Restricting Sales of Flavored Nicotine Vaping Products: Effects on Nicotine Vaping Product and Cigarette Sales in Canada

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Abstract

The rise of nicotine vaping products (NVPs) has led governments to consider banning or limiting flavored NVP sales to reduce their appeal. In particular, we study the effect of NVP flavor restrictions enacted in Canada, a country with historically high tobacco regulation, through June of 2023. Using a stacked DID model, we estimate that flavor restrictions increased cigarette sales by 9.6%. In gas and convenience stores, these restrictions nearly eliminated flavored non-menthol and menthol NVP sales while increasing tobacco and unflavored NVP sales by 123.4%. Substitution patterns arise in Canada despite its strict tobacco control environment, suggesting that patterns of substitution between e-cigarettes and cigarettes may be generalizable across countries with different tobacco regulatory strengths.

Keywords: e-cigarettes; tobacco policy; flavor ban
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1 Introduction

Governments worldwide are increasingly restricting flavored nicotine vaping products (NVPs). Over 40 countries ban the sale of all types of NVPs (World Health Organization, 2025), while 15 countries have flavor restrictions on NVP sales (Campaign for Tobacco-Free Kids, 2025). The United States does not have a federal ban, but 7 states, the District of Columbia, and over 185 localities have flavor restrictions on NVP sales (Friedman et al., 2025). In many cases, governments pass these restrictions with the stated goal of protecting youth from nicotine addiction by reducing the appeal of vaping (Hardie, McCool and Freeman, 2025; World Health Organization, 2025; Office of the Governor of New Jersey, 2020). However, restrictions could serve other less glamorous interests, such as revenue generation or protecting cigarette manufacturers from competition.

Whatever mix of motives drives these policies, critical questions include public health and welfare effects of these policies. From an economics framework, flavored NVP restrictions can be thought of as a partial ban within a differentiated product market. Consumers may respond to NVP flavor restrictions by exiting the nicotine market altogether, by substituting to unflavored NVPs (or legally allowed flavors), or by substituting to combustible tobacco. If restrictions on flavored NVPs reduce vaping without unintended spillovers, this could be a public health success given that vaping is not harmless (Allcott and Rafkin, 2022). But if NVP flavor restrictions instead cause substitution to combustible cigarettes—a deadly product that reduces life expectancy by 4.3 years on average (Darden, Gilleskie and Strumpf, 2018)—they risk worsening, rather than improving, population health, given that the average expert believes that vaping's effect on quality-adjusted life expectancy is 37% that of smoking (Allcott and Rafkin, 2022). From a welfare perspective even if consumers simply shift from flavored to unflavored NVPs—without net changes in health risk—the policy may still reduce consumer welfare by constraining choice and forcing substitution toward less-preferred products.

In the United States, there is substantial evidence to indicate that cigarettes and NVPs are economic substitutes. For example, analyses of sales data show that city- and state-level NVP flavor restrictions have been shown to reduce NVP sales while simultaneously increasing cigarette sales, with some evidence that youth-preferred cigarette brands are disproportionately affected (Cadham et al., 2022; Friedman et al., 2025). A recent systematic review of population-level studies finds 15 of 21 studies find evidence that restricting NVP availability increases youth smoking (Begh et al., 2025). A separate review of e-cigarette taxes, minimum legal sales age laws, and advertising restrictions finds 16 of 18 fixed effect studies exhibit evidence of economic substitution between NVPs and cigarettes (Pesko, 2023). This body of work situates flavor restrictions within the broader economics literature on the regulation of addictive goods, which shows that while consumers often respond in the intended direction, policies can also trigger offsetting behavioral responses that undermine or even outweigh their goals (Powell and Pacula, 2021; Evans, Lieber and Power, 2019; Harding, Leibtag and Lovenheim, 2012).

Yet whether this pattern generalizes beyond the U.S. remains unclear. Begh et al.

(2025) cautions that evidence from one country may not extrapolate to countries with different cultural or regulatory environments and calls for more research outside the United States. Canada provides a useful setting for such evidence because of its distinct regulatory environment that may alter substitution responses. Unlike the United States, Canada has banned menthol cigarettes nationwide, restricted flavored cigars, implemented plain packaging for combustible tobacco, and capped nicotine concentrations in NVPs at 20 milligrams/milliliter (mg/mL). These conditions mean that smokers have fewer combustible alternatives, while vapers face a market where flavors play an unusually large role in product differentiation. Because of these structural differences, the Canadian setting provides an important test of external validity: if cigarette substitution emerges even here in response to flavored NVP restrictions, it suggests patterns of substitution between e-cigarettes and cigarettes may be generalizable across countries with different tobacco regulatory strengths and not specific to the U.S. context of relatively loose tobacco regulation.

In this study, we exploit provincial heterogeneity in flavored NVP restrictions between 2018 and 2023, applying a stacked DID framework to cigarette sales data from Health Canada, retail NVP sales from NielsenIQ, and complementary Google Trends measures of search intensity. By leveraging quasi-experimental variation, we provide the first causal evidence outside the U.S. on how NVP flavor restrictions shape nicotine product markets. Our findings contribute to ongoing debates in economics and public health about the design of regulations for addictive goods, highlighting the potential for substitution effects to undermine stated policy goals.

2 Background

Analyses of NVP flavor restrictions' effects fit within a wider literature on the relationship between NVPs and cigarettes, as well as addiction more generally. Quasi-experimental analyses of state's minimum legal sales ages (Friedman, 2015; Pesko, Hughes and Faisal, 2016; Abouk and Adams, 2017; Dave, Feng and Pesko, 2019; Pesko and Currie, 2019; Pesko, 2023) and NVP taxes (Pesko, Courtemanche and Maclean, 2020; Saffer et al., 2020; Cotti et al., 2022; Friedman and Pesko, 2022; Abouk et al., 2023*b*,*a*; Diaz et al., 2025) typically indicate that these products are economic substitutes. Consistent with that conclusion, Liber et al. (2023) link Massachusetts' temporary ban on all NVP sales with increased cigarette sales, with the caveat that studies focused on policy responses to the US's 2019 outbreak of vaping-associated lung injuries may also reflect context-specific changes in perceptions of vaping's risk relative to that of smoking during that outbreak (Dave et al., 2020).

As policies that make a product more expensive, harder to access, or less appealing should increase consumption of its substitute, these findings suggest that NVP flavor restrictions will increase cigarette sales and use. Indeed, quasi-experimental analyses of US state flavor restrictions that assess evidence for parallel pre-trends and consider multiple years of post-2019 data bear that out. Analyzing Behavioral Risk Factor Surveillance System (BRFSS) data on 18-29 year-olds, Friedman, Pesko and Whitacre (2024) find that NVP flavor restrictions yield a 3.6 percentage-point reduction in daily vaping and a 2.2 percentage-point increase in daily cigarette smoking. Using stacked DID, Cotti et al. (2024) find that NVP flavor restrictions yield similarly sized reductions in daily NVP use as well as evidence of substitution towards unflavored NVPs and cigarettes for both high school students and young adults aged 18-30 (2 to 3 percentage-points), but statistically insignificant results for older adults. Using synthetic DID, Saffer et al. (2025) find analogous results for young adults and no significant response among adults aged 25-plus. Cheng et al. (2025)'s results concur but only considered past-30-day use instead of frequent or daily use. Critically, sales data are consistent with these findings: Friedman et al. (2025) find that 12 additional cigarettes are purchased for every 1 less 0.7 mL NVP pod sold due to NVP flavor restrictions, with the reduction in NVPs specific to non-tobacco-flavored ENDS and increases in cigarette sales stemming primarily from non-menthol cigarettes and brands used disproportionately by underage youth.

However, as all of the aforementioned studies' findings are based on variation in US flavor policies, their generalizability to other countries remains unclear. Differences in NVP and cigarette purchasing trends between the US, Canada, and England, three nations with substantial institutional and cultural similarities, underscore the need for separate analyses to determine behavioral responses to tobacco and nicotine policies (Roberson et al., 2023). Canada in particular has a more restrictive tobacco regulatory environment than the US, with cigar flavors limited to port, wine, rum, and whisky; menthol banned in most combustible tobacco products; and NVPs not widely available in convenience stores until after the Tobacco and Vaping Products Act's enactment in May of 2018 (Levy et al., 2023). To the extent that broader tobacco policy environments moderate flavor policies' effects, one might expect a different response in Canada than the US.

Evidence on the relationship between NVPs and cigarettes in Canada is limited. Analyzing retail sales data from 625 convenience stores across 159 Canadian municipalities, Xu et al. (2023) find reductions in cigarette sales volume following Juul's market entry, suggestive of substitution. However, Nguyen and Mital (2025)'s triple-difference analysis of provincial policies barring NVP sales to youth under age 18 or 19 finds non-significant impacts on smoking participation, with evidence for offsetting effects: 17-18 year-olds showed reductions in both smoking initiation and smoking cessation. Yet the latter analyses limits consideration to pre-2018 data, before NVPs became widely available in convenience stores and gas stations, and thus may not generalize to the current market. A third study finds that provincial menthol cigarette bans reduced e-cigarette use (Carpenter and Nguyen, 2021), suggesting that the products are economic complements.[1] This inconsistent evidence on the economic relationship between NVPs and cigarettes in Canada suggests that the US experience, in which e-cigarettes and cigarettes are regularly found to be economic substitutes, may not generalize; however, evidence from Canada is limited. Direct assessment of provincial NVP flavor restrictions' impacts is needed to understand these policies' effects in the Canadian context. Moreover, such analyses may help clarify the degree to which the US experience depends on its relatively more lenient

[1]Other Canadian studies of NVP policies did not exhibit consistent evidence of first-stage effects, such as from nicotine concentration restrictions (Davis, Friedman and Pesko, 2025) or indoor air laws (Nguyen and Bornstein, 2021).

tobacco regulatory environment. If the effects of Canada's NVP flavor restrictions mirror the US's, this would undercut claims that the US smoking-response to these policies could be prevented or reversed with more restrictive tobacco regulations.

