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Evaluating Canada's innovative policy for health warnings on cigarette sticks: A pre/post assessment among adults who smoke

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ABSTRACT

Objective: Evaluate Canada's innovative policy mandating warning messages on cigarette sticks.
Methods: We analyzed data from an open cohort of Canadian adults who smoke, surveyed every 3 months (February 2023–November 2024; n = 11,487 observations from 4716 individuals). Participants reported: liking the look of their cigarette sticks (1-Dislike a lot to 7-Like a lot); feelings when looking at sticks (1-Very bad to 7-Very good); frequency of thinking about smoking-related harms due to sticks (1-Not at all to 5-Extremely); and forgoing cigarettes they normally smoke due to the look of sticks (no vs. yes). Linear and logistic generalized estimating equations regressed these outcomes on implementation period (i.e., pre-policy 2023 surveys [ref.] vs post-policy 2024 surveys), adjusting for covariates and post-stratification weights. Analyzing participants followed to the next survey (n = 6959 observations, 2356 individuals), separate adjusted mixed-effects logistic models regressed quit attempts in the 3-month interval since the prior survey on each stick measure from the prior survey (coded: neutral [ref.], dislike, like; neutral [ref.], bad, good; no forgoing [ref.], forwent cigarettes).
Results: From pre- to post-policy periods, liking and feelings about sticks became more negative (B = -0.15, 95 % CI = -0.22, −0.08; B = -0.07, 95 %CI = -0.13, −0.01) and forgoing cigarettes increased (AOR = 1.18, 95 %CI = 1.06, 1.32). Those who felt bad (vs. neutral) when looking at sticks were more likely to try to quit by the next survey (AOR = 1.31, 95 %CI = 1.05, 1.62), as were those who forwent cigarettes (AOR = 1.73, 95 %CI = 1.40, 2.15).
Conclusions: Countries should consider expanding cigarette labeling to include on-cigarette warnings, which appear to have increased outcomes that predict quit attempts in Canada.

1. Introduction

Tobacco use continues to be the leading cause of preventable death and disease worldwide (World Health Organization, 2023). Most countries require health warnings on cigarette packs to communicate smoking-related harms (Society CC, 2023). These warnings can increase knowledge of smoking-related risks, discourage smoking uptake, and promote smoking cessation (Hammond, 2011). Warnings on packs, however, are not necessarily visible at the point of consumption. Health warnings printed on individual cigarette sticks could extend health message exposure to the smoking experience (Moodie, 2018). In 2024, Canada became the first country to implement an on-cigarette warning policy. No study has evaluated this policy under natural conditions of exposure.

Several qualitative studies–all in countries with prominent pictorial warnings on cigarette packs–have explored perceptions of on-cigarette warnings. Qualitative studies with adolescents in Scotland (Mitchell et al., 2020) and young people (aged 15–25) in France (Gallopel-Morvan et al., 2019) found that participants believed that on-cigarette warnings would deter smoking uptake and continued use among young people.

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Similarly, focus groups found that Scottish adults who smoke believed that the on-cigarette warning 'Smoking kills' would continuously remind them smoking-related health risks and may make them hesitant to smoke these cigarettes in public (Moodie et al., 2015; Moodie et al., 2020). Some (mostly younger) participants also expected on-cigarette warnings would encourage them to stub out cigarettes early, cut back on smoking, or quit entirely (Moodie et al., 2020). Similar expectations around reduced smoking frequency were found among young adults in Australia who smoke (Drovandi et al., 2019).

Several quantitative studies with adults who smoke also have explored on-cigarette warnings. One study involved two between-subject experiments with Scottish and Greek adults who smoke, finding increases in quit intentions after viewing a cigarette stick with a warning compared to a control cigarette or not viewing any cigarette (Hassan and Shiu, 2015). Another within-subject experiment in New Zealand tested a variety of pack (warning message; warning size; brand salience) and stick characteristics (warning message; stick paper color). Participants were less likely to indicate willingness to try a pack of cigarettes when it contained a cigarette stick warning (Hoek et al., 2016). Finally, in a cross-sectional survey in Australia, adults who smoke rated on-cigarette warnings as more effective than on-pack warnings for increasing their quit intentions (Drovandi et al., 2023). Overall, formative quantitative and qualitative studies consistently suggest that on-cigarette warnings are a promising policy option to extend health messaging (Al-Zalabani et al., 2023).

Pathways of impact for health warnings on cigarette sticks are likely similar to those for health warnings on cigarette packs. Warnings on cigarette packs may influence behavior through various psychosocial mechanisms, including by increasing attention to warnings, generating negative affect and cognitive elaboration of smoking-related risks, and, for people who smoke, behavioral precursors to cessation, such as forgoing cigarettes (Thrasher et al., 2019).

1.1. Study context

Canada first implemented pictorial warnings on cigarette packs in 2000, which reduced smoking prevalence (Huang et al., 2014), though effects wore out over time, as is often observed for health messaging (Hitchman et al., 2014). In 2012, Canada increased the warning size from 50 % to 75 % of the front and back of the pack, while also updating the content of 16 rotating warning messages. In 2020, Canada implemented standardized packaging, which removed brand imagery from packages, though warnings remained unchanged from 2012. A 2020 pre-post study of Canadian adults who smoke found no change in reported cognitive responses or forgoing cigarettes due to warning labels (Gravely et al., 2023a), suggesting the need for novel warning content and alternative warning messaging strategies like on-cigarette warnings.

