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Cigarette Use Before and After the 2009 Flavored Cigarette Ban

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A B S T R A C T

Purpose: On September 22, 2009, the U.S. Food and Drug Administration's national ban on flavored cigarette products went into effect, barring the sale of flavored cigarettes with the exception of menthol. Flavored cigarettes largely appeal to and were disproportionately used by youth (under age 18 years). However, little research has evaluated the effects of the ban. This study examined past 30-day cigarette use among youth (12–17 years), young adults (18–25 years), adults (26–49 years), and older adults (≥ 50 years) before and after the implementation of this ban.

Methods: Analyses were conducted using 2002–2017 National Survey on Drug Use and Health (NSDUH) data ($n = 893,226$). Regression models—weighted for national representation—were used to examine past 30-day cigarette use before and after the flavored cigarette ban in different age groups, using a quasi-experimental design incorporating elements of interrupted time series and difference-in-differences design. This design was used to examine differences in pre- versus post-ban smoking within age groups and heterogeneous policy effects between age groups, to help adjust for the generally stronger tobacco control environment over time.

Results: The flavor ban was associated with statistically significant immediate increases as well as reductions over time in youth and young adult use of any cigarettes and menthol cigarettes, compared to older adults. In 2017, the predicted probability of youth and young adult cigarette smoking were reduced by 43% and 27%, respectively, compared to the model predicted probability in absence of the ban. No such effect was observed for older adults. The predicted probability of menthol use was reduced by 60% and 55% for youth and young adults, respectively.

Conclusions: Findings support the effectiveness of flavored cigarette bans at reducing cigarette use among young people and suggest a substitution effect between flavored tobacco products.

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IMPLICATIONS AND CONTRIBUTION

This study evaluates the U.S. FDA's flavored cigarette ban using NSDUH data, finding that the flavored cigarette ban was associated with a statistically significant and meaningfully large reduction in the odds of cigarette use among youth and young adults, but not older adults.

Conflicts of interest:

None.
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Nearly 90% of smokers start smoking by age 18 years, and very few people ($\approx 1\%$) start smoking after age 26 years [1]. Thus, to reduce the number of preventable deaths and societal burden of tobacco use, one of the primary goals of tobacco control programs is to prevent youth and young adults from

initiating use [2]. According to tobacco industry documents, tobacco products with sweet, candy, or fruit flavors are designed to attract young smokers [3]. It is therefore not surprising that these flavored tobacco products, including menthol cigarettes, are disproportionately used by youth under 18 years of age [4–6], particularly the first time they use tobacco products [5,7]. Initiation with a flavored tobacco product, including menthol, is associated with sustained use [5,8,9]. Moreover, young people frequently cite flavors as the reason for continuing to use tobacco products [10]. Thus, prohibiting the sale of flavored tobacco products could be a key strategy to reduce tobacco use initiation.

The Family Smoking Prevention and Tobacco Control Act (FSPTCA) was signed into law on June 22, 2009, giving the U.S. Food and Drug Administration (FDA) authority to regulate cigarettes and smokeless tobacco products nationally [11,12]. Subsequently, the FDA banned the production and sales of flavored cigarettes, with the exception of menthol [13]. However, only one study has examined the association between the national flavored cigarette ban and youth tobacco use [14]. Courtemanche and colleagues (2017) [14] used National Youth Tobacco Survey (NYTS) data from six pre-ban (1999, 2000, 2002, 2004, 2006, and 2009) and three post-ban (2011, 2012, and 2013) years to examine differences in middle and high school students' tobacco use. They observed that, compared to pre-ban periods, there were reduced odds of youth smoking cigarettes after the ban [14]. Moreover, their findings suggested that there was a substitution effect, whereby youth were more likely to smoke menthol cigarettes after the flavor ban [14].

