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Original Investigation

Examining the Effectiveness of the 2012 Canadian Graphic Warning Label Policy Change by Sex, Income, and Education

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Abstract

Introduction: We examined the differential impact of the 2012 Canadian GWL policy changes on key indicators of warning label impact and quit intentions using national cohorts of Canadian and U.S. adults who smoke.

Aims and Methods: We used data from all waves of the International Tobacco Control surveys (2002–2020) in Canada and the United States. Our key measures were quit intentions and an index of warning label effectiveness (salience, cognitive and behavioral reactions). We estimated overall policy impact by comparing Canada (treatment group) with the United States (control group) using controlled interrupted time series (CITS) regression models, with interactions to examine whether policy impact varied by sex, education, and income.

Results: The CITS model showed a statistically significant increase in the warning label effectiveness in Canada post-policy, compared to the United States (β = 0.84, 95% CI 0.35,1.33). Similarly, the odds of quit intentions were relatively higher among adults who smoked in Canada compared to the United States (OR = 1.89, 95% CI 1.51,2.36) post-policy. The three-way interaction model showed that these associations were greater among adults from low socioeconomic status (SES) groups than in high SES groups.

Conclusions: The 2012 change in the Canadian GWL policy was associated with stronger cognitive and behavioral responses to GWLs and higher odds of quit intentions among adults who smoked in Canada when compared to the United States, specifically among individuals from low SES groups, suggesting a positive equity impact. Our findings affirm the need for countries to implement or enhance GWLs, in line with the WHO Framework Convention on Tobacco Control (FCTC).

Implications: The evidence on the potential health equity benefit of GWL policies is mixed. To further understand the influence of GWL policies on tobacco use disparities, more systematic research using pre/post-policy designs with control groups is needed. Using a CITS model, we aimed to strengthen the available evidence on the causal influence of this tobacco control approach. Our findings show that the 2012 GWL policy change had a greater impact on adults who smoked from low SES groups than it did on adults who smoked from high SES groups, indicating a potentially positive equity impact and confirming the need for countries to implement or maximize the size of GWLs, as recommended by the WHO FCTC.

Introduction

Graphic warning labels (GWLs) on cigarette packages are an effective policy that over 120 countries have implemented to inform the public of the health risks of smoking.[1,2] In 2000, Canada became the first country to include colored GWLs on cigarette packages.[1] All cigarette packages were mandated to include one of 16 exterior warnings covering 50% of the front and back, while also including messages inside of the packs with tips and encouragement to quit.[3] Compared to text-only cigarette pack warnings, policy implementation was associated with lower smoking prevalence,[4,5] increased knowledge of displayed health information, and stronger cognitive and behavioral responses to warnings, such as more frequent thinking about tobacco-related risks and higher intentions to quit.[4–7] However, from 2000 to 2009, GWL effectiveness gradually declined, with significant decreases in label warning salience and related cognitive and behavioral responses.[8]

In 2011, the Canadian Tobacco Products Labeling Regulations (Cigarettes and Little Cigars) replaced the 2000 GWL regulations with stronger requirements.[3] These requirements included a new set of 16 exterior GWLs covering 75% of the front and back of packs (up from 50% in 2000), eight interior pictorial messages (vs. text interior messages in 2000), additional information on the risks of the cigarette smoke toxic constituents on the side panel, and, for the first time, a toll-free quitline number.[3] The policy went into effect in 2012.[9] Observational studies (without a control country) examining the impact of the 2012 Canadian

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revisions among adults who smoke found an increased proportion that looked at or read the GWLs, increased risk perception, increased ad recall, increased call volume to the quitline number, and increased quit intentions and quit attempts.[10–12]

The cognitive and behavioral responses related to the 2012 change to the GWL policies are similar to those found in other countries. Substantial evidence from multiple countries with GWL policy revisions shows that large GWLs are more effective than text-only warnings across many tobacco-related outcomes.[13–15] Experimental and observational studies (with and without control groups) have found that strengthened GWLs, which include improved text warnings, changing from text to pictorial warnings, and improved pictorial warnings, or including quitline numbers on cigarette packages are associated with increased attention and recall of warnings, warning avoidance, knowledge of health effects, increase in risk beliefs, and increased quit intentions.[15,16]