In early 2024, Canada began implementing new content for pack warnings–both graphic warnings on pack exteriors and efficacy messages inside of packs–with manufacturers required to print the new warnings on all newly-made packs by January 31, 2024 and, by April 30, 2024, all retail cigarette sales had to be of packs with new labels. Starting during this period, Canada also implemented warnings on all "king size" cigarettes (~84 mm vs ~70 mm "regular" size), which comprise approximately 70 % of the Canadian cigarette market (Gazette, 2023). Warnings had to be printed on all king size cigarettes manufactured after April 30, 2024, with all king size cigarettes sold including them by July 31, 2024. These cigarettes contain one of six rotating messages ("cigarettes damage your organs," "poison in every puff," "cigarettes cause leukemia," "cigarettes cause cancer," "tobacco smoke harms children," and "cigarettes cause impotence") printed in both English and French on the filter tipping paper. By April 2025, all regular size cigarettes sold are also mandated to include these messages.

The current study evaluated perceptions of and responses to cigarette sticks among Canadian adults who smoke before and after implementation of on-cigarette warnings. We also assessed the association between these responses and subsequent attempts to quit smoking. To our knowledge, this is the first study to assess the innovative Canadian cigarette policy.

2. Methods

2.1. Sample

Every three months, from February 2023 to November 2024, we surveyed an open cohort of approximately 1500 Canadian adults who smoke, yielding eight waves of data ($n = 12{,}022$ observations from 4716 individuals). Participants were recruited through Leger, an online panel provider that specializes in market research for Canada (https://leger360.com/). At initial recruitment, eligible individuals were those who indicated that they could speak English or French, were ≥ 18 years old, reported $\geq$100 lifetime cigarettes, and smoked at least once in the past month. After the first wave of data collection, we re-recruited participants from the prior survey wave, whether they continued to smoke or had quit smoking, with an average of 68.5 % (range = 62 %–72 %) of participants re-surveyed at the subsequent wave. To maintain a total sample size of approximately 1500 participants per wave, we replenished the sample by recruiting new adults who smoked. During recruitment, we set target quotas for age, educational attainment, sex, and province that reflected the general population of Canada. Study protocols were approved by the University of South Carolina Institutional Review Board (Pro00083728). Participants gave informed consent before participation.

We excluded observations from participants who had quit smoking at the time of the survey ($n = 535$ observations from 302 individuals) because they were not asked cigarette stick questions. For the trend analysis, observations were excluded when participants selected 'don't know' or 'refused' for independent variables or outcomes (i.e., liking cigarette sticks $n = 653$ or 5.7 % of observations excluded; affect $n = 502$ or 4.4 % excluded; health risk elaboration $n = 413$ or 3.6 % excluded; forgoing $n = 299$ or 2.6 % excluded). The longitudinal sample was limited to participants surveyed in at least two consecutive waves ($n = 6959$ observations from 2356 individuals), with observations with incomplete data deleted from models (liking $n = 379$ or 5.4 % excluded; affect $n = 300$ or 4.3 %; health risk elaboration $n = 253$ or 3.6 %; forgoing $n = 181$ or 3.1 %).

2.2. Measures

Measures of responses to cigarette sticks were adapted from previous pack warning label research (Noar et al., 2016; Swayampakala et al., 2018; Slovic and Peters, 2006; Borland et al., 2009), focusing on the pathways of effect for which evidence is most consistent: affect, elaboration of risks, and forgoing cigarettes. As question content needed to be comprehensible both before and after policy implementation, before our first survey, we conducted cognitive interviews with 10 Canadian adults who smoke to confirm question comprehension and determined no changes to question wording were necessary.

2.2.1. Perceptions of and responses to cigarette sticks

At each survey, questions about cigarette sticks were prefaced with this introduction: "We are interested in knowing what you think about cigarette sticks you smoke - NOT the package the cigarettes come in." Then, participants were asked, "How much, if at all, do you like the look of your cigarette sticks?" ("Dislike a lot"–"Like a lot"). We measured affect by asking, "How do you usually feel when you look at the cigarette sticks you smoke?" ("Very Bad"–"Very Good"), adapted from measurement of "risk as feelings" (Slovic and Peters, 2006). Similar to questions on pack warnings (Noar et al., 2016; Swayampakala et al., 2018; Borland et al., 2009), we queried cognitive elaboration of health risks by asking, "How much, if at all, does the look of your cigarette sticks make you think about the health risks of smoking?" ("Not at

all"–"Extremely"). Lastly, we measured forgoing cigarettes by asking, "In the last 30 days, how often, if at all, has the look of your cigarette sticks stopped you from having a cigarette when you were about to smoke?" ("Never"–"Many times"), adapted from pack warning questions (Noar et al., 2016; Swayampakala et al., 2018; Borland et al., 2009).

2.2.2. Quit attempts

For our longitudinal analysis, participants who were re-surveyed reported whether they had tried to quit in the prior 3 months (i.e., since their previous survey), after which those who answered affirmatively reported the duration of their longest quit attempt during the prior 3-month period (<1 day; ≥1 day but <7 days; ≥7 days but <1 month; ≥1 month but <3 months; ≥3 months). Those who indicated that they had tried to quit and been abstinent for at least 24 h were considered as having tried to quit.

2.2.3. Covariates

Participants reported their biological sex at birth, age (recoded to: 18–34, 35–49, 50–64, 65+), highest educational attainment (recoded to: high school or less, technical school, college or more), and race/ethnicity (recoded to: White, other). Nicotine dependence was measured using the Heaviness of Smoking Index (range = 0–6), which combines smoking frequency with time from waking to smoking the first cigarette of the day (Heatherton et al., 1989). Participants reported past month use of: roll-your-own tobacco (recoded as 0 = None; 1 = Any); e-cigarettes (recoded to: 0 = No; 1 = Yes); and other tobacco/nicotine products (recoded as 0 = None; 1 = Yes: any cigars, cigarillos, pipes, chewing tobacco, or oral nicotine products). Participants also reported their intentions to quit smoking (recoded to: 0 = intend to quit after six months, no intention, or don't know; 1 = within the next month, three months, or six months).

