

Over-Time Impacts of Pictorial Health Warning Labels and their Differences across Smoker Subgroups

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Original investigation

Over-Time Impacts of Pictorial Health Warning Labels and their Differences across Smoker Subgroups: Results from Adult Smokers in Canada and Australia

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Abstract

Introduction: This study examines patterns of change in different smoker subgroups' responses to new pictorial health warning labels (HWLs) over the initial, two year post-implementation period in Canada, where HWLs include package inserts with cessation messages, and Australia, where "plain" packaging (i.e., prohibition of brand imagery) was also implemented.

Methods: Data were collected from online consumer panels in Canada ($n_{\text{smokers}} = 3153$; $n_{\text{observations}} = 5826$) and Australia ($n_{\text{smokers}} = 2699$; $n_{\text{observations}} = 5818$) from September 2012 to September 2014, with approximately 1000 adult smokers surveyed in each country every four months, using replenishment to maintain sample size. Data were analyzed using generalized estimating equation models where main effects and interactions among time, country, and socio-demographic factors on HWL responses (i.e., attention to HWLs; cognitive and behavioral responses to HWLs) were examined.

Results: Over time, attention to HWLs declined but cognitive and forgoing responses to HWLs increased, in both Canada and Australia. In both countries, compared to smokers with low income and/or education, smokers with high income and/or education showed an increase over time in attention and cognitive responses to HWLs ($p < .05$). In Australia only, compared to older smokers, younger smokers showed less decline over time in attention and greater increase in cognitive and forgoing responses to HWLs ($p < .001$).

Conclusions: Novel HWL policies in Canada and Australia appear effective in staving off "wear out" over the first 2 years after implementation, particularly amongst smokers who are from higher SES groups and, in Australia, who are younger.

Implications: Previous research shows that the effects of health warning label (HWL) on smokers decline over time, but no studies to date have evaluated whether trends differ across socio-demographic groups. This study suggests that innovative policy configurations that combine prominent pictorial HWLs with inserts (Canada) and with “plain” packaging (Australia) may delay wear out over the first 2 years after implementation. While this study found evidence for wear out in attention to HWLs, other HWL responses (cognitive responses, forgoing cigarettes) actually increased over time, with greater increases amongst smokers with higher income and/or education.

Introduction

The World Health Organization’s Framework Convention on Tobacco Control (FCTC) recommends large pictorial health warning labels (HWLs) on cigarette packs in order to inform consumers about the “health consequences, addictive nature, and mortal threat posed by tobacco consumption and exposure to tobacco smoke”.¹ Furthermore, to maintain attention and inform consumers of the range of tobacco-related diseases, FCTC guidelines recommend that multiple HWLs appear concurrently and that message content changes periodically.² By 2014, 77 countries had adopted prominent pictorial HWLs, to which almost half of the world’s population is now exposed.³ Nevertheless, there is great variability across countries in the number of HWLs used and the frequency of rotating HWL content. Research is lacking on the optimal HWL policy configurations for producing maximum, sustainable effects on consumers and potential consumers. Furthermore, research is needed to understand whether over time patterns of HWL effects vary across different smoker subgroups, particularly smokers from lower socioeconomic status (SES) groups that increasingly experience tobacco-related disparities.

Warning Wear Out

Evidence on changes in HWL effects over time primarily comes from the International Tobacco Control Policy Evaluation Survey, which has surveyed cohorts of adult smokers across a range of countries every 1 to 2 years. These studies indicate that HWLs have their greatest impact shortly after initial implementation,⁴⁻⁸ after which effects gradually decline,⁵⁻⁸ a pattern also found in low- and middle income countries (LMIC).⁹⁻¹¹ The rate of decline appears greater for attention to HWLs (e.g., noticing and reading HWLs) than for the cognitive elaboration of risks (e.g., think about smoking-related risks or about quitting due to HWLs) and micro-behavioral responses (e.g., forgoing a cigarette due to HWLs),⁶ both of which independently predict subsequent quit attempts.^{12,13} A recent study compared the longer term impact (i.e., up to 5 years post-implementation) of the first pictorial HWL policies in Canada (i.e., 50% of front and back of the pack, with 16 HWLs with different content) and Australia (i.e., 30% front and 90% of the back of the pack), where one of two different sets of seven HWLs were alternated every year.⁸ The Canadian HWLs appeared more effective on all HWL response measures, suggesting that HWL size (especially the size of the front of the pack) may be more important in preventing wear out than rotating HWL content. Nevertheless, in Thailand, when pictorial HWL content (50% front and back) was updated approximately two years after initial implementation, cognitive and behavioral responses to HWLs were sustained,¹¹ suggesting that refreshing the HWLs periodically may also stave off wear out. Regardless, it is unclear whether over-time responses to HWLs vary across smokers from different population subgroups.

Warning Effects Across Sociodemographic Groups

Low SES groups may differ in their ability to access, process, and act on health risk information, leading to “communication inequality”.^{14,15} However, HWLs policies reduce access issues because HWL messages on cigarette packs reach both low and high SES groups, which appear to result in higher awareness of smoking risks across SES groups.¹⁶ Indeed, pictorial HWLs appear to do a better job than text-only HWLs in reducing or even eliminating disparities in awareness of smoking-related risks across educational levels.^{17,18} Experimental studies comparing text-only and pictorial HWLs across groups with different educational attainments¹⁹⁻²¹ found that pictorial HWLs were universally more likely to attract attention, be perceived as credible, and increase smokers’ motivations to quit. Additionally, some experiments have found that pictorial HWLs are rated as more effective by smokers with low compared to higher education.^{20,21} These one-shot, forced exposure experimental studies, however, have limited ecological validity, and studies are needed that more adequately simulate realistic conditions of repeated exposure to HWLs.

