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INTENDED AND UNINTENDED EFFECTS OF BANNING MENTHOL CIGARETTES

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ABSTRACT

Bans on menthol cigarettes have been recommended by the World Health Organization, adopted throughout the European Union, and proposed by the United States Food and Drug Administration (FDA), primarily due to concerns that menthol cigarettes enable youth smoking. Yet there is almost no direct evidence on their effects using real-world policy variation. We provide the first comprehensive evaluation of this policy by studying Canada where seven provinces banned menthol cigarettes prior to a nationwide menthol ban in 2018. Using provincial sales data, we show that menthol cigarette sales fell to zero immediately after menthol bans, with no meaningful effect on non-menthol sales. Survey data confirm that provincial menthol bans significantly reduced menthol cigarette smoking among both youths and adults. We also find strong evidence of substitution, however: provincial menthol bans significantly increased non-menthol cigarette smoking among youths, resulting in no overall net change in youth smoking rates. We also document evidence of evasion: provincial menthol bans shifted smokers' cigarette purchases away from grocery stores and gas stations to First Nations reserves (where the menthol bans do not bind). Our results demonstrate the importance of accounting for substitution and evasion responses in the design of stricter tobacco regulations.

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1. Introduction

Economics research on the determinants and effects of cigarette smoking is voluminous and has yielded critical insights for the design of public policy and public health interventions (Cawley and Ruhm, 2011; Chaloupka and Warner, 2000). Cawley and Ruhm (2011) demonstrate that research in health economics has been dominated by studies of smoking and tobacco control, consistent with its disproportionate role in contributing to burden of avoidable diseases and mortality (World Health Organization, 2019). Experimentation with tobacco control regulations has also afforded economics research a wide array of policy interventions to study, ranging from taxes and prices (Adda and Cornaglia, 2006; DeCicca et al., 2002) to clean indoor air regulations (Adda and Cornaglia, 2010; Carpenter, 2009), graphic warning labels (Borland et al., 2009; Gospodinov and Irvine, 2004; Huang et al., 2014), advertising restrictions (Blecher, 2008; Kenkel et al., 2017), punitive liability for exposing children to smoke in cars (Nguyen, 2013), public health insurance coverage for smoking cessation treatment (Maclean et al., 2018), and others. Economics research on these interventions has in many cases contributed to their proliferation throughout the United States and worldwide.

In this paper we provide new and novel evidence on one of the most contested policy instruments in current debates about tobacco control that is being adopted at a rapid pace throughout the world: bans on menthol flavors in combusted cigarettes and other tobacco products. According to the World Health Organization,

menthol 'is a widely used flavoring agent characterized by a minty flavor and by its well-known cooling effect' (World Health Organization, 2016). In addition to changing the taste of tobacco products, menthol has been shown to change the physiologic response to tobacco smoke by reducing the harshness and irritation of smoking, providing reinforcing sensory stimulation, and changing the structure of nicotine receptors (see Wickham 2015 for a review). These physiologic factors make menthol smoking both easier to start and harder to quit. The first fact explains the public health focus on youths; i.e., menthol cigarettes are a 'starter product' for youth smoking (Anderson, 2011; Belluz, 2018). The second fact is consistent with research showing that menthol cigarettes decrease the likelihood of successful smoking cessation (Anderson, 2011). These factors led the World Health Organization in 2018 to explicitly recommend that countries ban menthol flavoring in tobacco products.

Notably, the United States has not yet adopted a menthol flavor ban. The 2009 Family Smoking Prevention and Tobacco Control Act did include a ban on all other flavors in cigarettes except menthol, highlighting its unique primacy. In 2011, a Food and Drug Administration (FDA) advisory panel concluded that the removal of menthol cigarettes from the US market would benefit public health through reducing smoking initiation and promoting smoking cessation, particularly among children. Tobacco companies, however, successfully challenged this

conclusion in court, citing lack of evidence showing menthol cigarettes are more harmful than non-menthol cigarettes (Reuters, 2014).[1]

Although no menthol ban was adopted in the US after the 2011 FDA report, many observers portended a change in US policy toward menthol cigarettes when in November 2018 the then-Commissioner of the FDA Scott Gottlieb issued a statement calling for a Notice of Proposed Rulemaking that would include a ban on menthol in combusted tobacco products (including cigarettes). To date, no federal menthol ban has been adopted in the United States.[2] Despite the lack of a federal ban, a handful of large cities within the US have adopted bans or restrictions on menthol cigarette sales: Chicago was the first to do so in July 2016 when it ruled that stores near schools could not sell menthol cigarettes. More recently, San Francisco adopted a city-wide ban on menthol cigarette sales in June 2018, and Los Angeles adopted a similar county-wide ban in October 2019. New York City and New York State are both considering menthol ban proposals as well. This level of menthol-specific regulation in the US is quite limited relative to worldwide activity: in Europe, bans on menthol tobacco products will take effect in 2020 (European Commission, 2018), and similar bans have been adopted in Brazil, Ethiopia, and Turkey.

[1] Several African American organizations such as the National Black Chamber of Commerce also rejected the bans arguing that a menthol ban would unfairly target African American smokers who disproportionately use menthol cigarettes (Chicago Tribune, 2010).
[2] Tobacco companies continue to voice their opposition and planned legal challenges to any bans on menthol flavor (Edgecliffe-Johnson and Gray, 2018).

Despite the extensive adoption of menthol bans worldwide, we are aware of no research in economics or other disciplines that has comprehensively evaluated the effects of menthol bans on smoking outcomes using gold-standard quasi-experimental methods. This absence of research is striking relative to the large body of work on other policy instruments and the widespread belief held by governments adopting these bans that the policies would reduce the population health burden of cigarette smoking. The significant potential for menthol bans as tools for further reducing cigarette smoking among vulnerable populations and their widespread adoption across the world underscore the importance of credible research on their effects.

One of the main reasons for the lack of credible study on the effects of menthol bans is that there has not been much real-world policy variation.[3] In this paper we overcome this fundamental challenge by studying the experience of Canada. Several provinces (including the highly populated Alberta, Ontario, and Quebec) banned menthol flavoring in combusted cigarettes at different times from 2015-2017, while three provinces (i.e., British Columbia, Saskatchewan, and Manitoba) did not adopt provincial menthol bans. We examine data on sales of menthol and non-menthol cigarettes by province and month, and we supplement this evidence with survey data on youth and adult cigarette smoking.

[3] For example, in the US context, no locality, state, or other regulatory body has banned menthol flavoring in combusted cigarettes, and indeed many large health surveys on smoking in the US do not include questions about menthol cigarette use.

We report several key findings from this research. First, the provincial cigarette sales data clearly indicate that provincial and federal menthol bans are effective at eliminating menthol cigarette sales. These effects are visually apparent in examinations of raw means and are supported in panel data evaluations. We also observe evidence of stockpiling behavior – i.e., increased menthol cigarette sales after announcement of bans but prior to enactment in Ontario, Quebec, Newfoundland and Labrador, and Prince Edward Island, which we account for in our analyses of survey data. Notably, we do not observe significant effects of provincial menthol bans on sales of non-menthol cigarettes.

Next, we turn to the survey data and show that our two-way fixed effects models with controls for province and time period fixed effects, individual demographics, economic conditions, and other province/time-varying smoking policies return evidence on menthol cigarette smoking that is highly consistent with the sales data: provincial menthol bans significantly reduced youth and adult menthol cigarette smoking. These effects are larger for older youths and aboriginal youths, both groups that had higher menthol smoking rates prior to provincial bans.

Interestingly, we also document evidence of substitution by youths: provincial bans are associated with statistically significant increases in the likelihood that youths report non-menthol cigarette smoking. For adults, we do not find evidence of substitution, but we do find evidence of evasion: provincial menthol bans were associated with significant increases in the likelihood that adults

reported purchasing cigarettes from a First Nations reserve (where menthol bans do not bind) and significant reductions in the likelihood that adults reported purchasing cigarettes from a gas station or grocery store not on a First Nations reserve. Finally, when we examine overall smoking outcomes, we do not find that provincial menthol bans had any significant effects on population rates of cigarette smoking or quit behaviors for either youths or adults. This finding is consistent with the null result on non-menthol cigarette sales described above.

Taken together, our results provide the first comprehensive evidence on the effects of banning menthol cigarettes. While we find clear evidence that the bans reduced menthol cigarette sales and menthol cigarette use, we also find that the bans are unlikely to be a panacea for reducing youth smoking rates because youths substitute toward non-menthol cigarettes. Moreover, the overall effect on adult smoking is somewhat blunted by evasion of menthol bans toward First Nations reserve purchases. Taken together, our results demonstrate the importance of accounting for substitution and evasion responses in the design of stricter tobacco control regulations.

The remainder of the paper proceeds as follows: Section 2 describes the menthol bans and discusses mechanisms for the effects we study. Section 3 provides a literature review, and Section 4 describes the data and empirical approach. Section 5 presents the results, and Section 6 offers a discussion and concludes.

2. Menthol Bans and Mechanisms

The policies we study here ban the use of menthol flavoring in combusted cigarettes.[4] Between May 2015 and July 2017, seven Canadian provinces enacted these bans. As shown in Appendix Table 1, the dates of adopting the bans vary across the provinces. Nova Scotia and Alberta adopted the policy in 2015, followed by Quebec and New Brunswick in 2016 and subsequently, by Ontario, Prince Edward Island and Newfoundland and Labrador in 2017. Three provinces (Saskatchewan, British Columbia and Manitoba) did not ban menthol. In October 2017, the Canadian federal government imposed a similar ban nationwide.

These menthol bans were part of a broader regulatory landscape directed at flavors in tobacco products more generally. Specifically, the Canadian federal government adopted a federal ban on non-menthol flavors in tobacco products in 2010.[5] Similar actions on non-menthol flavors in tobacco products were taken in the United States in 2009 with the Family Smoking Prevention and Tobacco

[4] The bans also applied to blunt wraps and some types of cigars. These include cigarillos (little cigars weighing ≤1.4g or having a cigarette filter), cigars that have tipping paper, cigars that have a wrapper that is not fitted in spiral form and cigars weighing more than 1.4g but less than 6g.

[5] The 2010 policy banned all flavors except menthol in cigarettes, small cigars and cigarillos below a certain size threshold (less than or equal to 1.4 grams), and blunt wraps. In 2015 the flavor ban – again, excluding menthol – was extended to larger cigars (between 1.4 and 6 grams). Thus, throughout our entire sample period for studying menthol cigarette use (2010-2016 for youths and 2015-2017 for adults), all non-menthol flavored cigarettes were banned. In the empirical work below, the federal ban will be accounted for by including year fixed effects.

Control Act; thus, the policy variation in Canada is similar to what would be the case if the United States banned menthol flavors.

Our study examines the effects of provincial menthol bans on menthol and non-menthol cigarette sales, self-reported menthol cigarette smoking, and a range of other outcomes that might reflect substitution or evasion, including use of non-menthol cigarettes and e-cigarettes as well as cigarette purchasing behavior in different regulated and unregulated locations. We have in mind several mechanisms through which the bans could affect these outcomes. First and most directly is the pure availability mechanism: to the extent that the provincial menthol bans were enforced, it should be much more difficult for individuals to obtain menthol cigarettes to smoke after the bans are in place. It may not be totally impossible, however, as individuals could stockpile menthol cigarettes prior to ban implementation or smuggle menthol cigarettes across borders from other provinces without bans (prior to the 2017 federal menthol ban) or from the United States where menthol cigarettes remain widespread. Smokers might also purchase menthol cigarettes from First Nations reserves that are generally exempt from federal and provincial smoking regulations (Curtis, 2015). These actions may give rise to illegal markets for menthol cigarettes (Edgecliffe-Johnson and Gray, 2018).

The physiologic effects of menthol flavor might also be mechanisms for effects of provincial menthol bans on smoking outcomes. For example, if the public health concern is valid that menthol use increases experimentation with cigarettes

by reducing the harshness and irritation of smoking, then we might expect menthol bans to reduce lifetime experimentation with cigarette smoking. Moreover, if it is also true that menthol flavoring in cigarettes reduces quit behavior by changing the physiologic response of the body's nicotine receptors, then menthol bans may also be expected to increase successful quitting and reduce overall smoking prevalence.