2.3. Analyses

Weighted and unweighted proportions and means were used to describe the two analytic samples. Weighted estimates adjusted for post-stratification weights, which were derived for each survey wave based on the sex, age, and education distribution of Canadian adults who smoke in the general population, according to the 2021 Canadian Community Health Survey (Canada, n.d.). Different weights were derived for the trend analysis sample and for the longitudinal analyses sample (i.e., limited to participants surveyed at the subsequent wave). To examine trends in the four cigarette stick outcomes and quit attempts, we used Generalized Estimating Equations (GEE) to adjust for repeated measurements from participants who answered multiple surveys, while also adjusting for covariates, survey wave, "time-in-sample" (i.e., number of prior surveys to which the participant had responded) and survey weights. For continuous outcomes (i.e., liking cigarette sticks, affect, and health risk elaboration), we modeled the original distribution of the variables using linear GEE models (liking: 1="Dislike a lot"–7="Like a lot"; feeling: 1 = "Very Bad"–7 = "Very Good"; health risk elaboration: 1="Not at all"–5 = "Extremely"); for the binary outcome (i.e., forgoing recoded as once or more vs never [reference]), we used logistic GEE models. We used post-estimation commands from

Table 1
Descriptive statistics of the samples of Canadian adults who smoke, 2023–2024.

Characteristics		Entire sample[1]		Longitudinal sample[2]	
		Unweighted %	Weighted %	Unweighted %	Weighted %
Age	18–34	25.3	23.8	18.5	23.5
	35–49	27.5	27.8	27.6	27.8
	50–64	32.5	33.1	36.1	33.4
	65+	14.8	15.3	17.8	15.4
Sex	Female	49.9	44.2	48.5	44.4
	Male	50.1	55.8	51.5	55.6
Race	White	80.2	81.8	82.1	83.5
	Other	19.8	18.2	17.9	16.5
Education	High school or less	38.1	43.9	35.4	43.7
	Technical school	39.1	39.6	40.0	39.8
	College or more	22.9	16.5	24.6	16.5
Smoking frequency	Daily	73.4	73.8	76.2	74.2
	Nondaily	26.6	26.2	23.8	25.8
Heaviness of smoking index	Mean (SE) [range = 0–6]	2.16(1.58)	2.19(1.60)	2.23(1.58)	2.20(1.59)
Quit intention	(in next 6 months)	36.9	35.7	35.0	35.1
Roll-your-own use	(any in last 30 days)	22.1	21.3	20.1	20.5
E-cigarette use	(any in last 30 days)	21.4	21.3	19.6	21.2
Other tobacco use	(any in last 30 days)	20.5	19.8	17.5	18.0
Survey wave	Feb 2023	13.1	13.1	14.3	14.3
	May 2023	12.7	12.7	13.0	13.0
	Aug 2023	12.6	12.6	14.7	14.7
	Nov 2023	12.6	12.6	14.7	14.7
	Feb 2024	12.3	12.3	13.9	13.9
	May 2024	12.3	12.3	14.7	14.7
	Aug 2024	12.2	12.2	14.7	14.7
	Nov 2024	12.3	12.3	N/A[3]	N/A[3]
Number of surveys completed	1	20.5	20.5	N/A[4]	N/A[4]
	2	13.4	13.4	11.6	11.6
	3	10.1	10.1	11.2	11.2
	4	10.0	10.0	12.4	12.4
	5	8.6	8.6	11.4	11.4
	6	8.3	8.3	11.5	11.5
	7	5.6	5.6	8.0	8.0
	8	23.5	23.5	34.1	34.1

[1] n = 11,487 observations in the table from 4716 individuals.
[2] n = 6959 observations shown in the table from 2365 individuals.
[3] Not applicable because survey wave 6 data (wave t) used to predict quit attempts at subsequent wave 7 survey (wave t + 1).
[4] Not applicable because participant had to be surveyed in at least 2 consecutive waves to be included in the analysis; those who completed only one survey were excluded from the analysis.