Though studies have established the benefits of strengthening GWLs on improving tobacco-related outcomes, the evidence on the impact of GWLs across sex and socioeconomic (SES) groups is mixed.[14,17–24] Several experimental and observational studies (with and without control groups) observed that females were more likely to notice GWLs, think about the risks of smoking, think about quitting, and rate GWLs as more effective compared to males.[17,25] Other studies found no differences in rating GWL's effectiveness or quit intentions by sex[18,26]; while another cross-sectional survey observed men were more likely to think about quitting after viewing GWLs compared to women.[27] Similarly, some studies indicate that larger GWLs are more effective for individuals from lower SES than higher SES,[14,20,28] while others show no association between SES and GWL effectiveness ratings or salience.[14,17,20,22,23] Two studies have found greater GWL effectiveness among individuals from relatively high-income groups who smoke.[21,28] However, a systematic review showed that only six of 32 observational studies used quasi-experimental methods with control or intervention countries.[15,16,29–31] The use of quasi-experimental methods allows researchers to make stronger inferences about the causal impact of policies because of improved control for unmeasured confounders.[32] More systematic research using pre/post-policy designs with control groups is needed, especially given the mixed results around the potential health equity impact of GWL policies. Despite the mixed results from studies on the effect of strengthened GWLs, the evidence mostly points to a positive health equity effect overall.[15,16]

Our quasi-experimental study aimed to assess the differential effectiveness of the 2012 enhancement to the Canadian GWL policy on cognitive and behavioral responses. Specifically, we examined pre/post-policy survey data from adults who smoke in Canada and the United States (control), which had the same text-only warnings over the observation period. Considering the evidence that suggests the effectiveness of strengthened GWLs among individuals from lower SES groups, we hypothesized that the 2012 Canadian GWL policy changes would be associated with higher values for the label impact index (LII) and greater quit intentions, with stronger results among individuals from lower SES groups, when compared to the United States text-only warnings.

Methods

Data source

Data were analyzed from waves 1–9 (2002–2015) of the International Tobacco Control Four Country (ITC 4C) Surveys and waves 1–3 (2016–2020) of the International Tobacco Control Four Country Smoking and Vaping (ITC 4CV) Surveys in Canada and the United States. The ITC surveys are longitudinal cohort studies that began in 2002, with follow-up surveys replenishing respondents lost to attrition. Data collection included telephone surveys till 4C6 (2007–2008) and moved to an online survey in stages starting from 4C7 (2008–2009). Full details of the ITC 4C and ITC 4CV Surveys sampling design can be found elsewhere.[33,34] Our data included adults aged 18 years and older who smoked more than 100 cigarettes in their lifetime and smoked at least once in the past 30 days.

Measures

Primary Outcomes

The *LII* is a composite measure of warning label salience, cognitive reactions, and behavioral reactions used in previous research.[35,36] *Warning label salience* was measured by a question about NOTICING (dichotomized as often/very often vs. never or once in a while): "In the last month, how often, if at all, have you noticed warnings on cigarette packages?" *Cognitive reactions* were measured by two questions: (1) THOUGHTS ON HEALTH RISKS: "To what extent, if at all, do the warning labels on cigarette packages make you think about the health risks of smoking?" and (2) THOUGHTS ON QUITTING (dichotomized as a lot vs. not at all/a little): "To what extent, if at all, do the warning labels make you more likely to quit smoking?" *Behavioral reactions* were measured by a question about FORGOING (dichotomized as once in a while/ many times vs. never): "In the last month, have the warning labels stopped you from having a cigarette when you were about to smoke one?" As in previous research,[35,36] the index was created by standardizing the measures and then weighting and summing the standardized scores as follows: LII = (NOTICING*1) + (THOUGHTS ON HEALTH RISKS*2) + (THOUGHTS ON QUITTING*2) + (FORGOING*3). The LII was coded as a continuous measure, with higher scores indicating a greater impact.

Intention to quit smoking was assessed by asking respondents, "Do you plan to quit smoking?" Respondents who selected "in the next month," "in the next 6 months," or "sometime in the future after 6 months" were defined as 1 = having an intention to quit, and those who responded "not at all/ don't know" were defined as 0 = having no intention to quit.

Policy Exposure Variable

The policy exposure measure was an interaction of two variables: (1) a *country* variable, and (2) a *pre/post*-policy variable. The *country* variable was an indicator with a value of 1 for individuals living in the treatment country, Canada (1), and 0 for those living in the control country, United States (0). The *pre/post policy* variable was created to indicate the period before (0 = before March 2012) and after (1 = March 2012 and after) the GWL policy change. Based on these definitions, the policy exposure variable was a value of 0 for all individuals living in both countries, Canada (1*0) and the United States (0*0) before the GWL policy change,

and a value of 1 for individuals living in Canada (1*1) after the policy change, while the United States remained 0 (0*1).