Arguably more interesting than the absolute increase in the cost of menthol cigarette smoking that is likely to follow from the sharp reduction in availability of menthol cigarettes are a range of other behavioral responses due to the relative increase in costs of using menthol cigarettes (versus non-menthol cigarettes) induced by menthol bans. Specifically, menthol smokers may substitute to non-menthol cigarettes in response to provincial menthol bans, depending on their relative preference for (or addiction to) menthol cigarette smoking. There is also a possibility that menthol bans induce substitution to e-cigarette use, to the extent that menthol cigarette smokers can find menthol flavored e-cigarettes (not subjected to the bans) and view the latter as a reasonable substitute to menthol cigarettes.[6]

[6] Tobacco marketing might also be an important alternative mechanism (other than relative price changes) through which menthol bans affect smoking outcomes. Specifically, research suggests that tobacco companies have engaged in strategies that encourage people to switch to 'smooth tasting' non-menthol tobacco alternatives in response to menthol bans (Schwartz et al., 2018). We do not observe proxies for this type of tobacco industry behavior by province and time, so we cannot evaluate its importance here.

3. Literature Review

While there is an enormous literature on the economics of cigarette smoking and regulations designed to reduce smoking (see, for example, Chaloupka & Warner, 2000), there is far less research in economics that has examined menthol smoking specifically. Kenkel, Mathios, & Wang (2017) study cigarette advertising in the context of menthol cigarettes and find that advertisers target demographic groups (e.g., African Americans in the United States) but that the advertising itself has little effect at increasing market share.

We are not aware of any studies in economics that have evaluated the effects of menthol bans such as those assessed in this study.[7] The public health and tobacco control literatures do include studies that investigate planned responses of menthol smokers to hypothetical menthol bans (D'Silva et al., 2015; O'Connor et al., 2012; Pearson et al., 2012; Wackowski et al., 2014), though these studies suffer from the well-documented challenge that actual behaviors can differ substantially from planned behaviors (Chaiton et al., 2018; Machado and Sinha, 2007; Moan and Rise, 2006).

[7] One relevant study examined the effects of non-menthol flavor bans on adolescent tobacco use in the United States using variation induced by the 2009 Family Smoking Prevention and Tobacco Control Act which banned non-menthol flavors in cigarettes. Courtemanche, Palmer, & Pesko (2017) use data from the 1999-2013 National Youth Tobacco Surveys and find that the ban on flavored cigarettes reduced the likelihood that middle and high school youths in the US were cigarette smokers, though there was also an increase in use of menthol cigarettes, cigars, and pipes which they interpret as evidence of substitution to unregulated substances. A major limitation of the study, however, is the lack of a control group due to the federal nature of the intervention. Thus, the authors are unable to rule out that other secular changes were responsible for the observed patterns of tobacco use.

Two public health studies have examined some of the same provincial menthol bans in Canada that we study here; both study Ontario's January 2017 ban (Chaiton et al., 2019, 2018). Chaiton et al. (2018) surveyed a small sample (N=325) of menthol smokers and found a substantial reduction in menthol cigarette use in the month following implementation of the menthol ban. This study did not include any unaffected control group, however, so it cannot rule out that shared secular shocks – and not the provincial menthol ban – were responsible for the observed changes in use. Chaiton et al. (2019) used interrupted time series methods to analyze wholesale sales data during the period of October 2012-September 2017 and used British Columbia (which did not adopt a menthol ban) as a control group. They found significant reductions in menthol cigarette sales and total cigarettes sales in Ontario after the ban while there was no significant reduction in British Columbia.

Our study improves on the one plausibly quasi-experimental study of menthol bans (Chaiton et al. 2019) in several key ways. First, we use more comprehensive sales data for all provinces over a longer period. Second, we complement the sales data with survey data that allow us to credibly differentiate the effects of menthol bans on youths separately from the effects on adults (which sales data cannot do). Given that most of the policy concern regarding menthol is about youth initiation, this is a major contribution of our work. Another advantage of survey data over sales data is that the former more directly measures actual use

whereas the latter blends changes in use with changes in purchase location. Third, we use gold-standard difference-in-differences methods applied to nationwide data by comparing changes over time in outcomes for ban-adopting provinces coincident with menthol ban implementation to the associated changes over time in outcomes for control provinces that did not adopt menthol bans. This more comprehensive scope increases the generalizability of our findings. Finally, we consider a wider range of outcomes than in prior work, including not only overall smoking participation and menthol smoking but also substitution to non-menthol cigarettes and to e-cigarettes, as well as evasion to unregulated locations.

By considering a range of substitution and evasion responses, our study relates to a body of research in economics demonstrating how smokers respond to tobacco control regulations, including increased excise taxes, clean indoor air laws, and minimum purchase ages. In particular, a number of studies have demonstrated that stricter tobacco regulations can induce a range of compensating behaviors of smokers. Adda and Cornaglia (2010), for example, find that smokers smoke cigarettes more intensely when cigarette excise taxes increase, resulting in no net change in total nicotine consumed. Evans and Farrelly (1998) find that smokers substitute from light to regular cigarettes in response to higher taxes. Multiple studies show that smokers move to higher quality cigarettes in response to taxes that are invariant to quality (Chiou and Muehlegger 2014, Harding et al. 2012). Several studies also find that higher excise taxes on cigarettes induce cross-border

cigarette smuggling to evade taxes (Stehr, 2005), while other research examines Native American reservations as an opportunity for cigarette tax evasion (DeCicca et al., 2015). Carpenter et al. (2011) show that Canadian local clean indoor air laws reduce non-smokers' exposure to cigarette smoke inside public buildings but increase non-smokers' exposure to cigarette smoke just outside buildings. Thus, our study contributes to a large literature on the intended and unintended consequences of stricter tobacco control.

3. Data Description, and Empirical Strategy

3.1 Data Description

To understand the effects of provincial menthol bans, we obtained data on menthol and non-menthol cigarette sales by province and month for 2012-2018 from Health Canada. We supplement the provincial cigarette sales data with two independent large surveys with information on menthol cigarette smoking and related outcomes: the Canadian Student Tobacco, Alcohol and Drugs Survey (CSTADS) and the Canadian Tobacco, Alcohol and Drugs Survey (CTADS) (formerly, the Canadian Tobacco Use Monitoring Survey (CTUMS)). CSTADS interviews approximately 40,000 students in grades 6-12 (i.e., age 11-17) across Canada every two years, providing timely and reliable national data on tobacco, alcohol and drug use and other related issues of Canadian students. Recruitment of schools and school districts for each survey cycle begins in June, with data collection starting in

October-December and ending by May of next year. The average student response rate is 66% (Burkhalter et al., 2018). Meanwhile, CTADS (and its predecessor, CTUMS) is a general population survey of tobacco, alcohol and drug use among Canadians aged 15 years and older. While CTUMS interviewed nearly 20,000 individuals annually between 1999 and 2012, CTADS surveys 15,000 persons biennially from 2013 with an average response rate of 70%. Both CSTADS and CTADS are designed to be representative at the province level.

Both CSTADS and CTADS contain questions on cigarette smoking, including whether the respondent reported smoking 100 cigarettes in their lifetime, as well as whether they smoked cigarettes within the past 30 days.[8] Past month smokers are also asked about whether they have ever tried to quit smoking. Both CSTADS and CTADS also ask respondents about menthol cigarette use, though the specific questions that allow us to distinguish past 30 day menthol cigarette use from non-menthol use were only asked in CTADS in 2015 and 2017. For youths in the CSTADS we have data on menthol and non-menthol cigarette use back to 2010. Adults in the CTADS were also asked about whether they have ever tried smoking a menthol cigarette, and past 30 day smokers in the CTADS were also asked whether their usual brand is menthol. To measure other substitution patterns, both CSTADS and CTADS ask respondents about e-cigarette use in the past 30 days,

[8] See Appendix Tables 2 and 3 for detailed question wording and years each question was asked.

though neither specifically asks about menthol-flavored e-cigarette use. Finally, CTADS (but not CSTADS) includes questions about whether within the past six months the respondent purchased cigarettes from a First Nations reserve (where menthol bans do not bind), as well as whether the respondent purchased cigarettes from a gas station or grocery store not on a First Nations reserve.

Each of the surveys we use has its own strengths and weaknesses. CSTADS has a much larger sample size but lacks detailed information on survey timing. In contrast, CTADS has a more modest sample size but includes information on month of interview that we can use to more accurately assign exposure to menthol bans. CTADS also has a wider range of questions about menthol cigarette smoking and location of recent cigarette purchases. For the directly targeted outcome of menthol cigarette smoking, the sample period is longer in CSTADS (2010-2017) than in CTADS (2015-2017), though we note that for outcomes related to any past 30 day smoking we can go back to 2003 in the CTADS data.

For the analysis based on the CTADS, we exclude the period of October – December 2017 as we want to evaluate the provincial bans separately from the federal ban which came into force in October 2017 (and the three months of the last quarter of 2017 are not long enough to credibly estimate effects of the federal ban on outcomes). For CSTADS analyses we also exclude the 2016/17 cycle for Ontario. While this cycle was started in Ontario (November 2016) before its policy introduction (January 2017), it is not possible to assign Ontario respondents into

pre- or post-policy periods due to lack of information on specific survey dates in CSTADS.[9] We explore robustness to this choice below and show that our core results are robust to excluding Ontario entirely.

3.2 Empirical Strategy

We estimate two-way fixed effects models of the following form for the sales data:

$$(1)\ Y_{pt} = \alpha + \beta_1(PROVINCIAL\ MENTHOL\ BAN)_{pt} + \beta_2 Z_{pt} + \beta_3 P_p + \beta_4 T_t + \xi_{pt}$$

where Y_{pt} are the cigarette sales outcomes in province p at time t. *PROVINCIAL MENTHOL BAN* is an indicator variable indicating whether the province has a ban in effect. Z_{pt} is a vector of time-varying provincial variables that includes the provincial unemployment rate, real cigarette price, and an indicator for whether the province has a minimum age restriction for purchasing e-cigarettes.[10] P_p is a vector of province dummies to control for time-invariant differences across provinces. T_t include year indicators (to control for time-specific factors that affect both the treatment and control provinces equally such as federal tobacco policies or secular anti-smoking sentiment) and month indicators (to control for seasonal effects).

For the survey data, we estimate similar models at the individual level:

$$(2)\ Y_{ipt} = \alpha + \beta_1(PROVINCIAL\ MENTHOL\ BAN)_{pt} + \beta_2 X_{ipt} + \beta_3 Z_{pt} + \beta_4 P_p + \beta_5 T_t + \xi_{ipt}$$

[9] In Ontario, CSTADS cycle 2016/17 runs from November 2016 to May 2017. Given that the smoking outcomes under consideration are based on past 30-day use, nearly half of the cycle (i.e., 3 months out of 7 months) can be considered as the pre-policy period.

[10] Other regulations on cigarettes over our time period – including bans on other non-menthol flavors in cigarettes – were primarily federal in nature and thus will be absorbed by the year fixed effects.

where Y_{ipt} are the various outcomes for individual *i* in province *p* at time *t* and where other variables are defined as above.[11] X_{ipt} is a vector of individual demographic characteristics. For analyses using the CSTADS, *X* includes respondents' grade (dummy variables for each grade, with grade 6 as the reference grade), sex (dummy variable for male; female is the excluded category), and aboriginal status. For analyses using the CTADS, *X* includes age, sex (dummy variable for male; female is the excluded category), marital status (a dummy variable for either married or widowed or divorced or separated; never married is the excluded category), household size (continuous variable with 5 levels), and an indicator for residing in an urban area (except for analysis using CTADS 2003-2017 as urban is only available from 2004).

The key identifying assumption underlying these models is that the trends in the outcomes in both the treatment and control provinces would have evolved similarly in the absence of the provincial menthol ban. We estimate equations (1) and (2) using OLS/linear probability models for ease of interpreting the marginal effects (Ai and Norton, 2003; Norton and Dowd, 2018). For statistical inference in

[11] The CTADS has information on survey month, which allows us to match with the policy dates. For the CSTADS, although data on specific months of the interviews in each province are not available, we can infer from the dates of survey (starting in October-December and finished by May of the next year) that among the 7 provinces with bans, 4 provinces (Nova Scotia, New Brunswick, Alberta, and Quebec) adopted the bans between the 2014/15 and 2016/17 cycles. Ontario implemented the ban two months after the 2016/17 cycle started. These 5 provinces are considered as treated provinces (although Ontario is included only for the period up to 2010-2015 in the main analyses). Meanwhile, Prince Edward Island and Newfoundland implemented the bans after the 2016/17 cycle and thus are treated as control provinces throughout the study period.

our context of small number of clusters[12], we use a recently developed method (Carter, Schnepel, and Steigerwald, 2017) that uses the *t*-distribution with G^*-1 degrees of freedom where G^* is effective number of clusters. Below, we show that our results are robust to using the wild cluster bootstrap method (Cameron, Gelbach, & Miller, 2008). All models use sample weights.