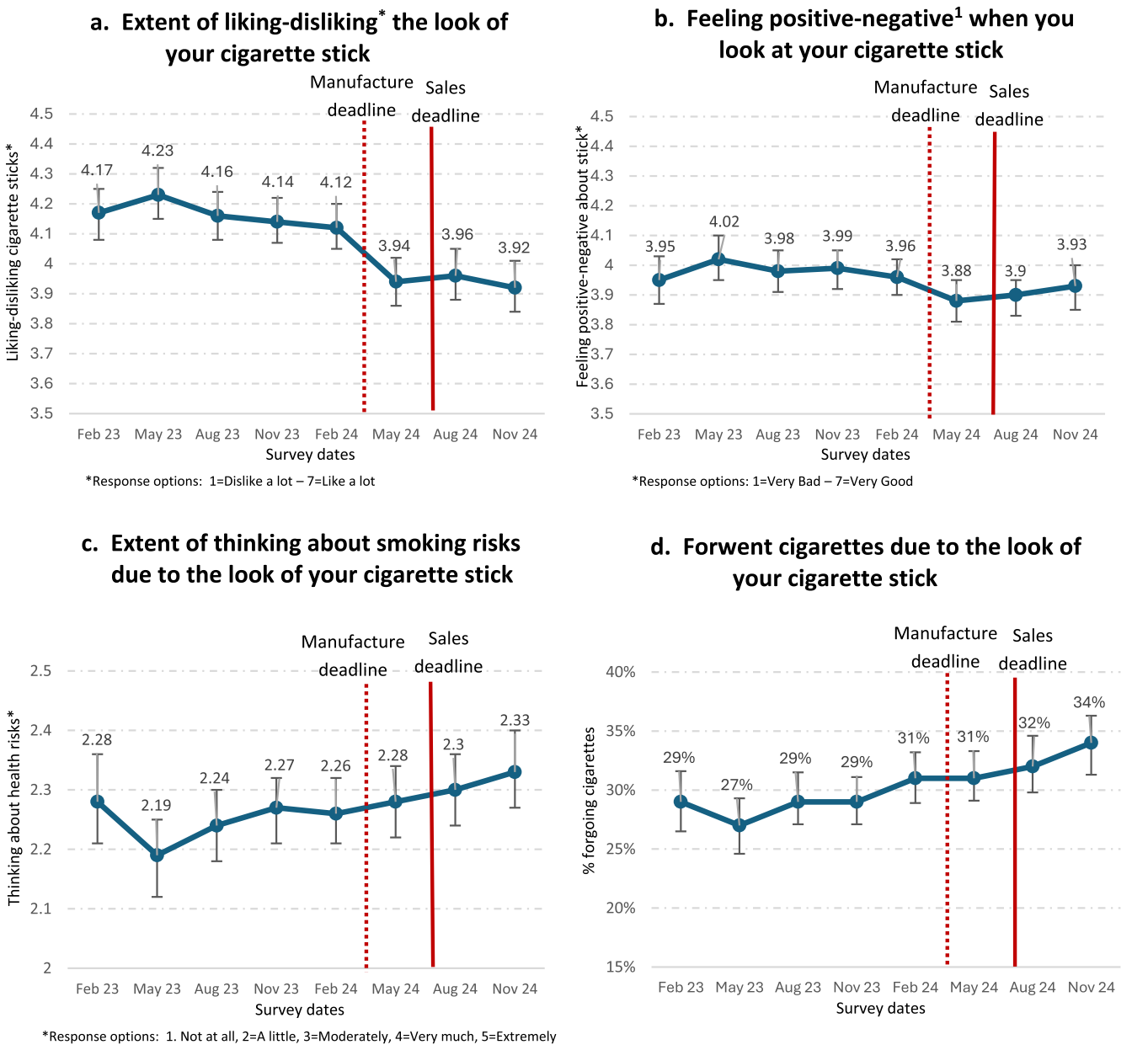

Fig. 1. a-d. Trends[1] in cigarette stick responses among Canadian adults who smoke before, during and after implementation of the dissuasive cigarette stick policy, 2023-2024.

[1]Values shown on graphics are the point estimates (along with 95% confidence interval bars) derived for each survey wave using weighted models that adjust for sex, age, education, HSI, roll your own tobacco use, other tobacco product use, e-cigarette use, quit intentions, and time in sample (i.e., number of previous surveys completed at the time of survey administration). "Manufacture deadline" was April 30, 2024, the date when all king-size cigarettes manufactured for the Canadian market were required to include warnings. "Sales deadline" was July 31, 2024, the date when all king-size cigarettes sold in Canada were required to include warnings. Cigarette stick warnings began to appear in the Canadian market in January, 2024.

each of these models to estimate means/proportions and associated 95 % confidence intervals for each survey wave, with estimates then integrated into figures. For the statistical test of change over time, we re-estimated each of these models after coding each survey wave as either pre-policy (waves 1–4) or post-policy (waves 5–8). Next, we-re-estimated these models after excluding the February 2024 survey (i.e., post-policy period = May–November 2024), which was before the manufacturer's deadline to make all king-size cigarette sticks with warnings but after they began to appear on the market.

For our longitudinal analyses, each observation included the cigarette stick response variables, covariates, and weights at one wave (time t) and quit smoking attempts by the subsequent wave (time t + 1). We used mixed-effects logistic regression models with random intercepts to adjust for multiple observations from individuals (i.e., participated in more than one pair of consecutive surveys). Separate models were estimated for each cigarette stick response variable (for ease of interpretation, liking recoded: 1–3 = Dislike, 4 = Neutral [reference], 5–7 = Like; feeling recoded: 1–3 = Negative feelings, 4 = Neutral [reference], 5–7 = Positive feelings; health risk elaboration recoded due to small sample sizes: 1 = Not at all [reference], 2 = Rarely, 3 = Sometimes, 4 = Very Much or Extremely), estimating crude associations with subsequent quit attempts, as well as adjusted associations that accounted for the covariates, time-in-sample, and weights. Finally, as sensitivity analyses, multiple imputation with chained equations was used to impute missing values for all adjusted models. Stata v16.1 was used for all analyses.

Table 2
Estimated differences between pre and post policy responses to cigarette sticks among Canadian adults who smoke, 2023–2024.

Post- vs pre-policy contrasts	Like-dislike[2] the look of your cigarette sticks		Feel bad-good[3] about cigarette sticks		How much stick makes you think about risks[4]		Forwent cigarettes because of how they look[5]	
	B	B adj[1]	B	B adj[1]	B	B adj[1]	OR	AOR[1]
	(95 % CI)	(95 % CI)	(95 % CI)	(95 % CI)	(95 % CI)	(95 % CI)	(95 % CI)	(95 % CI)
Post- (2024, including early implementation[#]) vs. pre-policy (2023)	-0.16 (−0.22, −0.11)	−0.15 (−0.22, −0.08)	−0.05 (−0.10, −0.01)	−0.07 (−0.13, −0.01)	0.04 (−0.01, 0.08)	0.03 (−0.02, 0.09)	1.20 (1.12, 1.28)	1.18 (1.06, 1.32)
Post- (2024, excluding early implementation[#]) vs. pre-policy (2023)	−0.21 (−0.27, −0.14)	−0.21 (−0.29, −0.13)	−0.06 (−0.12, −0.01)	−0.09 (−0.16, −0.02)	0.05 (0.00, 0.09)	0.05 (−0.01, 0.11)	1.20 (1.12, 1.31)	1.20 (1.05, 1.36)

[1] Adjusted for sex, age, education, HSI, roll your own tobacco use, other tobacco product use, e-cigarette use, quit intentions, and time in sample (i.e., number of previous surveys completed at the time of survey administration).
[2] 1-Dislike a lot to 7-Like a lot; estimates shown are betas from linear regression with generalized estimating equations (GEE).
[3] 1- Very Bad to 7-Very Good; estimates shown are betas from linear GEE regression.
[4] 1-Not at all to 5-Extremely; estimates shown are betas from linear GEE regression.
[5] 1-Any forgoing in prior month vs 0-no forgoing; estimates shown are from logistic GEE regression.
[#] February 2024 survey.