Third-Difference Variables

Sex (male/ female), *education* (low = high school degree or less; medium = some college degree/tech/trade school/community college or some university; and high = 4-year college degree or more/completed university or postgraduate; and not stated), and *annual household income* (low = less than $30 000; medium = $30 000– 59 999; high = $60 000 or greater; and not stated).

Control Variables

In addition to sex, education, and income, we included *age group* (18–24, 25–39, 40–54, and ≥55 years) and ethnicity (white/ nonwhite) as sociodemographic variables. We controlled for the respondents' smoking status (daily/ non-daily) and the use of vaping products (currently vaping/ not currently vaping). We included quit intentions as a control variable in the LII model. We included a time variable representing the survey waves and a time-in-sample variable representing the number of times respondents had been surveyed (1 = first time, 2 = second time, 3 = third time, and 4 = more than 3 times). Time-in-sample was included as a categorical variable given that repeated participation in a survey may affect responses. Previous research has shown that the number of times a respondent participated in the survey was statistically associated with the LII; this may be because of familiarity with the topic and content through repeated survey participation that could affect the psychological processing of labels and questions about labels and consequent behavioral changes.[33,35] We also controlled for the survey mode (internet vs. telephone survey).

Finally, we included an annual *cigarette price per daily dose* variable for both countries, representing daily expenditures on cigarettes, derived as the product of *cigarette per day* (a variable from participant responses in the ITC survey) and *price per cigarette*. For the price per cigarette, we used the self-reported prices for the respondent's last purchase for a cigarette carton, pack, or loose cigarettes in their last purchase. Canadian dollars were converted to U.S. dollars based on the corresponding year, converted to price per cigarette, and adjusted for inflation (indexed to 1 in November 2002).[37] Cigarette prices are a key tobacco control policy that influences smoking rates, hence the need to control them.[38] We used the natural log transformation for the time trend and cigarette price variables to help improve linearity.[39]

Statistical Analysis

We calculated the unweighted sample distribution by the country for information on the wave of recruitment, time-in-sample, sociodemographic characteristics at the time of recruitment, and smoking status at the time of recruitment. We estimated the weighted and unadjusted LII mean scores and quit intentions prevalence by wave, overall, and by sex, education, and income.

For the main models, we employed a quasi-experimental method comparing Canada as the treatment group with the United States as the control group. Specifically, we used a two-way interaction controlled interrupted time series (CITS) model to assess the effectiveness of the 2012 Canadian health warning label regulations, and a three-way interaction model to estimate differences in the effects of the policy among sex, education, and income groups. The CITS model serves as an extension of difference-in-difference and difference-in-difference-in-difference models. It compares pre- and post-policy mean differences among groups (and sub-groups) allowing for a different time trend within each group or sub-group.[40] The CITS model is specified as:

Model 1

$$\text{Logit(outcome =1)/outcome} = \beta o + \beta_1 \text{Country} + \beta_2 \text{Prepostpolicy} + \beta_3 \text{Country} * \text{Prepostpolicy} + \beta_4 \text{Agegroups} + \beta_5 \text{Sex} + \beta_6 \text{Income} + \beta_7 \text{Education} + \beta_8 \text{Surveymode} + \beta_9 \text{Smkstatus} + \beta_{10} \text{TIS} + \beta_{11} \text{Quitintentions} + \beta_{12} \text{Ethnicity} + \beta_{13} \text{Vaping} + \beta_{14} \ln(\text{Price}) + \beta_{15} \ln(\text{Price}) * \text{Country} + \beta_{16} \text{Wave} + \beta_{17} \text{Wave} * \text{Country}.$$

Linear regression models were used for LII while logistic regression models were used for quit intentions. C*ountry* is the indicator variable for the exposure (the United States) and the treatment (Canada) groups. *Prepostpolicy* is the pre/ post-policy variable indicating the period before and after the GWL policy change implementation. For the LII variable, the survey questions specifically asked about warning labels. Hence, we did not control for all potential confounders, specifically *price per dose* and *vaping status* as these two variables were considered irrelevant to affecting cognitive or behavioral responses to cigarette warning labels. However, we controlled for use in the model as price and vaping status may affect cigarette use.

This CITS model assumed that the impact of cigarette prices on the outcomes and time trends are linear but different between countries. After controlling for these non-parallel trends and other potential confounders, policy impacts are measured by the Prepostpolicy variable and the interaction of Country and Prepostpolicy. For the control group (the United States, Country = 0), the change between the pre-and post-policy periods is β_2. For the treatment group with the GWL policy implementation (Canada, Country = 1), the pre-and post-policy change is $\beta_2 + \beta_3$. The difference in policy impact between the two countries, therefore, is directly measured by β_3.