3 Data

3.1 NVP Sales (NielsenIQ)

We analyze NVP retail sales data from NielsenIQ. To the best of our knowledge, there is no academic subscription to Canadian NielsenIQ retail sales data like there is in the United States. Our data was purchased by Health Canada directly from NielsenIQ, and it contains all NVPs as of February 2011 to the end of our study period.[2] These data capture NVP sales by UPC ("Universal Product Code"; i.e., bar code) in gas and convenience stores by 4-week period in Alberta, British Columbia, Ontario, Quebec, and two province-groups: the Maritimes (New Brunswick, Nova Scotia, and Prince Edward Island[3]), and Manitoba and Saskatchewan. These data provide UPC-level information on price, quantity (units), flavor, device type (e.g., kits, cartridges, e-liquids, disposables), and nicotine concentration (mg/mL). Removing device types that do not contain nicotine (e.g., skins, chargers, devices only, and rechargeables), the remaining products are cartridges, disposables, e-liquids, and kits. 94.0% of unit sales in our sample are cartridges.

[2]Unfortunately, Health Canada has not purchased similar extracts of other tobacco products like cigarettes. Unlike for cigarettes, Canada does not mandate reporting of NVP shipments during this period of analysis; as such, administrative data is not available.

[3]Prince Edward Island (PEI) is included in the NVP analyses as part of the Maritimes panel, but excluded from the cigarette analyses. PEI is the smallest Canadian province with 154,000 residents.

While sales are recorded through two channels–convenience and gas (C&G) and grocery stores, drug stores, and mass merchandisers (GDM)–, we restrict consideration to C&G sales, which make up 98.4% of NVP unit sales in the sample. C&G represents sales from 5,918 stores and covers 24% of stores in the gas and convenience store sector in Canada. Nationally, C&G accounts for 31% of Canada's NVP product sales (Health Canada, 2022).

Aggregating UPC-level sales data to the province level, we approximate monthly NVP sales to align with the monthly frequency of our cigarette sales data. Because NVP sales are reported in 4-week periods, we prorate each 4-week period's sales across the calendar months into which the period falls. Specifically, for any 4-week interval that crosses a month boundary, we allocate the sales to months in proportion to the number of days of the interval that occur in each month. Finally, we restrict the sample from July 2018 to June 2023 to align with the time period of our cigarette analysis.

The primary outcome of interest is the natural log of unit sales per capita, with volume sales considered as a sensitivity check since product volume is missing for 0.92% of unit sales. Separate analyses consider overall sales and flavor-specific sales for three mutually-exclusive categories: tobacco and unflavored, mint/menthol, and other flavorings (henceforth "flavored"). Mint/menthol products include NVPs labeled as menthol, mint, menthol combined with tobacco, and mint combined with tobacco flavors. "Flavored" NVPs include products with other flavorings as well as those that combine another flavor with mint, menthol, or tobacco (e.g., cherry-menthol). The 0.02% of unit sales that lack flavor labels are omitted from flavor-specific analyses. Since our main outcome is the natural log of unit sales per capita, observations with zero unit sales in a given month-year and province are assigned one unit of sale.[4] [5]

Six provinces in the analytic NVP sample adopt NVP flavor restrictions during the period covered by these data. A full list of implementation dates can be found in Table A1. Three of those provinces prohibit all flavored NVP sales (Nova Scotia, New Brunswick, and Prince Edward Island), while three limit flavored NVP sales to adult-only vape shops (Ontario, British Columbia, and Saskatchewan). Ontario and Saskatchewan also had exemptions for mint/menthol flavors. The remaining provinces in this sample did not have flavored NVP sales restrictions in effect by June of 2023: Alberta, Manitoba, and Quebec.

Figure A1 presents unadjusted trends of average NVP unit sales per capita in treatment and control provinces for overall NVP sales and by flavor type. Prior to any NVP flavor restrictions (before April 2020) sales in treatment and control provinces were increasing over time and mirrored each other relatively closely for overall units and for sales of each flavor type. Once flavor restrictions began being implemented overall unit sales in treatment provinces leveled out and remained between 0.022 and 0.034 units per capita, while in control provinces unit sales continued growing until they peaked at 0.063 unit sales per capita in July 2021. For flavored units sales, in treatment provinces sales peaked

[4] In the analytic sample, the average number of flavored non-mentholated and mentholated unit sales is 55,110 and 63,639, respectively.

[5] In the analytic sample, 5% of province-month observations are zeros for flavored non-mentholated unit sales and 1% for mentholated unit sales.

in May 2020 at 0.016 units per capita and then began declining to close to zero after, while in control provinces flavored unit sales remained between 0.020 and 0.029 units per capita. For tobacco and unflavored unit sales, sales began diverging and increasing at a faster rate in treatment provinces relative to the control provinces. After January 2021, sales in treatment provinces remained between 0.012 and 0.021 units per capita, while in control provinces units sales never went over 0.008 units per capita. Finally, for menthol/mint unit sales, sales in treatment provinces leveled out around 0.01 units per capita once flavor restrictions began, while in control provinces sales continued growing, peaking at 0.026 units per capita in July 2021.

3.2 Cigarette Sales (Health Canada)

Health Canada provided data on wholesale cigarette sales by province and month for July 2018 to June 2023, compiled from cigarette manufacturers' and importers' monthly reports of direct shipments to wholesalers and retailers in accordance with Health Canada's Tobacco Reporting Regulations, Section 13 (Sales). While not a direct tax record, these data mirror the timing and scope of tax-paid sales because manufacturers remit taxes when those shipments leave their control. Wholesale sales data exhibit substantial month-to-month volatility because they reflect cigarette shipments, not when consumers actually purchase cigarettes. Shipments may be front-loaded or delayed in anticipation of excise tax changes, fiscal year ends, or regulatory deadlines such as the 2020 plain-packaging rules, producing spikes and drops. Despite this volatility, the data are useful for comparisons of trends between provinces that do versus do not adopt NVP flavor restrictions; therefore, netting out nationwide changes that drive much of the variation (Figure A2). As Health Canada's team noted concerns that the territories and Prince Edward Island may be serviced by wholesalers from larger neighboring provinces, our analytic sample excludes those regions (<1% of Canada's population) from unweighted analyses, focusing on the nine largest provinces, but we keep all territories and Prince Edward Island in our weighted analyses since the weights reduce their influence.

Figure A2 presents unadjusted trends of average cigarette stick sales per capita in treatment and control provinces. Prior to any NVP flavor restrictions being implemented (before April 2020), cigarette sales per capita were consistently higher in control provinces. After the flavor restrictions were implemented (post September 2021), the gap between treatment and control provinces closed considerably and cigarette sales were higher in treatment provinces in 15 out of 22 months.

As with the NVP data, the primary outcome of interest here is the natural log of wholesale cigarette sales (sticks) per capita by province, based on total populations as of July 2022 (Statistics Canada, 2023). Five provinces in the analytic cigarette sample adopt NVP flavor restrictions during the study period. The cigarette sample additionally includes Newfoundland and Labrador, which did not adopt a flavored NVP restriction during this period, and excludes Prince Edward Island, as noted earlier.

3.3 Google Trends

As our primary NVP analysis is based on sales in gas and convenience stores, it does not cover sales in vape shops or online markets. To consider changes in consumer interest in the NVP market beyond gas and convenience stores, analyses use Google Trends data capturing relative interest in search topics, measured on a scale of 0 to 100 at the month and province level.[6] We analyze two Google Search trends: searches that contain the phrase "Vape Shop" and searches related to NVP shopping which capture searches with a commercial or purchase intent. Searches related to a topic include search terms that share the same concept in any language. This approach is more robust as it does not rely on exact phrases but instead captures a broad range of searches that are conceptually linked, even when the specific wording varies. Downloading monthly data for January 2018 through January 2024, we restrict analysis to the same nine Canadian provinces used in the cigarette outcome analysis from July 2018 to June 2023.[7] Specifically, we drop Prince Edward Island and the Canadian territories due to low interest (which prevents scores from being calculated).

3.4 Summary Statistics

Summary statistics for outcome variables are presented in Table 1. Monthly NVP unit sales per capita are generally similar at baseline in adopting and non-adopting provinces

[6] In our analytic sample, these values contain no zeros and range from 7 to 100.

[7] This broader time horizon provided data at the monthly level, whereas pulling from July 2018 to June 2023 generates observations at the weekly level, yielding more missing values.

across flavor types. In non-adopting provinces, total monthly NVP sales increased from 0.0074 units per capita in the first year of the sample (July 2018 to June 2019) to 0.0466 in the final year (July 2022 to June 2023) - an increase of 0.0392 units (529.7%). Meanwhile, in adopting provinces, units sales per capita increased, but at a slower rate, from 0.0060 to 0.0254 - an increase of 0.0194 units per capita (323.3%). From these numbers, we derive an unadjusted difference-in-differences (DID) estimate that suggests 0.0198 (= 0.0194 - 0.0392) fewer monthly NVP unit sales per capita in adopting provinces versus non-adopting provinces. The unadjusted DID results are negative for flavored NVP sales and mentholated NVP sales, and positive for tobacco flavored NVP sales.