Population-based studies on the differential effects of HWLs are limited but also suggest that HWLs are either equally or more effective among groups with relatively lower education.²²⁻²⁵ A nationally representative, cross-sectional study found that the impact of European Union text-only warnings was highest among the lowest SES groups in France, Germany and the Netherlands, but not in the UK.²³ Another cross-sectional study compared smokers’ responses to HWLs in Brazil (pictorial HWLs with graphic imagery), Uruguay (pictorial HWLs with abstract imagery), and Mexico (text-only HWLs).²⁴ Mexican smokers with relatively higher education were more likely to attend to the text-only HWLs, while there was no association between education and attention to pictorial HWLs in Brazil or Uruguay. Furthermore, in Brazil, smokers with relatively lower education were more likely to report cognitive elaboration of smoking-related risks and thinking about quitting due to the pictorial HWLs. These studies suggest that pictorial HWLs may have a greater impact amongst smokers from lower than higher SES groups.

The effectiveness of HWLs across different age groups is another understudied research area. In general, for pictorial HWLs, younger smokers report greater attention and forgoing cigarettes than older smokers²⁴ whereas for text-only HWLs, older smokers report stronger HWL responses than younger smokers.²³ Some HWL policy configurations may be more capable to influence older smokers. In order to understand which HWL policies are most effective over time across socio-demographic groups, longitudinal research with ecological validity is needed.

Study Context

In 2012, Canada and Australia implemented new pictorial HWLs to replace existing pictorial HWLs. In July 2012, Canada implemented

16 new pictorial HWLs, all released into the market at once, to replace those that had been on packs since 2001, while also increasing HWL size from 50% to 75% of the front and back of the package. The new Canadian HWLs were accompanied by pack inserts that emphasize the benefits of quitting along with smoking cessation efficacy information.^{13,26} Australia implemented its first round of pictorial HWLs in 2006, which covered 30% of the front and 90% of the back of the pack. In December 2012, Australia increased the pictorial HWL size to 75% of the front (maintaining 90% of the back), using one of two sets of seven new HWLs that were alternated annually. The second set of HWLs was gradually introduced starting in August 2013 and fully implemented by December 2013. Also “plain” packaging was implemented in December 2012, standardizing the shape, color, and size of cigarette packs, while prohibiting brand symbols, logos, colors and font types. Details about HWL implementation and content have been described elsewhere.^{13,27}

The present study aimed to characterize and compare the trajectories of responses to newly implemented HWLs across socio-demographic subgroups among longitudinal panels of current smokers in Canada and Australia over a 2-year post-implementation period, with data collected every 4 months. The relatively short interval between surveys allowed for a more fine-grained assessment of the post-implementation period than in prior research with 1 to 2 years between follow-ups.^{4-9,11} We hypothesized that all HWL responses would decrease over time. We also hypothesized that HWL responses would show less wear out in Australia because of its plain packaging policy that has been shown to increase the salience of HWLs in experimental studies²⁸ and because Australia implemented a new set of HWLs half-way through the study period. Given limited data and theory, we had no expectations that trajectories of response would differ by age, education or income.

Methods

Data Source and Participants

Adult smokers were recruited from online consumer panels in Canada and Australia, which were provided by Global Market Insights (GMI: <http://www.gmi-mr.com>). Panel participants were purposively selected to be representative of key consumer segments in each country, with panels assembled in different ways across countries. Recruitment for the current study involved sending invitations to panel participants who were of eligible age and who were known smokers, as well as to general population samples for whom smoking status was unknown. Eligible participants were 18 to 64 years old, had smoked at least 100 cigarettes in their lifetime, and had smoked at least once in the previous month. From September 2012 to September 2014, seven waves of data were collected, every four months, following participants over time. To address attrition and maintain sample sizes of approximately 1000 participants per country at each wave, samples were replenished with eligible, new participants. Across all waves, the survey response rate was 16% in Canada (range = 8% to 22%) and 15% in Australia (range = 8% to 22%).²⁹ Follow-up from one wave to the next was 70% in Canada (range = 65% to 76%) and 76% in Australia (range = 73% to 78%). Only current smokers at each wave were included in the analytic sample as quitters were less likely to be exposed to the HWLs. Because the study aimed to examine HWL responses over the period after new pictorial HWLs were implemented, the analytic sample includes data from the first six waves in Canada ($n = 3153$ smokers, 5826 observations), and from the 2nd to 7th wave in Australia

($n = 2699$ smokers, 5818 observations), as the new HWLs were not implemented until after the 1st wave.