Model 2 (Differential Impact on Sex)

$$\text{Logit(outcome = 1)/outcome} = \beta o + \beta_1 \text{Country} + \beta_2 \text{Prepostpolicy} + \beta_3 \text{Country} * \text{Prepostpolicy} + \beta_4 \text{Agegroups} + \beta_5 \text{Sex} + \beta_6 \text{Income} + \beta_7 \text{Education} + \beta_8 \text{Surveymode} + \beta_9 \text{Smkstatus} + \beta_{10} \text{TIS} + \beta_{11} \text{Quitintentions} + \beta_{12} \text{Ethnicity} + \beta_{13} \ln(\text{PricePerDose}) + \beta_{14} \ln(\text{PricePerDose}) * \text{Country} + \beta_{15} \text{Wave} + \beta_{16} \text{Wave} * \text{Country} + \beta_{17} \text{Country} * \text{Sex} + \beta_{18} \text{Prepostpolicy} * \text{Sex} + \beta_{19} \text{Country} * \text{Prepostpolicy} * \text{Sex}.$$

where all the variables are defined the same as in model 1 with additions of the interaction terms of *sex* with *country, Prepostpolicy,* and *country* Prepostpolicy*. Model 2 was repeated for education (model 3) and income (model 4) with *Sex* replaced by *Education* and *Income* in the interaction terms, respectively. Given the very small sample size in the "not stated" responses for *Education* and its relative irrelevance in comparing different educational levels, the "not stated" observations are removed from model 2 for education.

For the analyses, we used longitudinal generalized estimating equations (GEE) models with robust standard errors, using linear regression for the LII outcome and logistic regression for the quit intentions outcome. We pooled all wave data for both countries to recode control variables that differed between countries e.g. education and ensure

that prevalence estimates were comparable at the same levels as the control variables. To address in-person correlations because of repeated measures over waves, we rescaled the cross-sectional weights to fit the GEE models. To rescale, we: (1) applied the cross-sectional weights at recruitment to each respondent for all the waves included in our study to ensure individual-level comparability of the between-wave data for recontacted samples, and (2) rescaled the sum of the weights to match the sample size at the recruitment wave to ensure comparability between cohorts. These weight adjustments allow us to compare prevalence estimates over time appropriately. All the analyses were conducted using SAS-Callable SUDAAN (V.11). The predicted marginal standardization method in the SUDAAN GEE model (PREDMARG) was used to estimate prevalence.[41] The linear regression results are presented as adjusted beta coefficients (aβ) while the logistic regression results are presented as adjusted odds ratios (aOR), with all confidence intervals (CIs) and statistical significance testing at the 95% confidence level.

Results

Descriptive Statistics

Table 1 presents the unweighted characteristics of the sample population at recruitment for each wave. More than half of the respondents were female, about 40% were in the low-education group, and about a third of the population was in the low-income group in both Canada and the United States. Approximately 20% of the participants were young adults (aged 18 to 24 years old), while more than 80% smoked daily in both Canada and the United States.

LII Mean Scores and Quit Intentions Prevalence

The weighted and unadjusted estimates of LII mean scores and quit intentions prevalence are reported by the wave in the Appendix, overall as well as by sex, education, and income (Appendices A and B). The overall LII mean scores ranged from −0.2 (in 4C8) to 1.3 (in 4C2) in Canada and −1.6 (in 4C9) to −0.7 (in 4C2) in the United States (Appendices A and C). Quit intentions prevalence ranged from 76.1% (in 4C7) to 84.2% (in 4CV1) in Canada and from 71.4% (in 4C3 and 4C7) to 77.4% (in 4C8) in the United States (Appendices B and D). The LII mean scores and quit intentions varied across waves; however, both outcomes increased in Canada and decreased in the United States from wave 4C8 (before the policy implementation) to 4C9 (after the policy implementation) among most of the subpopulation groups (Appendices A to D).

Regression Models

Results from the two-way interaction and three-way interaction CITS models are reported in Table 2 (Appendix G) for the LII model and Table 3 (Appendix H) for the quit intentions model. The LII model showed a statistically significant increase in mean scores in Canada after the policy change relative to the United States compared to the difference before the policy change ($\beta = 0.84$, 95% CI 0.35 to 1.33; Table 2; Appendix G). For quit intentions, the two-way interaction model showed that Canadians had higher odds of quit intentions after the policy change (OR = 1.89, 95% CI 1.51 to 2.36) relative to the U.S. participants compared to before the policy change (Table 3; Appendix H).