4. Results

4.1 Descriptive Statistics, Sales Data

Figure 1 presents monthly sales of menthol cigarettes, by province. Figure 2 presents the same information for non-menthol cigarette sales.[13] Vertical dashed lines represent provincial menthol bans; vertical solid lines represent the federal menthol ban. Several patterns are clear from Figure 1 for provincial menthol sales. First, bans are clearly effective at eliminating menthol cigarette sales. For the provinces that adopted bans, provincial menthol sales fall to zero immediately after provincial ban implementation. For the provinces that did not adopt provincial bans, menthol sales fall to zero immediately after the federal ban. Second, there is evidence of stockpiling behavior coincident with announcement but prior to implementation of bans. This is true for provincial bans in Ontario, Quebec, Newfoundland and Labrador, and Prince Edward Island. It is also visible for the

[12] There are 10 clusters (i.e., 10 provinces). For the survey data, 7 clusters (in CTADS) and 5 clusters (in CSTADS) are treated.
[13] Appendix Table 4 presents descriptive statistics for the sales data.

provinces that did not adopt provincial bans prior to the implementation of the federal ban. This stockpiling behavior has implications for our analyses of survey data, as it is possible that individuals continue to smoke menthol cigarettes after ban adoption because they have access to menthol cigarettes that were purchased prior to bans being enforced.[14] Finally, there is not much evidence of a substitution response in Figure 2 for non-menthol cigarette sales by province. That is, we do not see evidence of a persistent increase in non-menthol sales after provincial menthol bans are adopted.

4.2 Effects of Menthol Bans, Sales Data

Table 1 presents regression estimates from equation (1) corresponding to the provincial sales data shown in Figures 1 and 2. The results in Table 1 confirm what is visually apparent in Figure 1, namely, that provincial menthol bans significantly reduced menthol cigarette sales. Relative to the baseline mean in treatment provinces, the bans eliminated menthol cigarette sales. Moreover, there is no statistically significant association between provincial menthol bans and sales of non-menthol cigarettes: the point estimate is very small relative to the average non-menthol cigarette sales in treatment provinces in 2012, and it is not statistically significant.

[14] There are a handful of province-month observations where menthol cigarette sales are negative. None of our results are sensitive to recoding those observations to be zero.

In Figure 3 we present the event study estimates corresponding to the models in Table 1 where instead of controlling for the provincial ban directly we report coefficients on event time indicators relative to the timing of adoption of the menthol ban in each province. As suggested from Figure 1, the left panel of Figure 3 shows no evidence of systematic pre-trends prior to provincial menthol ban adoption and an immediate and sustained reduction in menthol cigarette sales. Moreover, the right panel of Figure 3 shows no meaningful effect of provincial menthol bans on sales of non-menthol cigarettes within a province. Taken together, the results in Figures 1-3 and Table 1 confirm that provincial menthol bans immediately eliminated sales of menthol cigarettes within the provinces that adopted bans, with no clear evidence of effects on non-menthol cigarette sales.

4.3 Descriptive Statistics, Survey Data

Figure 4 presents trends in past 30 day cigarette smoking, past 30 day menthol cigarette use, and past 30 day non-menthol cigarette use for youths in treatment and control provinces (i.e., provinces that did and did not adopt menthol bans between 2015 and 2017). For past 30 day cigarette smoking there is a reduction in smoking observed for youths in both treatment and control provinces, with no obvious difference in the most recent wave when bans went into effect. In contrast, the menthol cigarette smoking rate appears to diverge by provincial treatment status coincident with adoption of provincial menthol bans: youths in ban-adopting provinces report less menthol cigarette use in the most recent period, while youths

in non-adopting provinces report slightly more menthol cigarette use. Importantly, the trends in menthol cigarette use prior to ban adoption are broadly similar. For non-menthol use we see patterns that are somewhat mirroring those observed for menthol cigarette use: in the most recent post-ban period, youths in ban-adopting provinces report slightly more non-menthol cigarette use while youths in non-adopting provinces continue their trend downward for that same outcome. The raw trends in Figure 4 are thus suggestive of an effect of provincial menthol bans at reducing menthol cigarette use and possibly increasing non-menthol cigarette use, though more formal testing is needed.

Figure 5 shows the associated trends for adults for those same outcomes.[15] Note that for the past 30 day cigarette use the CTADS data permit us to go back to 2003, but we can only distinguish between menthol and non-menthol use in 2015 and 2017. For past 30 day cigarette use by adults in Figure 5 the pre-trends across treatment and control provinces track each other very well until the period of menthol ban adoption at which time smoking rates increase sharply in the non-adopting provinces but only modestly in the ban-adopting provinces. For menthol

[15] Appendix Table 5 presents descriptive statistics for youths and adults from the CSTADS and CTADS data in columns 1 and 2, respectively. For youths, about half the sample is male, the majority of youths are in the higher grades, and less than five percent is Aboriginal. For adults, the average age is 46.8 years, half the sample is male, 78.3 percent is married, and 81 percent reside in urban areas. Regarding exposure to the bans, 16.3 percent of youths and 5.9 percent of adults are observed in a province at a time when a menthol ban is in effect. Regarding smoking, 7.6 percent of youths and 17.8 percent of adults report past month smoking. Menthol cigarette use is low on average: 2.8 percent of youths and 1.6 percent of adults report past month menthol cigarette use. Finally, about 11.5 percent of adults report having purchased cigarettes from a First Nations reserve in the past six months.

cigarette use by adults in Figure 5 we see that menthol use actually increased between 2015 and 2017 in control provinces but fell over that same time period in treatment provinces. For non-menthol use we see that rates increased for adults in both treatment and control provinces, but the increase was steeper for adults in the control provinces. We also show trends in the likelihood of First Nations reserve purchases for adults in Figure 5 (this outcome is not asked in CSTADS for youths). As with past 30 day smoking, the longer-term pre-trends in this outcome track closely for treatment and control provinces, but during the period of ban adoption First Nations reserve purchases fall sharply in control provinces but do not fall in treatment provinces.[16]

In Table 2 we present descriptive evidence on heterogeneity in menthol cigarette smoking preferences. For each demographic group (presented in the rows) we show the population rate of past 30 day cigarette smoking in column 1, the population rate of past 30 day menthol cigarette smoking in column 2, and the menthol cigarette smoking rate among past 30 day smokers in column 3. Panel 1 shows these outcomes for youths aged 11-17 in the CSTADS versus adults aged 19+ in the CTADS. Panel 2 shows the patterns separately for aboriginal youths and non-aboriginal youths; panel 3 shows patterns separately for male and female youths; and panel 4 shows patterns separately for youths in grades 6-8 versus youths

[16] Below, we address concerns about offsetting behavior in the control provinces in the CTADS data for past 30 day cigarette consumption and First Nations reserve purchases by showing that our core results are robust to excluding non-adopting provinces one at a time.

in grades 9-12. Panel 5 shows patterns separately for male and female adults; panel 6 shows patterns separately for rural and urban adults; and panel 7 shows patterns separately for married and unmarried adults.

The patterns in Table 2 replicate patterns from the US in several respects. Most importantly, although population rates of youth smoking are lower than population rates of adult smoking, conditional on smoking youths use menthol cigarettes at a nearly three times higher rate than adults. We also observe that menthol cigarette preferences are stronger among aboriginal youths compared to non-aboriginal youths, though these differences are much smaller than the youth versus adult comparison. Although young males have higher smoking rates than young females, we do not observe strong differences in their menthol preferences across gender. Older youths in grades 9-12 have higher smoking rates and stronger menthol preferences than younger youths in grades 6-8.

For adults, we find that overall rates of menthol use are low, though we do find some differences in menthol preferences compared to the patterns for youths. For example, we find that adult women have stronger menthol preferences than those of adult men, and this difference is much larger than the associated pattern for youths. Urban adults also have stronger menthol preferences than rural adults, and unmarried adults have stronger menthol preferences than married adults, a pattern that is likely to be driven primarily by age differences related to marital status.

4.4 Effects of Menthol Bans, Survey Data

In Table 3 we present difference-in-differences estimates of the effects of the menthol bans on menthol cigarette smoking. We present results for youths aged 11-17 from the CSTADS data in the top panel and for adults aged 19+ from the CTADS data in the bottom panel of Table 3. We show results for the likelihood of 'Any Past 30 Day Menthol Cigarette Smoking' in column 1; for the likelihood of 'Ever Tried Smoking a Menthol Cigarette' in column 2; and for the likelihood that the 'Usual Brand of Cigarette is Menthol' (conditional on any past month smoking) in column 3. The latter two outcomes were only asked in the CTADS.

The results in Table 3 confirm the findings from Figure 1 and Table 1 and provide strong evidence that Canada's provincial menthol bans were effective at reducing menthol cigarette smoking. Specifically, we estimate that for youths aged 11-17 in the top panel of column 1 of Table 3, provincial menthol bans were associated with a statistically significant 2.4 percentage point reduction in the likelihood of any past 30 day menthol cigarette smoking. For adults in the bottom panel of Table 3 we also estimate that provincial menthol bans were associated with statistically significant reductions in menthol cigarette smoking on the order of 3.1 percentage points.[17] Moreover, the results in the bottom panel of columns 2 and 3

[17] Note that the survey data do not indicate that the bans completely eliminated menthol smoking, which is somewhat puzzling. There are several possibilities here, including: stockpiling behavior, incomplete compliance and enforcement, and smuggling of illegal menthol cigarettes from other provinces or areas such as First Nations reserves. Grant (2019) describes the problem of contraband tobacco throughout Canada, noting that federal officials estimate that there are 50 illegal cigarette

of Table 3 also confirm that menthol bans significantly reduced the likelihood of ever having tried a menthol cigarette and the likelihood that smokers report their usual brand of cigarette is menthol. Taken together, the findings of Table 3 confirm that menthol bans were enforced and induced meaningful reductions in menthol cigarette use.[18]

In Figure 6 we show CSTADS results from event study models where we explicitly show how menthol cigarette use varies in ban-adopting (i.e., treatment) versus non-adopting (i.e., control) provinces relative to the timing of ban implementation. As CSTADS has 4 policy cycles for all outcomes, we re-estimate the same regression model but replace the single policy indicator variable by 3 event time indicators corresponding to the 2010/11, 2012/13, and 2016/17 cycles (with the cycle 2014/15 just before the ban as the reference). The coefficients on the event time indicators shown in the top right panel of Figure 6 for youths indicate no systematic differences in pre-policy trends between the control and treatment groups in the pre-policy period. Moreover, the relative reduction in menthol smoking appears immediately after ban adoption.[19]

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factories and over 300 illegal smoke shops operating in the country. We revisit some of these alternative channels below.

[18] Regression estimates for control variables are reported in Appendix Tables 6 and 7 for youths and adults, respectively. Among youths, males and aboriginals are more likely to smoke menthol cigarettes compared with females and non-aboriginals, respectively. As expected, higher grade students are more likely to use any cigarettes, including menthol cigarettes. Higher age was associated with lower cigarette use among adults. Adult males are more likely to use cigarettes than adult females, and married adults are less likely to use cigarettes than unmarried adults.

[19] Given that we have just two CTADS waves of data for adults that include information on menthol and non-menthol use, we cannot implement similar event study models for those outcomes. For

Appendix Table 8 investigates the robustness of the estimated reductions in menthol smoking rates observed for youths and adults in Table 3. We reprint the baseline estimate from Table 3 in column 1 of Appendix Table 8 for reference. In column 2, we show that the main finding is not sensitive to excluding the other province-time varying smoking controls (real cigarette price, minimum age for e-cigarette access). In column 3 we show p-values from the Wild cluster bootstrap procedure (Cameron et al. 2008) and find that the estimated reductions in menthol cigarette smoking survive this adjustment. In columns 4-7 we show robustness to individually excluding the large ban-adopting provinces: Ontario, Alberta, Quebec, and the maritime provinces of Nova Scotia, New Brunswick, and Prince Edward Island, respectively. The results confirm that no single province is driving the estimated reduction in menthol cigarette smoking associated with the provincial menthol bans for either youths (top panel) or adults (bottom panel).[20] Finally, in column 8 of Appendix Table 8 we show results where we exclude any province that adopted a menthol ban and that exhibited stockpiling behavior in Figure 1 (Ontario, Quebec, Newfoundland and Labrador, and Prince Edward Island). Doing so does not fundamentally alter our main conclusions on menthol cigarette smoking.

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other CTADS outcomes where we observe smoking-related outcomes over a longer period we are able to implement event study models, and those are presented in Figure 7.