Monthly cigarette sales per capita started lower in NVP adopting provinces and ended higher. In non-adopting provinces, monthly cigarette sales declined from 64.6 per capita in the first year of the sample (July 2018 to June 2019) to 37.2 in the final year (July 2022 to June 2023) — a decrease of 27.4 cigarette sticks (42.4%). Meanwhile, in adopting provinces, monthly per capita cigarette sales declined at a slower rate, from 55.3 to 37.9 - a decrease of 17.4 cigarette sticks per capita (31.5%). The unadjusted DID estimate suggests 10.0 (= 27.4 - 17.4) extra monthly cigarette sales per capita in adopting provinces versus non-adopting provinces.

For Google search results, search levels are generally lower at baseline in non-adopting provinces and end sharply higher, compared to only small increases in adopting provinces. Accordingly, unadjusted DID coefficients are negative.

Data and Code Availability: All code used for data cleaning, variable construction, and statistical analysis is available at https://github.com/Social-Impact-Lab-SIL/Vape-Flavor-Restrictions-Canada. The underlying sales data were obtained from Health Canada and NielsenIQ and are subject to data-use agreements that prohibit public distribution.

4 Empirical Strategy

In order to estimate the NVP flavor restriction's effect on NVP and cigarette sales, we estimate the following two-way fixed effects (TWFE) model:

$$Y_{p,t} = \beta_0 + \beta_1 FlavorRestriction_{p,t} + \pi X_{p,t} + \gamma_p + \theta_t + \epsilon_{p,t} \tag{1}$$

$Y_{p,t}$ is logged sales per capita, where t indexes month-by-year time periods and p indexes each province or, in our NVP sales analyses, province-group. $FlavorRestriction_{p,t}$ is a treatment variable indicating the portion of month-year t a flavor restriction was in effect in province p, with this value population-weighted for the two province-groups in our NVP sales data. β_1 is the coefficient of interest. $X_{p,t}$ is a vector of covariates that control for tobacco-related policies, COVID-19-related factors that may have affected sales through both tobacco product use and access to illicit sources, and the unemployment rate (Statistics Canada, 2024). Tobacco-related policy covariates include cigarette taxes (per stick), NVP (e-cigarette) taxes (with separate variables for ad valorem rates and specific taxes per mL of vape liquid), and a binary indicator for the first policy limiting NVP nicotine concentrations in province p, whether provincial or federal (Davis, Friedman and Pesko, 2025). Time-varying covariates related to COVID-19 include monthly COVID-19 deaths per capita, a binary indicator for if the Atlantic Bubble[8] was in effect for over half of a given month, and two indexes of provincial policies capturing nonessential business closures and internal movement restrictions (Statistics Canada, 2022).[9] γ_p are province-level fixed effects that absorb time-invariant differences across provinces and θ_t are month-by-year fixed effects that absorb national changes in sales over time. Our standard results use conventional cluster-robust standard errors, though we show that inference is similar when using wild bootstrap standard and randomization inference approaches.

As causal interpretation of these results rests on the parallel trends assumption, we use event studies to consider that assumption's validity. In addition, recent advances in the DID literature have documented potential bias in estimates from two-way fixed effects models with staggered adoption, due to comparisons between newly treated and already treated groups (Goodman-Bacon, 2021). To avoid such bias, we use the stacked DID model proposed in Cengiz et al. (2019). Reconstructing the data in event-time rather than period-time, this approach restricts consideration to a balanced window of leads and lags around the treatment event for each natural experiment (i.e., cohort defined

[8]The Atlantic Bubble allowed unrestricted travel among the four Atlantic provinces (Newfoundland and Labrador, New Brunswick, Nova Scotia, and Prince Edward Island) while restricting entry from other provinces from July 2020 to November 2020. By limiting cross-border travel, the policy may have affected tobacco and vaping product sales through reduced access to out-of-province retailers and illicit sources.

[9]The NVP flavor restrictions we study do not appear to be strongly correlated with COVID-19. We re-estimate our model using each COVID-19 covariate as an outcome, and the NVP flavor restriction indicator is not statistically significant in any of these regressions, with or without remaining controls.

by treatment timing). The resulting cohort-specific datasets are then stacked to form a pooled sample. In the estimation, calendar time fixed effects θ_t are replaced with stack by event-time fixed effects, and unit fixed effects γ_p are replaced with stack by unit fixed effects, allowing each stack to have its own time and unit effects. The regression is weighted using the stack weights proposed in Wing, Freedman and Hollingsworth (2024).

5 Results

5.1 Main Results

Table 2 presents results using the stacked DID model. The estimated coefficient for monthly NVP unit sales is -0.350, a 29.5% decrease in monthly NVP unit sales per capita, though is not statistically significant (p=0.138). Although not statistically significant, this large coefficient is economically significant.[10] Considering NVP sales by flavor, however, reveals statistically significant estimates in different directions for products that were versus were not constrained by flavor restrictions. Coefficients are -3.461 (p<0.10) and -8.428 (p<0.001) for mint/menthol and other non-tobacco flavors respectively, corresponding to reductions of 96.9% and 99.9%.[11] In contrast, the estimated coefficient for tobacco and unflavored NVP sales is 0.804 (p<0.10), a 123.4% increase. This suggests sizable substitution between restricted versus unrestricted flavor types. The estimated coefficient for cigarette sales is 0.092, a 9.6% increase in monthly cigarette stick sales per capita.

[10] We show in subsequent results that it is statistically significant in several alternative specifications.

[11] Recall that two provinces contained exemptions for mint/menthol flavors. We later return to this and examine effects by specific province.

Figure 1 presents results using the stacked event study models estimating the impact of NVP flavor restrictions on sales of NVPs and cigarettes. For NVP sales, all four event studies exhibit strong evidence of parallel trends in the pre-period. For cigarette sales, 1 out of 20 leading coefficients are statistically different from zero in the pre-period and 3 out of 20 are marginally significant in the pre-period, which calls for caution in interpreting the positive cigarette sales effect as causal. We return to this later in the paper and show evidence that this effect is reasonably consistent with alternative models that provide stronger evidence of parallel trends.

Examining the dynamic post-treatment effects suggests a lagged response for both products. Overall NVP sales are relatively flat initially until they begin dropping around 6 months–driven by a steepening decline in flavored NVP sales–with statistically significant results evident at the 11-month mark. Consistent with this timeline, the increase in cigarette sales becomes more pronounced after about 10 months.

5.2 Sensitivity Checks

In Figure 3, we provide three sensitivity checks to test whether our results are sensitive to changing how sales are defined, excluding observations from the early months of the COVID-19 pandemic (March 2020 to August 2020), or population weighting. For the first check, we re-estimate our main specification but exclude observations from March 2020 to August 2020 to ensure that unobserved pandemic-related shocks are not driving the results. Findings are largely insensitive to dropping this time period.

For the second check, we redefine NVP sales using a volume-standardized measure rather than unit sales, as the latter treat sales as identical regardless of the amount of e-liquid. To represent the coefficient for volume sales per capita on the same scale as the previously reported coefficient for unit sales per capita, we divide month-by-province volume per capita by the mean monthly volume per unit across the entire sample. Resulting coefficient estimates are similar to the baseline model, suggesting that our choice of using units rather than volumes matters little.

For the third check, we retain the stack weights proposed in Wing, Freedman and Hollingsworth (2024), but additionally weight by province population within each stack. Estimated coefficients are virtually unchanged from the baseline results.

As our analyses rely on a small number of clusters, conventional cluster-robust standard errors may over-reject the null hypothesis (Angrist and Pischke, 2008). We therefore assess the sensitivity of our main results using two approaches designed for settings with few clusters. First, we use wild bootstrap inference, as suggested by Cameron, Gelbach and Miller (2008), and report the resulting p-values in curly brackets in Table 2. These p-values are similar to those from our baseline specification. Thus, conclusions regarding both flavor-specific NVP sales and cigarette sales are unchanged.

Second, we use randomization inference following the RI-β procedure of MacKinnon and Webb (2020), with results shown in Figure 2. For the NVP analyses, we enumerate all 720 possible province-group-level permutations of treatment histories (i.e., 6! permutations). For the cigarette analysis, there are 362,880 possible province-level permutations of treatment histories (i.e., 9! permutations), so we draw 5,000 random permutations. One-tailed p-values are computed as the share of placebo coefficients at least as extreme as the observed estimate in the hypothesized direction. Previously estimated statistically significant increases in cigarette sales, decreases in flavored non-mentholated NVP sales, and increases in tobacco/unflavored NVP sales remain statistically significant under randomization inference (all $p<0.05$); however, mentholated NVP sales, previously statistically significant in both conventional cluster-robust and wild bootstrap standard error cases, lose statistical significance ($p=0.104$) in the randomization inference case. Overall, however, randomization inference supports the robustness of our estimates.

Figure 4 presents results from analyses containing only one adopter at a time with the control group provinces. For NVP sales, only Saskatchewan experienced a statistically significant decrease in total NVP unit sales, mirroring the statistically insignificant effect we found earlier, but confidence intervals are wide. For cigarette sales, estimated coefficients are positive for all provinces, statistically significant at the 5% level for British Columbia and Ontario, and at the 10% level for New Brunswick.

For NVP flavor types, all provinces except the Maritimes grouping saw statistically significant reductions in non-mint/menthol flavored unit sales, with the latter significant at the 10% level. Coefficients are positive for all provinces for tobacco and unflavored unit sales. Notably, the two provinces without menthol exemptions—British Columbia and the Maritimes—exhibited a 99.9% and 99.1% decrease in mint/menthol unit sales, alongside the largest increases in tobacco and unflavored NVP unit sales: 464.8% and 711.1%, respectively, though the latter was not statistically significant. This pattern suggests that stronger substitution toward tobacco and unflavored products may occur when menthol-flavored NVPs are also prohibited. Indeed, provinces that exempted mint/menthol flavors—Saskatchewan and Ontario—did not show statistically significant changes in either tobacco and unflavored or mint/menthol sales.