The present study analyzed National Survey on Drug Use and Health (NSDUH) data to examine whether the flavored cigarette ban was associated with a reduction in the odds of cigarette use among youth (ages 12–17) and young adults (ages 18–25), compared to pre-ban time trends and older adults. NSDUH data were collected during every quarter of every year during the time period under investigation, as compared to NYTS data that were only collected every one to three years before 2011. Because data were collected annually and within four distinct quarters each year, more time points were available—including time points more proximal to the flavor ban. As a result, separate time trends could be examined pre- versus post-ban. Thus, NSDUH data allowed for more precise modeling of pre- and post-ban associations with cigarette use. Moreover, cigarette use may have decreased after the ban in general, by people of all ages, due to factors unrelated to the flavor ban, such as through other tobacco control initiatives including increased state and federal excise tax on tobacco products [15] as well as changing social norms over time. Thus, NSDUH data provide another strength over NYTS data because the former data are collected from a nationally representative sample of people 12 years and older, rather than only middle- and high-school students. Having older adult comparison groups statistically adjusts for general changes in cigarette use among people of all ages after versus before the implementation of the flavored cigarette ban. This is important because it provides stronger evidence that the flavored cigarette ban itself resulted in a decline in youth and young adult cigarette smoking rather than this effect being the result of an increasingly restrictive tobacco control environment over time.

Using this same approach, we examined whether there were significant differences in the probability of young people smoking menthol-flavored cigarettes pre- versus post-ban. A better understanding of the potential substitution from other flavored cigarettes to menthol flavored cigarettes is important, as it may help provide guidance regarding the effectiveness of further regulation.

Methods

Design

We evaluated the effect of the 2009 flavored cigarette ban on youth and young adult cigarette use by using a quasi-experimental design incorporating elements of both an interrupted time series and a difference-in-differences design. We analyzed quarterly cross-sections of self-reported past 30-day tobacco use from 2002 to 2017 including 31 quarters before the ban and 33 quarters after the ban went into effect (September 22, 2009).

There are two distinct ways that the ban on flavored cigarettes could impact youth and young adult cigarette smoking behavior. First, there may be an immediate reduction in cigarette use if some young smokers of flavored cigarettes abstain from smoking post-ban rather than switching to nonflavored or menthol cigarettes. Second, there may be a gradual reduction in cigarette use as fewer youth and young adults initiate smoking due to less appealing, nonflavored cigarettes being the only option on the market. Therefore, we estimated both immediate changes in the mean probability of self-reported past 30-day cigarette use and changes in the slope of the probability of past 30-day cigarette use over time. Although it is possible that other changes to the tobacco control environment may affect past 30-day tobacco use, the flavored cigarette ban is hypothesized to have a greater impact among youth and young adults compared to older adults [3–5,7,14]. Thus, to strengthen our quasi-experimental design, we analyzed whether there were differential effects of the flavored cigarette ban by age group.

Similarly, we hypothesized an immediate substitution effect towards menthol cigarettes among some young people who smoked other flavored cigarettes. However, we also hypothesized a gradual reduction in menthol use over time as the youth who were initially attracted to other flavors progressed into different age groups, and children who were never exposed to cigarettes of other flavors became adolescents. For these reasons, we used the same modeling approach to examine changes in the probability of young people smoking menthol-flavored cigarettes pre- versus post-ban.

Data

National Survey on Drug Use and Health (NSDUH) data are the primary source for substance use estimates in the United States [16]. Each quarter of each year, interview data are collected in the United States from more than 12,000 randomly selected participants aged 12 years and older. To help ensure that data include an adequately large sample for making reliable national estimates, 12- to 17-year-olds and 18- to 25-year-olds are intentionally oversampled [17]. To increase honesty of self-report, interviews are conducted in separate areas of the house, away from other household members [17]. The present study used NSDUH data from 2002 through 2017 [18]. This study was

exempt from human subjects review because NSDUH data were publicly available and did not include personally identifiable information.

Measures

Past 30-day cigarette use was dichotomized into categories of yes (any cigarette use within the past 30 days) or no (no cigarette use within the past 30 days); this measure has been commonly used for assessing smoking [19]. An indicator variable was coded for the enactment of the flavored cigarette ban on September 22, 2009 with 31 quarters before the ban and 33 quarters after the ban. Age groups were coded as follows: 12–17 years old (i.e., youth), 18–25 years old (i.e., young adults), 26–49 years old (i.e., adults), and 50 years and older (i.e., older adults). Race/ethnicity was categorized into mutually exclusive categories of Asian, black, Hispanic, multi-racial, Native American, Pacific Islander, and white.

Menthol cigarette use was assessed with the item, “Were the cigarettes you smoked during the past 30 days menthol?” Analyses pertaining to menthol cigarette use were restricted to the years 2004–2017, because the item used before 2004 had notably different wording and is therefore deemed not likely to be comparable according to the Substance Abuse and Mental Health Services Administration (SAMHSA) [20].