[20] The range of estimates when excluding individual provinces may also reflect evasion opportunities, as distance to the nearest province without a menthol ban is likely to be relevant. For example, the most populated province without a menthol ban is British Columbia. Excluding Alberta returned noticeably larger estimated effects of provincial menthol bans at reducing menthol use, perhaps suggesting that Alberta residents found it easier to evade the bans by travelling to nearby British Columbia to purchase menthol cigarettes.

In results not reported but available upon request, we also investigated robustness of our main findings to address a range of other concerns. For example, similar to excluding ban-adopting provinces one at a time, we also examined models where we dropped each control (i.e., non-adopting) province one at a time. Our estimated reductions in menthol cigarette use were robust to these sample restrictions for both youths and adults. We also estimated models using probit regression instead of linear probability models, and we estimated models without sample weights. Our results on menthol cigarette use were not sensitive to either of these choices. Additionally, we estimated models of menthol cigarette smoking that excluded controls for cigarette prices, which may be endogenous to outcomes, and our results were not meaningfully affected for either youths or adults. Related to this, we found no meaningful reduced form relationship between provincial menthol bans and cigarette prices.[21] Finally, we also examined whether forward looking behavior of individuals in provinces that adopted bans relatively late could have affected our estimates, as the federal ban was drafted in November 2016, finalized in April 2017, and reported in the media. To address this possibility, we estimated models excluding Ontario, Prince Edward Island, and Newfoundland and Labrador, all of which adopted menthol bans in 2017. Excluding these three

[21] Our provincial cigarette price measure does not separately identify menthol cigarette prices from non-menthol cigarette prices, however.

provinces did not meaningfully affect the finding that menthol bans significantly reduced menthol cigarette smoking among youths and adults.

In Table 4 we explore heterogeneity in the effects of provincial menthol bans at reducing menthol cigarette smoking. The broad format follows Table 2 in that we make the same demographic comparisons between youths and adults in the top panel, between aboriginal youth and non-aboriginal youth in the next panel, and so forth. In column 1 we report the pre-ban rate of menthol use in the full population for the group identified in each row, and in column 2 we report the estimated effect of the menthol ban on past 30 day menthol cigarette use from the fully saturated model with province and time fixed effects, other time-varying provincial controls, and individual covariates.

The patterns in Table 4 reveal that the effects of the provincial menthol bans at reducing menthol cigarette use were widespread across demographic groups. We find meaningful reductions in cigarette smoking for every subsample except younger youths in grades 6-8 and rural adults. These patterns are consistent with the idea that the menthol bans were mostly enforced as suggested by the very large estimated reductions in menthol use relative to pre-reform levels.[22]

In Table 5 we investigate the effects of provincial menthol bans on a variety of responses that could reflect substitution and evasion behaviors, which most of

[22] Below, we further investigate the rural vs. urban distinction and find that the lack of estimated effect on menthol cigarette smoking for rural adults may be due to their closer proximity to alternative sources such as First Nations reserves.

the prior public health literature has not studied. Specifically, we examine past 30 day use of non-menthol combusted cigarettes in column 1; past 30 day use of e-cigarettes in column 2; an indicator for having purchased cigarettes from a First Nations reserve in the past 6 months in column 3; and an indicator for having purchased cigarettes from a store or gas station not on a First Nations reserve in the past 6 months in column 4. The last two outcomes are only available for adults in the CTADS. Notably, provincial menthol bans are not binding on First Nations reserves, so it is plausible that adults may have responded to a provincial ban by changing the location of purchase to this type of exempt entity. Similar evidence from the United States suggests that cigarette purchases from Native American reservations to avoid excise taxes are quite common (Carpenter and Mathes, 2016; DeCicca et al., 2002; Harding et al., 2012).

The results in Table 5 return strong evidence that individuals responded to provincial menthol bans in a variety of ways that are consistent with substitution and evasion. Specifically, the results in the top panel for youths indicate that menthol bans were associated with statistically significant increases of 1.7 percentage points in the likelihood of past 30 day non-menthol cigarette smoking, consistent with the idea that young menthol smokers switched from menthol cigarettes to non-menthol cigarettes in response to the bans. The other possible substitution that the public health literature has identified as a target of concern is e-cigarettes, which we examine in column 2 of Table 5. We find no evidence that

provincial menthol bans were associated with statistically or economically meaningful increases in e-cigarette use; in fact, the point estimate is negative and very large relative to pre-reform levels for youths in the top panel, consistent with the idea that menthol cigarettes and e-cigarettes are complements as opposed to substitutes in consumption.

For adults, we find no evidence of substitution from menthol to non-menthol cigarette smoking in the bottom panel of column 1 of Table 5; the point estimate is sizable and negative. We similarly find no evidence that adults substituted toward e-cigarettes in response to provincial menthol bans. The coefficient on the provincial menthol ban dummy is negative and statistically significant, providing evidence that menthol cigarettes and e-cigarettes are complements and not substitutes in consumption for adults.[23]

Finally, the bottom panel of columns 3 and 4 of Table 5 provide strong evidence of another behavioral response to provincial menthol bans: evasion. Specifically, we estimate that menthol bans were associated with statistically significant increases in the likelihood a respondent reports that she purchased cigarettes on or from a First Nations reserve in the past six months, an effect on the

[23] This finding is consistent with Abouk and Adams (2017) and Cotti et al. (2018) who find evidence that e-cigarettes and combustible cigarettes are complements in consumption for youths in the MTF study and adults in the Nielsen consumer panel, respectively. Those studies do not examine menthol cigarettes specifically, however. In Appendix Table 9 we also show that there is no evidence that provincial menthol bans meaningfully affected past year marijuana or alcohol use for either youths or adults.

order of 4.3 percentage points. This is very large relative to the pre-reform mean and is most consistent with substitution behavior from regulated sources to unregulated sources. The bottom panel of column 4 of Table 5 indicates that purchases that were shifted toward First Nations reserves were shifted away from gas stations and grocery stores not located on First Nations reserves.[24] Taken together, the results in Table 5 indicate that behavioral responses in the form of substitution to non-menthol cigarettes by youths and evasion toward First Nations reserve purchases by adults likely blunted some of the overall intended impact of provincial menthol bans.[25]

Finally, in Table 6 we examine the effects of provincial menthol bans on population smoking outcomes. Column 1 shows results for the 'Ever Smoked 100 or More Cigarettes in Whole Life' outcome, column 2 shows results for the 'Past

[24] We unfortunately do not observe detailed sub-province information on residential location of the CTADS respondents, so we cannot directly test whether these effects are larger for individuals located nearer to First Nations reserves. Moreover, First Nations reserves are found in every province throughout Canada, so province-based sample restrictions are not particularly informative. We have, however, run models separately for rural versus urban respondents in the CTADS under the reasoning that the First Nations reserves are disproportionately found in rural areas, so rural residents are plausibly closer to a reserve than are urban residents. These results are reported in Appendix Table 10 and confirm that the evasion effects for purchases on First Nations reserves are much larger for individuals in rural areas than for individuals in urban areas (an 8.7 versus a 3.2 percentage point increase in columns 2 and 3, respectively).

[25] Appendix Table 11 shows that the substitution and evasion outcomes for adults and youths, respectively, are also largely robust along the same lines as the menthol use reductions shown in Appendix Table 8. Of particular note in Appendix Table 11 is column 8, which shows that our results on substitution for youths and evasion by adults are both robust to excluding ban-adopting that exhibit stockpiling behavior. This is important because it helps rule out that the ban-related increases in non-menthol cigarette smoking by youths are simply reporting artifacts, since for the sample in column 8 of Appendix Table 11, there are not likely to be stockpiled menthol cigarettes available. Figures 6 and 7 for youths and adults, respectively, confirm that event study models also return evidence that menthol bans increased youths' use of non-menthol cigarettes and increased adults' purchases of cigarettes from First Nations reserves.

30 Day Smoker' outcome, and column 3 shows results for the 'Ever Tried to Quit Smoking' outcome (conditional on any past 30 day smoking). The results in Table 6 provide no evidence that menthol bans affected cigarette smoking participation among youths in the top panel. All estimates are very small in magnitude and not statistically significant. For adults in the bottom panel we estimate that provincial menthol bans significantly reduced lifetime smoking, but this is not observed for past month smoking or quit attempts. Taken together, the mostly null findings in Table 6 provide little support for the idea that menthol bans would be an effective means of reducing overall rates of cigarette smoking in the population, and this is especially true for youths.

5. Discussion and Conclusion

This study is the first to our knowledge to estimate the intended and unintended effects of large-scale bans on menthol flavors in cigarettes on a range of smoking outcomes for youths and adults. Concerns that menthol flavoring enables youth smoking and makes it harder for adults to quit have generated much policy interest and public health literature on menthol bans, but research directly evaluating the effects of such bans is scarce. We sought to fill this gap by studying the experience of Canada where several provinces banned menthol cigarettes at different times from 2015-2017.

Our findings that provincial menthol bans significantly reduced menthol cigarette sales and self-reported menthol cigarette smoking among youths and adults are broadly consistent with the results from both the public health studies looking at planned responses and the one pre-post treatment-control design paper (Chaiton et al. 2019). This finding is also in line with a prior government report using sales data on menthol cigarettes in Canada (Health Canada, 2017), though we provide a more comprehensive evaluation by using sales data from all provinces spanning the entire period of provincial and federal ban adoptions.

While the reductions on menthol cigarette use are largely 'mechanical', our other findings on overall cigarette use, quit attempts, and substitution and evasion mechanisms are more novel and have not been systematically examined in prior work. These outcomes also directly address the main reasons that public health officials give for adopting menthol bans in the first place. In the words of former FDA commissioner Scott Gottlieb, "menthol-flavored products represent one of the most common and pernicious routes by which kids initiate on combustible cigarettes." Our results are not consistent with this broad claim for youths aged 11-17: banning menthol did not reduce smoking initiation by these youths as measured by the likelihood they smoked 100 cigarettes in their lifetime. We similarly did not find evidence that menthol bans reduced smoking among adults. We also found that the lack of systematic reductions in overall smoking rates is due to two factors: first, youths substituted toward non-menthol cigarettes; and second, adults evaded

the new regulation by shifting purchases toward First Nations reserves which are exempt from compliance.

Although ours are the first comprehensive quasi-experimental results on the effects of menthol bans in a large developed country, we are of course aware of possible external validity concerns. Europe has a broadly similar policy landscape to Canada, having banned non-menthol flavors in 2013 and is expanding it to menthol flavors in 2020. Moreover, Europe's menthol use rate is similar to Canada's (7% vs. 5%, respectively) (Zatoński et al., 2018). While the demographic makeup of Europe is more diverse than that of Canada, our findings are likely to be broadly applicable in that setting. For the US, in contrast, there may be more serious generalizability concerns, as the market share for menthol cigarettes is much larger in the US (30%) than in Canada (5%). The smaller size of menthol cigarette market in Canada might help explain the lack of illegal markets for menthol cigarettes in Canada following the bans (which, in turn, could have contributed to the effectiveness of the Canadian menthol bans at reducing menthol cigarette use). Another difference with the US is the demographic concentration of menthol cigarette use among African Americans in the US, which is not true in Canada.

Our study is subject to some limitations. First, due to the timing of our data relative to the provincial menthol ban variation, we are only able to study very short-term effects. Thus, although our estimates are timely, it is certainly possible that the medium or longer term effects might be different. Second, the pre-ban study

periods are short for the menthol and non-menthol cigarette smoking outcomes for adults, which limited our ability to address pre-trends in CTADS for those two outcomes. Third, survey respondents may be more likely to report having stopped smoking menthol cigarettes because of desirability bias. That we find evidence of substitution to non-menthol cigarettes for youths and a shift toward First Nations reserve purchases for adults in Table 5, however, suggests that the effects we identify are likely real. Fourth, because the CSTADS data are completed at schools, we cannot account for high school dropouts or other students who were absent on the day of the survey, though it is unlikely that this type of missing data would be systematically correlated with provincial menthol bans.

We are also limited in making strong welfare conclusions about the effects of menthol bans. Individuals who strongly prefer smoking menthol suffer utility loss from the menthol ban but may potentially gain utility from improved health. Unfortunately, the literature on the possibility of differential health effects of menthol vs. non-menthol cigarettes is not completely settled, and it is also possible that there are differential health effects of menthol cigarettes previously sold on the open market and menthol cigarettes sold on First Nations reserves. Moreover, the menthol bans may themselves result in changes in quality of menthol cigarettes produced and sold on First Nations reserves or via contraband sources since they now face much less competition. For these reasons, drawing strong welfare conclusions about the effects of menthol bans is beyond the scope of this project.

