is daily or occasional tobacco smoking prior to and during the COVID-19 pandemic. As noted earlier, data on smoking during the COVID-19 pandemic were collected in the COVID-19 baseline survey. Data on tobacco smoking were also collected at CLSA baseline and FUP1, allowing us to calculate the odds of smoking early in the pandemic, relative to before the pandemic. The questions at FUP1 were identical to those at COVID-19 baseline, asking if participants had ever smoked in their lifetime and if they were currently smoking daily, occasionally or not at all. Participants who indicated smoking daily or occasionally were grouped together. The questions at CLSA baseline were structured differently. Participants were first asked if they had ever in their lifetime smoked 100 cigarettes. If they indicated yes, they were asked if they were currently smoking daily, occasionally or not at all. Participants who reported smoking not at all (formerly smoked) and participants who reported never smoking 100 cigarettes in their lifetime (never smoked) were grouped together, while adults who smoked daily or occasionally were grouped together.

For the secondary objective, the outcome was a PHM score developed by De Rubeis *et al*,[28] which summarised adherence to the guidelines during the COVID-19 pandemic.[29 30] The summary measure included data from the COVID-19 baseline and three monthly follow-up surveys. Data on five behaviours were collected: self-quarantining, attending a public gathering, leaving home, masking and handwashing. Handwashing was only measured in the baseline survey and masking was only included in the monthly surveys. The other behaviours were included in all four surveys. For each behaviour,

Table 1 Descriptive characteristics of the Canadian Longitudinal Study on Aging (CLSA) cohort at CLSA baseline (2011–2015) and COVID-19 (2020)

	CLSA baseline*†		COVID-19 ‡§	
Characteristic	N=44 139	%	N=27 927	%
Sex				
Female	22 461	50.9	14 653	52.5
Male	21 678	49.1	13 274	47.5
Age				
45–54	12 593	28.5	1482	5.3
55–64	14 840	33.6	8794	31.5
65–74	10 069	22.8	9906	35.5
75–96	6637	15.1	7745	27.7
Region				
Atlantic	9080	20.5	5149	18.4
Quebec	8416	19.1	5064	18.1
Ontario	9626	21.8	6438	23.1
Prairies	9310	21.1	5958	21.3
British Columbia	7707	17.5	5318	19.1
Urban/rural				
Rural	8364	18.9	4998	18.0
Urban	35 775	81.1	22 786	82.0
Missing	0		143	
Racial background				
White	42 431	96.1	27 060	97.0
Non-white	1708	3.9	840	3.0
Missing	0		27	
Immigrant background				
Immigrant	6879	15.6	4409	15.8
Non-immigrant	37 260	84.4	23 502	84.2
Missing	0		6	
Marital status				
Single, never married or lived with a partner	3639	8.2	2333	8.4
Married or in a common-law relationship	31 293	70.9	19 528	70.5
Widowed or divorced or separated	9207	20.9	5862	21.1
Missing	0		204	
Household income				
<CA$20 000	2512	5.7	998	3.8
CA$20 000–CA$49 999	10 675	24.2	5550	21.2
CA$50 000–CA$99 999	15 873	36.0	9790	37.4
CA$100 000–CA$149 999	8286	18.7	5315	20.3
≥CA$150 000	6793	15.4	4538	17.3
Missing	0		1736	
Education				
<Secondary school	2818	6.4	1269	4.6
Secondary school	4741	10.7	2738	9.8
Some postsecondary	3265	7.4	2013	7.2
Postsecondary	33 315	75.5	21 859	78.4
Missing	0		48	
Smoking				
Daily or occasionally	3992	9.0	1790	6.4
Formerly or never	40 147	91.0	26 137	93.6
Adherence to public health measures				
Low	N/A	N/A	6201	22.2
Medium	N/A	N/A	14 555	52.2
High	N/A	N/A	7159	25.6
Missing	N/A		12	

*All characteristics were taken from CLSA baseline (2011–2015).
†This was the sample used for the weighted generalised estimating equation models examining the change in the prevalence of smoking.
‡Sex, education and racial background were taken from CLSA baseline (2011–2015). Household income and marital status were taken from CLSA FUP1 (2015–2018). Age group, region of residence and urban or rural residence were taken from COVID-19 baseline (2020). Adherence to public health measures was measured at COVID-19 baseline and in the monthly surveys (2020).
§This was the sample used for the multinomial regression models examining adherence to public health measures.
FUP, follow-up.

participants were assigned a score ranging from 0 to 1 depending on if they had adhered (1) or did not adhere to (0) to the guidance given by public health authorities. A score for each of the four surveys was calculated by averaging the score for each of the behaviours. A final PHM score was calculated by averaging the scores on the baseline and monthly surveys. The final PHM score was then divided into quartiles and the middle two quartiles were grouped together because they had similar adherence scores. Overall, participants had either a low, medium or high level of adherence. Scores for the individual behaviours were also averaged across time and converted into a three-level outcome using the same quartile method. Participants with missing data for more than one of the surveys were not included. Details on the PHM score, including the questions and the behaviour frequencies, are included in online supplemental tables 1 and 2.