Data on changes in cigarette prices between quarters were obtained from the Bureau of Labor Statistics (BLS) Consumer Price Index (CPI). This variable was important to adjust for in isolating the effect of the flavored cigarette ban because the price of cigarettes increased substantially during the study period, and especially around the time of the enactment of the flavor ban.

Statistical analyses

We estimated the effect of the flavored cigarette ban as a quasi-experimental design using segmented logistic regression analyses. Our model included a fully saturated model with three-way interactions of a linear term for quarter, the flavored cigarette ban policy indicator, and categorical age group. This allowed for estimates of both within age-group changes before and after the ban and whether these changes were statistically significantly different from changes seen in those 50 years old or older. The 50 years or older age category was used as the comparison group as an indicator of general cigarette smoking trends over time. Moreover, cigarette use rates among older adults were not expected to be influenced by the flavored cigarette ban because flavored cigarette use before the ban was extremely low among people in that age group (i.e., < 1% among smokers 55 years and older) [4]. From this model, we estimated the immediate change in the log-odds of cigarette use at enactment of the ban by age group as well as change in pre- and post-ban slopes in the log-odds of past 30-day cigarette use over time, expressing each as odds ratios. To estimate the total effect of the ban within each age group, we summed the immediate change in the log-odds associated with the ban with the estimated change in the log-odds over time after the ban (the change in slope multiplied by the number of post-ban time periods); this estimate was then exponentiated to express it as an odds ratio and confidence interval (CI). Odds ratios are interpreted as the percent increase in odds comparing the post-ban to the pre-ban period. To express the effects of the ban on an additive scale, we also estimated age group-specific predicted probabilities over time. These analyses

were then replicated for the model examining the predicted probability of menthol cigarette use. All regression models included the consumer price index for cigarettes as a covariate to adjust for variation in cigarette prices over time.

To account for the complex sampling design of NSDUH, all models were estimated using PROC SURVEYLOGISTIC in SAS v9.4. Survey weights were applied to make estimates nationally representative. Only complete cases were analyzed due to the small amount of missing data (less than 1% overall).

Sensitivity analyses

To assess the robustness of our results to modeling assumptions, we performed a series of sensitivity analyses. First, we assessed whether there were substantive differences based on the inclusion of individual-level demographic covariates: race/ethnicity and gender. In addition, for data collected during quarter 4 of 2009 (Q4-2009), participants' responses to questions asking about their use of cigarettes in the past 30 days may have been during a time period when flavored cigarettes were legal and illegal at some points in time. Therefore, pre- versus post-ban time periods were coded in two ways: (1) Q4-2009 was included in the post-ban time period and (2) Q4-2009 was included in the pre-ban time period. None of these changes in model specifications led to substantive changes in our results. We therefore present the results for the model with individual-level covariates (i.e., race/ethnicity and gender) and quarter 4 of 2009 included in the post-ban time period. We also re-estimated all models at an annual level to assure that weighted quarterly estimates were representative at the national level.

Results

The largest changes in cigarette use associated with the ban were seen for youth and young adults. Among youth, there was a 17% increase in the odds of reporting any cigarette use in the past 30 days immediately after the flavor ban (OR = 1.17, 95% CI [1.07,1.29], $p < .001$) compared to the pre-ban period. In addition, there was a 2.2% reduction in those odds each quarter (OR = .98, 95% CI [.97,0.98], $p < .001$) over the pre-ban trend. Similar patterns were seen for young adults, with a 9% immediate increase in the odds of reporting any cigarette use in the past 30 days (OR = 1.09, 95% CI [1.03,1.16], $p = .0047$), followed by an additional 1.2% reduction in the odds each quarter (OR = .99, 95% CI [.99,0.99], $p < .001$) over the pre-ban trend. For adults and older adults, no significant differences were observed in either group for an immediate change after the flavor ban, and the changes in slope were attenuated compared to the younger age groups (.25% reduction among adults; .5% reduction among older adults) (Table 1).