Despite these limitations, our study represents to our knowledge the first comprehensive quasi-experimental evidence on the effects of menthol bans and clearly indicates a range of tradeoffs that have not been considered by prior work. Future economics research and policymaker discussions on these increasingly popular policy instruments should take account of these findings to design the most effective approach for regulating menthol cigarette use specifically and population smoking behaviors in general.

REFERENCES

Abouk, R., Adams, S., 2017. Bans on electronic cigarette sales to minors and smoking among high school students. J Health Econ 54, 17–24. https://doi.org/10.1016/j.jhealeco.2017.03.003

Adda, J., Cornaglia, F., 2010. The effect of bans and taxes on passive smoking. American Economic Journal: Applied Economics 2, 1–32.

Adda, J., Cornaglia, F., 2006. Taxes, cigarette consumption, and smoking intensity. American Economic Review 96, 1013–1028.

Ai, C., Norton, E.C., 2003. Interaction terms in logit and probit models. Economics Letters 80, 123–129. https://doi.org/10.1016/S0165-1765(03)00032-6

Anderson, S.J., 2011. Menthol cigarettes and smoking cessation behaviour: a review of tobacco industry documents. Tob Control 20, ii49–ii56. https://doi.org/10.1136/tc.2010.041947

Belluz, J., 2018. The FDA cracks down on menthol cigarettes and flavored cigars [WWW Document]. Vox. URL https://www.vox.com/science-and-health/2018/11/14/18088468/juul-e-cigarette-menthol-fda-ban (accessed 1.20.19).

Blecher, E., 2008. The impact of tobacco advertising bans on consumption in developing countries. Journal of health economics 27, 930–942.

Borland, R., Wilson, N., Fong, G.T., Hammond, D., Cummings, K.M., Yong, H.-H., Hosking, W., Hastings, G., Thrasher, J., McNeill, A., 2009. Impact of graphic and text warnings on cigarette packs: findings from four countries over five years. Tobacco Control 18, 358–364. https://doi.org/10.1136/tc.2008.028043

Burkhalter, R., Cumming, T., Rynard, V., Schonlau, M., Manske, S., 2018. Research Methods for the Canadian Student Tobacco, Alcohol and Drugs Survey, 2010-2015. Waterloo, Ontario: Propel Centre for Population Health Impact, University of Waterloo.

Cameron, A.C., Gelbach, J.B., Miller, D.L., 2008. Bootstrap-Based Improvements for Inference with Clustered Errors. Rev Econ Stat 90, 414–427. https://doi.org/10.1162/rest.90.3.414

Carpenter, C., Postolek, S., Warman, C.R., 2011. Public-place smoking laws and exposure to environmental tobacco smoke (ETS) in public places. Am Econ J Econ Policy 3(3), 35–61.

Carpenter, C.S., 2009. The Effects of Local Workplace Smoking Laws on Smoking Restrictions and Exposure to Smoke at Work. J. Human Resources 44, 1023–1046. https://doi.org/10.3368/jhr.44.4.1023

Carpenter, C.S., Mathes, M.T., 2016. New Evidence on the Price Effects of Cigarette Tax Competition. Public Finance Review 44, 291–310. https://doi.org/10.1177/1091142115605375

Carter, A.V., Schnepel, K.T., Steigerwald, D.G., 2017. Asymptotic behavior of at-test robust to cluster heterogeneity. Rev Econ Stat 99, 698–709.

Cawley, J., Ruhm, C.J., 2011. Chapter 3 - The Economics of Risky Health Behaviors, in: Pauly, M.V., Mcguire, T.G., Barros, P.P. (Eds.), Handbook of Health Economics, Handbook of Health Economics. Elsevier, pp. 95–199. https://doi.org/10.1016/B978-0-444-53592-4.00003-7

Chaiton, M., Schwartz, R., Cohen, J.E., Soule, E., Eissenberg, T., 2018. Association of Ontario's Ban on Menthol Cigarettes With Smoking Behavior 1 Month After Implementation. JAMA Intern Med 178, 710–711. https://doi.org/10.1001/jamainternmed.2017.8650

Chaiton, M., Schwartz, R., Shuldiner, J., Tremblay, G., Nugent, R., 2019. Evaluating a Real World Ban on Menthol Cigarettes: An Interrupted Time-Series Analysis of Sales. Nicotine & Tobacco Research.

Chaloupka, F.J., Warner, K.E., 2000. Chapter 29 The economics of smoking, in: Handbook of Health Economics. Elsevier, pp. 1539–1627. https://doi.org/10.1016/S1574-0064(00)80042-6

Chicago Tribune, 2010. Blacks divided over possible menthol ban [WWW Document]. chicagotribune.com. URL https://www.chicagotribune.com/living/ct-xpm-2010-11-23-ct-met-menthol-cigarettes-blacks-20101123-story.html (accessed 1.20.19).

Cotti, C., Nesson, E., Tefft, N., 2018. The relationship between cigarettes and electronic cigarettes: Evidence from household panel data. J Health Econ 61, 205–219. https://doi.org/10.1016/j.jhealeco.2018.08.001

Courtemanche, C.J., Palmer, M.K., Pesko, M.F., 2017. Influence of the Flavored Cigarette Ban on Adolescent Tobacco Use. Am J Prev Med 52, e139–e146. https://doi.org/10.1016/j.amepre.2016.11.019

Curtis, C., 2015. Group wants proposed menthol cigarette ban to apply to aboriginal tobacco industry | Montreal Gazette. URL https://montrealgazette.com/news/group-wants-proposed-menthol-cigarette-ban-to-apply-to-aboriginal-tobacco-industry (accessed 7.25.19).

DeCicca, P., Kenkel, D., Liu, F., 2015. Reservation Prices: An Economic Analysis of Cigarette Purchases on Indian Reservations. NTJ 68, 93–118. https://doi.org/10.17310/ntj.2015.1.04

DeCicca, P., Kenkel, D., Mathios, A., 2002. Putting Out the Fires: Will Higher Taxes Reduce the Onset of Youth Smoking? Journal of Political Economy 110, 144–169. https://doi.org/10.1086/324386

D'Silva, J., Amato, M.S., Boyle, R.G., 2015. Quitting and Switching: Menthol Smokers' Responses to a Menthol Ban [WWW Document]. https://doi.org/info:doi/10.18001/TRS.1.1.6

Edgecliffe-Johnson, A., Gray, A., 2018. Big Tobacco prepares to fight proposed ban on menthol cigarettes [WWW Document]. Financial Times. URL

https://www.ft.com/content/56ac9180-ea02-11e8-885c-e64da4c0f981 (accessed 1.20.19).

European Commission, 2018. Press release - "Tobacco consumption still a threat to our societies": Statement by Commissioner Andriukaitis on World No Tobacco Day [WWW Document]. URL http://europa.eu/rapid/press-release_STATEMENT-18-3976_en.htm (accessed 1.20.19).

Gospodinov, N., Irvine, I.J., 2004. Global health warnings on tobacco packaging: evidence from the Canadian experiment. Topics in Economic Analysis & Policy 4.

Grant, G., 2019. Ontario is finally ready to bust contraband tobacco. Here's how Quebec did it | Financial Post. URL https://business.financialpost.com/opinion/ontario-is-finally-ready-to-bust-contraband-tobacco-heres-how-quebec-did-it (accessed 10.10.19).

Harding, M., Leibtag, E., Lovenheim, M.F., 2012. The heterogeneous geographic and socioeconomic incidence of cigarette taxes: Evidence from Nielsen Homescan Data. American Economic Journal: Economic Policy 4, 169–98.

Health Canada, 2017. Tobacco Reporting Regulations Section 13 [WWW Document]. URL https://laws-lois.justice.gc.ca/eng/regulations/SOR-2000-273/

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. Tobacco Control 23, i7–i12.

Kenkel, D., Mathios, A., Wang, H., 2017. Advertising and Health: A Case Study of Menthol Cigarette Advertising and Cigarette Demand. American Journal of Health Economics 4, 263–286. https://doi.org/10.1162/ajhe_a_00097

Machado, F.S., Sinha, R.K., 2007. Smoking cessation: A model of planned vs. actual behavior for time-inconsistent consumers. Marketing Science 26, 834–850.

Maclean, J.C., Pesko, M.F., Hill, S.C., 2018. The Effect of Insurance Expansions on Smoking Cessation Medication Prescriptions: Evidence from ACA Medicaid Expansions. NBER Working Paper.

Moan, I.S. ve, Rise, J., 2006. Predicting smoking reduction among adolescents using an extended version of the theory of planned behaviour. Psychology and Health 21, 717–738.

Nguyen, H.V., 2013. Do smoke-free car laws work? Evidence from a quasi-experiment. J Health Econ 32, 138–148.

Norton, E.C., Dowd, B.E., 2018. Log Odds and the Interpretation of Logit Models. Health Serv Res 53, 859–878. https://doi.org/10.1111/1475-6773.12712

O'Connor, R.J., Bansal-Travers, M., Carter, L.P., Cummings, K.M., 2012. What would menthol smokers do if menthol in cigarettes were banned?

Behavioral intentions and simulated demand. Addiction 107, 1330–1338. https://doi.org/10.1111/j.1360-0443.2012.03822.x

Pearson, J.L., Abrams, D.B., Niaura, R.S., Richardson, A., Vallone, D.M., 2012. A Ban on Menthol Cigarettes: Impact on Public Opinion and Smokers' Intention to Quit. Am J Public Health 102, e107–e114. https://doi.org/10.2105/AJPH.2012.300804

Reuters, 2014. U.S. judge tosses FDA panel report on menthol cigarettes. Reuters.

Schwartz, R., Chaiton, M., Borland, T., Diemert, L., 2018. Tobacco industry tactics in preparing for menthol ban. Tobacco Control 27, 577–577. https://doi.org/10.1136/tobaccocontrol-2017-053910

Stehr, M., 2005. Cigarette tax avoidance and evasion. Journal of Health Economics 24, 277–297. https://doi.org/10.1016/j.jhealeco.2004.08.005

Wackowski, O.A., Manderski, M.T.B., Delnevo, C.D., 2014. Young Adults' Behavioral Intentions Surrounding a Potential Menthol Cigarette Ban. Nicotine Tob Res 16, 876–880. https://doi.org/10.1093/ntr/ntu003

Wickham, R.J., 2015. How Menthol Alters Tobacco-Smoking Behavior: A Biological Perspective. Yale J Biol Med 88, 279–287.

World Health Organization, 2019. Tobacco [WWW Document]. URL https://www.who.int/news-room/fact-sheets/detail/tobacco (accessed 8.28.19).

World Health Organization, 2016. Banning Menthol in Tobacco Products -- WHO Study Group on Tobacco Product Regulation (TobReg) [WWW Document]. URL https://apps.who.int/iris/bitstream/handle/10665/205928/9789241510332_eng.pdf;jsessionid=DA5562F19F31DBDFA39EDF0BCE34DA52?sequence=1

Zatoński, M., Herbeć, A., Zatonski, W., Przewoźniak, K., Janik-Koncewicz, K., Mons, U., Fong, G.T., Demjen, T., Tountas, Y., Trofor, A.C., 2018. Characterising smokers of menthol and flavoured cigarettes, their attitudes towards tobacco regulation, and the anticipated impact of the Tobacco Products Directive on their smoking and quitting behaviours: The EUREST-PLUS ITC Europe Surveys. Tobacco Induced Diseases 16, A4.

Figure 1: Trends in Menthol Cigarette Sales, by Province
The provincial bans are represented by the vertical dashed lines.
The federal ban is represented by the vertical solid line.