The three-way interaction model showed that the LII was greater among individuals in the low-income group than those in the high-income group (Table 2; Appendices E and G). Similarly, the higher odds of quit intentions were greater in the low-educated group than in the high-educated group (Table 3; Appendices F and H). However, there were no differences in the estimates by sex or education for the LII models, nor by sex or income for the quit intentions models (Table 3; Appendix H).

Discussion

To the best of our knowledge, this is the first quasi-experimental study to examine the impact of 2012 Canada's GWL policy changes on sociodemographic disparities. Our results confirm existing evidence that shows that the 2012 policy was an effective measure associated with higher label warning salience, improved cognitive and behavioral responses, and increased quit intentions.[10–12] Our results contribute to existing evidence by showing that the positive impact of the 2012 revised GWL policy was more beneficial for individuals from lower SES groups than those from higher SES groups, as was hypothesized. We found no difference in policy impact by sex which aligns with some studies,[18,26] but is in contrast with other studies that found similar policies were more beneficial for females than males.[17,25] However, none of these studies had a pre/post-study design with a control group as ours did, and differences in study design may contribute to the comparability of our findings with previous studies.[32]

Article 11 of the WHO's Framework Convention on Tobacco Control (FCTC), the first international treaty negotiated under the auspices of WHO, calls for Parties to cover 50% or more of principal display areas of the cigarette package with GWLs, with periodic changes to counteract the effect of the graphic warning label wear-out.[9] GWLs are not only more effective than text-only warnings,[13,14] larger GWLs appear more effective than smaller GWLs.[14–16,42,43] Furthermore, other characteristics of Canada's 2012 GWL policy may help explain our results. Though our study did not decompose the 2012 CA GWL policy revisions, studies attest to the effectiveness of each intervention that was instituted through this policy change. In addition to the larger GWLs, Canada included inserts (i.e. small leaflets) inside of packs with messages about cessation benefits and tips and added a quitline number to the cigarette packages. Canada is the only country in the world whose labeling policy includes inserts, and post-implementation observational studies suggest that attention to inserts increases over time, enhances self-efficacy to quit, and promotes sustained cessation attempts.[44] Overall, our study results suggest that countries should go beyond the minimum FCTC recommendations of 50% GWL to maximize policy effectiveness. Countries with current GWLs policies are encouraged to align with the FCTC's recommendations of a 50% GWL on tobacco packages with periodic changes, and countries without GWLs or with text-only warnings should consider implementing large GWLs that include an identified cessation resource, such as a quitline, to improve cessation-related outcomes.

An added advantage of the Canadian GWL policy change appears to be its potential to reduce sociodemographic disparities in smoking. Specifically, we found in Canada relative to the United States, that favorable responses to warnings and intentions to quit increased more among

Table 1. Sample Sizes and Sample Characteristics at Recruitment: ITC Four Country Survey Wave 1 (2002) – Wave 9 (2012–2015) and the ITC Four Country Smoking and Vaping Survey Wave V1 (2016) to Wave V3 (2020)

	Canada		United States	
Sample size (recruited/ recontacted)	*N* (11 518)	%	*N* (12 020)	%
*4C1 (2002)	2189 / 0		2102 / 0	
4C2 (2003)	513 / 1490		676 / 1220	
4C3 (2004)	541 / 1348		879 / 1045	
4C4 (2005-06)	514 / 1260		730 / 1062	
4C5 (2006-07)	582 / 1159		729 / 1061	
4C6 (2007-08)	539 / 1169		698 / 1046	
4C7 (2008-09)	324 / 1186		391 / 1127	
4C8 (2010-11)	202 / 1041		367 / 895	
4C9 (2013-15)	459 / 750		1996 / 768	
4CV1 (2016)	2388 / 432		1242 / 955	
4CV2 (2018)	1522 / 1300		1252 / 814	
4CV3 (2020)	1745 / 1098		958 / 859	
Sex				
Female	6052	52.5	6370	53.0
Male	5466	47.5	5650	47.0
Age group				
18–24	2419	21.0	2241	18.6
25–39	3218	27.9	2888	24.0
40–54	3523	30.6	3490	29.0
55-max	2358	20.5	3401	28.3
Ethnicity				
White (CA & US)	9512	82.6	9133	76.0
Nonwhite (CA & US)	1903	16.5	2861	23.8
Don't know	103	0.9	26	0.2
Income				
Low (high school degree or less)	3580	31.1	4424	36.8
Medium (some college degree/ tech/trade school/community college/ some university)	3498	30.4	3667	30.5
High (4-year college degree or more/completed university or postgraduate)	3536	30.7	3431	28.5
Not Stated	904	7.9	498	4.1
Education				
Low	4465	38.8	5000	41.6
Medium	4566	39.6	4650	38.7
High	2428	21.1	2358	19.6
Not Stated	59	0.5	12	0.1
Smoking status				
daily	9581	83.2	10 440	86.9
non-daily	1937	16.8	1580	13.1

