Research Article

Association of Menthol in Cigarettes with Dependence and Cigarette Smoking Cessation: Analysis of The Population Assessment of Tobacco and Health Study Waves 4 and 5

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Background. Much speculation remains as to whether menthol increases the inherent dependence potential of cigarettes and interferes with the ability to quit smoking. This research evaluates differences in cigarette dependence and smoking cessation between adults who smoke (AS) menthol and non-menthol cigarettes, particularly non-Hispanic Black AS.

Methods. Data were drawn from the Population Assessment of Tobacco and Health (PATH) Study Waves 4-5 among AS 18+ (n = 7,007 [1,127 non-Hispanic Black AS]). Baseline characteristics, dependence outcomes (e.g., heaviness of smoking index, tobacco dependence index), and cessation rates were compared between AS by menthol use and race/ethnicity. Cessation rates by menthol preference and respondent characteristics were further assessed using backward stepwise logistic regressions.

Results. AS who prefer menthol cigarettes (MAS) had lower cigarette dependence and smoked fewer cigarettes per day than non-menthol preferring AS (NMAS); this was also true among non-Hispanic White AS. No difference in cessation rates were observed between MAS and NMAS. AS had lower odds of cessation if they were older, non-White, reported smoking every day, and had moderate/high dependence. AS with college or higher education or planning to quit had higher odds of cessation. Among all non-Hispanic Black AS, there was lower odds of cessation among everyday smokers reporting moderate cigarette addiction, and a higher odds of cessation among higher-income and current users of smoke-free products. Menthol use was not a significant correlate of cessation.

Conclusions. Menthol smoking was not associated with higher dependence or smoking cessation. Further, results suggest that household income and cigarette smoking frequency are potential barriers

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to cessation among non-Hispanic Black AS.

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1. Introduction

Whether menthol increases the inherent dependence potential of traditional cigarettes has been debated for over a decade. A substantial body of literature has examined the relationship between menthol cigarette use and measures of cigarette dependence, with mixed findings. A comprehensive literature review summarizing literature published between 1980-2021 examined the impact of menthol on cigarette smoking addiction.[1] Examination of the evidence tables from this review indicates that 160 of 214 analyses (~75%) indicated no difference or lower dependence among menthol cigarette smokers, with 54 analyses (~25%) indicating higher dependence. Additionally, 32 out of 36 cross-sectional analyses (~89%) involving dependence scales revealed either no effect (28) or lower dependence (4) among menthol cigarette smokers. Based on this evidence, the review concluded that "the evidence is not sufficient to support conclusions of an association of menthol in cigarettes with dependence among adults."[1]

Consistent with this conclusion, most existing evidence does not support a relationship between menthol cigarette use and increased dependence. Dependence-related measures from several national surveys including cigarettes per day, time to first cigarette ("TTFC") after waking, and the heaviness of smoking index ("HSI"), a validated measure of cigarette dependence, were analyzed.[2] The authors found that menthol smokers reported smoking significantly fewer cigarettes per day compared to non-menthol smokers. Across all surveys, there were no differences between menthol and non-menthol smokers in either TTFC or HSI.[2] The authors concluded that these data "... do not support an evidence-based conclusion that menthol in cigarettes increases dependence among U.S. smokers."[2] A recent longitudinal Population Assessment of Tobacco and Health (PATH) analysis similarly found no difference in subsequent dependence among youth or adults who first used menthol or non-menthol cigarettes.[1] While the majority of evidence does not show an impact of menthol on dependence, one recent national survey reported slightly increased, statistically significant adjusted odds ratio of smoking within 30 minutes after waking (AOR=1.11) and for daily use (AOR=1.13) among menthol cigarette smokers.[3] Taken together, there is little evidence to suggest that menthol increases the inherent dependence potential of cigarettes.