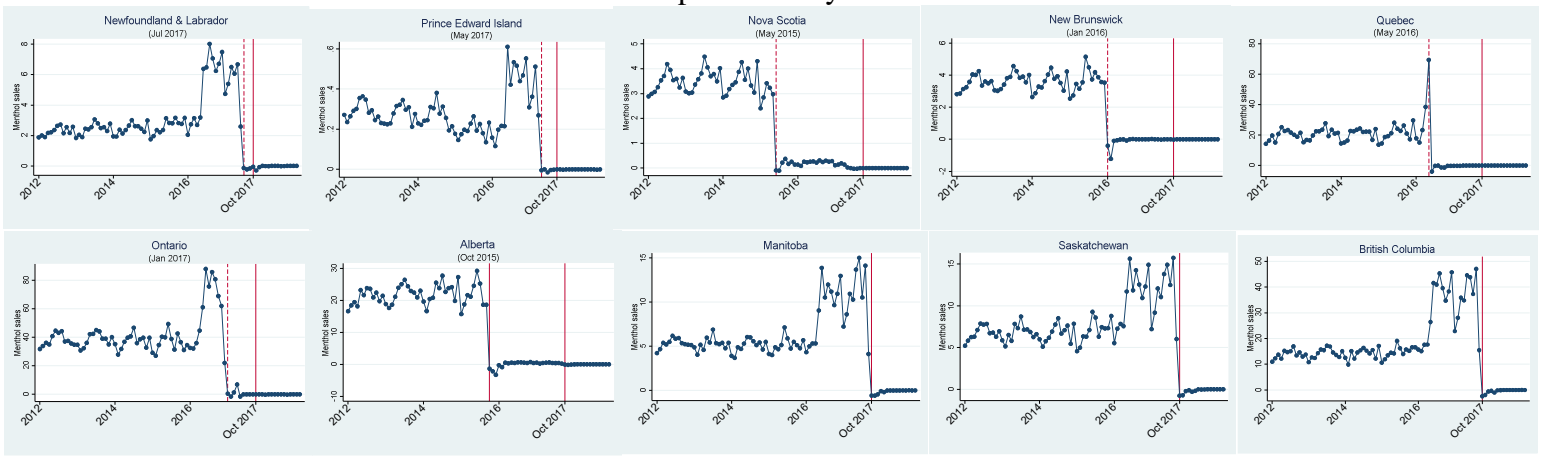


Figure 2: Trends in Non-Menthol Cigarette Sales, by Province
The provincial bans are represented by the vertical dashed lines.
The federal ban is represented by the vertical solid line.

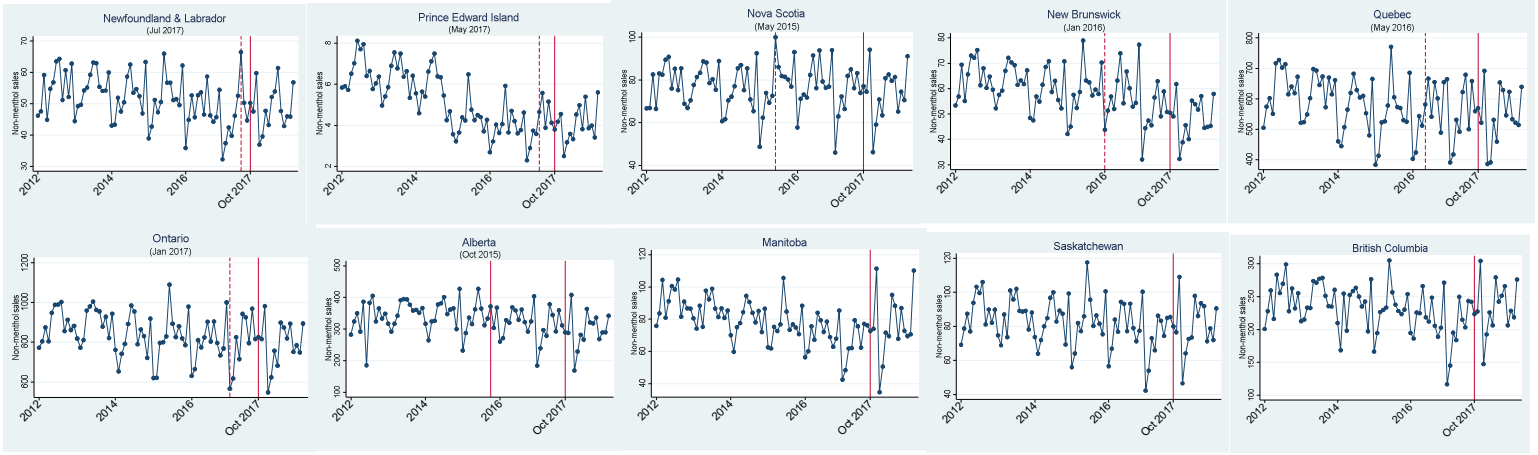


Figure 3: Event studies on Provincial Menthol Bans, Menthol and Non-Menthol Sales

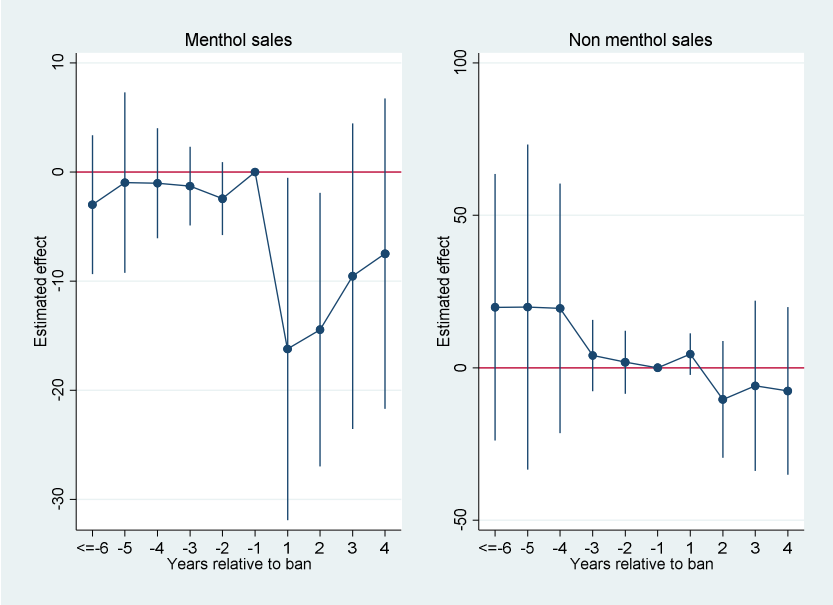
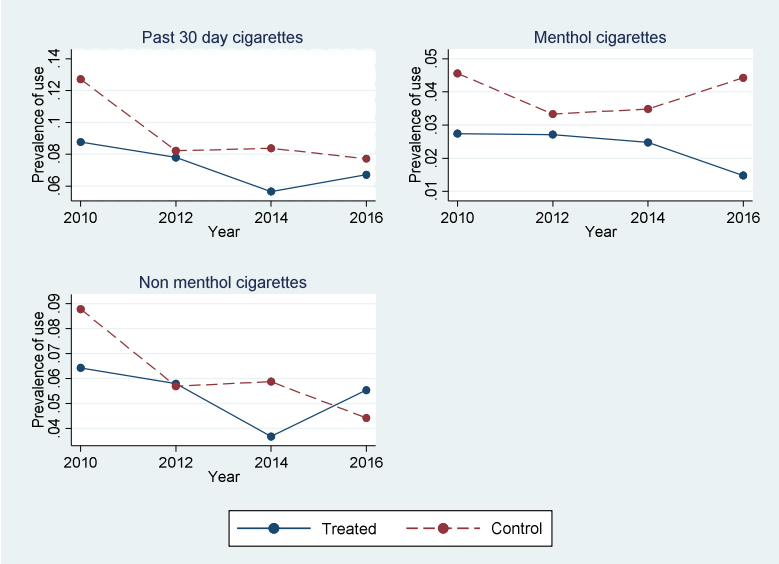
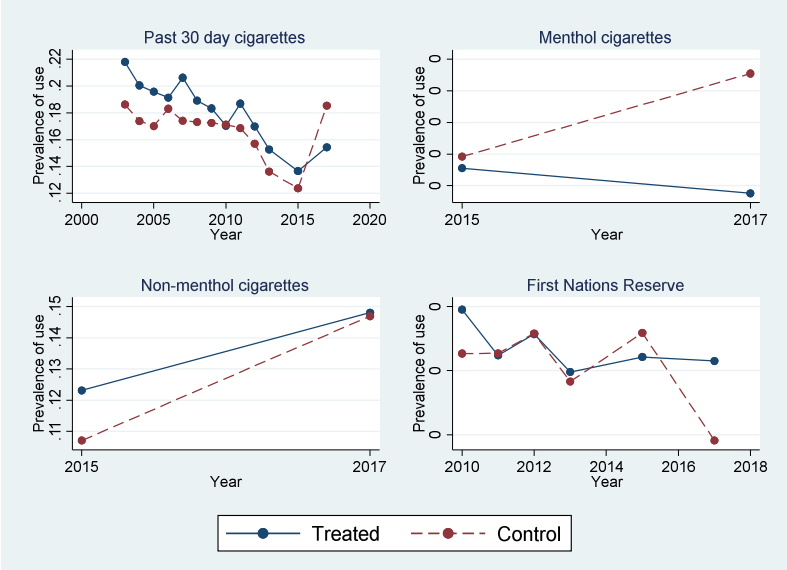


Figure 4: Yearly Trend in Outcomes, Treated vs. Control Provinces, Age 11 – 17 (CSTADS data)



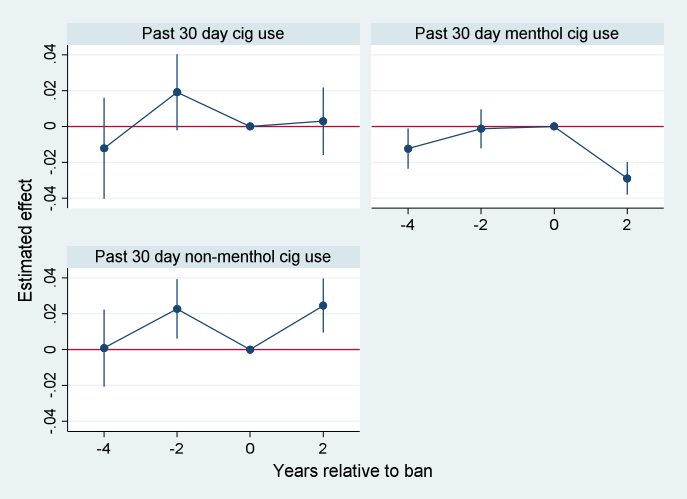
Note: CSTADS 2010-2017. Treatment provinces are Nova Scotia, New Brunswick, Alberta, Quebec and Ontario and control provinces are Prince Edward Island, Newfoundland and Labrador, Manitoba, British Columbia, and Saskatchewan.

Figure 5: Yearly Trend in Outcomes, Treated vs. Control Provinces, Age 19+ (CTADS data)



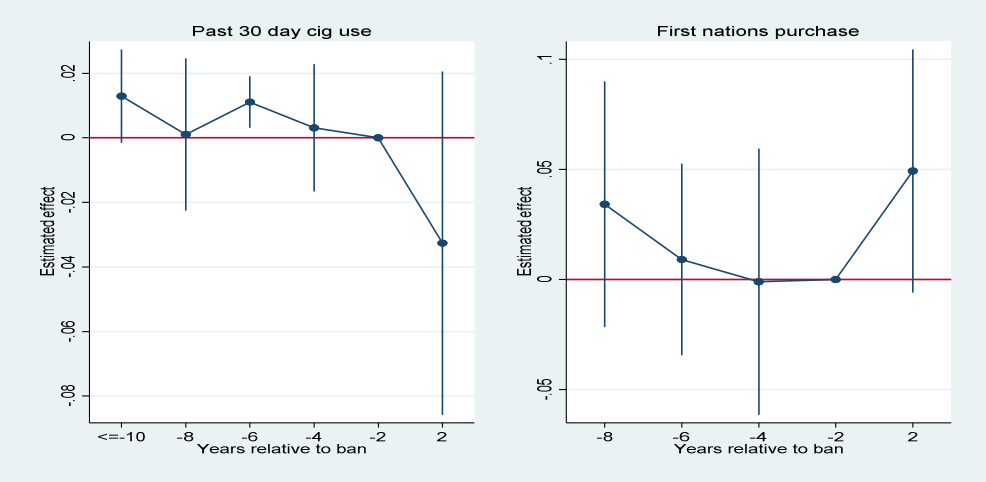
Note: CTADS 2015-2017 for menthol cigarette and non-menthol cigarette outcomes, CTUMS/CTADS 2003-2017 for any cigarette use and CTUMS/CTADS 2010-2017 for purchase from First Nations Reserve outcome. Treatment provinces are Nova Scotia, Alberta, Quebec, Ontario, Prince Edward Island, New Brunswick and Newfoundland and Labrador, and control provinces are Manitoba, British Columbia and Saskatchewan.

Figure 6: Event Study Estimates, Age 11-17 (CSTADS data)



Note: CSTADS 2010-2017. X-axis represents CSTADS cycles. Shown are estimated effects from difference-in-differences regressions in which a single policy indicator variable is replaced by a series of event time indicators for CSTADS cycles before and after the ban implementation in each province. First CSTADS cycle pre-policy (2014/15) is the reference time period.