Table 2 Weighted generalised estimating equation models examining the odds of daily or occasional tobacco smoking during the COVID-19 pandemic (2020), relative to the prepandemic period (2011–2018), by period and socioeconomic status (SES) among Canadian Longitudinal Study on Aging (CLSA) participants (N=44 139) for the SES characteristics that exhibited significant interaction with the period variable*†

Characteristic	Adjusted for all SES	Adjusted for sex×period‡	Adjusted for age×period‡	Adjusted for region×period‡	Adjusted for racial background×period‡	Adjusted for immigrant background×period‡	Adjusted for marital status×period‡	Adjusted for income×period‡
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Period								
COVID-19 pandemic	1.12 (1.07, 1.17)	1.12 (1.07, 1.17)	1.12 (1.06, 1.19)	1.14 (1.09, 1.19)	1.30 (1.13, 1.49)	1.23 (1.15, 1.32)	1.06 (1.01, 1.12)	1.14 (1.08, 1.19)
Prepandemic	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Sex								
Female	0.84 (0.79, 0.90)	0.83 (0.76, 0.89)	0.84 (0.79, 0.90)	0.84 (0.79, 0.91)	0.84 (0.78, 0.90)	0.84 (0.79, 0.90)	0.84 (0.78, 0.90)	0.84 (0.78, 0.90)
Male	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Age (prepandemic)								
55–64	0.75 (0.70, 0.80)	0.75 (0.70, 0.80)	0.79 (0.71, 0.89)	0.75 (0.70, 0.80)	0.75 (0.70, 0.80)	0.75 (0.71, 0.80)	0.75 (0.70, 0.80)	0.74 (0.69, 0.79)
65–74	0.49 (0.45, 0.54)	0.49 (0.45, 0.53)	0.53 (0.46, 0.59)	0.49 (0.45, 0.53)	0.49 (0.45, 0.54)	0.50 (0.46, 0.54)	0.49 (0.45, 0.53)	0.49 (0.45, 0.53)
75–96	0.29 (0.26, 0.32)	0.29 (0.26, 0.32)	0.30 (0.26, 0.34)	0.29 (0.26, 0.32)	0.29 (0.26, 0.32)	0.29 (0.26, 0.32)	0.29 (0.26, 0.32)	0.29 (0.26, 0.32)
45–54	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Region								
Quebec	1.10 (0.99, 1.22)	1.09 (0.99, 1.22)	1.09 (0.99, 1.21)	1.08 (0.96, 1.22)	1.10 (0.99, 1.22)	1.10 (0.99, 1.22)	1.10 (0.99, 1.22)	1.10 (0.99, 1.22)
Ontario	0.99 (0.88, 1.10)	0.98 (0.88, 1.10)	0.98 (0.88, 1.10)	1.01 (0.89, 1.14)	0.99 (0.88, 1.10)	0.99 (0.89, 1.10)	0.99 (0.88, 1.10)	0.98 (0.88, 1.10)
Prairies	1.12 (1.01, 1.25)	1.12 (1.00, 1.25)	1.12 (1.01, 1.25)	1.14 (1.01, 1.29)	1.13 (1.01, 1.25)	1.12 (1.01, 1.25)	1.12 (1.00, 1.24)	1.12 (1.01, 1.25)
British Columbia	0.78 (0.69, 0.89)	0.78 (0.69, 0.89)	0.78 (0.69, 0.88)	0.82 (0.73, 0.95)	0.78 (0.69, 0.89)	0.79 (0.70, 0.89)	0.79 (0.70, 0.89)	0.79 (0.70, 0.89)
Atlantic	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Urban/Rural								
Rural	1.03 (0.94, 1.13)	1.03 (0.95, 1.13)	1.03 (0.94, 1.12)	1.04 (0.95, 1.13)	1.03 (0.94, 1.13)	1.03 (0.95, 1.13)	1.03 (0.94, 1.12)	1.04 (0.95, 1.13)
Urban	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Racial background								
Non-white	1.03 (0.83, 1.27)	1.03 (0.84, 1.27)	1.03 (0.84, 1.27)	1.03 (0.83, 1.27)	1.08 (0.86, 1.36)	1.03 (0.83, 1.28)	1.02 (0.82, 1.26)	1.01 (0.82, 1.25)
White	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Immigrant background								
Immigrant	0.84 (0.74, 0.94)	0.84 (0.74, 0.94)	0.84 (0.75, 0.95)	0.85 (0.75, 0.95)	0.84 (0.74, 0.94)	0.88 (0.78, 1.00)	0.84 (0.75, 0.95)	0.84 (0.75, 0.95)
Non-immigrant	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Marital status								
Single, never married or lived with a partner	1.63 (1.45, 1.82)	1.62 (1.45, 1.82)	1.63 (1.45, 1.82)	1.63 (1.45, 1.82)	1.63 (1.45, 1.82)	1.63 (1.45, 1.82)	1.56 (1.38, 1.78)	1.63 (1.46, 1.82)
Widowed or divorced or separated	1.48 (1.35, 1.63)	1.48 (1.35, 1.63)	1.48 (1.35, 1.63)	1.48 (1.35, 1.62)	1.48 (1.35, 1.63)	1.48 (1.35, 1.62)	1.42 (1.29, 1.28)	1.49 (1.36, 1.63)
Married or in a common-law relationship	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Household income								