While evidence regarding the impact of menthol on cigarette dependence is fairly clear, its potential effect on smoking cessation outcomes remains less certain. Logically, if menthol does not affect smoking dependence, it should not impact smoking cessation outcomes, given that dependence level strongly predicts cessation success.[4] A recent probabilistic assessment using PATH Waves 1-4 data reported that menthol use decreased short- (30-day) and long-term (12-months) quitting success.[5] However, other, more comprehensive analyses have reached different conclusions. For example, a meta-analytic review by Smith et al. concluded, "[w]hen we combined all evidence, the association between menthol smoking and smoking cessation in the United States ("U.S.") was nonsignificant." [6] A recent systematic review of the cessation literature similarly determined that "...the current evidence base is not strong or consistent enough to support a clear association – positive or negative – between menthol cigarette use and smoking cessation." [7] A comprehensive review of the literature from 1980-2021 revealed mixed findings, with nearly equal numbers of studies reporting an effect or no effect[1]. Notably, many studies reporting an effect of menthol found it only among Black adults who smoke cigarettes (AS)and the authors of that review concluded that "...menthol in cigarettes is associated with reduced cessation success among Black individuals."[1].

A recently published report of a large longitudinal cohort study found no differences in cessation outcomes between menthol and non-menthol Black AS.[8] In a cohort of 16,425 mostly low-income African American and White AS enrolled over a seven-year period, quitting and relapse rates were calculated at three separate follow-ups conducted approximately 5 to 11 years after enrollment. Annual quit rates were 4.3% for menthol and 4.5% for non-menthol AS, with no difference in adjusted odds of quitting between the two groups, regardless of race. Relapse rates were 8.4% among menthol and 7.1% among non-menthol AS, but quit rates remained similar over time, regardless of race. Menthol use was not associated with cessation outcomes; however, age, income, and education demonstrated significant associations. These findings are important given the large sample (n=16,425) of a vulnerable population (e.g., low income, Black AS from the Southern U.S.), followed for an extensive period (11 years) with several follow-ups.[8] The authors concluded that "[i]n summary, the data presented herein suggest that one of the rationales (that menthols are harder to quit) for banning menthol cigarettes may not hold in some large segments of the American population." However, evidence is not entirely consistent; for example, a recent longitudinal analysis of PATH Waves 1-4 examining the impact of menthol cigarette use on smoking cessation indicated that menthol smokers, particularly non-Hispanic Black smokers, had lower cessation rates, while e-cigarette use was associated with higher cessation rates, especially among menthol smokers.[9]

In this study, we evaluated the impact of menthol use on cigarette dependence and cigarette smoking cessation among adults who smoke cigarettes. Using data from the Population Assessment of Tobacco and Health, a nationally representative longitudinal study, we evaluated differences in cigarette dependence (tobacco dependence index [TDI] and HSI) and smoking cessation between menthol (MAS) and non-menthol AS (NMAS), particularly non-Hispanic Black AS. We also evaluated the relationship between individual characteristics (e.g., household income, dependence severity, menthol use, age, gender) and cigarette smoking cessation among menthol and non-menthol AS.

2. Methods

We conducted a prospective cohort analysis using longitudinal PATH data to examine the impact of menthol cigarette use on dependence and cessation among AS. At the time of our analyses, there were five waves of publicly available PATH data[10], with annual data collections between Wave 1 (September 2013 to December 2014) to Wave 4 (December 2016 to January 2018) and biennial collections after Wave 4 (e.g., Wave 5 data collection: December 2018 to November 2019). Data were downloaded in October 2021 from ICPSR website (https://doi.org/10.3886/Series606). Data among AS in Wave 4 were treated as baseline. AS were defined as adult participants who were 18 or older, reported smoking cigarettes every day or some days, and had smoked 100 or more cigarettes in their entire life.

Given the disproportionately higher rates of menthol cigarette smoking among non-Hispanic Black AS, we compared the descriptive statistics between AS and non-Hispanic Black AS in Wave 4. Variables included demographic characteristics (e.g., sex, age, race/ethnicity, household income, and education), cigarette smoking behaviors (e.g., smoking frequency and

menthol use), current use of smoke-free products (e.g., e-vapor, smokeless or snus), and other individual-level characteristics (e.g., quit intention, disapproval of friends, cigarette harm perception, self-perception of overall health, and plans to switch to another product). Chi-squared tests were used to compare proportions, and Student's t-tests were used to compare means of continuous variables between groups.