Table 3 presents estimated coefficients under different model specifications such as two-way-fixed-effects, synthetic DID (Arkhangelsky et al., 2021)[12], and using levels rather than natural logs as the outcome variable. The first row repeats the baseline results from a stacked DID regression model, with logged outcomes. Across logged specifications (rows 1-3), the NVP results are broadly consistent, reinforcing the robustness of the main findings. The main difference is that the cigarette synthetic DID result is sizably larger, corresponding to an estimated coefficient on 0.195 (21.5% increase) versus 0.092 (9.6% increase) in the main specification.

There are some minor differences in precision of estimates as well; for example, the TWFE logged specification newly shows a reduction in all NVP units per capita of $p<0.10$. However, in this specification mentholated units per capita (column 4) is no longer statistically significant. In the last row, coefficients in levels are directionally the same as for the logged coefficients, and all results are statistically significant except for tobacco and

[12]Synthetic DID combines traditional differences-in-differences with synthetic control methods by using panel and time weights to construct a counterfactual that closely matches pre-treatment trends in both treatment and control units, improving robustness to violations of the parallel trends assumption.

unflavored units per capita. This includes for all NVP units per capita, which decreased by 0.034, which adds further evidence that NVP sales decreased overall.

Given previously mentioned concerns with parallel trends for cigarettes in our baseline specification (Figure 1), we re-estimate event studies using all four specifications of cigarette sticks per capita, as shown by column (1) of Table 3 with the corresponding event studies in Figure 5. The synthetic DID in particular appears to satisfy the parallel trends assumption, as no pre-period coefficients are statistically different from 0. This specification corresponds to the aforementioned 21.5% increase (coefficient = 0.195) in cigarette sales, suggesting that the baseline estimate's 9.6% increase (coefficient = 0.092) may be biased downwards due to unobserved time-varying heterogeneity.

We also conduct a back-of-the-envelope calculation to gauge the magnitude of the documented substitution in terms of nicotine consumed. In the year prior to adoption, average monthly NVP unit sales in treated provinces were 0.03244 units per capita in the NielsenIQ convenience and gas store data. Assuming these sales represent 7.44%[13] of the broader NVP market implies 0.436 NVP units per capita per month. Applying our estimated 29.5% reduction in NVP unit sales implies a decline of 0.129 units per capita per month. Using the sample average of 3.6 mL per unit and 28.73 mg/mL, this corresponds to 13.3 mg less nicotine sold per capita per month. Assuming that 20% to 80% of nicotine contained in e-liquid is ultimately absorbed by users,[14] this implies a

[13]Calculated as 24% of NielsenIQ coverage of C&G stores multiplied by C&G stores' 31% share of national NVP sales Health Canada (2022).

[14]National Academies of Sciences, Engineering, and Medicine (2018) reports that nicotine contained in e-cigarette aerosol ranges from 21% to 85% of the nicotine present in the cartridge, while St Helen et al.

reduction of approximately 2.7 to 10.6 mg of nicotine absorbed per capita per month. For cigarettes, pre-treatment sales averaged 57.42 cigarettes per capita per month. Our estimated 9.6% increase in cigarette sales implies approximately 5.5 additional cigarettes sold per capita per month. Assuming 1–2 mg of nicotine absorbed per cigarette (Institute of Medicine, 2001), this corresponds to an increase of approximately 5.5 to 11.0 mg of nicotine absorbed per capita per month. Thus, the increase in nicotine absorbed from cigarettes is of similar magnitude to the reduction in nicotine absorbed from NVPs.

5.3 Google Trends Results

Finally, results from Google Trends analyses are found in Figure 6. For Google searches related to NVP shopping, the statistically significant -0.245 coefficient estimate indicates a 21.7% reduction in searches. Searches containing the phrase "Vape Shop" yielded a non-significant the estimate of -0.186 (17.0%). With neither event study showing more than one pre-period coefficient statistically different from zero, these results are consistent with decreases in consumer interest in NVPs following flavored NVP policies with limited substitution to vape shops and online purchases.

6 Discussion

The analyses presented here find that Canadian provinces' restrictions on flavored NVP sales sharply reduced both flavored NVP sales in convenience stores and search in-

(2016) estimates that 93.8% of inhaled nicotine is systemically retained.

terest capturing alternative sourcing of NVPs. These reductions in flavored NVP sales reduced overall NVP sales in economically meaningful ways, though statistical significance varied somewhat across specifications due to substitution towards unrestricted NVP flavor categories. Yet as in the US, NVP flavor restrictions also had unintended effects, increasing sales of more-dangerous combustible tobacco products. Moreover, these effects are large, with estimates ranging from a 9.6% increase in cigarette sales per capita in our main specification, to a 21.5% increase with a synthetic DID approach. With cigarette sales declining in Canada over time (see Figure A2), these findings suggest that NVP flavor restrictions slowed the decline in per capita cigarette sales in adopting provinces relative to what would have otherwise occurred.

These findings suggest that policymakers should proceed with caution in restricting NVP flavors: harm due to these policies' unintended effects on cigarette consumption may outweigh the public health benefits from their impact on NVP use.

The results of this study are largely consistent with prior work on U.S. flavor policies. Friedman et al. (2025) found that flavored NVP restrictions increased cigarette sales while reducing NVP sales; however, the magnitude of their estimated effect on NVP sales was somewhat larger, finding approximately a 66.8% reduction compared to a 29.5% reduction in the current study. More restrictive regulation in Canada might explain this: with a national ban on menthol cigarettes and limited flavorings allowed in cigars, Canadian consumers who prefer flavors have fewer combustible substitutes for flavored NVPs. Even so, this study's findings demonstrate that the pattern of substitution from

NVPs to combustible tobacco persists outside the US, even in a nation with stricter tobacco laws.

These analyses face several limitations. First, cigarette/NVP sales are not the same as cigarette/NVP use. We cannot determine the extent to which changes in sales reflect changes in smoking/vaping participation versus frequency, nor separate out effects on youth versus adults.[15] Second, these data capture legal cigarette/NVP sales only. Canada's contraband market represents an unknown percentage of total cigarette/NVP consumption, which may vary by region and over time (Guindon, Burkhalter and Brown, 2017). This may impact the degree to which legal cigarette/NVP sales data capture changes in cigarette consumption.

From an economic perspective, restrictions on flavored NVP sales plausibly reduce welfare. These policies lower consumption of NVPs, which are widely regarded as substantially less dangerous than combustible cigarettes (Allcott and Rafkin, 2022). Absent meaningful externalities or large internalities, restricting access to a product that consumers value and choose reveals a welfare loss. Such restrictions might be justified if NVP use generated substantial harms to bystanders or if consumers systematically underestimated their risks. However, evidence for either justification is limited. NVPs emit little secondhand air pollution (National Academies of Sciences, Engineering, and Medicine,

[15] Prior work has estimated separate effects of US flavor policies on sales of cigarette brands disproportionately used by youth (Friedman et al., 2025). That method could not be applied here as the cigarette sales data were not brand-specific. The NielsenIQ data used in these analyses are an extract containing only NVP category data, which have been consistently purchased by Health Canada since February 2011. As such, we do not have access to sales data for other tobacco products within NielsenIQ.

2018; Seidenberg et al., 2024), consumers tend to overestimate rather than underestimate their risks relative to cigarettes (Pesko et al., 2025), and population-level evidence suggests that increased NVP availability is associated with reduced mortality (Cooper and Pesko, 2024; Pesko and Saenz, 2025). In this context, restricting access to flavored NVPs likely removes a valued product choice without clearly correcting a market failure. To the extent that these policies induce substitution toward combustible cigarettes, they may also worsen population health by increasing consumption of a far more lethal product. Taken together, the available evidence suggests that NVP flavor restrictions risk reducing both economic welfare and population health.

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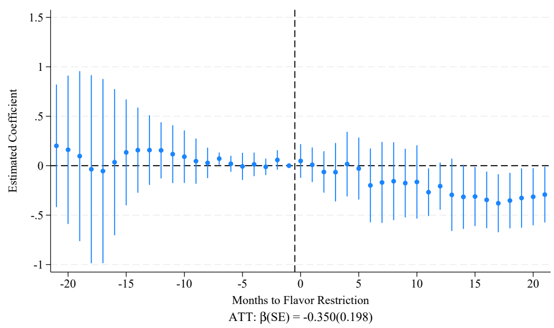
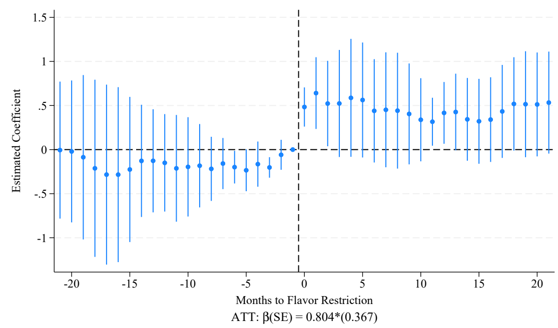
Figure 1: Stacked Event Studies for Analyses of NVP Flavor Restriction Effects on NVP and Cigarette Sales