For menthol cigarettes, the largest changes associated with the ban were also seen among youth and young adults. Among youth, there was an immediate 33% increase in the odds of reporting menthol cigarette use in the past 30 days (OR = 1.33, 95% CI [1.15,1.54], $p < .001$), followed by an additional 3.6% reduction in the odds each quarter (OR = .96, 95% CI [.96,0.97], $p < .001$) over the pre-ban trend. Among young adults, there was an estimated immediate increase of 29% in the odds of reporting menthol cigarette use in the past 30 days (OR = 1.29, 95% CI [1.19,1.41], $p < .001$), followed by a 2.6% reduction in the odds each quarter (OR = .97, 95% CI [.97,0.98], $p < .001$) over the pre-ban trend. Among adults, there was an estimated 17% immediate increase in the odds of past 30-day menthol cigarette use (OR = 1.17, 95% CI

Table 1
Estimated effect of flavor ban by age on cigarette use

	Immediate change	Change in slope	Total effect
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Adolescents	1.172 (1.068, 1.286)	.978 (.974, .983)	.569 (.490, .661)
Young adults	1.089 (1.027, 1.156)	.988 (.985, .991)	.733 (.655, .821)
Adults	1.063 (.985, 1.147)	.994 (.992, .997)	.883 (.785, .994)
Older adults	1.017 (.926, 1.116)	.995 (.990, 1.000)	.854 (.702, 1.039)

Bold text indicates statistically significant findings.

[1.06,1.30], $p < .001$), with no corresponding reduction after the ban. Among older adults, there was no statistically significant immediate increase in past 30-day menthol cigarette use associated with the ban. Similar to any cigarette use, among older adults, there was an attenuated reduction in the slope of past 30-day menthol cigarette use after the ban (1.1%) (Table 2).

Though there is a temporary increase in the probability of past 30-day use of any cigarettes and menthol cigarettes associated with the enactment of the flavored cigarette ban for both youth and young adults, the ban overall was associated with a decrease in the probability of past 30-day any cigarette use and menthol cigarette use over time among these age groups. This can be seen when examining the estimated total effects (Tables 1 and 2). However, these relative effects must be interpreted relative to the baseline (pre-ban) prevalence of each outcome within age group. The pre-ban rate of both any cigarette and menthol cigarette use varies across age group, which may mask important differences when looking at the total effect odds ratios in isolation. Figures 1 and 2 present the same results on an additive scale, by graphing the age-specific predicted probabilities over time. Consistent with our odds ratio estimates, the largest effects are seen among youth and young adults.

In 2017, the predicted probability of youth and young adults smoking cigarettes were reduced by 43% and 27%, respectively, compared to the model predicted probability in absence of the ban. In 2017, the predicted probability of menthol use was reduced by 60% and 55% for youth and young adults, respectively. No such effects were observed for older adults.

Discussion

Our analyses showed a statistically significant difference between age groups compared to older adults in both the immediate change and change in the slope of past 30-day cigarette use after the flavored cigarette ban. Similarly, we found statistically significant differences by age group compared to older adults in both the immediate change and change in the slope of past 30-day menthol cigarette use. The predicted probability of youth and young adults smoking cigarettes were reduced by 43% and 27%, respectively, compared to the model predicted probability in the absence of the ban. These findings

Table 2
Estimated effect of flavor ban by age on menthol cigarette use

	Immediate change	Change in slope	Total effect
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Adolescents	1.330 (1.154, 1.535)	.964 (.956, .972)	.399 (.293, .543)
Young Adults	1.292 (1.186, 1.409)	.974 (.969, .980)	.549 (.440, .685)
Adults	1.174 (1.064, 1.297)	.999 (.994, 1.005)	1.152 (.941, 1.409)
Older Adults	1.058 (.914, 1.223)	.989 (.977, 1.001)	.727 (.453, 1.165)

Bold text indicates statistically significant findings.

suggest that the flavored cigarette ban was associated with a reduction in cigarette use among youth and young adults.

The association between the flavored cigarette ban and reduced smoking was most pronounced among those not legally allowed to smoke, who were most likely to use flavored cigarettes [5]. Previous research has found that past 30-day cigarette use among youth is a strong predictor of smoking as a young adult [19]. Together, these findings support bans on the sale of flavored cigarettes as a means to prevent smoking initiation, and thereby improving public health.