*4C represents the Four Country Survey while the number represents the wave, so 4C1 = Four Country Survey wave 1.
4CV represents the Four Country Smoking and Vaping Survey while the number represents the wave, so 4CV1 = Four Country Smoking and Vaping Survey wave 1.

individuals from lower SES groups compared to higher SES groups. These findings align with existing evidence that shows that GWLs are more impactful among low SES populations.[14] Individuals from lower SES groups are more likely than those from higher SES groups to think about stopping smoking or think of tobacco's health risks after seeing GWLs.[14,20] Studies conducted solely within lower SES groups also confirm that GWLs are more effective at improving quit intentions, label avoidance, or remembering label warning indicators than text-only warnings.[45] These findings are critical considering that lower SES groups smoke more than higher SES groups, and subsequently bear the health burden of tobacco use. However, though GWLs may lead to positive cognitive and behavioral outcomes

Table 2. Controlled Interrupted Time Series Models Examining Impact of the Canadian 2012 GWL Policy on Label Impact Index by Sex, Education, and Income. International Tobacco Control Survey 2002–2020

Variable	Beta coefficient (95% CI)			
	Main model (model 1)	Sex interaction (model 2)	Education interaction (model 3)	Income interaction (model 4)
GWL policy * country		0.61 (0.02 to 1.19)		
Canada after March 2012	**0.84(0.35 to 1.33)**	2.94 (2.49 to 3.39)	0.62(–0.03 to 1.26)	1.09 (0.42 to 1.77)
Canada (vs. USA)	2.83 (2.45 to 3.22)	0.42 (–0.05 to 0.87)	2.66 (2.2 to 3.11)	2.48 (1.98 to 2.98)
GWL policy—after March 2012	0.27 (–0.12 to 0.66)	0.47 (0.17 to 0.77)	0.16 (–0.36 to 0.66)	–0.15 (–0.66 to 0.38)
Sex (ref: male)	0.35 (0.18 to 0.53)		0.36 (0.19 to 0.54)	0.35 (0.18 to 0.53)
Education (vs. completed university or postgraduate)			0.34 (–0.10 to 0.58)	
High school or less	0.34 (0.10 to 0.58)	–0.19 (–0.42 to 0.03)	1.09 (0.80 to 1.59)	0.34 (0.10 to 0.58)
Some college/trade/technical school	–0.19 (–0.42--0.03)	1.69 (–0.52 to 3.90)	0.48 (0.10 to 0.85)	–0.19 (–0.41 to 0.03)
Not stated	1.70 (–0.51 to 3.91)			1.70 (–0.53 to 3.92)
Income (vs. High)		0.88 (0.67 to 1.09)		
Low	0.88 (0.67 to 1.09)	0.37 (0.19 to 0.56)	0.86 (0.66 to 1.07)	1.56 (1.21 to 1.91)
Medium	0.37 (0.19 to 0.56)	0.36 (0.02 to 0.70)	0.37 (0.18 to 0.55)	0.71 (0.39 to 1.03)
Not Stated	0.37 (0.02 to 0.71)		0.36 (0.01 to 0.70)	0.80 (0.21 to 1.38)
Sex interaction				
GWL policy * sex (female, after March 2012 policy)		–0.30 (–0.76 to 0.17)		
Country * sex (Canada, female)		–0.22 (–0.65 to 0.23)		
GWL policy * country * female (Canada, female, after March 2012 policy)		0.50 (–0.13 to 1.12)		
Education interaction				
GWL policy * education				
High school or less, after March 2012			–0.59 (–1.17 to 0.02)	
Some college/trade/technical school, after March 2012			–0.57 (–1.11 to 0.03)	
Country * education				
CA, high school or less			–0.76 (–1.34 to 0.19)	
CA, some college/trade/technical school			–0.50 (–1.07 to 0.07)	
GWL policy *country * education				
Canada, high school or less after March 2012			–0.52 (–1.33 to 0.28)	
Canada, Some college/trade/technical school, after March 2012			–0.24 (–1.01 to 0.54)	
Income interaction				
GWL policy * income				
Low, after March 2012				–1.02 (–1.57 to 0.47)
Medium, after March 2012				–0.59 (–1.09 to 0.09)
Not stated, after March 2012				–1.21 (–2.56 to 0.15)
Country * income				
CA, low				–0.80 (–1.32 to 0.29)
CA, medium				–0.42 (–0.87 to 0.04)
CA, not stated				–0.49 (–1.29 to 0.31)
GWL policy *country * income				
Canada, low, after March 2012				**0.80 (0.05 to 1.54)**
Canada, medium, after March 2012				0.65 (–0.05 to 1.35)
Canada, not stated, after March 2012				1.17 (–0.41 to 2.74)