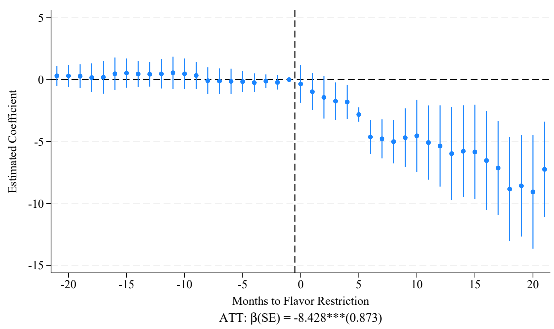
(a) Ln(NVP Units/Capita)



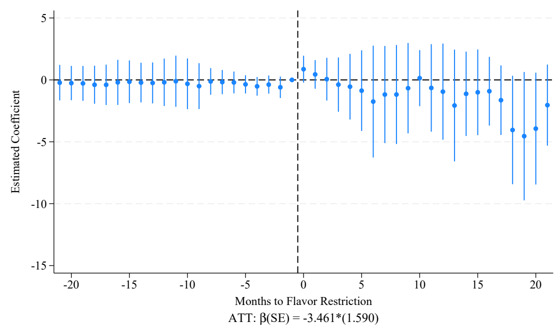
(b) Ln(NVP Tobacco & Unflavored Units/Capita)



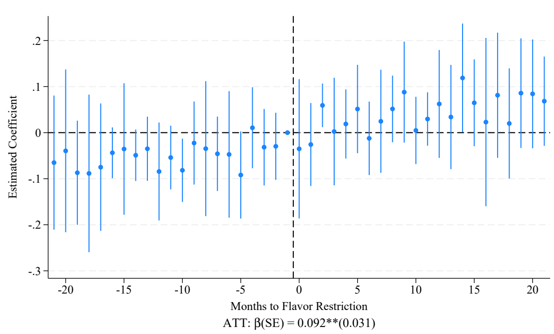
(c) Ln(NVP Flavored Non-Mentholated Units/Capita)



(d) Ln(NVP Mentholated Units/Capita)



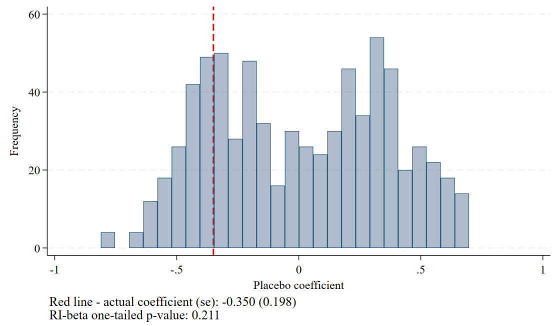
(e) Ln(Cigarettes/Capita)



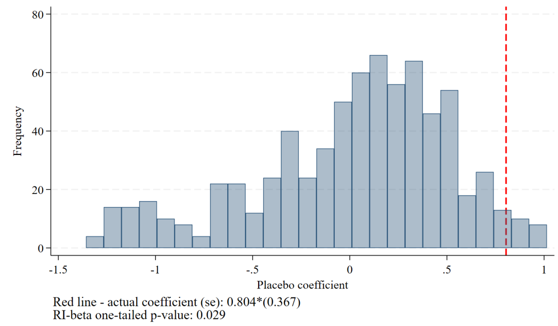
Notes: Cigarette data are monthly wholesale cigarette sales in each province from July 2018 to June 2023 provided by Health Canada. NVP data are gas and convenience stores unit sales from July 2018 to June 2023 by province and month from NielsenIQ. 0.02% of unit sales are missing flavor. These units are omitted from the flavor-specific analysis. Mentholated units include products labeled as menthol, mint, menthol combined with tobacco, and mint combined with tobacco flavors. Flavored non-mentholated units include flavored products, including those that combine flavors with menthol or mint (e.g., cherry-menthol), but exclude products that are exclusively menthol/mint, exclusively tobacco, or menthol/mint combined with tobacco. Covariates include cigarette taxes, NVP taxes (ad valorem and per mL), NVP nicotine limits, the unemployment rate, COVID-19 deaths per capita, internal movement restrictions index, non-essential retailer restrictions index, and an indicator for the Atlantic Bubble. Fixed effects includes stack by month-year and stack by province. The regressions are weighted by stack weight as proposed in Wing, Freedman and Hollingsworth (2024). Standard errors are clustered at the province level. 95% confidence intervals are shown. * p<0.10, ** p<0.05, *** p<0.01

Figure 2: Frequency of Coefficients from Placebo Tests

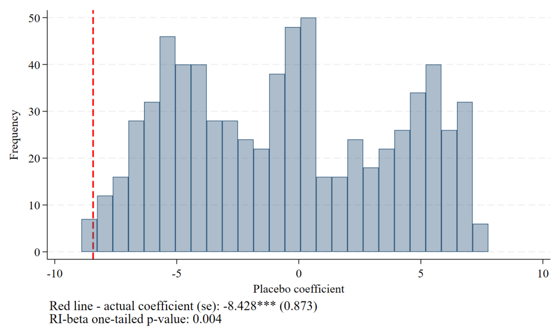
(a) Ln(NVP Units/Capita)



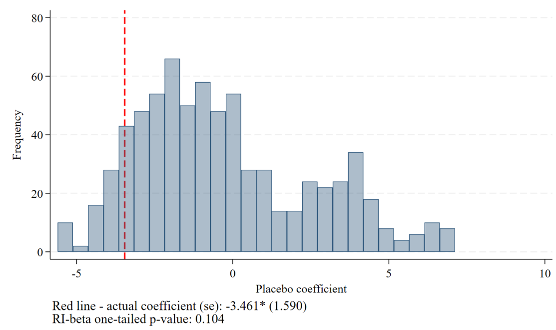
(b) Ln(NVP Tobacco & Unflavored Units/Capita)



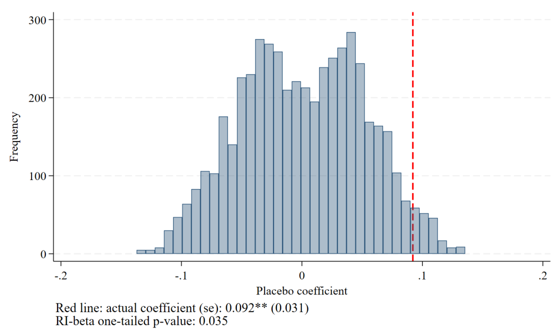
(c) Ln(NVP Flavored Non-Mentholated Units/Capita)



(d) Ln(NVP Mentholated Units/Capita)



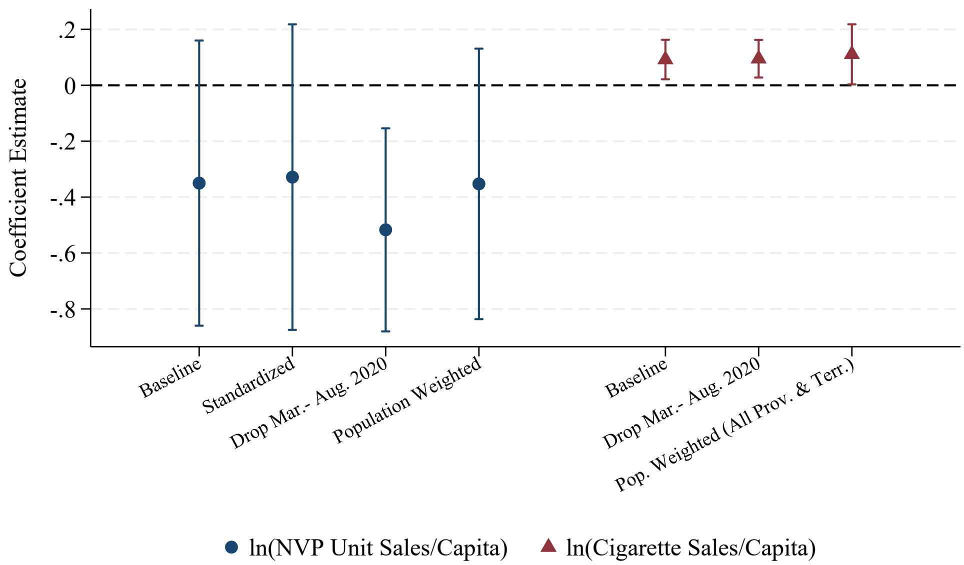
(e) Ln(Cigarettes/Capita)



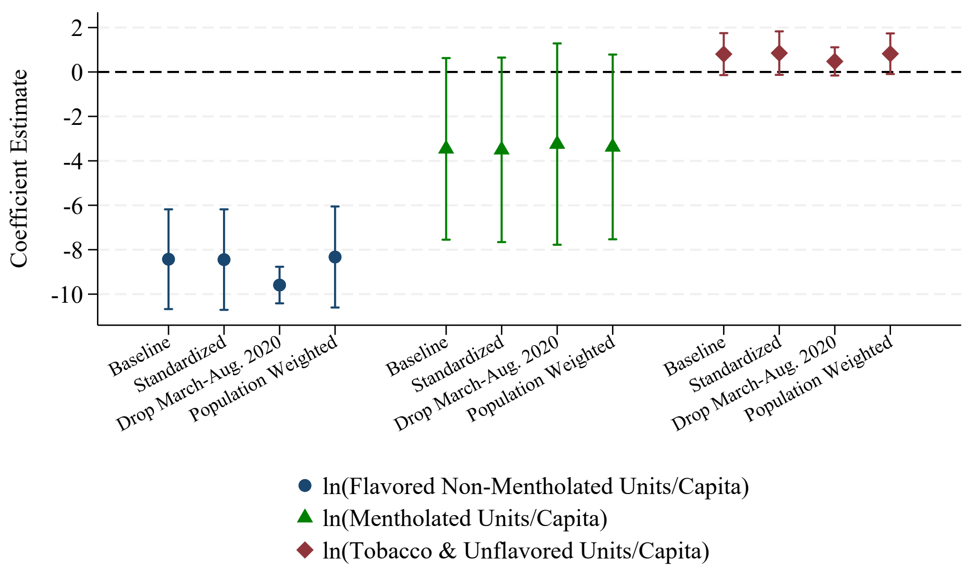
Notes: Histograms show the distribution of placebo coefficients from randomization inference tests that reassign treatment timing across provinces. The dashed red line denotes the actual estimated coefficient from the stacked DID specification in Table 2. RI-beta one-tailed p-values report the share of placebo coefficients at least as extreme as the actual coefficient in the hypothesized direction. For the NVP analyses, placebo distributions are constructed using all 720 possible province-level treatment permutations. For cigarette analyses, placebo distributions are constructed using 5,000 random province-level permutations.

