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The effect of menthol use and transitions in use on short and long-term cessation from cigarettes among US smokers

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Abstract

Objectives.—To estimate the effect of menthol use and transitions in use (switching to or from menthol) on short- and long-term cessation from cigarette smoking and whether this differed across demographic groups (age, sex, race).

Methods.—We compared the probability of 30+ day and 12-month abstinence from cigarette smoking by menthol use status using two cohorts of US adult cigarette smokers who attempted to quit smoking in the Population Assessment of Tobacco Use and Health (wave 1-wave 3 & wave 2-wave 4; n=5759), inverse probability of treatment weighting and adjusted risk ratios (aRRs).

Results.—Using menthol (vs. non-menthol) prior to a quit attempt decreased the probability of 30+ day abstinence by 28% (aRR =0.78; 95%CI: 0.67–0.91) and the probability of 12-month abstinence by 53% (aRR =0.65; 95%CI: 0.47–0.88). Additionally, switching from menthol (vs. maintaining menthol use) increased the probability of 30+ day abstinence by 58% (aRR = 1.58; 95% CI: 1.00–2.50) and the probability of 12-month abstinence by 97% (aRR = 1.86; 95% CI: 0.92–3.74). Switching to menthol (vs. maintaining non-menthol use) was associated with a lower probability of 30+ day (aRR = 0.70; 95% CI: 0.42–1.16) and 12-month abstinence (aRR = 0.64; 95% CI: 0.30–1.36), but these associations were imprecise. The effects of menthol use on impaired quitting were slightly larger for non-Hispanic Black smokers, but not differ for other demographic groups.

Conclusion.—These results demonstrate that menthol impaired menthol smokers’ attempts to quit smoking but switching from menthol improved success. This suggests that removing menthol may improve menthol smokers’ success during quit attempts.

Introduction

Since 2000, the prevalence of menthol cigarette use in the United States has not declined at the same rate as the prevalence of other cigarette usage, and, in the past decade, menthol brands have absorbed an increasing proportion of current cigarette smokers.1–3 Additionally,
the prevalence of menthol use is disproportionately high among smokers that are young, non-Hispanic Black, Hispanic, and female and these groups have experienced slower declines in smoking prevalence. These groups have been disproportionately targeted tobacco industry marketing of menthol and—particularly in the case of non-Hispanic Black smokers—experience poorer cessation outcomes. One posited explanation for the slower declines in the prevalence of menthol smoking is that menthol smokers experience more difficulty when they attempt to quit smoking.

There are several biological mechanisms that may contribute to menthol impairing a smoker’s ability to quit. The “cooling” sensation of menthol masks the harshness of cigarette smoke allowing for a deeper inhalation of smoke resulting in a greater absorption of nicotine per puff. Additionally, exposure to nicotine combined with menthol relative to nicotine alone results in a greater number of nicotinic acetylcholine receptors and more dopaminergic activation in the ventral tegmental area, both potentially leading to greater reinforcement from nicotine and greater reward-related behavior.

While there is biological plausibility of menthol to impair quitting, there are limitations in the various population-based studies conducted to date that if addressed could strengthen evidence base for the impact of menthol on quitting. For instance, all of the prospective studies included in two recent reviews came from observational samples that either were not representative of the US, did not include multi-wave assessments, or had short follow-up periods (<26 weeks). Moreover, when considering assessments among sub-populations, there is some evidence that menthol differentially impacts non-Hispanic Blacks’ and Hispanics’ quitting success, but little evidence exists comparing the impact of menthol use among females and young adults (18–24 years) despite their smoking menthol cigarettes at higher rates than their counterparts.

The launch of the Population Assessment of Tobacco and Health (the PATH Study) in 2013 has provided the best opportunity for a robust nationally representative longitudinal analyses of menthol use in the United States. To date, two analyses have used the PATH Study to investigate the relationship between menthol use and quitting. Schneller et al used the first two waves of the PATH study to examine the association between menthol delivery methods (i.e., menthol in the tobacco only, crushable capsules only or both) and cessation, finding that regardless of delivery method smokers who used menthol at wave 1 were not less likely to be quit at wave 2. Mills et. al used waves 1–4 to prospectively examine the association between menthol cigarette use and cessation among non-daily and daily adult smokers at adjacent waves (e.g., wave 2 & 3 or 3 & 4), finding that daily menthol smokers had lower odds of cessation in a subsequent wave but non-daily menthol smokers did not.