Measures

HWL Responses

To assess attention to HWLs, smokers were asked how often they had noticed HWLs, and those who indicated noticing were asked how often they had read or looked closely at the HWLs (1 = “never”; 2 = “rarely”; 3 = “sometimes”; 4 = “often”; 5 = “very often”). Smokers who reported “never” noticing HWLs were coded as “never” for reading HWLs. Cognitive elaboration of HWLs was assessed by asking: “To what extent do the warning labels make you think about the health risks of smoking?”; “To what extent do the warning labels on cigarette packs make you more likely to quit smoking?”; and “How much do the warning labels make you feel like you would be better off without smoking?”. Responses (i.e., 9-point response scale, from “not at all” to “extremely”) to all three questions had high internal consistency (range = 0.91–0.94 across waves in each country) and were averaged. Smokers were also asked: “In the last month, have the warning labels stopped you from having a cigarette when you were about to smoke one?” (“never”; “once”; “a few times”; “many times”). Given the skewed distribution, responses were re-coded to “never” versus other options. For all these questions, “don’t know” responses were offered and recoded to missing (range = 0.5%–2%).

Socio-demographics

Socio-demographics included age (18–29 years, 30–39 years, 40–49 years, and 50–64 years), education and income. Education was categorized into three levels: low (completed high school or less), medium (attended some college or university without completing the degree or technical education), and high (university degree or post-graduation). Annual income was categorized into three levels: low (\$29 000 or less), medium (\$30 000–\$59 999) and high (\$60 000 or more).

Covariates

Nicotine dependence was measured with the Heaviness of Smoking Index (HSI),³⁰ which predicts successful cessation.³¹ At each wave, participants were asked the number of cigarettes smoked per day and their time to first cigarette, which were combined to provide the HSI score (range = 0 to 6). Also smokers were asked whether they had made any attempts to stop smoking in the previous four months (yes vs. no). To adjust for effects due to participation in prior survey waves, a “time-in-sample” variable was derived based on the number of prior survey waves a participant had completed. All models also adjusted for smoker’s sex (male vs. female).

Data Analysis

All analyses were conducted using STATA version 13. Sample characteristics were compared between countries using omnibus chi-square tests for categorical variables and ANOVA for continuous variables. To assess sociodemographic differences in HWL responses at baseline, only data collected at the first post-implementation survey was used (i.e., wave 1 in Canada and wave 2 in Australia).

Trajectories of HWL responses

Linear generalized estimating equation (GEE) models were used to examine correlates of attention to HWLs and of cognitive responses,

two continuous outcome measures of interest whilst logistic GEE models were used to examine correlates of the dichotomous indicator of forgoing cigarettes due to HWLs. We assumed an exchangeable correlation structure and used robust variance to compute the p values for the parameter estimates. Linear trends in HWL responses over time were assessed with a linear term indicating post-implementation survey wave (i.e., range = 1 to 6). All GEE models included socio-demographics (age, sex, education, income), time-varying smoking-related variables (HSI, cigarette consumption, and quit attempts), survey wave, and time-in-sample.

First, data from both countries were pooled, with an indicator for country (Canada as reference group). A two-way interaction between country and wave was examined to assess between-country differences in linear trend for HWL responses while adjusting for all covariates. To assess whether there were any between-country differences in HWL responses over time across key socio-demographic variables, we created a three-way interaction between country, wave and each of the socio-demographic factor separately. An overall test for the significance of the three-way interaction of country \times wave \times socio-demographic factor was assessed. If the three-way interaction term was not statistically significant, we estimated a model with a two-way interaction between wave and socio-demographic factor while including an indicator term for country. However, if the three-way interaction term was significant, country-stratified models were estimated with a two-way interaction term between wave and socio-demographic factor. In either case, an overall test for the significance of the two-way interaction term was assessed. If this term was significant, for each socio-demographic group we graphed marginal means from models including indicator terms for wave.

Sensitivity analyses were conducted to assess potential selection bias and attrition bias issues. Because participants were from an

undefined sampling frame, analyses were re-estimated using weights that were developed based on the age, sex and educational profile of the general population of smokers in Canada and Australia.^{32,33} To further account for potential biases caused by differential attrition, further analyses were adjusted using propensity scores (i.e., predicted probabilities of completing survey waves, with methods described elsewhere).³⁴ The pattern of results from sensitivity analyses was consistent in direction, magnitude, and statistical significance of effects, although a few results from the weighted models became marginally non-significant.

Results

Sample Characteristics

Table 1 presents sample characteristics by country. Compared to Canadian smokers, Australian smokers were more likely to be of older in age, have higher education, higher income and to report higher HSI score.

Hwl Responses at Baseline

For both Canada and Australia, at baseline, compared to smokers of 18–29 years of age, smokers of 50–64 years of age reported lower attention, fewer cognitive responses and forgoing cigarettes due to HWLs (attention to HWLs: $\beta = -0.30$; 95% CI = -0.45 to -0.15 ; cognitive responses to HWLs: $\beta = -0.51$; 95% CI = -0.81 to -0.22 ; forgoing cigarettes: OR = 0.48; 95% CI = 0.34 to 0.68). At baseline, across the three income groups, there were no significant differences in the reported HWL responses. Except for education, there were no significant between-country differences in HWL responses by sociodemographic factors. In Canada, only for cognitive responses, but not for attention

Table 1. Sample characteristics of smoker participants in Canada and Australia, September 2012 to September 2014