Figure 3: Stacked Estimates of Flavored NVP Policy Effects on NVP and Cigarette Sales

(a) Effect on Cigarette and NVP Unit Sales



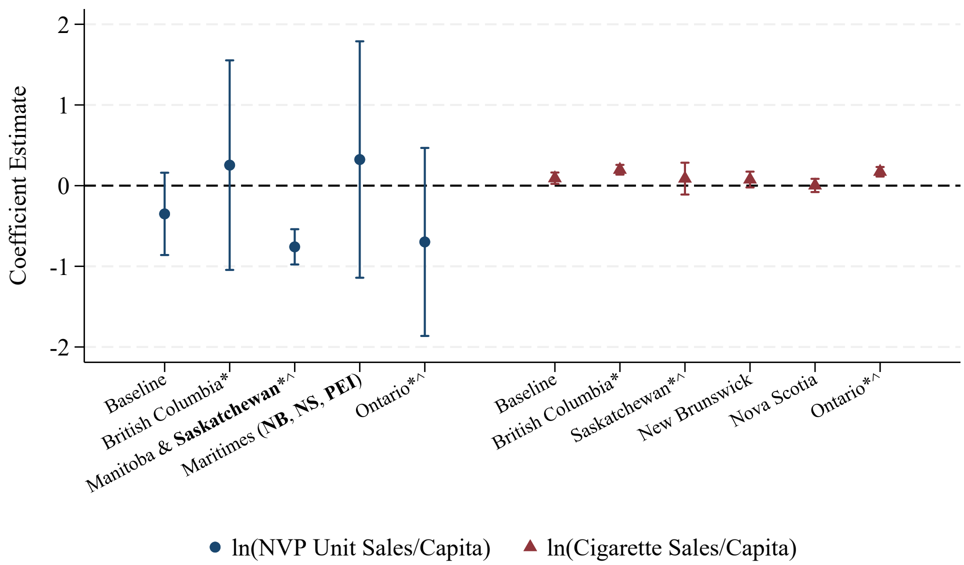
(b) Effect on NVP Unit Sales by NVP Flavor



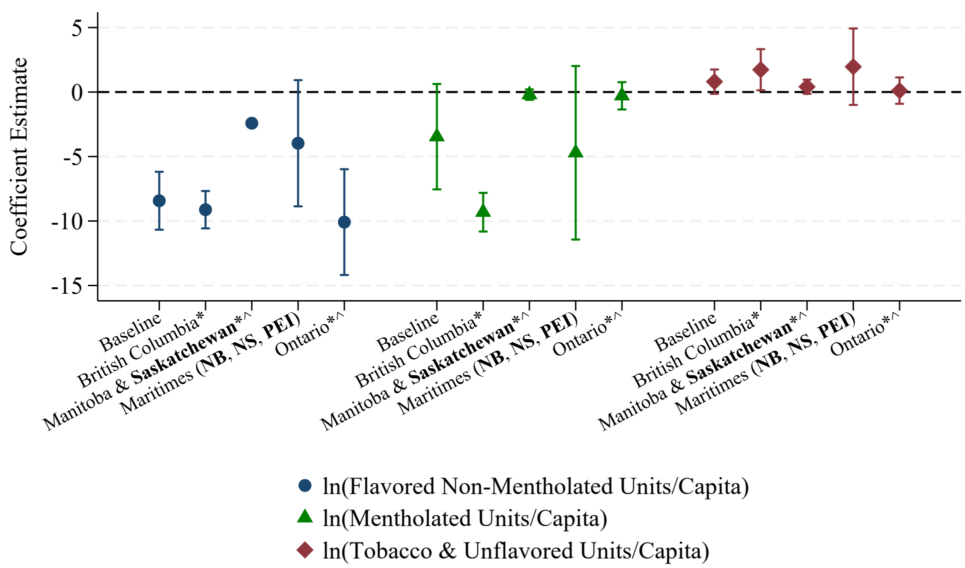
Notes: Cigarette data are monthly wholesale cigarette sales in each province from July 2018 to June 2023 provided by Health Canada. NVP data are gas and convenience stores unit sales from July 2018 to June 2023 by province and month from NielsenIQ. 0.02% of unit sales are missing flavor. These units are omitted from the flavor-specific analysis. Mentholated units include products labeled as menthol, mint, menthol combined with tobacco, and mint combined with tobacco flavors. Flavored non-mentholated units include flavored products, including those that combine flavors with menthol or mint (e.g., cherry-menthol), but exclude products that are exclusively menthol/mint, exclusively tobacco, or menthol/mint combined with tobacco. Covariates include cigarette taxes, NVP taxes (ad valorem and per mL), NVP nicotine limits, the unemployment rate, COVID-19 deaths per capita, internal movement restrictions index, non-essential retailer restrictions index, and an indicator for the Atlantic Bubble. 95% confidence intervals are shown. Fixed effects include stack by month-year and stack by province. The regressions are weighted by stack weight as proposed in Wing, Freedman and Hollingsworth (2024), and by population as well in the population-weighted specification. Standard errors are clustered at the province level.

Figure 4: Stacked Estimated Effect of NVP Flavor Restriction, One Adopter at a Time

(a) Effect on NVP and Cigarette Sales



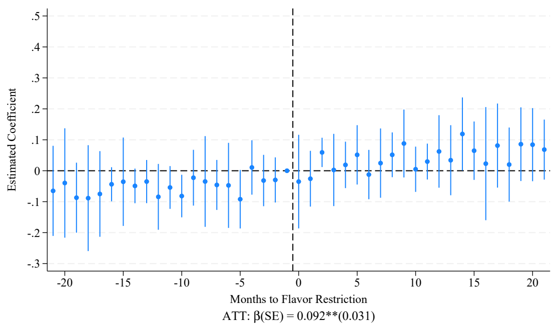
(b) Effect on NVP Unit Sales by Flavor



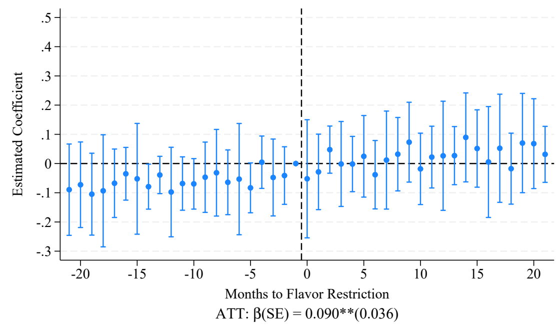
Notes: These regressions re-estimate the main analysis of logged cigarette sales per capita and logged NVP units sales per capita, but compare non-adopters to one adopting province at a time. Each coefficient and 95% confidence interval corresponds to the flavor policy effect estimated from the sample indicated on the x-axis. Cigarette data are monthly wholesale cigarette sales in each province from July 2018 to June 2023 provided by Health Canada. NVP data are gas and convenience stores unit sales from July 2018 to June 2023 by province and month from NielsenIQ. 0.02% of unit sales are missing flavor. These units are omitted from the flavor-specific analysis. Flavor restrictions with exemptions for vape shops are indicated with an asterisk (*), and exemptions for mint flavors are indicated with a caret (ˆ). In cases where multiple provinces are included in a panel, the treated province is bolded. Covariates include cigarette taxes, NVP taxes (ad valorem and per mL), NVP nicotine limits, the unemployment rate, COVID-19 deaths per capita, internal movement restrictions index, non-essential retailer restrictions index, and an indicator for the Atlantic Bubble. Fixed effects include stack by month-year and stack by province. The regressions are weighted by stack weight as proposed in Wing, Freedman and Hollingsworth (2024). Standard errors are clustered at the province level. 95% confidence intervals are shown.