3. Results

Table 1 shows the unweighted and weighted characteristics of each sample (i.e., for the trend and longitudinal analyses), which was approximately half male and four-fifths White ethnicity. About three-quarters of the sample smoked daily, about a third intended to quit, and a fifth had used any roll your own tobacco, e-cigarettes, or other tobacco products in the prior 30 days. Sample size was uniformly distributed across survey waves, and while participation waned over time, approximately one quarter of the entire sample (23.5 %) was surveyed at all eight waves, and a third (34.1 %) of the longitudinal sample participated in all waves. Among those who tried to quit, quit attempt duration in the total and longitudinal sample was, respectively: <1 day = 16 %/19 %; <7 days, but more than 1 day = 49 %/53 %; <30 days, but more than 7 days = 21 %/19 %; >one month = 13 %/9 %.

3.1. Responses to warnings on cigarettes over the pre- and post-policy periods

Weighted and adjusted estimates of the means/proportion for each cigarette stick outcome at each wave are shown in Fig. 1a-d. In weighted and adjusted models that included the post- vs. pre-policy contrast and controlled for covariates (see measurement) and time-in-sample (See Table 2), liking cigarettes sticks and feeling about cigarette sticks became more negative in the post-policy period compared to the pre-policy period, whether the post-policy period included the early implementation survey ($\beta_{adj} = -0.15$, 95 %CI = -0.22, −0.08; $\beta_{adj} = -0.07$, 95 %CI = -0.13, −0.01, respectively) or excluded it ($\beta = -0.21$, 95 %CI = -0.29, −0.13; $\beta_{adj} = -0.09$, 95 %CI = −0.16, −0.02, respectively). Self-reported frequency of thinking about health risks from smoking due to the look of cigarette sticks did not increase post-policy (β_{adj} = 0.03, 95 %CI = -0.02, −0.09; β_{adj} = 0.05, 95 %CI = -0.01, 0.11, respectively), and neither did quit attempts (AOR = 1.09, 95 %CI = 0.97, 1.23; AOR = 1.11, 95 %CI = 0.97, 1.27, respectively). However, forgoing cigarettes due to the look of cigarette sticks was higher in both post-policy periods compared to the pre-policy period (AOR = 1.18, 95 %CI = 1.06, 1.32; AOR = 1.20, 95 %CI = 1.05, 1.36, respectively). Results from sensitivity analyses (Supplementary Table 2b) were consistent with those presented here in terms of valence and statistical significance.

3.2. Cigarette stick responses and quit attempts by the subsequent survey

In adjusted models that included post-stratification weights and controlled for covariates (see measurement) and time-in-sample (See Table 3), disliking the appearance of cigarette sticks was unassociated with subsequent quit attempts. Participants who reported feeling negative about how their cigarette sticks looked (compared to feeling neutral) were more likely to attempt to quit smoking at follow-up (AOR = 1.31, 95 % CI = 1.05, 1.62). Similarly, participants who forwent their cigarettes due to their appearance also increased the likelihood of a quit attempt (AOR = 1.73, 95 % CI = 1.40, 2.15). Participants who thought about the health risks of smoking due to the look of their cigarette sticks were more likely to attempt to quit than those who did not, with the strongest association among those who did so most frequently ($AOR_{very\ much/extremely\ vs\ never} = 2.57$, 95 %CI = 1.90, 3.49). In all models, F-tests for the interactions between these focal independent variables and the pre- vs post-policy period indicators (with or without Feb 2024 included) were not statistically significant ($p > 0.20$). In sensitivity analyses using multiple imputation, the valence and statistical significance of the results were consistent with those presented here (Supplementary Table 3b).

Table 3
Cigarette stick responses (time t) and quit attempts at the subsequent survey (time t + 1) among Canadian adults who smoke, 2023–2024.

		%[1]	OR (95 % CI)	AOR[2] (95 %CI)
Like-dislike the look of your cigarette sticks	Neutral	31	1.00	1.00
	Like	30	0.94 (0.71, 1.24)	0.93 (0.73, 1.17)
	Dislike	34	1.38 (0.98, 1.96)	1.09 (0.82, 1.44)
Feel bad-good about cigarette sticks	Neutral	30	1.00	1.00
	Positive	29	0.93 (0.67, 1.30)	0.86 (0.65, 1.14)
	Negative	36	1.86 (1.42, 2.43)	1.31 (1.05, 1.62)
How much stick makes you think about smoking risks	Not at all	24	1.00	1.00
	A little	31	2.15 (1.57, 2.95)	1.53 (1.18, 1.98)
	Moderately	34	2.97 (2.20, 4.02)	1.56 (1.21, 2.02)
	Very much or extremely	43	6.77 (4.66, 9.82)	2.57 (1.90, 3.49)
Forwent cigarettes because of how they look	No	27	1.00	1.00
	Yes	40	3.35 (2.61, 4.30)	1.73 (1.40, 2.15)

[1] Percentages are marginal proportions of trying to quit for at least 24 h over three months of follow up from weighted, unadjusted models.
[2] Adjusted for sex, age, education, HSI, roll your own tobacco use, e-cigarette use, other tobacco product use, quit intentions, survey wave, and time in sample (i.e., number of previous surveys completed at the time of survey administration).