Herein, we extend these prior studies making several unique contributions that improve upon prior methods and maximize the design of the PATH Study. First, we utilize Inverse Probability of Treatment Weighting (IPTW) to ensure that our estimates of the impact of menthol use on quitting success are adequately adjusted for individual factors that make quitting difficult and are also related to self-selected use of menthol (e.g., cigarette consumption levels). While past studies have sought to address such “confounding” variables using multivariable regression, this method cannot determine whether balance...
between comparison groups was achieved.\textsuperscript{25,26} By contrast, IPTW adjusts for confounding and also allows us to check that the comparisons are similar with respect to potential measured confounding variables.\textsuperscript{27,28} Secondly, we exploited the multi-wave design of the PATH Study that allows us to assess the impact that switching to and from menthol has on quitting success using a target trial framework.\textsuperscript{29} In this way, our analysis resembles how a randomized control trial might test the impact that a hypothetical menthol ban. Lastly, we assessed whether the effect of menthol on quitting success differed by race, sex, age and frequency of smoking.

Methods

Data source and analytical sample

Our data incorporate waves 1–4 of public use files of the PATH study. Wave 1 data collection (September 2013-December 2014) resulted in an initial nationally representative household sample of 45,971 individuals (including 32,320 adults aged 18 and older and 13,651 youths aged 12–17) and follow-up samples were conducted approximately annually. The response rates for waves 1–4 of the adult sample were as follows: initial household screener survey, 54%; interview at wave 1, 74.0%; annual follow-ups, 83.1%, 78.4%, and 73.5% for waves 2, 3, and 4, respectively. All surveys included informed consent and the study procedures were overseen by the Westat Institutional Review Board. Our analytical sample consisted of a pooled sample of two cohorts (waves 1–3, 2013–2016: n= 3590 or waves 2–4, 2014–2017: n=2169; Pooled: n=5759) of adult current established cigarette smokers who maintained use for a least two waves (to assess transitions in use) prior to making an attempt to quit smoking (to assess success among “quit attempters”). The schema of this analytical sample is presented in Supplementary Table 1 and statistics summarizing this analytical sample are presented in Supplementary Table 2.

Measures

Quitting Behavior.—A current established cigarette smoker was defined as an adult who has smoked at least 100 cigarettes in their lifetime and at the time of the survey smoked manufactured cigarettes every day or some days. All current established smokers were asked: “in the past 12 months have you tried to quit cigarettes completely?” and “in the past 12 months, have you tried to quit by gradually cutting back on cigarettes?” Respondents were considered to have made a quit attempt in the past 12 months if they responded yes to either of these questions or were previously established smokers but reported not smoking at the time of the survey. Former established smokers were asked, “about how long has it been since you last smoked cigarettes?” We used $\geq 30$ days of abstinence from cigarettes as an early marker of successful cessation and $\geq 12$ months as abstinence from cigarettes as long-term marker of successful cessation.\textsuperscript{30}

Menthol Cigarette Use.—Adult menthol smoking status was based on a “yes” response to the question, “is your regular/last used brand you smoke flavored to taste like menthol or mint?” Switching to menthol was defined as reporting non-menthol cigarette use at one wave and menthol use at the next wave, switching from as menthol cigarette use at one wave.
and non-menthol at the next wave and maintaining as either reporting menthol or non-menthol use at both waves.

**Study Covariates.**—The supplementary appendix presents the survey questions for the potential confounders we identified a priori. This included: use of non-cigarette tobacco products, cigarette consumption, having a regular brand of cigarettes, behavioral dependence to tobacco, policies on household tobacco use, lifetime drug and alcohol use, symptoms of internalizing or externalizing mental health issues, self-reported physical health, perceived social norms of tobacco, time spent around smokers, perceived harm of cigarettes, as well as sociodemographic variables.

**Statistical Analysis**

Estimates were weighted using the wave 1 through wave 3 and wave 1 through wave 4 longitudinal composite survey weights, which were adjusted for the sampling design, survey nonresponse, and longitudinal drop out. Complete case analyses were conducted as ≤1.8% of observations were missing from any variable. Weighted means, percentages and confidence intervals were calculated using the replicate composite survey weights calculated with balanced repeated replication with Fay’s adjustment (ρ = 0.3).  