Figure 5: Alternative Event Study Models: Effect of NVP Flavor Restriction on Cigarette Sales

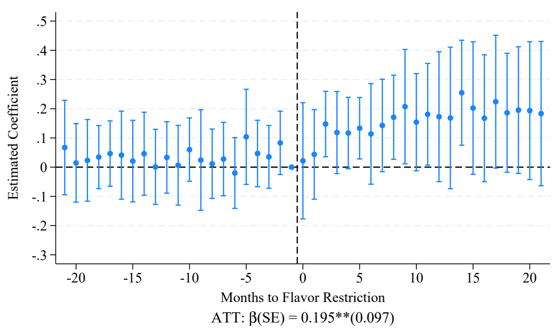
(a) Ln(Cigarettes/Capita) - Stacked DID



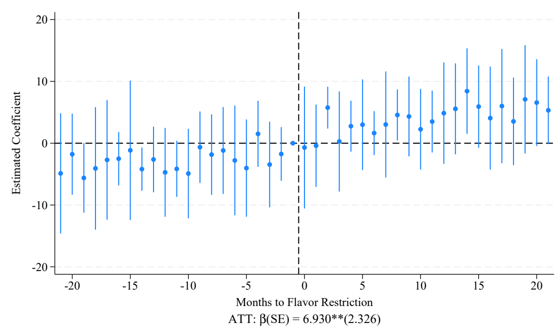
(b) Ln(Cigarettes/Capita) - TWFE



(c) Ln(Cigarettes/Capita) - Synthetic DID



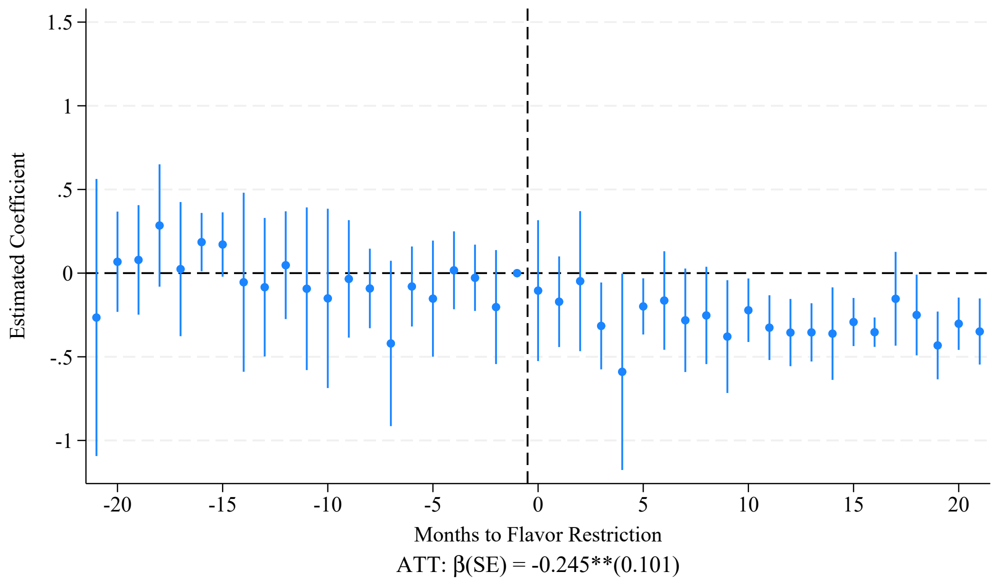
(d) Cigarettes/Capita - Stacked DID



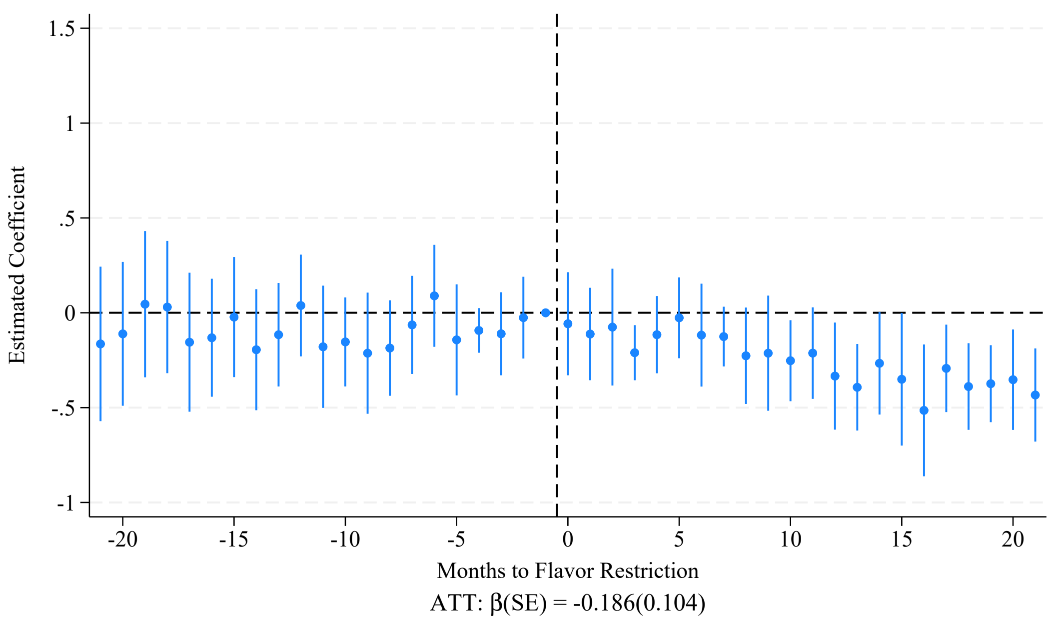
Notes: Cigarette data are monthly wholesale cigarette sales in each province from July 2018 to June 2023 provided by Health Canada. Covariates include cigarette taxes, NVP taxes (ad valorem and per mL), NVP nicotine limits, the unemployment rate, COVID-19 deaths per capita, internal movement restrictions index, non-essential retailer restrictions index, and an indicator for the Atlantic Bubble. Standard errors are clustered at the province level. 95% confidence intervals are shown. * p<0.10, ** p<0.05, *** p<0.01

Figure 6: Stacked Event Studies for Analyses of NVP Flavor Restriction on Google Search Trends

(a) Ln(Google Searches Related to E-Cigarette Shopping)



(b) Ln(Google Searches for "Vape Shop")



Notes: Google Trends data are monthly measures of Google Search interest at the province level from July 2018 to June 2023. Covariates include cigarette taxes, NVP taxes (ad valorem and per mL), NVP nicotine limits, the unemployment rate, COVID-19 deaths per capita, internal movement restrictions index, non-essential retailer restrictions index, and an indicator for the Atlantic Bubble. Fixed effects include stack by event time and stack by province. The regressions are weighted by stack weight as proposed in Wing, Freedman and Hollingsworth (2024). Standard errors are clustered at the province level. 95% confidence intervals are shown. * p<0.10, ** p<0.05, *** p<0.01

Table 1: Summary Statistics of Outcome Variables

	Full Sample	Non-Adopters		Adopters		
	July 2018 - June 2023	July 2018 - June 2019	July 2022 - June 2023	July 2018 - June 2019	July 2022 - June 2023	DID
	(1)	(2)	(3)	(4)	(5)	(6)
Outcomes						
Monthly NVP Units/Capita	0.0284	0.0074	0.0466	0.0060	0.0254	-0.0198
	(0.0201)	(0.0091)	(0.0199)	(0.0058)	(0.0098)	(0.0039)
Monthly NVP Flavored Units/Capita	0.0100	0.0044	0.0219	0.0035	0.0013	-0.0196
	(0.0103)	(0.0054)	(0.0077)	(0.0034)	(0.0022)	(0.0016)
Monthly NVP Mentholated Units/Capita	0.0099	0.0021	0.0191	0.0017	0.0074	-0.0113
	(0.0095)	(0.0026)	(0.0096)	(0.0016)	(0.0075)	(0.0021)
Monthly NVP Tobacco Unflavored Units/Capita	0.0085	0.0009	0.0057	0.0008	0.0167	0.0112
	(0.0103)	(0.0011)	(0.0031)	(0.0008)	(0.0143)	(0.0030)
Monthly Cigarettes Sticks/Capita	50.1	64.6	37.2	55.3	37.9	10.0
	(16.5)	(18.1)	(8.9)	(14.0)	(11.9)	(3.7)
Google Searches Related to E-Cigarette Shopping	38.3	30.2	45.4	41.4	45.7	-10.9
	(14.1)	(15.2)	(13.8)	(10.2)	(13.1)	(3.6)
Google Searches for "Vape Shop"	45.9	38.3	64.5	43.8	51.3	-18.8
	(17.5)	(13.1)	(10.7)	(13.8)	(18.7)	(4.0)
N[1]	540	48	48	60	60	216

Notes: Cigarette data are monthly wholesale cigarette sales in each province from July 2018 to June 2023 provided by Health Canada. NVP data are monthly gas and convenience store unit sales from July 2018 to June 2023 from NielsenIQ. 0.02% of unit sales are missing flavor. These units are omitted from flavor-specific categories. [1] The NVP panel combines Manitoba and Saskatchewan, and also combines the Maritimes (Nova Scotia, New Brunswick, and Prince Edward Island). Newfoundland and Labrador is not included in the data. As a result, the number of observations differs across columns: 360, 24, 24, 48, and 48.