All models controlled for age group, ethnicity, survey mode, smoking status, e-cigarette use, time-in-sample, wave, price per dose, country and wave interaction, and country and price per dose interaction. Full models are included in the Appendices.

among people from lower SES groups who smoke, those differences may not translate into reductions in disparities in smoking prevalence.[46] For example, even though the 2000 Canadian GWL policy was associated with reduced smoking prevalence, it had no impact on reducing disparities by SES.[4,5] Therefore, it is vital to develop policy and programmatic interventions that take advantage of the potential positive health equity impact generated by GWL policy enhancements and translate this potential into successful cessation.

Table 3. Controlled Interrupted Time Series Models Examining Impact of the Canadian 2012 GWL Policy on Quit Intention by Sex, Education, and Income. International Tobacco Control Survey 2002–2020

Variable	Odds ratio (95% CI)			
	Main model (model 1)	Sex interaction (model 2)	Education interaction (model 3)	Income interaction (model 4)
GWL policy * country				
Canada after March 2012	1.89 (1.51 to 2.36)	1.98 (1.52 to 2.57)	2.10 (1.57 to 2.82)	2.04 (1.52 to 2.73)
Canada (vs. USA)	1.72 (1.47 to 2.02)	1.78 (1.47 to 2.14)	1.67 (1.39 to 2.00)	1.59 (1.31 to 1.93)
GWL policy—after March 2012	0.63 (0.53 to 0.75)	0.55 (0.45 to 0.67)	0.62 (0.50 to 0.76)	0.61 (0.49 to 0.76)
Sex (ref: Male)	1.18 (1.09 to 1.27)	1.12 (1.00 to 1.26)	1.18 (1.09 to 1.27)	1.18 (1.09 to 1.27)
Education (vs. completed university or postgraduate)				
High school or less	0.85 (0.77 to 0.95)	0.85 (0.76 to 0.94)	0.83 (0.70 to 0.98)	0.85 (0.77 to 0.95)
Some college/trade/technical school	1.07 (0.97 to 1.19)	1.07 (0.97 to 1.18)	1.01 (0.86 to 1.20)	1.07 (0.97 to 1.19)
Not stated	0.84 (0.46 to 1.52)	0.82 (0.45 to 1.49)		0.83 (0.46 to 1.52)
Income (vs. High)				
Low	0.78 (0.71 to 0.86)	0.78 (0.71 to 0.86)	0.78 (0.71 to 0.86)	0.84 (0.73 to 0.98)
Medium	0.88 (0.81 to 0.96)	0.88 (0.81 to 0.96)	0.88 (0.81 to 0.97)	0.94 (0.81 to 1.08)
Not Stated	0.68 (0.59 to 0.79)	0.68 (0.59 to 0.79)	0.68 (0.59 to 0.79)	0.67 (0.54 to 0.83)
Sex interaction				
GWL policy * sex (Female, after March 2012 policy)		1.32 (1.08 to 1.60)		
Country * sex (Canada, female)		0.94 (0.79 to 1.11)		
GWL policy * country * female (Canada, female, after March 2012 policy)		0.90 (0.68 to 1.19)		
Education interaction				
GWL policy * education				
High school or less, after March 2012			0.91 (0.70 to 1.19)	
Some college/trade/technical school, after March 2012			0.90 (0.69 to 1.17)	
Country * education				
CA, high school or less			0.93 (0.73 to 1.19)	
CA, some college/trade/technical school			1.02 (0.79 to 1.31)	
GWL policy *country * education				
Canada, high school or less after March 2012			**1.54 (1.05 to 2.25)**	
Canada, some college/trade/technical school, after March 2012			1.44 (0.99 to 2.08)	
Income interaction				
GWL policy * income				
Low, after March 2012				0.93 (0.73 to 1.19)
Medium, after March 2012				0.90 (0.71 to 1.14)
Not stated, after March 2012				1.30 (0.71 to 2.38)
Country * income				
CA, low				0.84 (0.68 to 1.05)
CA, medium				0.92 (0.75 to 1.13)
CA, not stated				1.03 (0.76 to 1.40)
GWL policy *country * income				
Canada, low, after March 2012				1.15 (0.82 to 1.62)
Canada, medium, after March 2012				1.13 (0.81 to 1.59)
Canada, not stated, after March 2012				0.74 (0.36 to 1.52)

All models controlled for age group, ethnicity, survey mode, smoking status, e-cigarette use, time-in-sample, wave, price per dose, country and wave interaction, and country and price per dose interaction. Full models are included in the Appendices.