To conduct a thorough assessment of cigarette dependence, we considered several measures, including cigarettes per day, HSI [11][12] and Tobacco Dependence Index (TDI).[13][14] The HSI is a brief, validated measure of nicotine dependence derived from the Fagerström Test for Nicotine Dependence (FTND). It uses two key questions that are most predictive of dependence: 1) time to first cigarette after waking (TTFC) and 2) number of cigarettes smoked per day (CPD). These two items are scored and summed to

create a six-point scale (0-6) with scores 0-1 as low dependence, 2-4 as moderate dependence, and 5-6 as high dependence. [15]

TDI was developed and validated by Strong et al.[13], based on the PATH study data, which includes 16 items that focus on self-reported psychological and physiological effects. It is a single primary latent construct underlying responses to tobacco dependence indicators for mutually exclusive tobacco product user groups, such as adults who smoke or use cigarettes, e-cigarettes, cigars, hookah, and smokeless tobacco products, and dual/poly users. The TDI consists of 16 items (15 Likert-scale items scored 1="Not true of me at all" to 5="Extremely true of me" and one dichotomous item scored 1="No" or 5="Yes") assessing dependence symptoms such as craving, loss of control, and behavioral reinforcement.[13] [14] Scores are averaged across items, with higher scores indicating greater dependence. The measures of cigarette dependence were compared using Student's t-test among AS who smoke menthol versus non-menthol, and by race/ethnicity. We included HSI in our statistical models as a measure of dependence, as it includes the number of cigarettes smoked per day and the average time to first cigarette.

Wave 4 AS were followed up in Wave 5 to obtain cigarette smoking status. Cigarette cessation rates, defined as the proportion of past 30-day cigarette smoking abstinence, were calculated for overall AS and by menthol smoking status and race/ethnicity groups. Lastly, we developed backward stepwise logistic regression models to identify covariates that may be associated with smoking cessation, including demographics, tobacco product use behaviors, cigarette dependence, overall health perceptions, harm perceptions, intentions to quit, friend disapproval, and intentions to switch. At each step, a variable with the highest p-value exceeding 0.05 was removed until all remaining variables had p-values below the threshold (see Supplementary Table 1). Four models were fitted to understand potential differences in covariates associated with quitting smoking between overall AS (Model 1), non-Hispanic Black AS (Model 2), non-Hispanic Black MAS (Model 3), and non-Hispanic Black NMAS (Model 4). Logistic regression models with firth option were built to account for small sample sizes potentially resulting in sparse data bias or separation issues in Models 3 and 4. [16][17] All statistics and models were generated with longitudinal weights and replicate weights with balanced repeated replication (BRR) and a Fay's adjustment value of 0.3 for variance estimation based on guidance provided in the PATH user guide.[10] All statistical analyses were conducted in Statistical Analysis System (SAS) version 9.4 (SAS Institute, Cary, NC). All figures were constructed using Microsoft Office Suite.

3. Results

Descriptive statistics of included participants at Wave 4.