Although the ban appeared to be effective in reducing cigarette smoking among young populations, it is possible that other events may contribute to this observed reduction, such as the increased use of electronic cigarettes. However, young people who use electronic cigarettes are far more likely to initiate smoking shortly thereafter [21,22]. In addition, a temporary increase in the probability of past 30-day smoking was observed at its enactment in both youth and young adults. One possible explanation for these temporary increases is that tobacco companies expanded marketing leading up to the ban. Given that price discounts are a leading tobacco industry tactic [23], the industry could have used price promotions to recruit new smokers and to sell off soon to be illicit stock. Moreover, it is plausible that the immediate increase in menthol use corresponded to the production and marketing of new menthol products that are attractive to new smokers such as Camel Crush [24], as well as to populations who smoked at lower rates, such as the marketing of Camel No. 9 to adolescent girls [25].

Consistent with previous research, we found that the 2009 flavor ban was associated with reduced use of cigarettes among underage youth as well as a substitution effect among this demographic toward flavors that were not banned [14]. The observed reduction in menthol cigarette use among youth over time after the flavored cigarette ban is consistent with research conducted using 2011–2018 NYTS data [26]. Together, our study's findings related to immediate and long-term changes in youth/young adult smoking and menthol substitution support the need for comprehensive flavor bans, that include all tobacco products/devices and flavors (i.e., menthol). Because flavors are currently being banned in only some products (e.g., e-cigarette cartridge-based devices) and exclude menthol flavoring, we should expect a large substitution among young demographics toward products that contain characterizing flavors, including other e-cigarette devices, cigarillos, and so on.

Strengths

This study adds to the scant literature examining the effectiveness of the national flavored cigarette ban on cigarette use [14]. Similar to the study conducted by Courtemanche and colleagues (2017) [14], the present study relied on large national surveillance data weighted for national estimation and found that the FDA's 2009 flavored cigarette ban was associated with reduced cigarette use among youth. The present study builds on these findings in two key ways. First, the present study used more data to more precisely estimate the effect of the ban. Because data were collected annually and within four distinct quarters each year, more time points were available—including time points more proximal to the flavor ban. As a result, separate time trends could be examined pre- versus post-ban. Second, data were available for more age categories than in previous studies conducted only among youth. This comparison helped

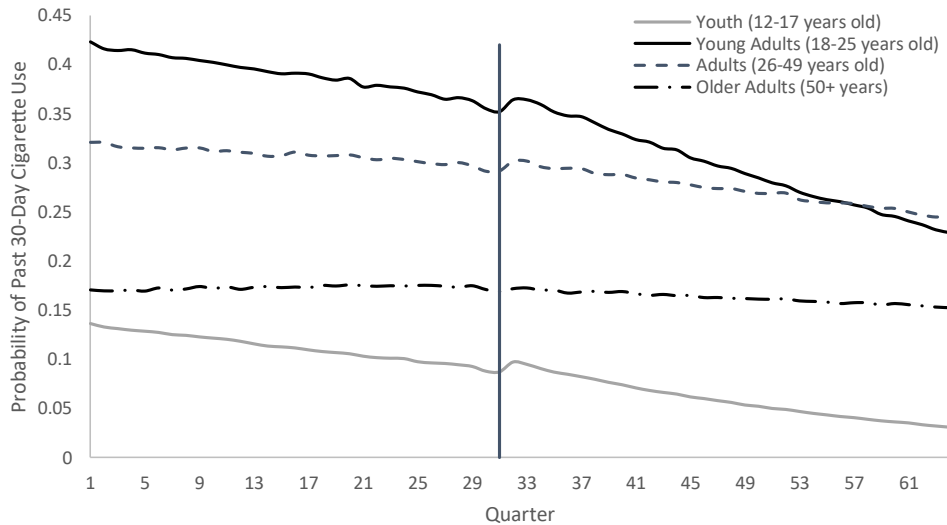


Figure 1. Past 30-day smoking probabilities before and after the flavored cigarette ban by age group, 2002–2017 NSDUH data. Numbers provided on the x-axis represent the first quarter of each year, with 1 representing the first quarter of 2002 and 61 representing the first quarter of 2017. The vertical line depicts the enactment of the U.S. FDA's national ban on flavored cigarette products (third quarter of 2009).

assess whether there was a general decline in cigarette use among people of all ages before versus after the implementation of the flavored cigarette ban. The observed decline in cigarette use after ban was unique to youth and young adults, suggesting that the flavored cigarette ban itself caused this decline, rather than a generally stronger tobacco control environment over time. However, the study by Courtemanche and colleagues (2017) [14] examined whether the cigarette smoked was flavored and examined use of tobacco products beyond cigarettes. Together, these studies support the effectiveness of the FDA's flavored cigarette ban in reducing adolescent smoking.