Variable of Interest	Canada ($N_{\text{Smokers}} = 3153$, $N_{\text{observations}} = 5826$) %	Australia ($N_{\text{Smokers}} = 2699$, $N_{\text{observations}} = 5818$) %	Both countries combined ($N_{\text{Smokers}} = 5852$, $N_{\text{observations}} = 11\ 644$) %
Socio-demographic factors			
Age ^c			
18–29	22%	18%	20%
30–39	22%	25%	24%
40–49	21%	23%	22%
50–64	34%	35%	34%
Sex			
Female	55%	53%	54%
Education ^c			
Low	31%	33%	32%
Medium	45%	40%	42%
High	24%	27%	26%
Income ^c			
Low	27%	22%	24%
Medium	32%	27%	29%
High	42%	51%	46%
Smoking related factors			
Heaviness of Smoking Intensity ^c			
Mean (SD)	2.4 (1.6)	2.7 (1.6)	2.6 (1.6)
Quit attempt in prior 4 months			
Yes	40%	39%	40%

Chi-square test for between country differences: $a < 0.05$; $b < 0.01$; $c < 0.0001$

Education categories: low = high school or less; medium = some college; high = university or more

Income categories: low = \$29 000 or less; medium = \$30 000–\$59 999; high = \$60 000 or more

Table 2. Socio-demographic differences in HWL responses, Canadian and Australian Smokers, September 2012 to September 2014

Independent variable of interest	Attention to HWLs			Cognitive Responses to HWLs			Forgoing Cigarettes due to HWLs		
	Canada	Australia	Australia	Canada	Australia	Australia	Canada	Australia	Australia
	Adjusted Model* Estimate (95% CI)	Adjusted Model* Estimate (95% CI)	Adjusted Model* Estimate (95% CI)	Adjusted Model* Estimate (95% CI)	Adjusted Model* Estimate (95% CI)	Adjusted Model* Estimate (95% CI)	Adjusted Model* Odds Ratio (95% CI)	Adjusted Model* Odds Ratio (95% CI)	Adjusted Model* Odds Ratio (95% CI)
Age									
18-29	REF	REF	REF	REF	REF	REF	REF	REF	REF
30-39	-0.1 [-0.202-0.003]	-0.08 [-0.192-0.037]	-0.08 [-0.192-0.037]	-0.06 [-0.270-0.142]	0.01 [-0.208-0.231]	0.01 [-0.208-0.231]	0.81 [0.653-1.016]	0.81 [0.655-0.999]	0.81 [0.655-0.999]
40-49	-0.25 [-0.359-0.142]	-0.30 [-0.421-0.179]	-0.30 [-0.421-0.179]	-0.25 [-0.479-0.025]	-0.50 [-0.749-0.257]	-0.50 [-0.749-0.257]	0.62 [0.487-0.798]	0.37 [0.288-0.485]	0.37 [0.288-0.485]
50-64	-0.32 [-0.428-0.222]	-0.34 [-0.453-0.220]	-0.34 [-0.453-0.220]	-0.63 [-0.837-0.416]	-0.95 [-1.193-0.710]	-0.95 [-1.193-0.710]	0.52 [0.407-0.653]	0.27 [0.208-0.357]	0.27 [0.208-0.357]
Education									
Low	REF	REF	REF	REF	REF	REF	REF	REF	REF
Medium	-0.10 [-0.185-0.011]	0.04 [-0.052-0.123]	0.04 [-0.052-0.123]	-0.27 [-0.435-0.111]	-0.02 [-0.208-0.161]	-0.02 [-0.208-0.161]	0.83 [0.689-1.006]	1.11 [0.892-1.376]	1.11 [0.892-1.376]
High	-0.04 [-0.139-0.068]	0.25 [0.138-0.353]	0.25 [0.138-0.353]	0 [-0.208-0.214]	0.50 [0.281-0.721]	0.50 [0.281-0.721]	1.56 [1.254-1.928]	2.61 [2.074-3.272]	2.61 [2.074-3.272]
Income									
Low	REF	REF	REF	REF	REF	REF	REF	REF	REF
Medium	0.03 [-0.061-0.119]	0.08 [-0.017-0.167]	0.08 [-0.017-0.167]	0.06 [-0.104-0.234]	0.22 [0.050-0.387]	0.22 [0.050-0.387]	1.07 [0.872-1.306]	1.24 [0.999-1.547]	1.24 [0.999-1.547]
High	0.06 [-0.030-0.150]	0.10 [0.003-0.193]	0.10 [0.003-0.193]	-0.01 [-0.186-0.168]	0.35 [0.170-0.532]	0.35 [0.170-0.532]	1.07 [0.869-1.307]	1.17 [0.940-1.457]	1.17 [0.940-1.457]
Post-implementation survey wave	-0.03 [-0.050-0.007]	-0.01 [-0.035-0.008]	-0.01 [-0.035-0.008]	0.05 [0.008-0.096]	0.04 [-0.005-0.083]	0.04 [-0.005-0.083]	1.08 [1.032-1.135]	1.04 [0.988-1.084]	1.04 [0.988-1.084]

*Models adjust for the independent variables listed in table as well as for sex, heaviness of smoking index, quit attempts, and time in sample. Bold values are significant at $p < 0.05$.

or forgoing cigarettes, medium education smokers reported fewer cognitive responses compared to the low education smokers ($\beta = -0.52$; 95% CI = -0.87 to -0.18). In Australia, only for forgoing cigarettes due to HWLs but not for attention or cognitive responses to HWLs, high education smokers reported greater forgoing due to HWLs compared to low education smokers (OR = 4.11; 95% CI = 2.54 to 6.64).