Table 1 provides summary statistics of demographic variables and other characteristics among all AS, non-Hispanic Black AS, further stratified by their self-reported menthol use at Wave 4. There was a total of 7007 AS, out of which 2792 smoked menthol cigarettes and 3727 smoked non-menthol cigarettes. There was a significantly higher proportion of menthol smoking among non-Hispanic Black (78.9%) compared to the overall AS population (36.3%). Among MAS, there was a relatively larger proportion of non-Hispanic Blacks (28.4%, 95% CI 26.4-30.5) and Hispanics (16.3%, 95% CI 14.5-18.3) when compared to NMAS (3.5%, 95% CI 2.9-4.3 and 10.9%, 95% CI 9.7-12.2, respectively). A larger proportion of NMAS have considered switching from cigarettes to another product (15.6%, 95% CI 14.4-17.0) than MAS (13.9%, 95% CI 12.5-15.5), albeit the difference was not statistically significant. While the majority of non-Hispanic Black NMAS were aged 45 or older (67.7%), a statistically significantly higher proportion of MAS were between 25 and 44 years old (48.4%, 95% CI 44.6-52.3) compared to NMAS (27.5%, 95% CI 19.6, 37.1; $p<0.05$). Similar to the overall population of AS, a larger proportion of non-Hispanic Black NMAS have considered switching from cigarettes to another product (15.1%, 95% CI 9.1-24.1) than menthol peers (10.6%, 95% CI 8.4-13.3), albeit the difference was not statistically significant.

Tobacco Dependence Index among menthol and non-menthol AS.

Fig. 1 shows Tobacco Dependence Index (TDI) distribution among MAS and NMAS, and by race and ethnicity at Wave 4. The data demonstrated a statistically significantly higher mean TDI among NMAS (mean = 2.8, 95% CI 2.8-2.9, $p<0.0001$) than MAS (mean = 2.7, 95% CI 2.6-2.7). Similarly, non-Hispanic White NMAS had a statistically significantly higher TDI (mean = 2.9, 95% CI 2.8-2.9, $p=0.0205$) than non-Hispanic White MAS (mean = 2.8, 95% CI 2.7-2.9). We observed no statistically significant differences in mean TDI among non-Hispanic Black, non-Hispanic Other, and Hispanic MAS and NMAS.

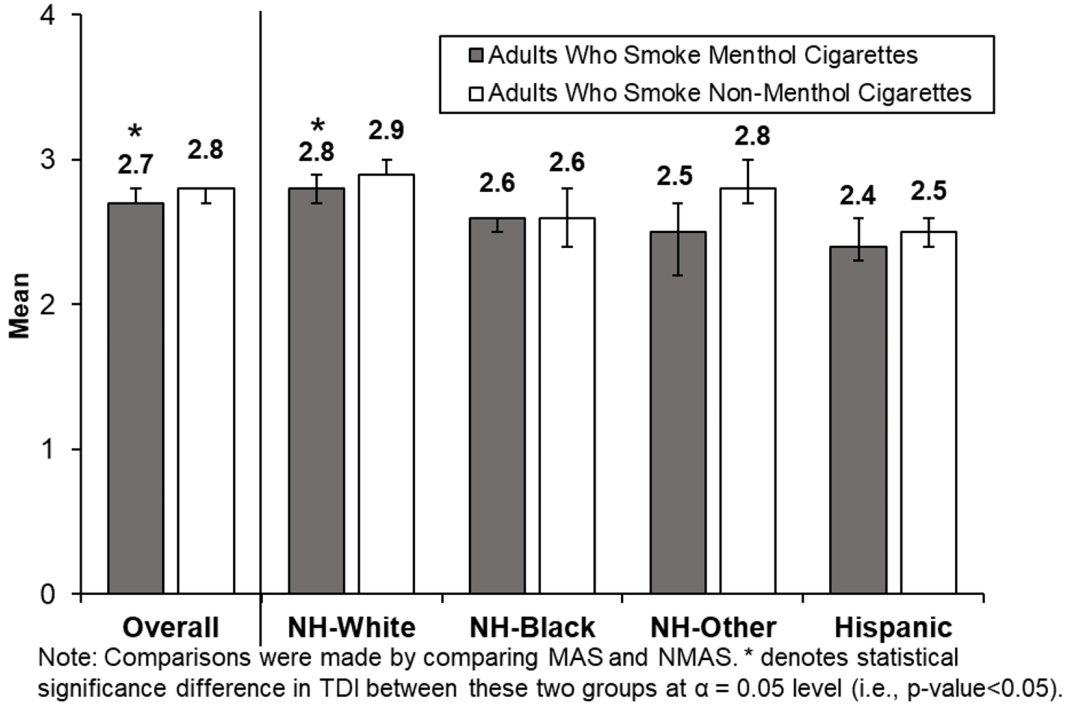

Figure 1. Baseline Tobacco Dependence Index by Race/Ethnicity and Menthol Status Among Adults Who Smoke. Note: Comparisons were made by comparing MAS and NMAS. * denotes statistical significance difference in TDI between these two groups at α = 0.05 level (i.e., p-value<0.05).