To calculate propensity scores, separate logistic models were fitted to predict four comparisons of menthol use (menthol use vs. non-menthol use, maintained menthol use vs. maintained non-menthol use, switched to menthol vs. maintained non-menthol use, and switched from menthol vs. maintained menthol use). Predictors in these models included all potential confounders and, as recommended, the composite weights. Stabilized inverse propensity score weights were computed with the resulting propensity scores. Diagnostics of the resulting distributions of stabilized weights suggested no evidence of non-positivity or of misspecification of the propensity score model as all means were near 1.0 and there were no extreme observations (Supplementary Table 3). The resulting stabilized weights were multiplied by the composite survey weights to form a final weight for subsequent balance assessments and effect estimation.

To assess balance between the menthol use groups, weighted Standardized Mean Differences (SMD) of each potential confounder were computed between the exposed and unexposed groups before and after including the stabilized inverse propensity scores with the composite weights. We chose a conventional threshold of the absolute value of the SMD below 0.2, as an indicator of good balance.

The impact of menthol use on cessation was estimated through adjusted risk ratios (aRR) and 95% CIs obtained from log-binomial models with IPTW that included short- or long-term abstinence from cigarettes as the outcome and menthol use status as the exposure. To estimate effect modification (on the multiplicative scale) by race, sex, age and frequency of smoking we calculated adjusted ratios of risk ratios (aRRR) and 95% CIs using log-binomial models with IPTW that included short- or long-term abstinence from cigarettes as the outcome, menthol status as the exposure and the demographic/smoking characteristic of interest entered as main effects and interactions with menthol status.
We also conduct a sensitivity analyses for our choice to restrict the analytical samples to quit attempters by repeating the IPTW balance checks and effect estimation without restricting on this variable.

All analyses were conducted in R, version 4.0.4 (R Foundation for Statistical Computing, Vienna, Austria) and weighted analyses were conducted using the R package “survey”.^38

**Results**

Forty percent (40.2%; 95% CI: 38.6–41.9) of US adult quit attempters used menthol cigarettes prior to their quit attempt (Table 1). When examining patterns of menthol use across two waves, the most prevalent pattern of use was maintaining non-menthol use (56.7%; 95% CI: 54.9–58.5), followed by maintaining menthol use (36.1%; 95% CI: 34.4–37.8), switching to menthol (4.0%; 95% CI: 3.5–4.6), and switching from menthol (3.1%; 95% CI: 2.6–3.6). Twelve percent (12.7%; 95% CI: 11.2–14.2) of menthol quit attempters achieved at least 30+ day abstinence from cigarettes at follow-up, compared to 17.2% (95% CI: 15.6–18.8) of non-menthol quit attempters. Across transitions, 30+ day abstinence was highest among those who switched from menthol (23.9%; 95% CI: 16.2–31.6), followed by maintaining non-menthol (16.8%; 95% CI: 15.1–18.6), switching to menthol (16.1%; 95% CI: 11.2–21.1) and maintaining menthol (12.3%; 95% CI: 10.8–13.9). Similarly, 12-month abstinence was highest among those among those who switched from menthol (11.7%; 95% CI: 5.0–18.3), followed by switching to menthol (6.0%; 95% CI: 2.9–9.1), maintaining non-menthol (4.8%; 95% CI: 3.8–5.7), and maintaining menthol (3.8%; 95% CI: 2.9–4.7).