Continued

Table 2 Continued

Characteristic	Adjusted for all SES	Adjusted for sex×period‡	Adjusted for age×period‡	Adjusted for region×period‡	Adjusted for racial background×period‡	Adjusted for immigrant background×period‡	Adjusted for marital status×period‡	Adjusted for income×period‡
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
<CA$20 000	3.75 (3.14, 4.47)	3.75 (3.14, 4.47)	3.73 (3.12, 4.45)	3.72 (3.11, 4.45)	3.77 (3.16, 4.51)	3.72 (3.12, 4.44)	3.74 (3.13, 4.46)	3.54 (2.92, 4.29)
CA$20 000 –CA$49 999	2.29 (1.99, 2.62)	2.28 (1.98, 2.61)	2.28 (1.99, 2.62)	2.28 (1.99, 2.61)	2.29 (2.00, 2.63)	2.28 (1.98, 2.61)	2.28 (1.99, 2.61)	2.18 (1.89, 2.52)
CAD$50 000–CAD$99 999	1.70 (1.50, 1.92)	1.70 (1.50, 1.92)	1.70 (1.50, 1.92)	1.69 (1.50, 1.91)	1.70 (1.50, 1.92)	1.69 (1.49, 1.91)	1.69 (1.49, 1.91)	1.63 (1.43, 1.86)
CA$100 000–CA$149 999	1.42 (1.25, 1.62)	1.43 (1.25, 1.63)	1.42 (1.24, 1.62)	1.42 (1.24, 1.62)	1.42 (1.25, 1.62)	1.41 (1.23, 1.61)	1.42 (1.24, 1.62)	1.39 (1.21, 1.60)
≥CA$150000	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Education								
<Secondary school	1.84 (1.61, 2.11)	1.85 (1.61, 2.11)	1.84 (1.61, 2.11)	1.84 (1.61, 2.11)	1.84 (1.61, 2.11)	1.84 (1.61, 2.11)	1.84 (1.61, 2.11)	1.84 (1.61, 2.10)
Secondary school	1.65 (1.49, 1.83)	1.65 (1.49, 1.83)	1.65 (1.49, 1.82)	1.65 (1.49, 1.82)	1.65 (1.49, 1.83)	1.65 (1.50, 1.84)	1.65 (1.49, 1.83)	1.65 (1.50, 1.83)
Some postsecondary	1.42 (1.25, 1.61)	1.42 (1.26, 1.61)	1.42 (1.25, 1.61)	1.42 (1.25, 1.61)	1.42 (1.25, 1.61)	1.42 (1.26, 1.61)	1.43 (1.26, 1.62)	1.43 (1.26, 1.61)
Postsecondary	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Period, adjusted for interaction with sex (ref=prepandemic)								
Female		0.92 (0.84, 1.01)						
Male		Reference						
Period, adjusted for interaction with age (ref=prepandemic)								
55–64			0.83 (0.76, 0.90)					
65–74			0.57 (0.52, 0.62)					
75–96			0.33 (0.29, 0.38)					
45 to 54			Reference					
Period, adjusted for interaction with region (ref=prepandemic)								
Quebec				1.10 (0.96, 1.26)				
Ontario				1.12 (0.98, 1.29)				
Prairies				1.23 (1.08, 1.41)				
British Columbia				1.00 (0.86, 1.16)				
Atlantic				Reference				
Period, adjusted for interaction with racial background (ref=prepandemic)								
Non-white					1.41 (1.03, 1.93)			
White					Reference			
Period, adjusted for interaction of immigrant background (ref=prepandemic)								
Immigrant						1.09 (0.93, 1.27)		
Non-immigrant						Reference		
Period, adjusted for interaction of marital status (ref=prepandemic)								
Single, never married or lived with a partner							1.72 (1.47, 2.02)	
Widowed or divorced or separated							1.56 (1.38, 1.77)	

Continued

Table 2 Continued

Characteristic	Adjusted for all SES	Adjusted for sex×period‡	Adjusted for age×period‡	Adjusted for region×period‡	Adjusted for racial background×period‡	Adjusted for immigrant background×period‡	Adjusted for marital status×period‡	Adjusted for income×period‡
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Married or in a common-law relationship							Reference	
Period, adjusted for interaction of income (ref=pre-pandemic)								
<CA$20 000								4.10 (3.23, 5.20)
CA$20 000–CA$49 999								2.22 (1.12, 2.61)
CA$50 000–CA$99 999								1.99 (1.72, 2.30)
CA$100 000–CA$149 999								1.78 (1.51, 2.08)
≥CA$150 000								Reference

*Age was included in the model as a time-varying covariate. All other variables were taken from CLSA baseline (2011–2015).
†aOR: Adjusted OR.
‡Adjusted for all SES and the indicated interaction.

Statistical analyses

The characteristics of the 44 139 participants at CLSA baseline (used to model the change in smoking using weighted generalised estimating equations (WGEEs)) and 27 929 participants at COVID-19 (used to model the adherence to PHMs) were described.

For the primary objective, we used WGEE regression models with a logit link to calculate the prevalence of smoking in the prepandemic period and during the COVID-19 pandemic for 44 139 participants. WGEE models were used to account for longitudinal data missing at random and reduce bias in prevalence estimates from survey non-response over time.[31–33] We structured the data so that participants could only have missing information on their smoking status in a monotonic pattern.[34] However, they did not need to report their smoking status at all three time points as WGEEs are able to incorporate their values by using subject-specific weights that account for the probability of drop out.[34] Still, participants could not have missing data on any of the SES characteristics at baseline, answer the smoking questions intermittently or lack information on smoking due to death. This information is summarised in figure 1. Of the 44 139 participants, 39 830 answered the smoking questions at FUP1 (response rate=89%) and 25 767 answered the smoking questions at COVID-19 baseline (response rate=58%).

We used the WGEE models to determine the prevalence of smoking during the two time periods. We ran the unadjusted models, in which only the primary exposure period was included, and the adjusted model, in which we controlled for all SES characteristics. Then, we examined the interaction of the period variable with each of the SES characteristics. When the interaction was significant ($p<0.10$ using the Wald statistic),[35] we stratified the sample by the different SES subgroups and calculated the prevalence of smoking at the different periods. We reported when the period variable was significant ($p<0.05$) for the different subgroups, suggesting a change in smoking across time for the subgroup. The odds of reporting smoking during the pandemic, relative to before the pandemic, were also modelled.

For the secondary objective, we used multinomial logistic regression to evaluate the association of tobacco smoking with the PHM score. We assessed the odds of being categorised into the low, medium and high adherence groups, treating the low adherence group as the reference group. The models were adjusted for the following SES characteristics: age group, sex, region of residence, urban or rural residence, immigrant background, racial background, marital status, household income and education level. More recent data were available on some of the characteristics. Therefore, data on household income and marital status were extracted from FUP1, while age, region of residence and urban or rural residence were extracted from the COVID-19 baseline survey.