4. Discussion

This first study to evaluate responses to cigarette stick warnings under natural conditions of exposure found evidence of their effectiveness in generating negative affect about cigarette sticks and forgoing of cigarettes that people would normally smoke, both of which were associated with subsequent attempts to quit smoking. This pattern of responses is similar to what has been found when the content of warnings on cigarette packs is changed (Thrasher et al., 2019; Noar et al., 2016). However, we observed these patterns in the context of simultaneous implementation of novel messages for the already large, cigarette pack warnings (75 % of front and back of the pack). Hence, on-cigarette warnings may extend health messaging exposures from when viewing the pack to when selecting, smoking, and putting out the cigarette. As more than 125 countries have implemented prominent, pictorial warnings on packs (Society CC, 2023), decision makers may consider adding this messaging medium to their labeling policies. Our measures focused on perceptions of and responses to cigarette sticks to evaluate this specific medium for warning messages; however, randomized controlled field trials that systematically manipulate each medium through which warning messages could be delivered may be necessary to quantify the additional effects that on-cigarette warnings contribute.

Affective responses to cigarette sticks–whether measured as "liking" or the valence of feelings about the look of cigarette sticks–became more negative after implementation of the dissuasive cigarette policy. These results are consistent with qualitative studies where participants disliked the look of dissuasive sticks and thought they would create a less positive image of people who smoke (Moodie et al., 2015; Moodie et al., 2020). These findings are important because prior research has identified the negative affect that pack warnings generate as a critical pathway for explaining warning label effects on cessation behaviors (Hall et al., 2018; Cho et al., 2018a; Yong et al., 2014), and on-cigarettes warnings are likely to operate similarly. Indeed, the valence of feeling about cigarette sticks also predicted subsequent quit attempts; however, disliking the sticks did not. Negative feelings about cigarette sticks may be a better predictor of cessation attempts because dislike of the look of cigarette sticks after policy implementation may have also captured participants' reactance against the policy, which can mitigate – although not eliminate - warning effectiveness (Hall et al., 2017; Cho et al., 2016; Thrasher et al., 2016). Indeed, most Canadian adults who smoke do not appear to support this policy, although support has grown since its implementation (Hackworth, in press), as found for other tobacco control policies.

Cognitive elaboration of risks – measured by the extent to which the look of the cigarette stick made participants think about smoking risks – did not increase after policy implementation. Compared to pack warnings, on-cigarette warnings are less prominent, do not include graphic imagery, and involve less elaborated messages; as such, warnings on cigarettes may be less likely than those on packs to promote elaboration of risks. Furthermore, cognitive risk perceptions appear less sensitive to pack warnings than affective responses (Hall et al., 2017; Brewer et al., 2019), even though cognitive elaboration of risk messages on pack warnings predicts cessation behaviors (Cho et al., 2018b), as we found in this study. It is notable that from before to after policy implementation, a stable proportion of participants reported that the look of their cigarette sticks made them think about smoking risks. Pack warnings, other anti-tobacco communications, and psychosocial factors (e.g., social desirability) may affect self-reported elaboration of risks that participants attribute to cigarette sticks, whether they have warnings or not. These other factors may also help explain the associations we found between this variable subsequent cessation attempts.

We also found that forgoing cigarettes due to the look of cigarette sticks increased after policy implementation and predicted quit attempts. This is consistent with qualitative studies, in which people who smoke described how dissuasive cigarettes would make them forgo cigarettes (Moodie et al., 2020; Drovandi et al., 2019), as well as with observational studies of forgoing cigarettes as a predictor of cessation behaviors (Thrasher et al., 2016; Partos et al., 2014). While both forgoing and feeling negative about sticks increased post-policy and predicted quit attempts, quit attempts did not increase over time. As such, the relatively moderate increases in stick-specific responses did not translate into substantial increases in quit rates. Some of this may be due to people in our sample who were not exposed to cigarette warnings that were only implemented on king-size cigarettes: those who smoke regular size cigarettes (approximately 30 %), use roll your own tobacco, and, potentially, who purchase non-regulated cigarettes from First Nations. Nevertheless, due to the high population burden of tobacco use, even relatively small increases in cessation rates could still translate into meaningful public health benefits.

Our convenience sample has limited generalizability. Our use of quota targets and weighting resulted in similarities to the general population of smokers in Canada (e.g., smoking frequency), though over-representation of some groups, such as those who are older and have lower intentions to quit, may have introduced some selection biases. Such biases, however, may have underestimated the observed policy impact given that these groups appear less sensitive to warning label policies (Swayampakala et al., 2018). Although our sample appears to have over-represented Canadians who did not intend to quit within the next six months (Gravely et al., 2023b), the fact that we found some evidence of policy effects is important given that interventions have limited effectiveness on this majority subpopulation of people who smoke (Klemperer et al., 2023). We were unable to evaluate sustained cessation due to small sample sizes. Future research–including with nationally representative samples–should evaluate changes in smoking prevalence, though the simultaneous implementation of new warnings and on-cigarette warnings, as well as a cigarette tax increase, will make

it challenging to separate out the effects. Our study addressed this issue by evaluating cigarette-stick specific questions, but, nevertheless, these responses may have been influenced by these other changes in the policy environment.