Limitations

The present study findings should be interpreted with the following two limitations in mind. First, other changes in the tobacco environment during the study timeline may have

affected cigarette use via changes in social acceptability, such as through the introduction of electronic cigarettes, retail availability, including CVS stores no longer carrying cigarettes, and price, including increased state and federal excise tax on cigarettes [15]. Although these myriad changes could have contributed to the reduction in smoking prevalence among youth and young adults, these did not occur immediately and simultaneously with the implementation of the FSPTCA. Thus, this limitation is mitigated by our adjustment for time trends and use of an older adult control group. Although cigarette prices increased drastically around the time of the flavored cigarette ban—and price is strongly associated with smoking, this study adjusted for changes in price. However, the use of state-specific price controls was not possible given the use of public-use data. Finally, other provisions of the FSPTCA, for example, federal minimum age of 18 years to buy cigarettes, were already in place in all states and therefore would not impact underage smoking rates.

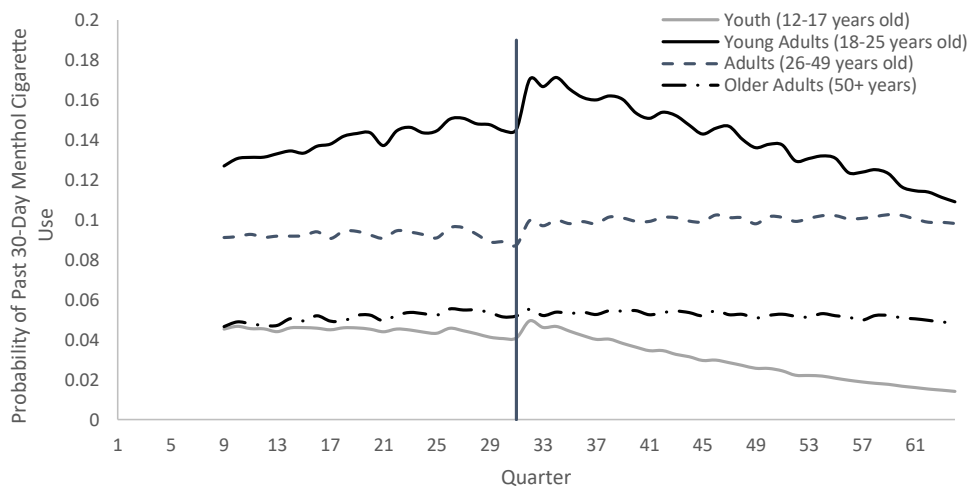


Figure 2. Past 30-day probabilities of menthol cigarette use before and after the flavored cigarette ban by age group, 2004–2017 NSDUH data. Numbers provided on the x-axis represent the first quarter of each year, with nine representing the first quarter of 2004 and 61 representing the first quarter of 2017. The vertical line depicts the enactment of the U.S. FDA's national ban on flavored cigarette products (third quarter of 2009).

Second, panel data are ideal for examining individuals' responses to policy change. Some youth and young adults could be adopting other flavored tobacco products rather than using cigarettes after the ban [14]. However, NSDUH data do not contain items assessing all tobacco products used over time, such as e-cigarettes or hookah. As a result, other tobacco product use—including use of multiple tobacco products—was not examined in the present study. More research is needed on the role of flavor bans on the use of different tobacco products, including poly-tobacco use patterns. Future research on flavored tobacco use should include e-cigarettes because they have become the most commonly used tobacco product among middle- and high-school students in the United States and flavor is a primary reason reported for e-cigarette use [27,28]. The results of this study do not provide insight on the temporary increase in cigarette use among youth and young adults after the ban. Overall, more research is needed to better understand youth and young adults' changes in overall tobacco use over time after flavor bans.

Conclusion

Findings from the present study strongly suggest that the U.S. flavored cigarette ban instituted in 2009 reduced cigarette use in youth and young adults. Flavor bans for other tobacco products, including electronic cigarettes, cigarillos, hookah, and smokeless tobacco products, should be explored as a strategy for reducing youth use of these products, particularly in light of industry efforts to blur the distinction between tobacco products [29]. Study findings suggest that, to maximize their effectiveness, flavor bans should include all products and flavors. Researchers should continue to evaluate the impact of flavor bans on youth and young adult tobacco use.

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