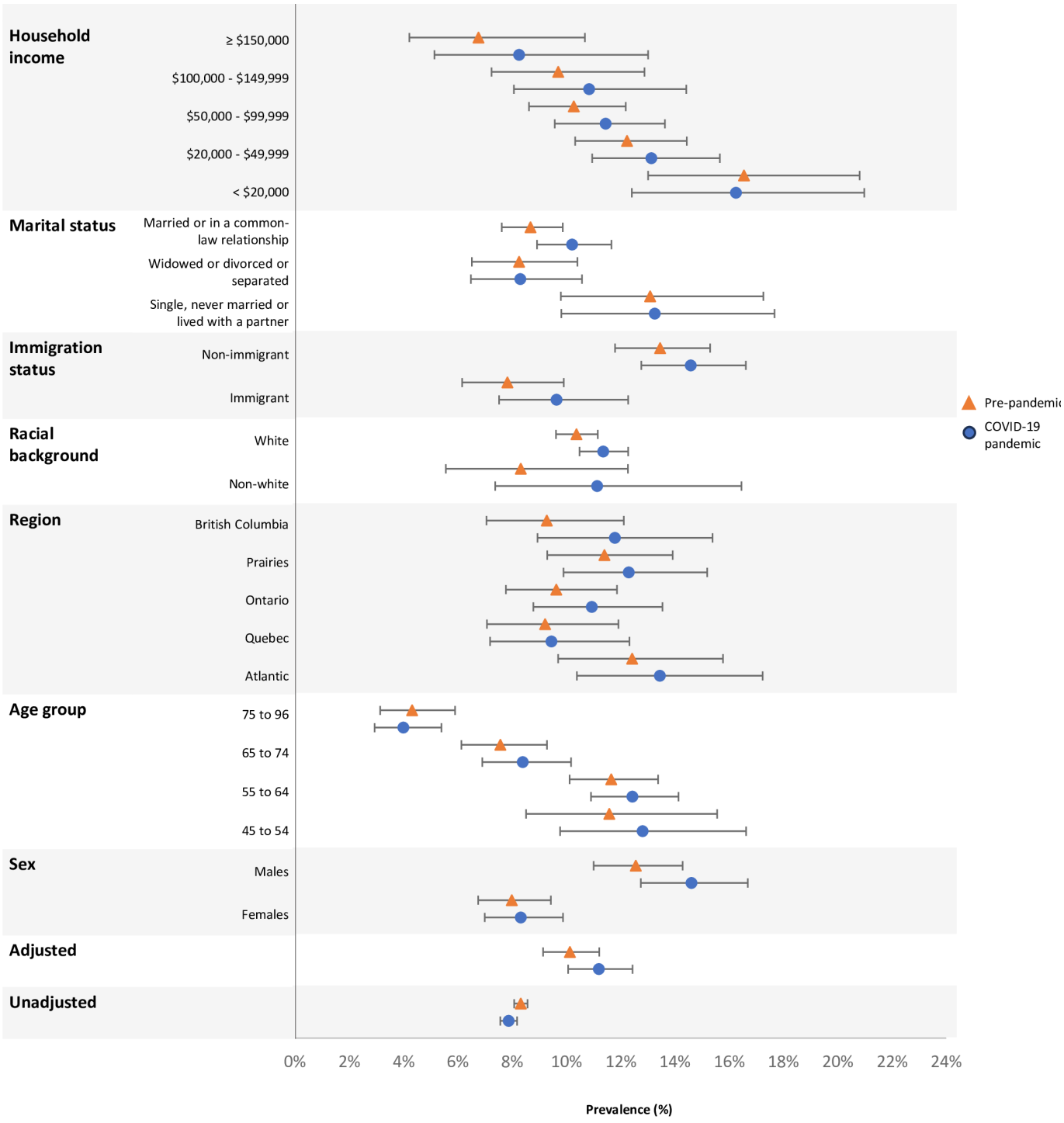

Figure 2 Prevalence of daily or occasional tobacco smoking in the Canadian Longitudinal Study on Aging prepandemic period (2011–2018) and COVID-19 pandemic (2020) stratified by the socioeconomic status characteristics.

RESULTS

Descriptive characteristics of the sample used at CLSA baseline for the WGEE models and the start of the COVID-19 pandemic are shown in table 1. There was roughly an even proportion of males and females at both baseline and the COVID-19 survey. Respondents of the COVID-19 survey were slightly more likely to have higher income and education levels than the full baseline sample. During the COVID-19 pandemic, 22.2% of the sample reported a low level of adherence to PHMs, while 52.2% reported a medium level and 25.6% reported a high level. Using the WGEE models, we observed that the unadjusted prevalence of smoking was 7.9% (95% CI 7.6%, 8.2%) during the COVID-19 pandemic, lower than the prepandemic prevalence of 8.3% (95% CI 8.1%, 8.6%) with a significance of p<0.001. After adjusting for covariates, the prevalence of smoking during the pandemic was 11.2% (95% CI 10.1%, 12.4%), higher

Table 3 Multinomial logistic regression models examining the association of the adherence to public health measure (PHM) score with tobacco smoking during the COVID-19 pandemic (2020)

	Adherence to public health measures	
	Medium vs low OR (95% CI)	High vs low OR (95% CI)
Smoking (Unadjusted)		
Daily or occasional	0.98 (0.86, 1.11)	1.35 (1.18, 1.55)
Never or former	Reference	Reference
Smoking (Adjusted)*		
Daily or occasional	1.09 (0.95, 1.24)	1.53 (1.31, 1.78)
Never or former	Reference	Reference

*Models were adjusted for age group, sex, region of residence, urban or rural residence, immigrant background, racial background, marital status, household income and education level.

than the prepandemic prevalence of 10.1% (95% CI 9.1%, 11.2%) with a significance of p<0.001. In relative terms, the ORs for daily or occasionally tobacco smoking are presented in table 2 (for the fully adjusted model and the SES characteristics with significant interaction with the period variable) and online supplemental table 3 (SES characteristics that did not have significant interaction with the period variable). The unadjusted ORs of daily or occasional smoking were 0.94 (95% CI 0.91, 0.98) times lower during the COVID-19 pandemic compared with the prepandemic period. Overall, the adjusted ORs (aORs) of daily or occasional smoking during the COVID-19 pandemic were 1.12 (95% CI 1.07, 1.17) times as high, relative to prepandemic, as seen in table 2.