We evaluated only the initial policy implementation phase and analyzed data from all smokers, even though on-cigarette warnings were implemented only for king-size cigarettes. After our initial pre-policy surveys, the Canadian government announced policy implementation in stages: first for king-size cigarettes–which comprise approximately 70 % of the market–with implementation for regular-size cigarettes in mid-2025. As such, our study may underestimate on-cigarette warning effects, since most, but not all, of our participants were likely exposed to these warnings. Research is needed over the entire implementation period, including to evaluate "wear out" over time as people habituate to the warnings. Furthermore, every 24 months, Canada will alternate between two sets of on-cigarette warnings, and future assessments should evaluate whether this strategy staves off wear out.

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James F. Thrasher: Conceptualization, Resources, Writing – original draft, Writing – review & editing, Visualization, Supervision, Funding acquisition. **Samantha Petillo:** Project administration, Investigation, Data curation, Writing – review & editing. **Yanwen Sun:** Software, Validation, Formal analysis, Data curation, Writing – review & editing. **Liyan Xiong:** Software, Validation, Formal analysis, Data curation, Writing – review & editing. **Emily E. Hackworth:** Project administration, Investigation, Data curation, Writing – review & editing. **Stuart G. Ferguson:** Conceptualization, Writing – review & editing, Funding acquisition. **David Hammond:** Conceptualization, Writing – review & editing, Funding acquisition. **Crawford Moodie:** Conceptualization, Writing – review & editing.

Declaration of competing interest

SFG has provided expert advice to various pharmaceutical companies on matters related to smoking cessation, and he has also received researcher-initiated project grant funding and travel funds. These companies are not involved in the current study. Otherwise, the authors have no conflicts or potential conflicts of interest to report.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2025.108330.

Data availability

Data will be made available on request.

References

Al-Zalabani, A.H., Monshi, S.S., Al-Ahmadi, A.F., et al., 2023. Dissuasive cigarettes as a tobacco control measure: a scoping review. Tob. Control. https://doi.org/10.1136/tc-2023-057974 [published Online First: 20230706].

Borland, R., Wilson, N., Fong, G.T., et al., 2009. Impact of graphic and text warnings on cigarette packs: findings from four countries over five years. Tob. Control. 18 (5), 358–364. https://doi.org/10.1136/tc.2008.028043 [published Online First: 20090628].

Brewer, N., Parada, H., Hall, M., et al., 2019. Understanding why pictorial cigarette pack warnings increase quit attempts. Ann. Behav. Med. 53 (3), 232–243.

Canada, S.. Canadian Community Health Survey 2021. Available from: https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=1314175.

Cho, Y., Thrasher, J., Swayampakala, K., et al., 2016. Does reactance against cigarette warning labels matter? Warning label responses and downstream smoking cessation amongst adult smokers in Australia, Canada, Mexico and the United States. PLoS One 11 (7), e0159245.

Cho, Y.J., Thrasher, J.F., Yong, H.H., et al., 2018a. Path analysis of warning label effects on negative emotions and quit attempts: a longitudinal study of smokers in Australia, Canada, Mexico, and the US. Soc. Sci. Med. 197, 226–234. https://doi.org/10.1016/j.socscimed.2017.10.003 [published Online First: 20171030].

Cho, Y., Thrasher, J., Borland, R., et al., 2018b. Path analysis of warning label effects on negative emotions and quit attempts: a longitudinal study of smokers in Australia, Canada, Mexico, and the US. Soc. Sci. Med. 197, 226–234.

Drovandi, A., Teague, P.A., Glass, B., et al., 2019. Do health warnings on cigarette sticks dissuade smokers and non-smokers? A focus group and interview study of Australian university students. Psychol. Res. Behav. Manag. 12, 361–373. https://doi.org/10.2147/PRBM.S193754 [published Online First: 20190513].

Drovandi, A., Glass, B., Malau-Aduli, B., 2023. Australian perceptions of warnings on cigarette sticks. Int. J. Ment. Heal. Addict. 24 (1), 432–450. https://doi.org/10.1007/s11469-021-00605-z.

Gallopel-Morvan, K., Droulers, O., Pantin-Sohier, G., 2019. Dissuasive cigarettes: which cues are the most effective at deterring young people from smoking? Public Health 174, 22–30. https://doi.org/10.1016/j.puhe.2019.05.034 [published Online First: 20190711].

Gazette, C., 2023. Regulations Amending the Cannabis Regulations: Canada Gazette, Part II [Available from: https://www.gazette.gc.ca/rp-pr/p2/2023/2023-06-07/html/sor-dors97-eng.html.

Gravely, S., Chung-Hall, J., Craig, L.V., et al., 2023a. Evaluating the impact of plain packaging among Canadian smokers: findings from the 2018 and 2020 ITC smoking and vaping surveys. Tob. Control. 32 (2), 153–162. https://doi.org/10.1136/tobaccocontrol-2021-056635 [published Online First: 20210921].

Gravely, S., Driezen, P., McClure, E.A., et al., 2023b. Prevalence of depressive symptoms and cannabis use among adult cigarette smokers in Canada: cross-sectional findings from the 2020 international tobacco control policy evaluation project Canada smoking and vaping survey. CMAJ Open 11 (3), E516–E526. https://doi.org/10.9778/cmajo.20220081 [published Online First: 20230613].

Hackworth, E.E., Petillo, S., Sun, Y., et al., in press. Pre-post implementation policy support for warnings on cigarette filters in Canada among adults who smoke cigarettes. Tob. Control. Online ahead of print. doi:10.1136/tc-2024-059007.

Hall, M., Sheeran, P., Noar, S., et al., 2017. Negative affect, message reactance and perceived risk: how do pictorial cigarette pack warnings change quit intentions? Tob. Control. 27 (E2), e136–e142.

Hall, M.G., Sheeran, P., Noar, S.M., et al., 2018. Negative affect, message reactance and perceived risk: how do pictorial cigarette pack warnings change quit intentions? Tob. Control. 27 (e2), e136–e142. https://doi.org/10.1136/tobaccocontrol-2017-053972 [published Online First: 20171216].