Comparison of the SMDs identified imbalance across the menthol use groups on many of the covariates we assessed in the dataset weighted with only the composite survey weights (Figure 1, grey dots). Imbalance (using SMD > |0.2| as an a-priori threshold) was observed for menthol use vs. non-menthol on two race variables, where a larger proportion of non-Hispanic Blacks (SMD = 0.78) and a smaller proportion of non-Hispanic Whites (SMD = −0.69) used menthol. Similarly, a larger proportion of menthol maintainers were non-Hispanic Black (SMD = 0.82) and a smaller proportion were non-Hispanic White (SMD = −0.72). Comparing those who switched to menthol to those who maintained non-menthol use, a larger proportion where 18–24 years old (vs. 25+ years; SMD = 0.27) and non-Hispanic Black (SMD = 0.94), while a smaller proportion were non-Hispanic White (SMD = −0.85), had attended college (SMD = −0.20) or smoked cigarettes every day (SMD = −0.27). Those who switched to menthol (vs. maintained non-menthol) also consumed fewer cigarettes per day (SMD = −0.30) and were less dependent to tobacco (SMD = −0.26). Comparing those who switched from menthol to those who maintained menthol use, a larger proportion were 18–24 years old (vs. 25+ years; SMD = 0.38) and were in the wave 1–3 cohort (SMD = 0.44), while a smaller proportion had a regular brand of cigarettes (SMD = −0.41) or smoked cigarettes every day (SMD = −0.27). Those who switched from menthol (vs. maintained menthol) also consumed fewer cigarettes per day (SMD = −0.42) and reported poorer physical health (SMD = −0.24).

While comparisons were imbalanced using the composite weights, IPTW improved the comparability of these comparison (Figure 1, blue dots) for nearly every variable we

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assessed including the propensity scores, resulting in SMDs that were closer to 0 than using only the composite weights. The final IPTW comparisons were well-balanced, as SMDs for all variables and the propensity scores were below the conventional threshold of $\text{SMD} < |0.2|$ for all comparisons.

In Figure 2 we present the IPTW-adjusted associations between menthol use and transitions in use with 30+ day and 12-month abstinence from cigarette smoking. Using menthol (vs. non-menthol) prior to a quit attempt decreased the probability of 30+ day abstinence by 28% ($\text{aRR} = 0.78; 95\% \text{CI}: 0.67–0.91$) and the probability of 12-month abstinence by 53% ($\text{aRR} = 0.65; 95\% \text{CI}: 0.47–0.88$). Among transitions in use, maintaining menthol use (vs. maintaining non-menthol use) decreased the probability of 30+ day abstinence by 28% ($\text{aRR} = 0.78; 95\% \text{CI}: 0.65–0.93$) and the probability of 12-month abstinence by 49% ($\text{aRR} = 0.67; 95\% \text{CI}: 0.45–0.99$). Additionally, switching from menthol (vs. maintaining menthol use) increased the probability of 30+ day abstinence by 58% ($\text{aRR} = 1.58; 95\% \text{CI}: 1.00–2.50$) and the probability of 12-month abstinence by 97% ($\text{aRR} = 1.86; 95\% \text{CI}: 0.92–3.74$). Switching to menthol (vs. maintaining non-menthol use) was associated with a lower probability of 30+ day ($\text{aRR} = 0.70; 95\% \text{CI}: 0.42–1.16$) and 12-month abstinence ($\text{aRR} = 0.64; 95\% \text{CI}: 0.30–1.36$), but these associations were imprecise.

In Figure 3 we present the IPTW-adjusted associations between menthol use with 30+ day and 12-month abstinence from cigarette smoking by age, race and sex. At the 95% confidence level, there was no evidence for effect modification by sex, race or age as all confidence intervals included the null of $\text{aRR} = 1.0$. However, the association between menthol use and 12-month abstinence was notably lower for Non-Hispanic Blacks vs. non-Hispanic White ($\text{aRR} = 0.51; 95\% \text{CI}: 0.23–1.13$).

The sensitivity analyses suggested that balance was also achieved for the analyses that did not restrict the analytical sample to quit attempters, with all IPTW-weighted SMDs below $|0.2|$ except for one minor exception of an SMD = 0.21 for established users of other non-cigarette tobacco products among those who switched to menthol (Supplementary Figure 1). Moreover, the results were similar (all confidence intervals were overlapping), suggesting this choice had a negligible impact on our effect estimates (Supplementary Figure 2).

**Discussion**

In this nationally representative US study, 40% of adults who attempted to quit cigarette smoking used menthol cigarettes prior to their quit attempt. Menthol use appeared to be stable, as few quit attempters had transitioned to (4.0%) or from (3.1%) menthol use before attempting to quit. There were clear patterns of menthol preference by race/ethnicity, with non-Hispanic black smokers preferring menthol. Those who switched to or from menthol tended to be younger and smoked fewer cigarettes. The IPTW procedure considerably improved the comparability of menthol use groups across these variables, resulting in a well-balanced analytical sample. Using effect estimates that were balanced using IPTW, we estimated that menthol use decreased both short- and long-term abstinence from cigarettes particularly among those who maintained menthol use for two consecutive survey waves.
However, when compared to maintaining menthol use, switching from menthol increased the probability short- and long-term abstinence.