The following characteristics showed a significant interaction with the period variable: sex (p=0.014), age (p=0.060), province (p<0.001), racial background (p=0.022), immigration status (p<0.001), marital status (p<0.001) and income (p=0.007). Urban/rural status (p=0.253) and education level (p=0.235) did not show a significant interaction with time period. The adjusted prevalence of smoking prepandemic and during the COVID-19 pandemic periods have been presented in figure 2, stratified by the characteristics that exhibited statistically significant interaction. Males, adults aged between 55 and 74 years, residents of British Columbia and Ontario, individuals who were married or in a common-law relationship and who earned over CA$20 000 were significantly more likely to smoke during the COVID-19 pandemic than in the prepandemic period. The increase in the risk of smoking was greater for immigrants and non-white participants. While immigrants and non-white participants had a lower prevalence of smoking before the pandemic, relative to non-immigrants and white participants, respectively, they had a higher prevalence of smoking than their reference groups during the pandemic.

The results of the multinomial logistic regression models that examine the association of tobacco smoking and PHM adherence are presented in table 3. Individuals who smoked daily or occasionally had higher odds of high adherence compared with low adherence, relative to individuals who never or formerly smoked (OR 1.35, 95% CI 1.18, 1.55), even after adjustment for covariates (aOR 1.53; 95% CI 1.31, 1.78). When the behaviours were examined separately, individuals who smoked daily or occasionally had higher odds of being in the high adherence group than the low adherence group for self-quarantining (aOR 1.48; 95% CI 1.22, 1.79) and public gathering (aOR 1.47; 95% CI 1.18, 1.83), relative to individuals who never or formerly smoked. However, they had lower odds of being in the medium (aOR 0.79; 95% CI 0.69, 0.91) and high (aOR 0.77; 95% CI 0.66, 0.89) adherence groups for handwashing. The results of the multinomial regression models for the individual components of the PHM score are in online supplemental table 4.

DISCUSSION

Among Canadian middle-aged and older adults, the adjusted prevalence of smoking was 1.1% higher during the COVID-19 pandemic, which is equivalent to a relative change of 10.9% from baseline. We found evidence that change in smoking varied by certain socioeconomic characteristics. Males, adults aged between 55 and 74 years, residents of British Columbia and Ontario, individuals who were married or in a common-law relationship and that earned over CA$20 000 were more likely to smoke during the COVID-19 pandemic than in the prepandemic period. Additionally, the increase in risk of smoking was greater in racialised adults and immigrants. We also found that individuals who smoked daily or occasionally had higher odds of adhering to PHMs during the early stage of the COVID-19 pandemic, relative to those formerly or never smoked.

We observed a small increase in the adjusted prevalence of smoking during the COVID-19 pandemic. The literature on changes in smoking during the COVID-19 pandemic has been inconsistent. Studies have reported mixed findings, suggesting both increases and decreases in the prevalence of smoking during the COVID-19 pandemic.[8 36–38] In a longitudinal study of nearly two million adults in the USA, the prevalence of smoking decreased among adults below the age of 55, while remaining unchanged in adults aged 55 years or older.[8] Among studies of exclusively adults who smoke, there was evidence of both cessation and intensification of use.[36 39 40] Lack of social opportunities for smoking and being in the constant presence of all household members have been suggested as reasons for decreases in smoking.[8] Fear of COVID-19 was noted to be a significant motivation to quit smoking.[40–42] In contrast, stress was a potential reason for increases in smoking.[7 43] High levels

of anxiety were noted in Canada during the pandemic.[44] However, the prevalence of smoking in Canada has been steadily declining and some adults may have quit smoking between 2018 (the end of FUP1) and 2020. This decline may have led to an underestimation of the pandemic-related change in prevalence in our study.

Our study found that the pandemic had a differential impact on the prevalence of smoking, across SES characteristics. Initiation of tobacco smoking usually occurs in adolescence or young adulthood.[45 46] It is possible that the increased prevalence of smoking was among those who formerly smoked beginning to smoke again. We observed an increase in smoking in males but not females, which is consistent with other work during the pandemic.[47] Notably, we found an increase in smoking in wealthier adults. While previous work has suggested that increases in smoking during the pandemic were associated with financial distress, it has relied on recall of prior smoking habits or exclusively examined the habits of adults who already smoked when the pandemic began.[48–50] A longitudinal study of nearly two million adults in the USA found no significant effect of income on change in smoking.[8] It is possible that adults with lower levels of income were unable to purchase cigarettes, due to financial constraints. There is other evidence of wealthier adults in the CLSA partaking in health risk behaviours during the pandemic, with one study finding that binge drinking was associated with higher levels of income and education.[51] The shift to remote work, which was associated with increased smoking,[48 52] was largely seen in higher-paying industries.[53] With respect to marital status, the stress of isolating and cohabiting together for long periods of time may have led to an uptake of smoking.[54 55] The prevalence of smoking rose significantly in immigrants and racialised adults. This result was surprising because they had lower levels of smoking prepandemic. While considerable progress has been made, efforts must continue to promote smoking cessation.