Figure 7: Event Study Estimates, Age 19+ (CTADS data)



Note: CTUMS/CTADS 2003-2017 for any cigarettes and 2010-2017 for first nations reserve. X-axis represents 2-yearly intervals to date of ban implementation. Shown are estimated effects from difference-in-differences regressions in which a single policy indicator variable is replaced by a series of event time indicators for 2-yearly intervals before and after the ban implementation in each province. 2-years immediately preceding ban implementation is the reference time period.

Table 1: Provincial Menthol Bans Significantly Reduced Menthol Cigarette Sales and Had No Effect on Non-Menthol Cigarette Sales, 2012-2018

	(1) Menthol sales (in millions)	(2) Non-menthol sales (in millions)
Mean of dependent variable in 2012:	12.59	295.08
Provincial menthol ban	-14.299**	-3.323
	(2.40)	(5.863)
Provincial e-cigarette minimum legal age restriction	5.862	-4.780
	(1.34)	(5.627)
Provincial cigarette price	-0.168	0.114
	(0.31)	(0.548)
Provincial unemployment rate	-0.427	1.803
	(0.38)	(2.618)
R^2	0.67	0.98
N	840	840

Notes: Data are provincial menthol and non-menthol cigarette sales from 2012-2018 provided by Health Canada. All models are estimated using OLS regressions and include province, year and month fixed effects in addition to the covariates listed. Robust standard errors are clustered at the province level. Significance levels are *** significant at 1%, ** significant at 5%, * significant at 10%.

Table 2: Heterogeneity in Menthol Preferences, Survey Data
CSTADS (youths) and CTADS (adults)

	(1) Smoking rate [prior to menthol bans]	(2) Menthol smoking rate, unconditional [prior to menthol bans]	(3) Menthol smoking rate, conditional on any smoking [prior to menthol bans]
Youths, 11-17	0.075* (0.263)	0.027* (0.161)	0.308* (0.462)
Adults, 19+	0.182* (0.386)	0.016* (0.125)	0.115* (0.319)
Non-aboriginal youths, 11-17	0.071* (0.256)	0.025* (0.155)	0.300* (0.458)
Aboriginal youths, 11-17	0.209* (0.406)	0.086* (0.280)	0.379* (0.485)
Male youths, 11-17	0.083* (0.275)	0.031* (0.173)	0.311 (0.463)
Female youths, 11-17	0.066* (0.248)	0.022* (0.146)	0.303 (0.460)
Grades 6-8 youths	0.022* (0.147)	0.007* (0.085)	0.254* (0.436)
Grades 9-12 youths	0.112* (0.316)	0.040* (0.197)	0.315* (0.465)
Male adults, 19+	0.207* (0.405)	0.013* (0.114)	0.078* (0.268)
Female adults, 19+	0.159* (0.365)	0.018* (0.134)	0.170* (0.376)
Urban adults, 19+	0.176* (0.381)	0.017 (0.128)	0.128* (0.334)
Rural adults, 19+	0.190* (0.393)	0.013 (0.112)	0.081* (0.273)
Married adults, 19+	0.163* (0.369)	0.012* (0.109)	0.102* (0.303)
Unmarried adults, 19+	0.253* (0.435)	0.030* (0.170)	0.148* (0.355)

Notes: Author calculations. * indicates the difference between the two groups is significant. CSTADS 2010-2017 for age 11-17, CTUMS/CTADS 2003-2017 for age 19+ for smoking rate (except for urban vs. rural adults 19+ based on CTUMS/CTADS 2004-2017) and CTADS 2015-2017 for age 19+ for unconditional menthol smoking rate and menthol smoking rate conditional on any smoking.

Table 3: Menthol Bans Reduced Menthol Cigarette Use Among Youths and Adults, Survey Data

CSTADS 2010-2017 and CTADS 2015-2017

Coefficient on Provincial Menthol Ban, Fully Saturated Model

	(1) Smoked menthol cigarettes in past 30 days	(2) Ever tried smoking a menthol cigarette	(3) Usual brand of cigarette is menthol (among past month smokers)
Youths 11-17, CSTADS			
Pre-reform mean	0.027		
Provincial Menthol Ban	-0.024***	--	--
	(0.001)		
R-squared	0.02		
N	178,387		
Adults 19+, CTADS			
Pre-reform mean	0.016	0.360	0.059
Provincial Menthol Ban	-0.031**	-0.079**	-0.112***
	(0.033)	(0.018)	(0.001)
R-squared	0.01	0.03	0.05
N	22,376	22,378	3,580

Notes: Each entry is the coefficient on Menthol Ban from a separate regression. CSTADS 2010-2017 and CTADS 2003-2017. All models are estimated using OLS regressions and include province fixed effects and indicators for survey cycles. Models using CSTADS control for individual level factors: grade, sex (male; female is the excluded category), aboriginal status and province level factors: unemployment rate, cigarette prices. Models using CTADS control for individual level factors: age, sex (male; female is the excluded category), marital status (married/widowed/divorced/separated, never married is the excluded category), household size, urban, and province level factors: unemployment rate, real cigarette prices and an indicator for a provincial minimum legal age for e-cigarette purchases. Standard errors are clustered at the province level. P-values are in parentheses and are estimated using the method of effective number of clusters. Significance levels are *** significant at 1%, ** significant at 5%, * significant at 10%.

Table 4: Heterogeneity in the Effects of Menthol Bans
CSTADS (youths) and CTADS (adults)

	(1) Pre-policy menthol use rate, unconditional	(2) Estimated effect of Provincial Menthol Ban on menthol cigarette use
Youths, 11-17	0.027	-0.024 (0.001)***
Adults, 19+	0.016	-0.031 (0.033)**
Non-aboriginal youths, 11-17	0.025	-0.019 (0.002)***
Aboriginal youths, 11-17	0.086	-0.078 (0.005)***
Male youths, 11-17	0.031	-0.022 (0.000)***
Female youths, 11-17	0.022	-0.025 (0.004)***
Grades 6-8 youths	0.007	-0.002 (0.461)
Grades 9-12 youths	0.040	-0.035 (0.000)***
Male adults, 19+	0.013	-0.011 (0.074)*
Female adults, 19+	0.018	-0.051 (0.050)*
Urban adults, 19+	0.017	-0.039 (0.026)**
Rural adults, 19+	0.013	-0.003 (0.720)
Married adults, 19+	0.012	-0.031 (0.066)*
Unmarried adults, 19+	0.030	-0.034 (0.016)**

Notes: *** significant at 1%, ** significant at 5%, * significant at 10%. See notes to Table 3. P-values are in parentheses and are estimated using the method of effective number of clusters.

Table 5: Substitution and Evasion Effects of Menthol Bans
CSTADS 2010-2017 and CTADS 2010-2017
Coefficient on Provincial Menthol Ban, Fully Saturated Model

	(1) Smoked non-menthol cigarettes in past 30 days	(2) Used e-cigarettes in past 30 days	(3) Purchased cigarettes on/from a First Nations reserve in past 6 months	(4) Purchased cigarettes from a store or gas station not on a First Nations reserve in past 6 months
Youths 11-17, CSTADS				
Pre-reform mean	0.053	0.051		
Provincial Menthol Ban	0.017***	-0.064	---	---
	(0.004)	(0.111)		
R-squared	0.05	0.05		
N	174,030	81,436		
Adults 19+, CTADS				
(CTADS Time period for the outcome:)	*2015-17*	*2013-17*	*2010-17*	*2011-17*
Pre-reform mean	0.122	0.019	0.120	0.863
Provincial Menthol Ban	-0.017	-0.029**	0.043*	-0.076**
	(0.352)	(0.016)	(0.056)	(0.011)
R-squared	0.02	0.01	0.04	0.01
N	22,110	33,414	13,997	11,107

Notes: *** significant at 1%, ** significant at 5%, * significant at 10%. See notes to Table 3. P-values are in parentheses and are estimated using the method of effective number of clusters.

Table 6: Menthol Bans Did Not Affect Overall Smoking Initiation, Participation, or Quits

CSTADS 2010-2017 and CTADS 2003-2017

Coefficient on Provincial Menthol Ban, Fully Saturated Model

Outcome is ➔	(1) Ever smoked 100 or more cigarettes in whole life	(2) Any cigarette smoking in past 30 days	(3) Ever tried to quit smoking (among past 30 day cigarette smokers)
Youths 11-17, CSTADS			
Pre-reform mean of the outcome	0.049	0.075	0.662
Provincial Menthol Ban	-0.001	0.002	0.018
	(0.806)	(0.803)	(0.417)
R-squared	0.05	0.06	0.02
N	180,391	180,387	11,058
Adults 19+, CTADS			
Pre-reform mean of the outcome	0.463	0.182	0.840
Provincial Menthol Ban	-0.065**	-0.039	0.008
	(0.044)	(0.143)	(0.536)
R-squared	0.05	0.03	0.01
N	193,405	193,408	27,928

Notes: *** significant at 1%, ** significant at 5%, * significant at 10%. See notes to Table 3. P-values are in parentheses and are estimated using the method of effective number of clusters.

Appendix Table 1: Timing of Provincial and Federal Menthol Bans

	Date law introduced (first reading)	Date law passed	Royal Assent	Date law came into effect
Nova Scotia	April 17, 2015	April 28, 2015	May 11, 2015	May 31, 2015
Alberta	---	May 2015	---	September 30, 2015
New Brunswick	May 29,2015	June 5, 2015	June 5, 2015	January 1, 2016
Quebec	May 5, 2015	November 26, 2015	November 26, 2015	May 26, 2016
Ontario	November 24, 2014	May 26, 2015	May 28, 2015	January 1, 2017
Prince Edward Island	June 2015	September 2016	September 2016	May 1, 2017
Newfoundland & Labrador	June 2, 2016	June 6, 2016	June 7, 2016	July 1, 2017
Manitoba	No ban adopted	No ban adopted	No ban adopted	No ban adopted
Saskatchewan	No ban adopted	No ban adopted	No ban adopted	No ban adopted
British Columbia	No ban adopted	No ban adopted	No ban adopted	No ban adopted
Federal Ban	April 29, 2016 (Notice to Interested Parties for proposed amendment) November 22, 2016 (First reading) April 2017 (Order amended to include menthol)	June 1, 2017	----	October 2, 2017

Appendix Table 2: Survey Questions and Years Available, CSTADS (youths)

Outcome	Survey years	Variable construction
Ever smoked 100 or more cigarettes in lifetime	2010-2017	Based on survey question: "*Have you ever smoked 100 or more whole cigarettes in your life? – Yes/No*".
Any cigarette smoking in past 30 days	2010-2017	Binary variable equal to 1 if the respondent reported smoking one or more cigarettes on at least 1 day in the 30 days preceding the survey; 0 otherwise.
Ever tried to quit smoking	2010-2017	Binary variable equal to 1 if the respondent tried to quit at least once; 0 otherwise.
Past 30-day menthol cig use	2010-2017	Based on survey question: "*In the last 30 days, did you use …(Menthol cigarette)?*"
Past 30-day non-menthol cig use	2010-2017	Respondents who smoked one or more cigarettes in 30 days preceding the survey excluding those who smoked menthol cigarettes in past 30 days.
Past 30-day e-cigarette use	2014-2017	Based on survey question: "*In the last 30 days, did you use any of the following? … (E-cigarettes) – Yes/No*"

Appendix Table 3: Survey Questions and Years Available, CTADS (adults)

Outcome	Survey years	Variable construction
Ever smoked 100 or more cigarettes in lifetime	2003-2017	Based on survey question: "*Have you smoked at least 100 cigarettes in your life? – Yes/No"*
Any cigarette smoking in past 30 days	2003-2017	Based on survey question: *"In the past 30 days, did you smoke any cigarettes? – Yes/No"*
Ever tried to quit smoking	2006-2017	Based on survey question: "*Have you ever tried to quit smoking? – Yes/No*"
Past 30-day menthol cig use	2015-2017	Based on survey question: "*In the past 30 days have you smoked any menthol cigarettes? – Yes/No*"
Past 30-day non-menthol cig use	2015-2017	Respondents who smoked in the 30 days preceding the survey (as per Survey on Smoking in Canada definition) excluding those who smoked menthol cigarettes in past 30 days (where available).
Past 30-day e-cigarette use	2013-2017	Based on survey question: "*In the past 30 days did you use an electronic cigarette, also known as an e-cigarette? – Yes/No*"
Purchase from First Nations reserve	2010-2017	Based on survey question: "*In the past six months, did you buy cigarettes on/from a First Nations Reserve?- Yes/No*".
Purchase from grocery store or gas station not on First Nations reserve	2010-2017	Binary variable equals 1 if the respondent reported buying cigarettes from a grocery store or gas station not on a First Nations reserve in the past 6 months.