Heaviness of smoking distribution among menthol and non-menthol AS.

Fig. 2 shows cigarette dependence distribution as measured by heaviness of smoking (HSI) among MAS and NMAS at Wave 4. The data demonstrated a larger proportion of MAS with low cigarette dependence (60.5%, 95% CI 58.2-62.7) than among NMAS (52.6%, 95% CI 50.5-54.7). Smaller proportions of moderate (36.3%, 95% CI 34.1-38.5, p<0.0001) and high cigarette (3.3%, 95% CI 2.5-4.3) were noted among MAS than among NMAS. Fig. 3. demonstrates statistically significantly higher proportion of non-Hispanic White MAS with low cigarette dependence (55.4%, 95% CI 52.0-58.7, p<0.0001) and statistically significantly lower proportion with high cigarette dependence (4.1%, 95% CI 2.9-5.8, p<0.0001) when compared to NMAS (48.3%, 95% CI 46.0-50.7 and 7.9%, 95% CI 6.9-9.0, respectively). In general, we observed relatively higher proportions of non-Hispanic Black, Hispanic, and non-Hispanic Other AS with low cigarette dependence compared to non-Hispanic Whites, regardless of their self-reported menthol use.

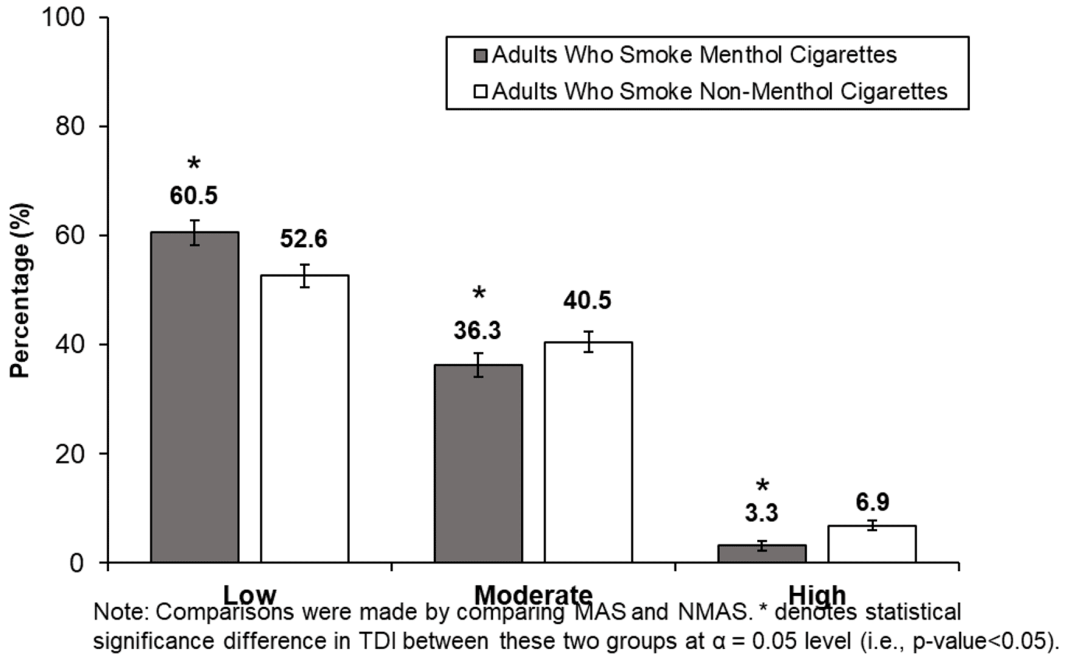

Figure 2. Heaviness of Smoking Index by Menthol Status Among Adult Smokers in PATH Waves 4-5