Our study suggests that individuals who smoked were more likely to adhere to COVID-19 PHM, particularly self-quarantining and avoidance of public gatherings, early in the pandemic in Canada. This may be attributed to fear of COVID-19.[56] Individuals with psychological concerns about COVID-19 have shown to exhibit greater adherence to guidelines.[29 57] In cross-sectional studies of European and Korean adults, smoking was associated with lower odds of adhering to isolation guidelines.[58 59] However, another study found that adults who smoked in five European countries were more likely to engage in self-protecting behaviours.[60] The adoption of PHM is known to be highly context specific.[61] Countries had diverse approaches to the COVID-19 pandemic, with different restrictions, enforcement and communication strategies. This may have resulted in differing awareness among adults who smoked of their vulnerability to COVID-19, influencing their adherence. Canadian youth who smoked were more likely to find PHM as excessively restrictive.[62] Our sample was composed of middle-aged to older adults, who may have been more likely to perceive COVID-19 as a risk. Although fear has been associated with adherence to PHM, messaging from public health authorities that promotes self-efficacy would be a positive alternative.[63]

Limitations and future directions

The CLSA COVID-19 study was administered in 2020, in the early stages of the pandemic and the questions related to smoking were only included in the COVID-19 baseline survey. Thus, we were unable to measure how smoking behaviours changed after the initial lockdown. Data on the quantity of cigarettes consumed were also unavailable. Our analysis of how the prevalence of smoking varied by SES may have been limited by the small sample sizes of some subgroups. Our summary measure gave equal importance to each behaviour included and assumed they were independent. Participants may have reported greater adherence to PHM, perceiving it as a socially desirable behaviour. Lastly, the CLSA sample excludes the territories and has a greater proportion of wealthier and non-racialised participants than the Canadian population, limiting the generalisability of the results.

The strengths of our study include a large sample size, longitudinal data collection and comprehensive measurement of variables both prior to and early during the COVID-19 pandemic. We observed that people who smoked were more likely to not respond to the COVID-19 surveys and addressed this bias by using weighted GEE analysis. By assessing for interaction, we identified factors associated with change in smoking over time. We examined adherence to COVID-19 PHMs using a novel measure. However, common tools to measure adherence to PHMs are needed. Studies conducted during the pandemic have relied on self-recall questions, meaning that future longitudinal studies are necessary to monitor long-term changes in smoking.

CONCLUSION

The adjusted prevalence of daily and occasional tobacco smoking during the early stages of the COVID-19 pandemic was significantly higher than before the pandemic among middle-aged and older adults in Canada. Changes in smoking varied by SES. Our results highlight the need for continued efforts to promote smoking cessation. It is necessary that efforts continue to ensure informative communication from governments and public health authorities about PHMs, particularly for a group that is at higher risk of developing COVID-19 complications.

Contributors Conceptualisation: JK, LNA, MDG, YJ and LG; Analysis: JK, UEO, LNA, VDR and LG; Writing–original draft: JK and LNA; Writing–review and editing: JK, LNA, VRD, LG, UEO, MDG and YJ; The members of the Canadian Longitudinal Study on Aging team have contributed to the collection of the data across Canada. JK accepted full responsibility for the finished work and the conduct of the study, had access to the data and controlled the decision to publish. JK is the guarantor.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and ethics approval of the core CLSA study and the CLSA COVID-19 Questionnaire Study was granted by the Hamilton Integrated Research Ethics Board (HiREB) at McMaster University and the research ethics boards at all collaborating Canadian institutions. The HiREB approval numbers are 10-423 for the Comprehensive Cohort and 09-213 for the Tracking Cohort. The HiREB approval number for this study is 14090. The CLSA Consortium data access approval number is 2201020. Participants gave informed consent to participate in the study before taking part.

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ORCID iDs
Vanessa De Rubeis http://orcid.org/0000-0002-6756-1887
Laura N Anderson http://orcid.org/0000-0002-6106-5073