We found that menthol use decreased both short- and long-term abstinence from cigarettes. To our knowledge, our analyses 12-month abstinence is the longest duration period among studies assessing the impact of menthol use on cessation. The finding of impaired short-term quitting (30+ day abstinence) is consistent with the conclusions of two recent reviews that suggested that the removal of menthol from cigarettes is likely to reduce improve smoking cessation outcomes in adult smokers.\textsuperscript{13, 14} Notably, our sample design and findings are consistent with the study Vallanti et. al.\textsuperscript{14} regarded as most valuable to their review as it studied smokers who are motivated to quit and thus, controlled for confounding by cessation cognitions and intention to quit.\textsuperscript{39} The findings are also consistent with a well-designed national cross-sectional study that focused on quit attempters.\textsuperscript{11} We have previously discussed how neglecting this focus on quit attempters can introduce a substantial bias in comparison of the impacts of products and product constituents on smoking cessation in the PATH study.\textsuperscript{40} Fortunately, this analytical choice did not appear to significantly impact our results, as a sensitivity analysis among all smokers regardless of their attempts to quit returned very similar results to our analysis among quit attempters.

A unique contribution to the literature was our examination of switching to and from menthol and how this impacts cessation. Our analysis of the PATH Study data identified a similarly low prevalence of switching to or from menthol (3–8\%) and a similar switching profile as participants of a previous cohort study that examined these transitions.\textsuperscript{41} Our analyses expanded on that study by assessing whether switching to or from menthol impacted cessation success, finding that switching from menthol increased both short and long-term cessation, while switching to menthol decreased cessation success. This pattern of association is consistent with subjective reports from adult smokers in the Tobacco Use Supplement of the Current Population Survey, which suggested that menthol smokers find nonmenthol cigarettes a less effective substitute than nonmenthol smokers find menthol cigarettes.\textsuperscript{42} The finding of improved cessation among those who switched from menthol is also consistent with subjective reports of 35\%--40\% of menthol smokers reporting that they would quit if menthol cigarettes were banned.\textsuperscript{43, 44} However, rather than providing a subjective impression of what a menthol smoker might do in the event of a ban, our analytical design provides an assessment of the impact of a change in behavior. In this way, our design mirrors how a randomized control trial might estimate the effect of a menthol ban. Indeed, the results are consistent with the reductions in smoking found in a within-subject trial of forced changes to non-menthol brands among menthol smokers in Connecticut.\textsuperscript{45} Finally, the finding that switching from menthol improved cessation should also be considered in light of recent evaluations of the bans on menthol cigarettes in Canada. While one quasi-experimental study found that the enactment of provincial and federal bans in Canada did not decrease smoking among adults,\textsuperscript{46} evidence from other cohort studies has shown that these bans may have improved cessation among adult smokers,\textsuperscript{47--49} further corroborating our findings.

Some limitations of our study should be noted. First, while the analysis of switching to or from menthol can be viewed as a strength, the extent to which this unprompted change in
behavior models a forced change in behavior—as would be the case in menthol ban—is unclear. Second, it is possible that a few of the respondents’ use of nonmenthol were an artifact of local jurisdictions enactment of menthol policies. We cannot account for these and other policy-related geographical differences, because the geographic location data are not publicly available in the PATH Study. However, it is unlikely that many respondents lived in jurisdictions that had enacted menthol bans, as the majority of bans were enacted in 2019, whereas the PATH data were collected from 2013–2018. Third, while some of the antecedent factors that could explain the choice to use menthol and also success during a quit attempt (e.g., being less dependent to nicotine) were identified and accounted for with IPTW, as with any observational study it is possible that there additional unmeasured variables that we could not account for that explain this association. Finally, although Hispanics are regularly treated as a homogenous category, different patterns for menthol smoking and cessation have been noted when Hispanics are disaggregated. Unfortunately, the numbers in our sample that focuses on quit attempters precludes the disaggregation of Hispanics.