Trajectories of HWL Responses

Attention to HWLs

In fully-adjusted analyses that pooled data across countries, there were no significant between-country differences in the trends of attention to HWLs; but there was a significant overall linear decline in attention to HWLs ($\beta = -0.02$; 95% CI = -0.038 to -0.001) (results not shown in tables). Three-way interactions between age, country and wave ($p = .0011$) and between education, country and wave ($p = .0002$) were significant. In models stratified by country, compared to 18–29 year old smokers in Australia, smokers of 40–49 years and 50–64 years of age had a greater decline in attention to HWLs overtime ($p < .05$; Figure 1A). Although the pattern of interaction differed between the two countries for education, there were no significant differences in attention across educational groups in Canada or Australia. In both countries, compared to low income smokers, high income smokers had lesser declines in attention to HWLs over time ($p < .05$; Figure 1B).

Cognitive Responses to HWLs

In fully-adjusted, pooled analysis, there were no significant between-country differences in the trends of cognitive responses to HWLs; however, there was a significant overall linear increase in cognitive responses to HWLs over time ($\beta = 0.05$; 95% CI = 0.02 to 0.78) (results not shown in tables). Three-way interactions between age, country and wave ($p = .0001$), education, country and wave ($p = .006$) and income, country and wave ($p = .0456$) were significant. In models stratified by country, compared to older smokers in Australia, younger smokers reported greater cognitive responses to HWLs over time ($p < .0044$; Figure 2A). In both Canada and Australia, compared to smokers with low education, those with high education reported greater increases in cognitive responses to HWLs ($p = .012$ and $p = .0242$, respectively; Figure 2B and C) although the pattern of interaction differed between the two countries. Also, compared to low income smokers, medium and high income smokers in Canada and only high-income smokers in Australia reported greater increases in cognitive responses to HWLs ($p < .05$, $p < .0001$ in Canada—Figure 2D and $p < .05$ in Australia—Figure 2E).

Forgoing cigarettes due to HWLs

In fully-adjusted analyses with pooled data, no significant between-country differences were found for time trends in forgoing cigarettes due to HWLs. Nevertheless, there was a significant overall linear increase in forgoing over time (OR = 1.07; 95% CI = 1.03 to 1.12; results not shown in tables). The only significant three-way interaction was between age, country and wave ($p = .0002$). In models stratified by country, compared to older smokers in Australia, younger smokers reported greater increases in forgoing cigarettes due to HWLs over time ($p < .05$; Figure 2F).

Discussion

The current study suggests that over 2 years after implementation of more prominent pictorial HWLs with new content in Canada and Australia, attention to HWLs declined over time, but cessation-related cognitive responses and forgoing of cigarettes due to HWLs increased among smokers in both countries. The lack of evidence for wear out of cognitive or forgoing responses to HWLs is contrary to prior studies. However, these studies involved much longer intervals between surveys (i.e., 1 to 2 years) and examined wear out for up to nine years after HWL implementation.^{5–11,35} Hence, the two years period of data collection in our study may not have been long enough to detect wear out for these variables. Indeed, the general lack of differences between Canada and Australia with regard to overall trends (i.e., for the entire sample) in HWL responses suggests that HWL policy characteristics across both countries have similar effects over the initial two years of implementation. Due to its plain packaging policy, we expected a greater impact in Australia than in Canada. The similarity of impact across the two countries could be because we examined adult smokers. Other studies of plain packaging in Australia found that its effects are primarily found among youth,³⁶ whereas the HWLs were more likely to influence adult smokers.^{37,38} The pattern of results suggests some increase in concern about smoking-related risks over time, in spite of declining attention to HWLs, so, overall, the HWLs appear to have retained considerable potency over the study period.

This first study to examine trajectories of response to newly implemented pictorial HWLs across sociodemographic groups suggested that low SES smokers in both countries reported either similar or stronger HWL responses immediately after implementation of new, larger, pictorial HWLs. However, over time, higher SES smokers in both countries not only reported relatively stronger responses to HWLs (i.e., attention, cognitive and behavioral responses), but also they appeared to

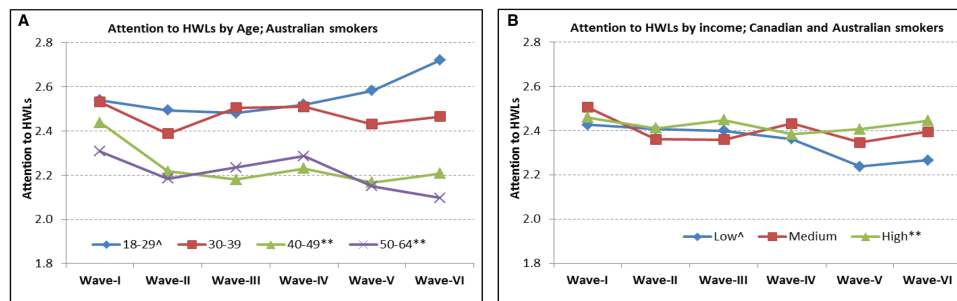


Figure 1. Marginal Means for Attention to HWLs. Marginal means Dummy coded survey wave estimated in GEE models adjusting for age, sex, education, income, heaviness of smoking intensity, quit attempts in previous four-months and time-in-sample effects. [^]Reference group; **** $p < .001$, *** $p < .01$, ** $p < .05$, * $p < .1$. Wave numbers in Figure refer Post-implementation period and not actual survey waves.