REFERENCES

1 Desson Z, Weller E, McMeekin P, *et al*. An analysis of the policy responses to the COVID-19 pandemic in France, Belgium, and Canada. *Health Policy Technol* 2020;9:430–46.
2 McCoy LG, Smith J, Anchuri K, *et al*. Characterizing early Canadian federal, provincial, territorial and municipal nonpharmaceutical interventions in response to COVID-19: a descriptive analysis. *cmajo* 2020;8:E545–53.
3 Government of Canada. COVID-19 in canada: a two-year update on social and economic impacts. 2022. Available: https://www150.statcan.gc.ca/n1/pub/11-631-x/11-631-x2022001-eng.htm [Accessed 16 Jun 2023].
4 Government of Canada. COVID-19 in Canada: A One-year Update on Social and Economic Impacts, 2021. Available: https://www150.statcan.gc.ca/n1/pub/11-631-x/11-631-x2021001-eng.htm#a4 [Accessed 4 Mar 2022].
5 Chun H-R, Cheon E, Hwang J-E. Systematic review of changed smoking behaviour, smoking cessation and psychological states of smokers according to cigarette type during the COVID-19 pandemic. *BMJ Open* 2022;12:e055179.
6 Sarich P, Cabasag CJ, Liebermann E, *et al*. Tobacco smoking changes during the first pre-vaccination phases of the COVID-19 pandemic: A systematic review and meta-analysis. *eClinMed* 2022;47:101375.
7 Almeda N, Gómez-Gómez I. The Impact of the COVID-19 Pandemic on Smoking Consumption: A Systematic Review of Longitudinal Studies. *Front Psychiatry* 2022;13:941575.
8 Gaffney A, Himmelstein DU, Woolhandler S. Smoking Prevalence during the COVID-19 Pandemic in the United States. *Ann Am Thorac Soc* 2022;19:1065–8.
9 Sylvestre M-P, Dinkou GDT, Naja M, *et al*. A longitudinal study of change in substance use from before to during the COVID-19 pandemic in young adults. *Lancet Reg Health Am* 2022;8:100168.
10 Health Canada. Canadian tobacco and nicotine survey (ctns): summary of results for 2020. 2022. Available: https://www.canada.ca/en/health-canada/services/canadian-tobacco-nicotine-survey/2020-summary.html [Accessed 15 Jun 2023].
11 Health Canada. Canadian tobacco and nicotine survey (ctns): summary of results for 2021. 2023. Available: https://www.canada.ca/en/health-canada/services/canadian-tobacco-nicotine-survey/2021-summary.html [Accessed 15 Jun 2023].
12 Graham R, Bharthi K, Williams J, *et al*. Trends in vaping and smoking behavior before and during the COVID-19 pandemic in Canada: Beneficial and potentially detrimental changes. *Addict Behav* 2024;149:107839.
13 Statistics Canada. Canadians who report lower self-perceived mental health during the covid-19 pandemic more likely to report increased use of cannabis, alcohol and tobacco. 2020. Available: https://www150.statcan.gc.ca/n1/pub/45-28-0001/2020001/article/00008-eng.htm [Accessed 2 May 2022].
14 Manuel DG, Perez R, Sanmartin C, *et al*. Measuring Burden of Unhealthy Behaviours Using a Multivariable Predictive Approach: Life Expectancy Lost in Canada Attributable to Smoking, Alcohol, Physical Inactivity, and Diet. *PLoS Med* 2016;13:e1002082.
15 Pelekanakis A, O'Loughlin JL, Gagné T, *et al*. Initiation or cessation: what keeps the prevalence of smoking higher in Quebec than in the rest of Canada? *Health Promot Chronic Dis Prev Can* 2021;41:306–14.
16 CIHI. Trends in Income-Related Health Inequalities in Canada, 2016. Available: https://secure.cihi.ca/free_products/trends_in_income_related_inequalities_in_canada_2015_en.pdf?_gl=1*1wudcaz*_ga*MTMyMjU4ODc3OC4xNjc5MzI1MzMy*_ga_44X3CK377B*MTY5MTkwMTg5NC43LjEuMTY5MTkwMTkxMS4wLjAuMA..&_ga=2.252384266.2033182826.1691901894-1322588778.1679325332
17 Statistics Canada. Measuring the Correlation Between COVID-19 Restrictions and Economic Activity, March 2022. Available: https://www150.statcan.gc.ca/n1/pub/11-633-x/11-633-x2022003-eng.htm [Accessed 20 Mar 2023].
18 Shushtari ZJ, Salimi Y, Ahmadi S, *et al*. Social determinants of adherence to COVID-19 preventive guidelines: a comprehensive review. *Osong Public Health Res Perspect* 2021;12:346–60.
19 Kawuki J, Chan PS-F, Fang Y, *et al*. Knowledge and Practice of Personal Protective Measures Against COVID-19 in Africa: Systematic Review. *JMIR Public Health Surveill* 2023;9:e44051.
20 Hagan KK, Javed Z, Cainzos-Achirica M, *et al*. Social Determinants of Adherence to COVID-19 Risk Mitigation Measures Among Adults With Cardiovascular Disease. *Circ Cardiovasc Qual Outcomes* 2021;14:e008118.
21 Kavanagh NM, Goel RR, Venkataramani AS. County-Level Socioeconomic and Political Predictors of Distancing for COVID-19. *Am J Prev Med* 2021;61:13–9.
22 Yoshida-Montezuma Y, Keown-Stoneman CDG, Wanigaratne S, *et al*. The social determinants of health as predictors of adherence to public health preventive measures among parents and young children during the COVID-19 pandemic: a longitudinal cohort study. *Can J Public Health* 2021;112:552–65.
23 Raina P, Wolfson C, Kirkland S, *et al*. Cohort Profile: The Canadian Longitudinal Study on Aging (CLSA). *Int J Epidemiol* 2019;48:1752–1753j.
24 Forgetta V, Li R, Darmond-Zwaig C, *et al*. Cohort profile: genomic data for 26 622 individuals from the Canadian Longitudinal Study on Aging (CLSA). *BMJ Open* 2022;12:e059021.