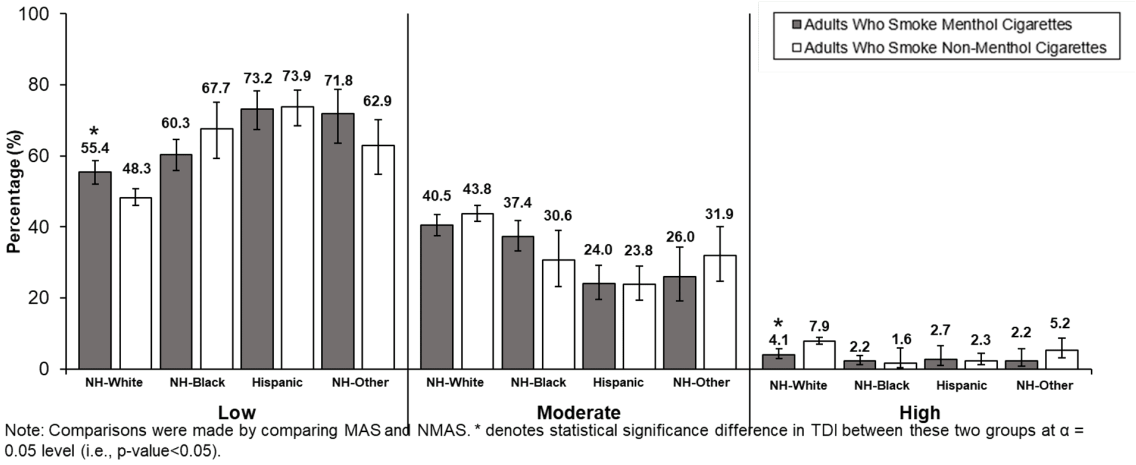

Figure 3. HSI Categories by Race/Ethnicity and Menthol Status Among Adult Smokers, PATH Waves 4-5

Smoking cessation rate among menthol and non-menthol AS.

Fig. 4 shows the smoking cessation rate among MAS and NMAS from Wave 4 to Wave 5. While no statistically significant differences were noted between MAS and NMAS, data showed an overall higher

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cessation rate among non-Hispanic White MAS (14.4%, 95% CI 11.5-17.8) and Hispanic MAS (16.6%, 95% CI 12.0-22.5) when compared to non-menthol smoking peers. There was a lower smoking cessation rate among non-Hispanic Black MAS (7.3%, 95% CI 5.4-9.7) than among non-Hispanic Black NMAS (11.6%, 95% CI 7.1-18.5), albeit the difference was not statistically significant.