Although the 2009 Family Smoking Prevention and Tobacco Control Act prohibited tobacco manufacturers from producing and distributing cigarettes with added characterizing flavors, it exempted menthol from this flavor ban. These results suggest that this choice to leave menthol in cigarettes impaired menthol smokers’ attempts to quit smoking. Those menthol smokers who were able to switch from menthol saw improvements in their attempts to quit smoking. Taken together, the findings provide strong support the now decade-old recommendations of the Tobacco Products Scientific Advisory Committee’s to ban menthol cigarettes and support the US Food and Drug Administration’s recent commitment to ban menthol cigarettes in the United States.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Funding Details:

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What this study adds

- The launch of the Population Assessment of Tobacco and Health (the PATH Study) in 2013 has provided the first opportunity for a robust nationally representative longitudinal analyses of menthol use in the United States.

- We compared the probability of 30+ day and 12-month abstinence from cigarette smoking by menthol use status using two cohorts of US adult cigarette smokers who attempted to quit smoking in the Population Assessment of Tobacco Use and Health and inverse probability of treatment weighting to adjust for variables associated with both menthol use and success during quit attempts.

- The results suggested that menthol use may impair smokers’ attempts to quit smoking and that switching from menthol may improve cessation efforts.

- The findings reinforce recommendations to remove menthol from cigarettes in order to improve cessation efforts.
Figure 1.
Standardized mean differences showing the balance improvement obtained by weighting the propensity scores for use and transitions in use of menthol.
Note: Each dot in the figure indicates the standardized mean difference of the covariate between menthol use and transitions in use calculated either by using original data sets and weights (grey dots) or using the inverse probability of treatment weights (blue dots).
Standardized mean difference values < 0.2 indicate good balance (to the left of the vertical black line). IPTW = inverse probability of treatment weighting.
Figure 2.
Probability of remaining abstinent from cigarette smoking for 30+ days or 12-months according to menthol use or transitions in use. Note: All estimates are calculated using inverse probability of treatment weighting. The x-axis is log scaled to improve interpretability. CI = confidence interval.
Figure 3.
Ratio in the probability of remaining abstinent from cigarette smoking for 30+ days or 12-months by menthol use and age, sex, race and smoking frequency. Note: All estimates are calculated using inverse probability of treatment weighting. The x-axis is log scaled to improve interpretability. CI = confidence interval; NH = non-Hispanic
Table 1.

Prevalence of menthol use and transitions in use and probability of remaining abstinent from cigarette smoking for 30+ days or 12-months by menthol use and transitions in use among quit attempters in the PATH Study, United States, 2013–2016 & 2014–2017

<table>
<thead>
<tr>
<th>Menthol Use</th>
<th>Prevalence</th>
<th>Achieved 30+ Day Abstinence From Cigarette Smoking</th>
<th>Achieved 12-Month Abstinence From Cigarette Smoking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>% (95% CI)</td>
<td>% (95% CI)</td>
</tr>
<tr>
<td>Overall</td>
<td>2436</td>
<td>40.3% (95% CI: 38.6–42.0)</td>
<td>12.7% (95% CI: 11.2–14.2)</td>
</tr>
<tr>
<td>Used Menthol</td>
<td>240</td>
<td>4.0% (95% CI: 3.5–4.6)</td>
<td>16.1% (95% CI: 11.2–21.1)</td>
</tr>
<tr>
<td>Used Non-Menthol</td>
<td>3240</td>
<td>59.7% (95% CI: 58.0–61.4)</td>
<td>17.2% (95% CI: 15.6–18.8)</td>
</tr>
<tr>
<td>Maintained Menthol Use</td>
<td>2165</td>
<td>36.1% (95% CI: 34.4–37.8)</td>
<td>12.3% (95% CI: 10.8–13.9)</td>
</tr>
<tr>
<td>Switched to Menthol</td>
<td>187</td>
<td>3.1% (95% CI: 2.6–3.6)</td>
<td>23.9% (95% CI: 16.2–31.6)</td>
</tr>
<tr>
<td>Switched from Menthol</td>
<td>3028</td>
<td>56.7% (95% CI: 54.9–58.5)</td>
<td>16.8% (95% CI: 15.1–18.6)</td>
</tr>
</tbody>
</table>

Note: All estimates are weighted using the PATH longitudinal composite survey weights.