Appendix Table 4: Descriptive Statistics, Sales Data

	Menthol sales		Non menthol sales	
	Pre-ban	Post-ban	Pre-ban	Post-ban
Newfoundland & Labrador	3.20	-0.05	51.70	49.64
	(1.64)	(0.09)	(7.54)	(7.72)
Prince Edward Island	0.28	-0.00	5.27	4.21
	(0.10)	(0.00)	(1.45)	(0.84)
Nova Scotia	3.48	0.17	76.42	76.70
	(0.47)	(0.45)	(10.00)	(11.70)
New Brunswick	3.61	-0.05	61.48	52.31
	(0.55)	(0.21)	(8.11)	(9.89)
Quebec	21.85	-0.27	585.63	559.34
	(8.06)	(0.76)	(89.58)	(91.24)
Ontario	41.38	0.19	849.81	794.53
	(13.60)	(1.52)	(104.56)	(122.10)
Alberta	21.77	0.02	342.38	311.01
	(3.12)	(0.77)	(48.22)	(53.19)
Manitoba	5.38		78.34	
	(3.66)		(14.27)	
Saskatchewan	6.66		82.40	
	(4.10)		(13.74)	
British Columbia	16.27		232.15	
	(12.45)		(35.47)	

Notes: Provincial sales data from 2012-2018 provided by Health Canada.

Appendix Table 5: Descriptive Statistics, Survey Data
2010-2017 CSTADS (youths) and 2003-2017 CTADS (adults)

	(1) CSTADS youths aged 11-17		(2) CTADS adults aged 19+	
	Mean (sd)	*N*	Mean (sd)	*N*
Age	--		46.776 (17.143)	196,250
Male	0.513 (0.500)	192,349	0.492 (0.500)	196,250
Grade 6-8	0.394 (0.489)	192,349	--	
Grade 9-12	0.606 (0.489)	192,349	--	
Aboriginal	0.048 (0.214)	190,545	--	
Married	--		0.783 (0.412)	193,619
Urban	--		0.807 (0.394)	173,710
Household size			2.795 (1.235)	196,071
Lives in a province with a menthol ban at time of survey	0.163 (0.369)	192,349	0.059 (0.236)	196,250
Ever smoked 100 or more cigarettes in lifetime	0.049 (0.216)	192,283	0.456 (0.498)	196,215
Any cigarette smoking in past 30 days	0.076 (0.265)	192,277	0.178 (0.382)	196,218
Ever tried to quit smoking (among past 30 day smokers)	0.663 (0.473)	11,537	0.841 (0.365)	28,269
Used menthol cigarettes in past 30 days	0.028 (0.166)	190,012	0.016 (0.124)	22,730
Used non-menthol cigarettes in past 30 days	0.054 (0.225)	185,637	0.133 (0.339)	22,463
Used e-cigarettes in past 30 days	0.077 (0.266)	92,234	0.022 (0.148)	34,455
Purchased cigarettes from a First Nations reserve in past 6 months	--		0.115 (0.320)	14,694
Purchased cigarettes from a store or gas station not on a First Nations reserve in past 6 months	--		0.858 (0.350)	11,639

Means and standard deviations. Author calculations. Sample size varies across the outcomes based on the years the questions were included in each survey. See Appendix Tables 2 and 3 for a list of which years each survey included the relevant questions. Provinces with a menthol ban include Nova Scotia, Alberta, Ontario and Quebec for CSTADS and Nova Scotia, Alberta, Ontario, Quebec, Newfoundland and Labrador, Prince Edward Island and New Brunswick for CTADS. Urban variable is only available for CTADS 2004-2017.

Appendix Table 6: Expanded set of Coefficient Estimates, Youths
CSTADS 2010-2017

Outcome	Any cigarette smoking in past 30 days	Menthol cigarette use in past 30 days	Non-menthol cigarette use in past 30 days
Provincial Menthol Ban	0.002	-0.024***	0.017***
	(0.803)	(0.001)	(0.004)
Male	0.015***	0.008***	0.011**
	(0.009)	(0.013)	(0.026)
Aboriginal	0.130***	0.051***	0.096***
	(0.001)	(0.008)	(0.000)
Grade 7	0.013*	0.004*	0.010**
	(0.068)	(0.108)	(0.048)
Grade 8	0.036**	0.011**	0.027**
	(0.039)	(0.055)	(0.041)
Grade 9	0.067***	0.027***	0.047***
	(0.005)	(0.004)	(0.011)
Grade 10	0.092***	0.037***	0.062***
	(0.000)	(0.000)	(0.001)
Grade 11	0.130***	0.045***	0.094***
	(0.000)	(0.000)	(0.000)
Grade 12	0.173***	0.059***	0.131***
	(0.000)	(0.000)	(0.000)
Provincial cigarette price	0.001	0.001*	0.001
	(0.596)	(0.093)	(0.720)
Provincial minimum age for e-cigarette purchase	-0.010	-0.006	-0.006
	(0.490)	(0.566)	(0.582)
Provincial unemployment rate	0.001	-0.000	0.000
	(0.882)	(0.976)	(0.917)
R-squared	0.06	0.02	0.05
N	180,387	178,387	174,030

Note: CSTADS 2010-2017. All models are estimated using OLS regressions and include province fixed effects and indicators for survey cycles. Standard errors are clustered at province level. P-values are in parentheses and are estimated using the method of effective number of clusters. Significance levels are ***p<0.01, **p<0.05, *p<0.1.

Appendix Table 7: Expanded set of Coefficient Estimates, Adults
CTADS 2010-2017

Outcome	Any cigarette smoking in past 30 days	Menthol cigarette use in past 30 days	Purchased cigarettes from a First Nations reserve in past 6 months
Provincial Menthol Ban	-0.039	-0.031**	0.043*
	(0.143)	(0.033)	(0.056)
Age	-0.003***	-0.001**	-0.000
	(0.000)	(0.047)	(0.487)
Male	0.044***	-0.007	-0.008
	(0.002)	(0.124)	(0.401)
Married	-0.032**	-0.002	-0.012
	(0.043)	(0.853)	(0.201)
Urban	--	0.002	-0.059***
		(0.529)	(0.006)
Household size	-0.023***	-0.006**	0.004
	(0.000)	(0.028)	(0.692)
Provincial cigarette price	0.000	0.000	-0.001
	(0.621)	(0.449)	(0.739)
Provincial minimum age for e-cigarette purchase	0.024	0.006	0.028
	(0.188)	(0.418)	(0.434)
Provincial unemployment rate	0.005**	0.004	0.009
	(0.025)	(0.417)	(0.280)
R-squared	0.03	0.01	0.04
N	193,408	22,376	13,997

Note: CTUMS/CTADS 2003-2017 for 'Any cigarette smoking in past 30 days', CTADS 2015-2017 for 'Menthol cigarette use in past 30 days' and CTUMS/CTADS 2010-2017 for 'Purchased cigarettes from a First Nations reserve in past 6 months'. All models are estimated using OLS regressions and include province fixed effects and indicators for survey cycles. Standard errors are clustered at province level. P-values are in parentheses and are estimated using the method of effective number of clusters. Significance levels are ***p<0.01, **p<0.05, *p<0.1.

Appendix Table 8: Effects of Menthol Bans at Reducing Menthol Cigarette Use are Robust, Survey Data
CSTADS 2010-2017 and CTADS 2015-2017
Coefficient on Provincial Menthol Ban, Fully Saturated Model

	(1) Baseline model (from Table 3)	(2) (1), but exclude controls for other smoking policies	(3) (1), but Wild bootstrap cluster	(4) (1), but drop Ontario	(5) (1), but drop Alberta	(6) (1), but drop Quebec	(7) (1), but drop Nova Scotia, New Brunswick, and Prince Edward Island	(8) (1), but drop treated provinces that exhibit stockpiling (Newfoundland, Prince Edward Island, Ontario and Quebec)
Youths 11-17, CSTADS, menthol cigarette use								
Provincial Menthol Ban	-0.024***	-0.024***	-0.024*	-0.027***	-0.023**	-0.021**	-0.024***	-0.018**
	(0.001)	(0.000)	(0.053)	(0.000)	(0.029)	(0.035)	(0.004)	(0.027)
R-squared	0.02	0.02	0.02	0.03	0.02	0.03	0.02	0.03
N	178,387	178,387	178,387	154,853	153,066	160,214	142,911	106,079
Adults 19+, CTADS, menthol cigarette use								
Provincial Menthol Ban	-0.031**	-0.029**	-0.031**	-0.026**	-0.046***	-0.037**	-0.033*	-0.017**
	(0.033)	(0.030)	(0.020)	(0.032)	(0.001)	(0.028)	(0.066)	(0.033)
R-squared	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
N	22,376	22,376	22,376	19,005	20,139	19,812	16,488	12,612

Notes: *** significant at 1%, ** significant at 5%, * significant at 10%. See notes to Table 3. P-values are in parentheses and are estimated using the method of effective number of clusters.

Appendix Table 9: Provincial Menthol Bans Did Not Affect Use of Other Substances

CSTADS 2010-2017 and CTADS 2010-2017

Coefficient on Provincial Menthol Ban, Fully Saturated Model

	(1) Used marijuana in past 12 months	(2) Used alcohol in past 12 months	(3) Binge drinking in past 12 months
Youths 11-17, CSTADS			
Pre-reform mean	0.182	0.565	
Provincial Menthol Ban	-0.005	-0.006	
	(0.657)	(0.652)	
R-squared	0.11	0.19	
N	158,022	151,081	
Adults 19+, CTADS			
(CTADS Time period for the outcome:)	*2004-17*	*2013-17*	*2013-17*
Pre-reform mean	0.087	0.777	0.076
Provincial Menthol Ban	-0.052	0.001	-0.005
	(0.125)	(0.914)	(0.546)
R-squared	0.10	0.03	0.07
N	168,770	33,257	32,857

Notes: *** significant at 1%, ** significant at 5%, * significant at 10%. See notes to Table 3. P-values are in parentheses and are estimated using the method of effective number of clusters.

Appendix Table 10: Adult Evasion Effects are Larger for Adults in Rural Areas

CTADS 2010-2017

Coefficient on Provincial Menthol Ban, Fully Saturated Model

	(1) Baseline model (from Table 7)	(2) Adults in rural areas	(3) Adults in urban areas
Adults 19+, CTADS, First Nations cigarette purchase			
Provincial Menthol Ban	0.043*	0.087**	0.032
	(0.056)	(0.027)	(0.248)
R-squared	0.04	0.05	0.04
N	13,997	4,315	9,682

Notes: *** significant at 1%, ** significant at 5%, * significant at 10%. See notes to Table 3. P-values are in parentheses and are estimated using the method of effective number of clusters.

Appendix Table 11: Effects of Menthol Bans on Substitution and Evasion Outcomes are Robust

CSTADS 2010-2017 and CTADS 2010-2017

Coefficient on Provincial Menthol Ban, Fully Saturated Model

	(1) Baseline model (from Table 7)	(2) (1), but exclude controls for other smoking policies	(3) (1), but Wild bootstrap cluster	(4) (1), but drop Ontario	(5) (1), but drop Alberta	(6) (1), but drop Quebec	(7) (1), but drop Nova Scotia, New Brunswick, and Prince Edward Island	(8) (1), but drop treated provinces that exhibit stockpiling (Newfoundland, Prince Edward Island, Ontario and Quebec)
Youths 11-17, CSTADS, non-menthol cigarette use								
Provincial Menthol Ban	0.017***	0.016***	0.017**	0.013***	0.020**	0.014	0.016**	0.016*
	(0.004)	(0.007)	(0.035)	(0.001)	(0.039)	(0.229)	(0.020)	(0.079)
R-squared	0.05	0.05	0.05	0.04	0.05	0.05	0.05	0.06
N	174,030	174,030	174,030	150,928	149,120	156,145	139,626	103,523
Adults 19+, CTADS, First Nations cigarette purchase								
Provincial Menthol Ban	0.043*	0.048*	0.043	0.021*	0.049	0.056**	0.049*	0.059*
	(0.056)	(0.081)	(0.123)	(0.087)	(0.238)	(0.023)	(0.085)	(0.072)
R-squared	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.07
N	13,997	13,997	13,997	12,653	12,610	12,432	9,795	6,478

Notes: *** significant at 1%, ** significant at 5%, * significant at 10%. See notes to Table 3. P-values are in parentheses and are estimated using the method of effective number of clusters.