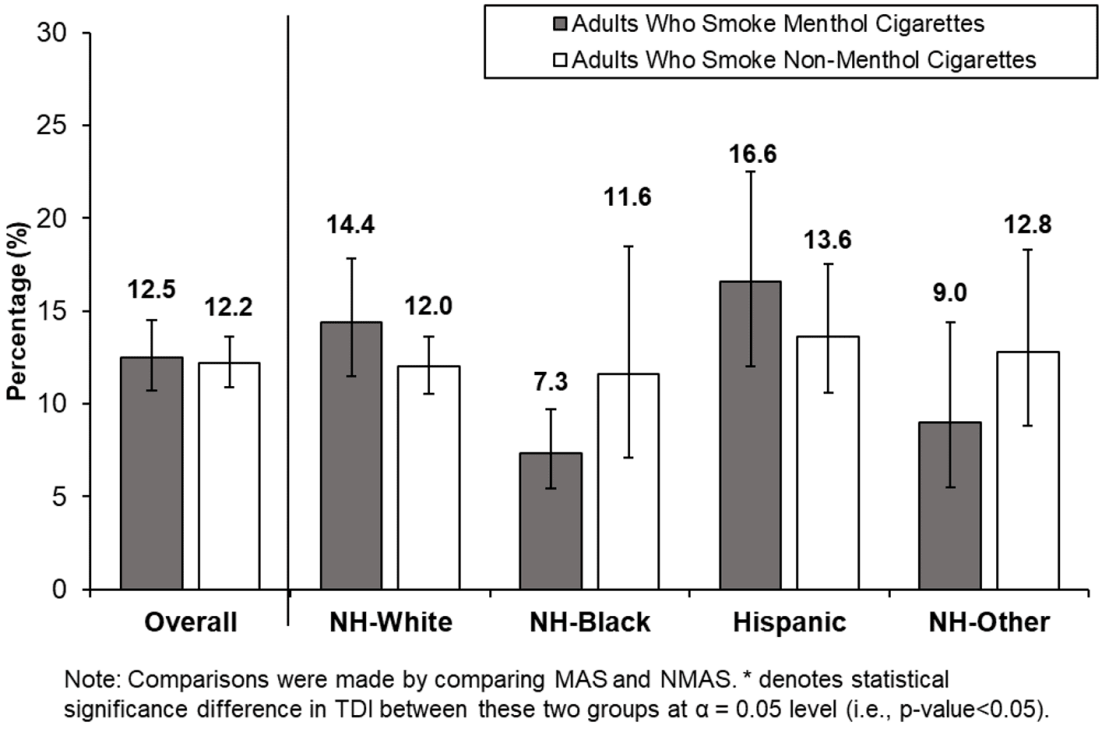

Figure 4. Wave 5 Cessation Rate Among Wave 4 Adult Smokers by Menthol Status

Logistic Regression Model 1 (Overall AS) Results

Fig. 5 shows results from the logistic regression model evaluating the odds of smoking cessation in Wave 5 among Wave 4 AS versus continuing to smoke cigarettes. It is important to note that menthol use was not a statistically significant variable (p=0.1482) in the backward stepwise logistic regression model and did not make it into the final model. The model results demonstrated lower odds of smoking cessation among adults who were older (25-44-years old, aOR=0.62, 95% CI 0.49-0.77, p<0.0001); 45+, (aOR=0.55, 95% CI 0.41-0.73, p<0.0001), non-Hispanic Black (aOR=0.53, 95% CI 0.38-0.74, p=0.0001) or non-Hispanic Others (aOR=0.64, 95% CI 0.44-0.94, p=0.0228), smoked cigarettes every day (aOR=0.36, 95% CI 0.29-0.45, p<0.0001), and reported moderate (aOR=0.60, 95% CI 0.45-0.80, p=0.0007) or high addiction (aOR=0.45,

95% CI 0.25-0.81, p=0.0084). All AS had higher odds of stopping smoking than continue smoking if they were planning to quit within the next year (aOR=1.28, 95% CI 1.00-1.65, p=0.0506).

Category	Characteristic	AOR	95% CI
Age	*18-24*	*1.00*	*REF*
	25-44	**0.62**	(0.49, 0.77)
	45+	**0.55**	(0.41, 0.73)
Race/Ethnicity	*Non-Hispanic White*	*1.00*	*REF*
	Non-Hispanic Black	**0.53**	(0.38, 0.74)
	Non-Hispanic Others	**0.64**	(0.44, 0.94)
Education	*Less than College*	*1.00*	*REF*
	Some College	1.21	(0.93, 1.57)
	College and Higher	**1.50**	(1.10, 2.04)
Frequency of Cigarette Smoking	*Some Day*	*1.00*	*REF*
	Every Day	**0.36**	(0.29, 0.45)
HSI	*Low Addiction*	*1.00*	*REF*
	Moderate Addiction	**0.60**	(0.45, 0.80)
	High Addiction	**0.45**	(0.25, 0.81)
Quitting	Planning to quit within next year	**1.28**	(1.00, 1.65)
Switching	Have considered switching from cigarettes to another product	0.85	(0.62, 1.18)