Table 2: Stacked Estimated Effect of NVP Flavor Restriction on NVP and Cigarette Sales

	(1)	(2)	(3)	(4)	(5)
	ln(NVP Units per Capita)	ln(NVP Flavored Non-Mentholated Units per Capita)	ln(NVP Mentholated Units per Capita)	ln(NVP Tobacco and Unflavored Units per Capita)	ln(Cigarettes per Capita)
NVP Flavor Restriction	-0.350	-8.428***	-3.461*	0.804*	0.092**
	(0.198)	(0.873)	(1.590)	(0.367)	(0.031)
	[0.138]	[0.000]	[0.081]	[0.080]	[0.017]
	{0.625}	{0.031}	{0.062}	{0.031}	{0.032}
N	516	516	516	516	903
Province-by-Stack FE	Yes	Yes	Yes	Yes	Yes
Month-Year-by-Stack FE	Yes	Yes	Yes	Yes	Yes
Tobacco Policies	Yes	Yes	Yes	Yes	Yes
COVID-19 Covariates	Yes	Yes	Yes	Yes	Yes
Unemployment Rate	Yes	Yes	Yes	Yes	Yes

Notes: Cigarette data are monthly wholesale cigarette sales in each province from July 2018 to June 2023 provided by Health Canada. NVP data are gas and convenience stores unit sales from July 2018 to June 2023 by province from NielsenIQ. 0.02% of unit sales are missing flavor. These units are omitted from the flavor-specific analysis. Mentholated units include products labeled as menthol, mint, menthol combined with tobacco, and mint combined with tobacco flavors. Flavored non-mentholated units include flavored products, including those that combine flavors with menthol or mint (e.g., cherry-menthol), but exclude products that are exclusively menthol/mint, exclusively tobacco, or menthol/mint combined with tobacco. Tobacco policies include cigarette taxes, NVP tax (percent), NVP tax (per mL), and NVP nicotine limit. COVID-19 covariates includes COVID-19 deaths per capita, internal movement restriction index, non-essential retailer restriction index, and an indicator for the Atlantic Bubble. The regressions are weighted by stack weight as proposed in Wing, Freedman and Hollingsworth (2024). Standard errors are clustered at the province level. Conventional cluster-robust p-values are in brackets and wild bootstrap p-values are in curly brackets. * p<0.10, ** p<0.05, *** p<0.01

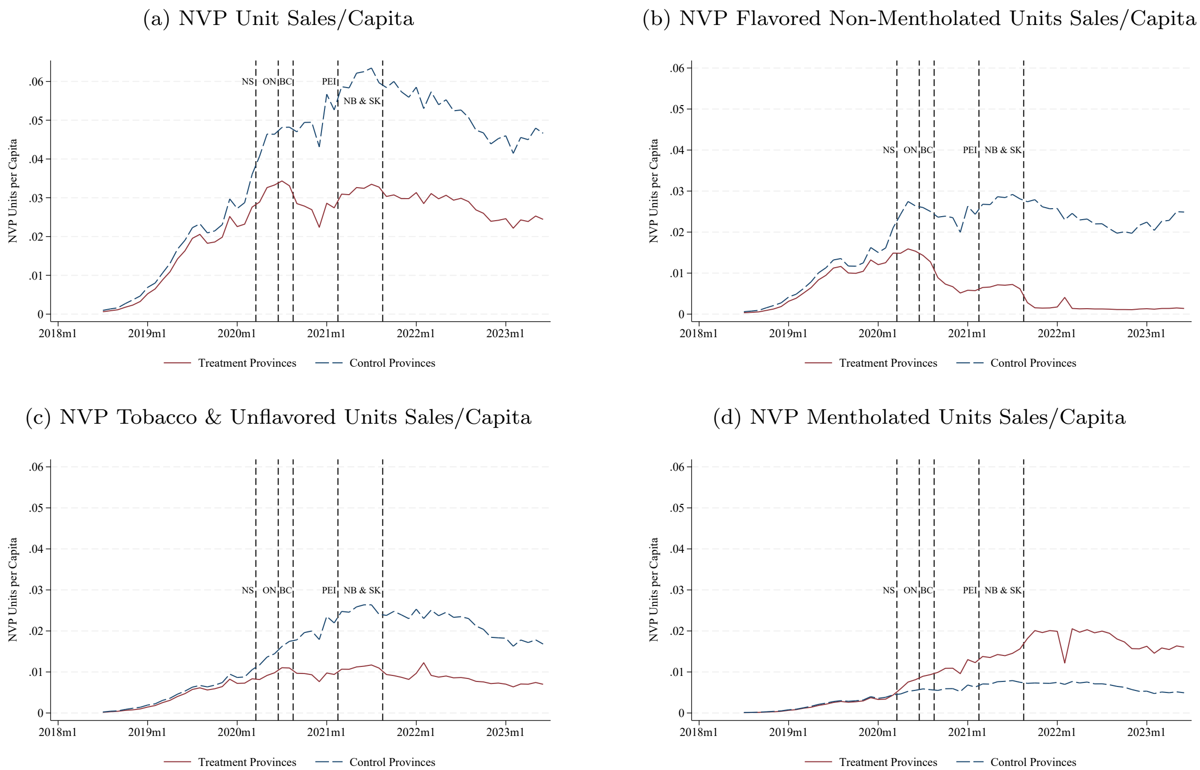
Table 3: Alternative Models: Effect of NVP Flavor Restriction on NVP and Cigarette Sales

	NVP Units per Capita	NVP Flavored Non-Mentholated Units per Capita	NVP Mentholated Units per Capita	NVP Tobacco and Unflavored Units per Capita	Cigarette Sticks per Capita
	(1)	(2)	(3)	(4)	(5)
Baseline	-0.350	-8.428***	-3.461*	0.804*	0.092**
(Stacked DID - Logged)	(0.198)	(0.873)	(1.590)	(0.367)	(0.031)
TWFE - Logged	-0.329*	-8.643***	-2.920	0.844*	0.090**
	(0.152)	(0.726)	(1.897)	(0.372)	(0.036)
Synthetic DID - Logged	-0.256	-6.233***	-3.767*	0.784*	0.195**
	(0.324)	(1.585)	(1.946)	(0.405)	(0.097)
Stacked DID - Levels	-0.034***	-0.024***	-0.017**	0.007	6.930**
	(0.008)	(0.002)	(0.005)	(0.004)	(2.326)
	{0.025}	{0.013}	{0.009}	{0.004}	{51.263}

Notes: Cigarette data are monthly wholesale cigarette sales in each province from July 2018 to June 2023 provided by Health Canada. NVP data are gas and convenience stores unit sales from July 2018 to June 2023 by province and month from NielsenIQ. 0.02% of unit sales are missing flavor. These units are omitted from the flavor-specific analysis. Mentholated units include products labeled as menthol, mint, menthol combined with tobacco, and mint combined with tobacco flavors. Flavored non-mentholated units include flavored products, including those that combine flavors with menthol or mint (e.g., cherry-menthol), but exclude products that are exclusively menthol/mint, exclusively tobacco, or menthol/mint combined with tobacco. Covariates include cigarette taxes, NVP taxes (ad valorem and per mL), NVP nicotine limits, the unemployment rate, COVID-19 deaths per capita, internal movement restrictions index, non-essential retailer restrictions index, and an indicator for the Atlantic Bubble. Fixed effects include month-year and province. For levels, pre-treatment means for the 12 months prior to adoption are in curly brackets. Standard errors are clustered at the province level. * p<0.10, ** p<0.05, *** p<0.01

7 Appendix

Figure A1: Trends in NVP Unit Sales per Capita



(a) NVP Unit Sales/Capita

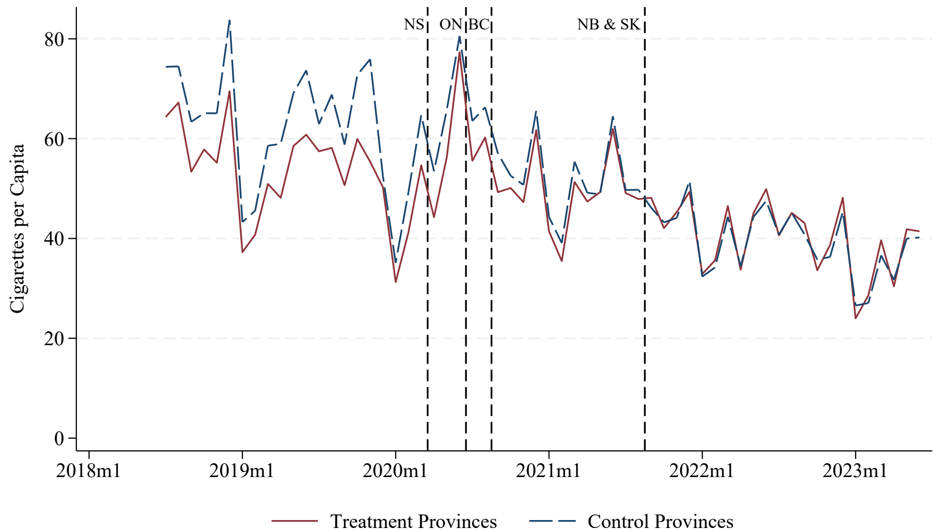
(b) NVP Flavored Non-Mentholated Units Sales/Capita

(c) NVP Tobacco & Unflavored Units Sales/Capita

(d) NVP Mentholated Units Sales/Capita

Notes: NVP data are average monthly gas and convenience store NVP unit sales from July 2018 to June 2023 in treatment (BC, MB & SK, ON, Maritimes [NB, NS, PEI]) and control (AB, QC) provinces from NielsenIQ. 0.02% of unit sales are missing flavor. These units are omitted from the flavor-specific analysis. Mentholated units include products labeled as menthol, mint, menthol combined with tobacco, and mint combined with tobacco flavors. Flavored non-mentholated units include flavored products, including those that combine flavors with menthol or mint (e.g., cherry-menthol), but exclude products that are exclusively menthol/mint, exclusively tobacco, or menthol/mint combined with tobacco.

Figure A2: Trends in Cigarette Sales per Capita



Notes: Cigarette data are average monthly wholesale cigarette sales in treatment (BC, NB, NS, ON, SK) and control provinces (AB, MB, NF, QC) from July 2018 to June 2023 provided by Health Canada.

Table A1: Flavor Restriction Implementation Dates

Province	Implementation Date
Nova Scotia[1]	April 1, 2020
Ontario	July 1, 2020
British Columbia	September 15, 2020
Prince Edward Island[1]	March 1, 2021
New Brunswick[1]	September 1, 2021
Saskatchewan[2]	September 1, 2021

Notes: [1]Nova Scotia, New Brunswick and Prince Edward Island come aggregated in the NielsenIQ data. [2]Manitoba and Saskatchewan come aggregated in the NielsenIQ data. Manitoba is a control group. When provinces are aggregated, the treatment variable is defined as the proportion of the population in the aggregation subject to a flavor restriction. In event study models, treatment begins when the first province in an aggregation is treated.