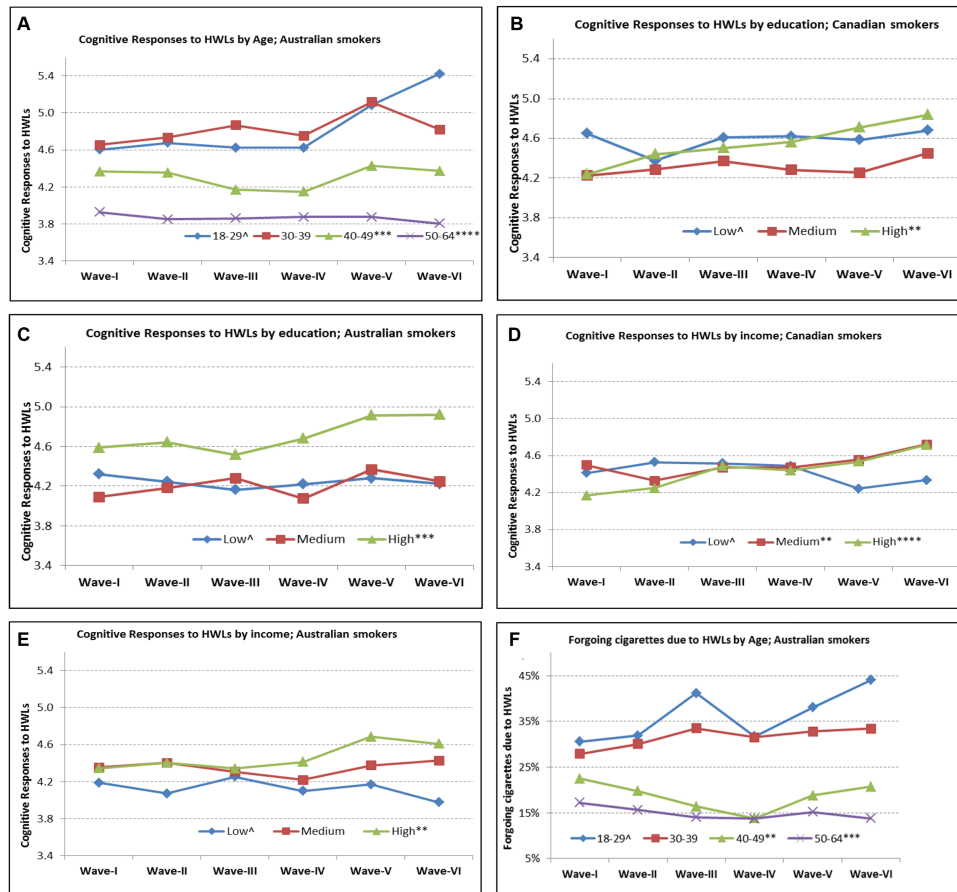


Figure 2. Marginal Means for Cognitive and Forgoing responses to HWLs. Marginal means Dummy coded survey wave estimated in GEE models adjusting for age, sex, education, income, heaviness of smoking intensity, quit intentions in next six-months, and time-in-sample effects. [^]Reference group; ^{****} $p < .001$, ^{***} $p < .01$, ^{**} $p < .05$, ^{*} $p < .1$. Wave numbers in Figure refer Post-implementation period and not actual survey waves.

experience either less or no wear out than their low SES counterparts. This was unexpected, given that both experimental and cross-sectional studies suggest that pictorial HWLs are more effective among lower SES groups.¹⁹⁻²⁵ This difference may be due to lack of resources for lower SES smokers to act on their responses to HWLs.^{14,15} Furthermore, our study found that the introduction of a second set of HWLs with new content half-way through the observation period in Australia did not appear to alter education-related differences in trends for HWL responses over time. Besides changing HWL content, additional cessation programs and interventions may be necessary to better support lower SES smokers who want to quit. Further research is needed to see whether similar patterns apply to LMICs and countries with shorter histories of pictorial HWLs and tobacco control, in general.

Our study found stronger responses to HWLs amongst younger smokers immediately following implementation of new pictorial HWLs in both countries, with these differences increasing over time in Australia. Relatively stronger responses to HWLs over time amongst younger smokers may be due to “plain” packaging, as its effects appear primarily amongst youth.³⁶ Our results are important, given that prior research with shorter, post-implementation follow up suggests that the larger pictorial HWLs in Australia, and not plain packaging, accounts for policy effects amongst adult smokers.^{37,38} In Canada, the lack of change in age-related differences in HWL responses over time may be due to the implementation of complementary package inserts that emphasize the benefits

of quitting and provide behavioral recommendations and coping information that appear to enhance smokers’ self-efficacy to quit.¹³ The messaging on these inserts goes substantially beyond providing a telephone number (i.e., quitline) and/or website with cessation resources, which many countries include on HWLs, and this information may help older smokers remain engaged with HWLs. Indeed, reading cigarette pack inserts is not only associated with stronger subsequent self-efficacy to quit, but also with quit attempts, and sustained quitting.^{13,26} Complementary policies and programs might nevertheless be needed to better support smoking cessation amongst older smokers and those from lower SES groups. Future research should consider whether different trajectories of response to specific HWL policy configurations ultimately translate into meaningful differences in public health outcomes (i.e., cessation rates), including effects on health disparities. Our results suggest that pictorial HWLs may still need to be re-designed to better promote quitting-related thoughts and behaviors across all socio-demographic groups.