Hammond, D., 2011. Health warning messages on tobacco products: a review. Tob. Control. 20 (5), 327–337. https://doi.org/10.1136/tc.2010.037630 [published Online First: 20110523].

Hassan, L.M., Shiu, E., 2015. No place to hide: two pilot studies assessing the effectiveness of adding a health warning to the cigarette stick. Tob. Control. 24 (e1), e3–e5. https://doi.org/10.1136/tobaccocontrol-2013-051238 [published Online First: 20131213].

Heatherton, T.F., Kozlowski, L.T., Frecker, R.C., et al., 1989. Measuring the heaviness of smoking: using self-reported time to the first cigarette of the day and number of cigarettes smoked per day. Br. J. Addict. 84 (7), 791–799. https://doi.org/10.1111/j.1360-0443.1989.tb03059.x.

Hitchman, S.C., Driezen, P., Logel, C., et al., 2014. Changes in effectiveness of cigarette health warnings over time in Canada and the United States, 2002-2011. Nicotine Tob. Res. 16 (5), 536–543. https://doi.org/10.1093/ntr/ntt196 [published Online First: 20131209].

Hoek, J., Gendall, P., Eckert, C., et al., 2016. Dissuasive cigarette sticks: the next step in standardised ('plain') packaging? Tob. Control. 25 (6), 699–705. https://doi.org/10.1136/tobaccocontrol-2015-052533 [published Online First: 20151216].

Huang, J., Chaloupka, F.J., Fong, G.T., 2014. Cigarette graphic warning labels and smoking prevalence in Canada: a critical examination and reformulation of the FDA regulatory impact analysis. Tob. Control. 23 Suppl 1 (01), i7–12. https://doi.org/10.1136/tobaccocontrol-2013-051170 (published Online First: 20131111).

Klemperer, E.M., Streck, J.M., Lindson, N., West, J.C., Su, A., Hughes, J.R., Carpenter, M. J., 2023 Apr. A systematic review and meta-analysis of interventions to induce attempts to quit tobacco among adults not ready to quit. Exp. Clin. Psychopharmacol. 31 (2), 541–559. https://doi.org/10.1037/pha0000583. Epub 2022 Jun 30. PMID: 35771496; PMCID: PMC10106992.

Mitchell, D., Moodie, C., Critchlow, N., et al., 2020. Adolescents' reactions to, and perceptions of, dissuasive cigarettes: a focus group study in Scotland. Drug Educ. Prev. Policy 27 (6), 462–469. https://doi.org/10.1080/09687637.2020.1732300.

Moodie, C., 2018. Warnings on every cigarette: extending health messaging to the consumption experience. CMAJ 190 (43), E1271–E1272. https://doi.org/10.1503/cmaj.180781.

Moodie, C., Purves, R., McKell, J., et al., 2015. Novel means of using cigarette packaging and cigarettes to communicate health risk and cessation messages: a qualitative study. Int. J. Ment. Heal. Addict. 24 (4), 328–334. https://doi.org/10.1007/s11469-014-9530-1.

Moodie, C., O'Donnell, R., Fleming, J., et al., 2020. Extending health messaging to the consumption experience: a focus group study exploring smokers' perceptions of health warnings on cigarettes. Addict. Res. Theory 28 (4), 328–334. https://doi.org/10.1080/16066359.2019.1653861 [published Online First: 20190829].

Noar, S.M., Francis, D.B., Bridges, C., et al., 2016. The impact of strengthening cigarette pack warnings: systematic review of longitudinal observational studies. Soc. Sci. Med. 164, 118–129. https://doi.org/10.1016/j.socscimed.2016.06.011 [published Online First: 20160713].

Partos, T., Borland, R., Thrasher, J., et al., 2014. The predictive utility of micro indicators of concern about smoking: findings from the international tobacco control four country study. Addict. Behav. 39 (8), 1235–1242.

Slovic, P., Peters, E., 2006. Risk perception and affect. Curr. Dir. Psychol. Sci. 15 (6), 322–325. https://doi.org/10.1111/j.1467-8721.2006.00461.x.

Society CC, 2023. Cigarette Package Health Warnings: International Status Report, Eighth edition. Available from: https://cancer.ca/-/media/files/about-us/media-releases/2024/international-warnings-report/ccs-international-cigarette-packaging-report-2023-english.pdf2024.

Swayampakala, K., Thrasher, J.F., Yong, H.H., et al., 2018. Over-time impacts of pictorial health warning labels and their differences across smoker subgroups: results from adult smokers in Canada and Australia. Nicotine Tob. Res. 20 (7), 888–896. https://doi.org/10.1093/ntr/ntx134.

Thrasher, J., Swayampakala, K., Hammond, D., et al., 2016. Influences of self-efficacy, response efficacy and reactance on responses to cigarette health warnings: a longitudinal study of adult smokers in Australia and Canada. Health Commun. 31 (12), 1517–1526.

Thrasher, J.F., Brewer, N.T., Niederdeppe, J., et al., 2019. Advancing tobacco product warning labels research methods and theory: a summary of a grantee meeting held by the US National Cancer Institute. Nicotine Tob. Res. 21 (7), 855–862. https://doi.org/10.1093/ntr/nty017.

World Health Organization, 2023. WHO Report on the Global Tobacco Epidemic, 2023: Protect People from Tobacco Smoke. World Health Organization, Geneva [Available from: https://www.who.int/initiatives/mpower.

Yong, H.H., Borland, R., Thrasher, J.F., et al., 2014. Mediational pathways of the impact of cigarette warning labels on quit attempts. Health Psychol. 33 (11), 1410–1420. https://doi.org/10.1037/hea0000056 [published Online First: 20140630].