Our study has several strengths and limitations. First, our use of a quasi-experimental study design with a control group allows us to make stronger inferences about the real-world effect of the GWL policy change comparing two countries.[32] Second, our analyses excluded young adults, 18–24 years old, to allow for completion of maximum educational attainment for most respondents which is a strength; however, young adults constitute a large proportion of adults who smoke,[47] and our results do not assess the overall impact of the policy for this age group, including differences by sociodemographic

factors. Third, given that ITC surveys are open cohorts, there is a potential impact on responses for individuals who participated in more than one wave, which may alter the prevalence estimates. Nevertheless, our study controlled for time-in-sample and within-individual correlations to minimize this type of bias. Then, our study did not examine the impact of the GWL policy on quit success, which is an important outcome to consider in parallel to quit attempts. Future research should consider assessing the impact of GWL revisions on quit success as such studies would add more context to our findings. Next, we did not assess the impact of specific types of GWL messages or designs. Research has shown that disgust-related images may be more impactful than anxiety-based GWLs for public health cessation efforts.[48] Also, the potential synergies between the multiple policy interventions reduce the external generalizability of our findings. Future studies should consider differentiating the impact of the varied package designs as well as the individual policy effects, possibly through self-reported responses,[49] as such studies could help develop more effective GWLs. Finally, our combination of salience, and cognitive and behavioral outcomes into an index limit the possibility of applying our findings to cognitive or behavioral-specific outcomes. However, the use of a tobacco measure index is becoming increasingly popular making our findings comparable to the others.[30,35,36]

Conclusion

The 2012 policy to enhance Canadian GWL size and refresh their content led to a significantly greater impact in noticing warning labels, thinking about quitting, thinking about the risks of smoking, forgoing a cigarette, and greater quit intentions among adults who smoke when compared to the United States, which did not implement a GWL policy during the study period. Importantly, the 2012 policy change impact was greater among adults who smoked from low-income and low-education groups than in high-income and high-education groups, yielding a potentially positive equity impact. Together, these findings affirm and strengthen the need for countries to implement or maximize the size of GWLs, in line with the WHO FCTC.

Supplementary Material

A Contributorship Form detailing each author's specific involvement with this content, as well as any supplementary data, are available online at https://academic.oup.com/ntr.

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Declarations of Interest

GTF and JFT have served as expert witnesses or consultants for governments defending their country's policies or regulations in litigation. GTF served as a paid expert consultant to the Ministry of Health of Singapore in reviewing the evidence on plain/standardized packaging. All other authors have no conflicts of interest to declare.

Ethics

The survey protocols and all materials, including the survey questionnaires for the ITC Four Country Surveys (ORE#10556, ORE#13978, ORE#17469) were cleared for ethics by Office of Research Ethics, University of Waterloo, Canada and IRB NT 02-20 by the Office of Research Subject Protection, Roswell Park Comprehensive Cancer Center, US. The survey protocols and all materials, including the survey questionnaires for the ITC Four Country Smoking and Vaping Surveys (ORE#20803/30878) were cleared for ethics by Office of Research Ethics, University of Waterloo, Canada and Medical University of South Carolina (waived because of minimal risk). All participants provided consent to participate.

Data Availability

In each country participating in the international Tobacco Control Policy Evaluation (ITC) Project, the data are jointly owned by the lead researcher(s) in that country and the ITC Project at the University of Waterloo. Data from the ITC Project are available to approved researchers 2 years after the date of issuance of cleaned data sets by the ITC Data Management Center. Researchers interested in using ITC data are required to apply for approval by submitting an International Tobacco Control Data Repository (ITCDR) request application and subsequently to sign an ITCDR Data Usage Agreement. The criteria for data usage approval and the contents of the Data Usage Agreement are described online (http://www.itcproject.org). The authors of this paper obtained the data following this application process. They did not have any special access privileges. Others would be able to access these data in the same manner as the authors.

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