This study has several limitations. Data were collected from online panels of consumers who came from no clearly defined sampling frame, thereby limiting the generalizability of our results and our ability to make cross-country comparisons of the HWL responses at baseline and compare findings with other studies that use population-based representative samples. Internet penetration rates in Canada and Australia are high (82% and 90% respectively),³⁹ suggesting that the inability to participate due to our survey mode is

limited, although the lower SES groups on which this study focused were still less likely to have had Internet access. This lack of participation may bias our results in unpredictable ways. Furthermore, our response rates (15%–16%) are lower than desired and may further bias our results. Also, research shows that online surveys yield similar estimates regarding health behaviors compared with mail and phone surveys.⁴⁰ About 70% of the sample was followed up from one wave to the next, so attrition biases may have had some effects on our results. To help address these concerns, sensitivity analyses adjusted for propensity scores that accounted for likelihood of dropping out and weighted the data based on national estimates of the profiles of smokers in each country. The results were consistent in direction, strength and statistical significance, suggesting that these biases are not so substantial as to meaningfully change our findings or their interpretation. Furthermore, the primary focus of this study was not to provide population-based estimates but to examine the trajectories of HWL responses over time and to determine whether these responses vary across socio-demographic groups. In this regard, our study, which involved surveys every four months, provides greater precision over other studies with 1 to 2 years between survey intervals.^{5–11,35}

Our survey questionnaire also queries other responses to HWLs (i.e., interpersonal communication about HWLs, avoiding HWLs.) which were not examined. For comparability with prior research, we focused on HWL responses that were most often studied with respect to SES in population-based research. Moreover, cognitive responses and forgoing cigarettes due to HWLs have been shown to be associated with downstream quitting in smoker samples from Canada, Australia, Europe and the US.^{12,41}

Overall, the current study findings indicate that over the two years after implementation of new, more prominent pictorial HWLs in Canada and Australia, attention waned, yet smokers' cognitive and behavioural responses to HWLs continued to increase. Some age- and SES-related differences in HWL responses were found, with differences primarily indicating older smokers and lower SES smokers were less likely to experience strengthened responses over this time; still, their HWL responses generally did not "wear out".

Supplementary Material

Supplementary data are available at *Nicotine and Tobacco Research* online.

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Declaration of Interests

The funding agency had no role in study design; collection, analysis, and interpretation of data; writing the report; or the decision to submit the report for publication. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

References

1. WHO. *WHO Report on the Global Tobacco Epidemic, 2008: The MPOWER package*. Geneva: World Health Organization; 2008.
2. WHO. *Guidelines for implementation of Article 11 of the WHO Framework Convention on Tobacco Control (packaging and labelling of tobacco products)*. Geneva, Switzerland: World Health Organization; 2008.
3. Society CC. *Cigarette package warning labels: International status report*. 2014. http://www.fctc.org/images/stories/2016/CCS-international_cigarette_packaging_report_2016-English.pdf. Accessed December 22, 2016.
4. Borland R, Hill D. Initial impact of the new Australian tobacco health warnings on knowledge and beliefs. *Tob Control*. 1997;6(4):317–325.
5. Borland R, Wilson N, Fong GT, et al. Impact of graphic and text warnings on cigarette packs: findings from four countries over five years. *Tob Control*. 2009;18(5):358–364.
6. Hammond D, Fong GT, Borland R, et al. Text and graphic warnings on cigarette packages: findings from the international tobacco control four country study. *Am J Prev Med*. 2007;32(3):202–209.
7. Hitchman SC, Driezen P, Logel C, et al. Changes in effectiveness of cigarette health warnings over time in Canada and the United States, 2002–2011. *Nicotine Tob Res*. 2014;16(5):536–543.
8. Li L, Borland R, Yong H, et al. Longer term impact of cigarette package warnings in Australia compared with the United Kingdom and Canada. *Health Educ Res*. 2015;30(1):67–80.
9. Green AC, Kaai SC, Fong GT, et al. Investigating the effectiveness of pictorial health warnings in Mauritius: findings from the ITC Mauritius survey. *Nicotine Tob Res*. 2014;16(9):1240–1247.
10. Thrasher JF, Pérez-Hernández R, Arillo-Santillán E, et al. Towards informed tobacco consumption in Mexico: effect of pictorial warning labels in smokers. *Salud Publica Mex*. 2012;54(3):242–253.
11. Yong HH, Fong GT, Driezen P, et al. Adult smokers' reactions to pictorial health warning labels on cigarette packs in Thailand and moderating effects of type of cigarette smoked: findings from the international tobacco control southeast Asia survey. *Nicotine Tob Res*. 2013;15(8):1339–1347.
12. Borland R, Yong HH, Wilson N, et al. How reactions to cigarette packet health warnings influence quitting: findings from the ITC Four-Country survey. *Addiction*. 2009;104(4):669–675.
13. Thrasher JF, Swayampakala K, Cummings KM, et al. Cigarette package inserts can promote efficacy beliefs and sustained smoking cessation attempts: A longitudinal assessment of an innovative policy in Canada. *Prev Med*. 2016;88:59–65.
14. Ramanadhan S, Viswanath K. Health and the information nonseeker: a profile. *Health Commun*. 2006;20(2):131–139.
15. Viswanath K, Breen N, Meissner H, et al. Cancer knowledge and disparities in the information age. *J Health Commun*. 2006;11(suppl 1):1–17.
16. Hammond D. Health warning messages on tobacco products: a review. *Tob Control*. 2011;20(5):327–337.
17. Siahpush M, McNeill A, Hammond D, et al. Socioeconomic and country variations in knowledge of health risks of tobacco smoking and toxic constituents of smoke: results from the 2002 International Tobacco Control (ITC) Four Country Survey. *Tob Control*. 2006;15(suppl 3):iii65–70.
18. Mutti S, Hammond D, Reid JL, Thrasher JF. The efficacy of cigarette warning labels on health beliefs in the United States and Mexico. *J Health Commun*. 2013;18(10):1180–1192.
19. Cantrell J, Vallone DM, Thrasher JF, et al. Impact of tobacco-related health warning labels across socioeconomic, race and ethnic groups: results from a randomized web-based experiment. *PLoS One*. 2013;8(1):e52206.
20. Hammond D, Thrasher J, Reid JL, et al. Perceived effectiveness of pictorial health warnings among Mexican youth and adults: a population-level intervention with potential to reduce tobacco-related inequities. *Cancer Causes Control*. 2012;23(Suppl 1):57–67.
21. Thrasher JF, Carpenter MJ, Andrews JO, et al. Cigarette warning label policy alternatives and smoking-related health disparities. *Am J Prev Med*. 2012;43(6):590–600.
22. *European Commission Eurobarometer: Survey on Tobacco (Analytical Report)* 2009.
23. Hitchman SC, Mons U, Nagelhout GE, et al. Effectiveness of the European Union text-only cigarette health warnings: findings from four countries. *Eur J Public Health*. 2012;22(5):693–699.