25 Freedman KS, Nelson NM, Feldman LL. Smoking initiation among young adults in the United States and Canada, 1998-2010: a systematic review. *Prev Chronic Dis* 2012;9:E05.
26 Newbold KB, Neligan D. Disaggregating Canadian immigrant smoking behaviour by country of birth. *Soc Sci Med* 2012;75:997–1005.
27 Corsi DJ, Boyle MH, Lear SA, *et al*. Trends in smoking in Canada from 1950 to 2011: progression of the tobacco epidemic according to socioeconomic status and geography. *Cancer Causes Control* 2014;25:45–57.
28 De Rubeis V, Griffith LE, Duncan L, *et al*. Self-reported chronic conditions and COVID-19 public health measures among Canadian adults: an analysis of the Canadian longitudinal study on aging. *Public Health (Fairfax)* 2024;231:99–107.
29 Bearth A, Luchsinger L, Siegrist M. Reactions of older Swiss adults to the COVID-19 pandemic: A longitudinal survey on the acceptance of and adherence to public health measures. *Soc Sci Med* 2021;280:114039.
30 Courdi C, Ramazan Ali S, Pelletier-Dumas M, *et al*. How level of understanding and type of used sources relate to adherence to COVID-19 public health measures in Canada. *Sci Rep* 2023;13:13065.
31 Salazar A, Ojeda B, Dueñas M, *et al*. Simple generalized estimating equations (GEEs) and weighted generalized estimating equations (WGEEs) in longitudinal studies with dropouts: guidelines and implementation in R. *Stat Med* 2016;35:3424–48.
32 Preisser JS, Galecki AT, Lohman KK, *et al*. Analysis of Smoking Trends with Incomplete Longitudinal Binary Responses. *J Am Stat Assoc* 2000;95:1021.
33 Kirkland SA, Griffith LE, Oz UE, *et al*. Increased prevalence of loneliness and associated risk factors during the COVID-19 pandemic: findings from the Canadian Longitudinal Study on Aging (CLSA). *BMC Public Health* 2023;23:872.
34 Fitzmaurice GM. Applied Longitudinal Analysis2nd ed. Wiley, 2011.
35 Selvin S. The analysis of contingency table data: logistic model i. In: Selvin S, ed. *Statistical Analysis of Epidemiologic Data*. Oxford University Press, 2004.
36 Bandi P, Asare S, Majmundar A, *et al*. Changes in Smoking Cessation-Related Behaviors Among US Adults During the COVID-19 Pandemic. *JAMA Netw Open* 2022;5:e2225149.
37 Choi S, Bahk J, Park S, *et al*. Smoking, drinking, and physical activity among Korean adults before and during the COVID-19 pandemic: a special report of the 2020 Korea National Health and Nutrition Examination Survey. *Epidemiol Health* 2022;44:e2022043.
38 Jackson SE, Beard E, Angus C, *et al*. Moderators of changes in smoking, drinking and quitting behaviour associated with the first COVID-19 lockdown in England. *Addiction* 2022;117:772–83.
39 Gravely S, Craig LV, Cummings KM, *et al*. Smokers' cognitive and behavioural reactions during the early phase of the COVID-19 pandemic: Findings from the 2020 ITC Four Country Smoking and Vaping Survey. *PLoS ONE* 2021;16:e0252427.
40 Nagawa CS, Ito Fukunaga M, Faro JM, *et al*. Characterizing Pandemic-Related Changes in Smoking Over Time in a Cohort of Current and Former Smokers. *Nicotine Tob Res* 2023;25:203–10.
41 Munarini E, Stival C, Boffi R, *et al*. Factors associated with a change in smoking habit during the first COVID-19 lockdown: an Italian cross-sectional study among ever-smokers. *BMC Public Health* 2022;22:1046.
42 Li Y, Duong HT, Massey ZB, *et al*. When Cigarette Smoking Meets COVID-19: How the Two Types of Threat and Efficacy Perceptions Interactively Predict Danger Control and Fear Control Processes. *IJERPH* 2023;20:2970.
43 Koopmann A, Georgiadou E, Reinhard I, *et al*. The Effects of the Lockdown during the COVID-19 Pandemic on Alcohol and Tobacco Consumption Behavior in Germany. *Eur Addict Res* 2021;27:242–56.
44 Government of Canada SC. The Daily — Survey on COVID-19 and Mental Health, September to December 2020, 2021. Available: https://www150.statcan.gc.ca/n1/daily-quotidien/210318/dq210318a-eng.htm [Accessed 6 Sep 2022].
45 Gagné T, Veenstra G. Trends in smoking initiation in Canada: Does non-inclusion of young adults in tobacco control strategies represent a missed opportunity? *Can J Public Health* 2017;108:e14–20.
46 Barrington-Trimis JL, Braymiller JL, Unger JB, *et al*. Trends in the Age of Cigarette Smoking Initiation Among Young Adults in the US From 2002 to 2018. *JAMA Netw Open* 2020;3:e2019022.
47 Lee SY, Kim S, Kim W-H, *et al*. Employment, Economic, and Sociodemographic Factors Associated with Changes in Smoking and Drinking Behaviors during the COVID-19 Pandemic in South Korea. *IJERPH* 2022;19:2802.
48 Koyama S, Tabuchi T, Okawa S, *et al*. Changes in Smoking Behavior Since the Declaration of the COVID-19 State of Emergency in Japan: A Cross-sectional Study From the Osaka Health App. *J Epidemiol* 2021;31:378–86.
49 Han MA, Kim HR. Smoking Behavior Changes during COVID-19 among Korean Adults. *Am J Health Behav* 2021;45:1031–40.
50 Sampson L, Ettman CK, Abdalla SM, *et al*. Financial hardship and health risk behavior during COVID-19 in a large US national sample of women. *SSM Popul Health* 2021;13:100734.
51 McMillan JM, Hogan DB, Zimmer C, *et al*. Predictors of reported alcohol intake during the first and second waves of the COVID-19 pandemic in Canada among middle-aged and older adults: results from the Canadian Longitudinal Study on Aging (CLSA). *Can J Public Health* 2022;113:665–77.
52 Reynolds CME, Purdy J, Rodriguez L, *et al*. Factors associated with changes in consumption among smokers and alcohol drinkers during the COVID-19 "lockdown" period. *Eur J Public Health* 2021;31:1084–9.
53 Messacar D, Morissette R, Deng Z. Statistics Canada; Inequality in the Feasibility of Working from Home during and after COVID-19, 2020. Available: https://www150.statcan.gc.ca/n1/en/catalogue/45280001202000100029
54 Schokkenbroek JM, Hardyns W, Anrijs S, *et al*. Partners in lockdown: Relationship stress in men and women during the COVID-19 pandemic. *Couple and Family Psychology: Research and Practice* 2021;10:149–57.
55 Bevan JL, Murphy MK, Lannutti PJ, *et al*. A descriptive literature review of early research on COVID-19 and close relationships. *J Soc Pers Relat* 2023;40:201–53.
56 Duong HT, Massey ZB, Churchill V, *et al*. Are smokers scared by COVID-19 risk? How fear and comparative optimism influence smokers' intentions to take measures to quit smoking. *PLoS One* 2021;16:e0260478.
57 Gerretsen P, Kim J, Brown EE, *et al*. Determinants of social distancing adherence. *Front Public Health* 2022;10:977857.
58 Kwon RH, Jung M. Associations Between Conventional Healthy Behaviors and Social Distancing During the COVID-19 Pandemic: Evidence From the 2020 Community Health Survey in Korea. *J Prev Med Public Health* 2022;55:568–77.
59 Mendoza-Jiménez MJ, Hannemann TV, Atzendorf J. Behavioral Risk Factors and Adherence to Preventive Measures: Evidence From the Early Stages of the COVID-19 Pandemic. *Front Public Health* 2021;9:674597.
60 Taye AD, Borga LG, Greiff S, *et al*. A machine learning approach to predict self-protecting behaviors during the early wave of the COVID-19 pandemic. *Sci Rep* 2023;13:6121.
61 Urbán R, Király O, Demetrovics Z. Who complies with coronavirus disease 2019 precautions and who does not? *Curr Opin Psychiatry* 2021;34:363–8.
62 Romano I, Patte KA, de Groh M, *et al*. Perceptions of and adherence to early COVID-19-related restrictions and associations with substance use among youth in Canada. *Health Promot Chronic Dis Prev Can* 2022;42:479–89.
63 Jørgensen F, Bor A, Petersen MB. Compliance without fear: Individual-level protective behaviour during the first wave of the COVID-19 pandemic. *Br J Health Psychol* 2021;26:679–96.