24. Thrasher JF, Villalobos V, Szklo A, et al. Assessing the impact of cigarette package health warning labels: a cross-country comparison in Brazil, Uruguay and Mexico. *Salud Publica Mex.* 2010;52(suppl 2):S206–S215.
25. Nagelhout GE, Willemsen MC, de Vries H, et al. Educational differences in the impact of pictorial cigarette warning labels on smokers: findings from the International Tobacco Control (ITC) Europe surveys. *Tob Control.* 2015.
26. Thrasher JF, Osman A, Abad-Vivero EN, et al. The use of cigarette package inserts to supplement pictorial health warnings: an evaluation of the Canadian policy. *Nicotine Tob Res.* 2015;17(7):870–875.
27. Swayampakala K, Thrasher JF, Hammond D, et al. Pictorial health warning label content and smokers' understanding of smoking-related risks—a cross-country comparison. *Health Educ Res.* 2015;30(1):35–45.
28. Stead M, Moodie C, Angus K, et al. Is consumer response to plain/standardised tobacco packaging consistent with framework convention on tobacco control guidelines? A systematic review of quantitative studies. *PLoS One.* 2013;8(10):e75919.
29. AAPOR. *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys.* 8th ed. Oakbrook Terrace, IL: The American Association for Public Opinion Research; 2015.
30. Heatherton TF, Kozlowski LT, Frecker RC, et al. Measuring the heaviness of smoking: using self-reported time to the first cigarette of the day and number of cigarettes smoked per day. *Addiction.* 1989;84:791–800.
31. Borland R, Yong HH, O'Connor RJ, et al. The reliability and predictive validity of the heaviness of smoking index and its two components: findings from the international tobacco control four country study. *Nicotine Tob Res.* 2010;12 (Suppl):S45–S50.
32. Canadian Research Data Centre Network. *Canadian Community Health Survey.* 2012. <http://www.rdc-cdr.ca/datasets/cchs-canadian-community-health-survey>. Accessed February 10, 2016.
33. Welfare ALoHa. *The National Drug Strategy Household Survey, 2010.* 2010. <http://www.aihw.gov.au/publication-detail/?id=32212254712>. Accessed February 6, 2017.
34. Thrasher JF, Osman A, Moodie C, et al. Promoting cessation resources through cigarette package warning labels: a longitudinal survey with adult smokers in Canada, Australia and Mexico. *Tob Control.* 2015;24(e1):e23–e31.
35. Fathelrahman AI, Omar M, Awang R, et al. Impact of the new Malaysian cigarette pack warnings on smokers' awareness of health risks and interest in quitting smoking. *Int J Environ Res Public Health.* 2010;7(11):4089–4099.
36. White V, Williams T, Wakefield M. Has the introduction of plain packaging with larger graphic health warnings changed adolescents' perceptions of cigarette packs and brands? *Tob Control.* 2015;24:ii42–ii49.
37. Wakefield M, Coomber K, Zacher M, Durkin S, Brennan E, Scollo M. Australian adult smokers' responses to plain packaging with larger graphic health warnings 1 year after implementation: results from a national cross-sectional tracking survey. *Tob Control.* 2015;24(suppl 2):ii17–ii25.
38. Durkin S, Brennan E, Coomber K, Zacher M, Scollo M, Wakefield M. Short-term changes in quitting-related cognitions and behaviours after the implementation of plain packaging with larger health warnings: findings from a national cohort study with Australian adult smokers. *Tob Control.* 2015;24(suppl 2):ii26–ii32.
39. GMI. *GMI Global Panel Book.* Bellevue, WA: Global Market Insight, Inc.; 2013.
40. An LC, Hennrikus DJ, Perry CL, et al. Feasibility of Internet health screening to recruit college students to an online smoking cessation intervention. *Nicotine Tob Res.* 2007;9(suppl 1):S11–S18.
41. Thrasher JF, Swayampakala K, Borland R, et al. 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.* 2016:1–10.