Note: Ref = Wave 5 Continuing Smoking

Figure 5. Correlates of Cigarette Smoking Cessation in PATH Wave 5 Among Adult Smokers Using Logistic Regression

Logistic Regression Model 2 (Non-Hispanic Black AS) Results

Fig. 6 shows results from the logistic regression model evaluating the odds of smoking cessation among non-Hispanic Black AS versus continuing to smoke cigarettes. Similar to Model 1 analysis, menthol use was not a statistically significant variable (p=0.1467) in the backward stepwise logistic regression model and did not make it into this analysis. The model results demonstrated a statistically significantly lower odds of stopping smoking among non-Hispanic Black AS who smoked cigarettes every day (aOR=0.52, 95% CI 0.28-0.95, p=0.0331) and reported moderate cigarette addiction (aOR=0.41, 95% CI 0.21-0.82, p=0.0122). There was a higher odds of stopping smoking among non-Hispanic Black AS who reported higher income (aOR=2.92, 95% CI 1.34-6.34, p=0.0073) and current use of smoke-free products (aOR=2.19, 95% CI 1.08-4.42, p=0.0296).

Category	Characteristic	AOR	95% CI
Frequency of Cigarette Smoking	*Some Day*	*1.00*	*REF*
	Every Day	**0.52**	(0.28, 0.95)
Income	*<$50K*	*1.00*	*REF*
	$50K-100K	**2.92**	(1.34, 6.34)
HSI	*Low Addiction*	*1.00*	*REF*
	Moderate Addiction	**0.41**	(0.21, 0.82)
	High Addiction	0.21	(0.01, 2.73)
Quitting	Planning to quit within next year	1.78	(0.86, 3.70)
Non-Combustible Use	Current use of smoke-free products	**2.19**	(1.08, 4.42)

Note: Ref = Wave 5 Continuing Smoking

Figure 6. Correlates of Smoking Cessation in PATH Wave 5 Among Non-Hispanic Black Adult Smokers Using Logistic Regression

Logistic Regression Models 3 and 4 (Non-Hispanic Black MAS and NMAS) Results

Fig. 7 and Fig. 8 show results from the firth logistic regression model evaluating the odds of smoking cessation among non-Hispanic Black MAS and NMAS, respectively, to further evaluate associated factors specific to self-reported use of menthol. Among non-Hispanic Black MAS, there was a lower odds of stopping smoking associated with everyday smoking (aOR=0.36, 95% CI 0.21-0.62, 0.0002), and higher odds associated with moderate income ($50K-$100K; aOR=2.46, 95% CI 1.28-4.71, p=0.0635) as well as with self-reported current use of smoke-free products (aOR=2.75, 95% CI 1.45-5.21, p=0.0020) (Fig. 6). Among non-Hispanic Black NMAS, there was a strong association and higher odds of stopping smoking among those who reported moderate income (aOR=6.00, 95% CI 1.98-18.12, p=0.0547). Higher income ($100K or more) was not significantly associated with cessation in either model, and no other covariates reached statistical significance.

Category	Characteristic	AOR	95% CI
Income	*<$50K*	*1.00*	*REF*
	$50K-100K	**2.46**	(1.28, 4.71)
	>=$100K	0.30	(0.02, 5.71)
Frequency of Cigarette Smoking	*Some Day*	*1.00*	*REF*
	Every Day	**0.36**	(0.21, 0.62)
Non-combustible Use	Current Use of Smoke-Free Products	**2.78**	(1.45, 5.22)

Note: Ref = Wave 5 Continuing Smoking

Figure 7. Correlates of Smoking Cessation in PATH Wave 5 Among Non-Hispanic Black Adult Menthol Smokers

Category	Characteristic	AOR	95% CI
Income	*<$50K*	*1.00*	*REF*
	$50K-100K	**6.00**	(1.98, 18.12)
	>=$100K	0.95	(0.04, 23.52)

Note: Ref = Wave 5 Continuing Smoking

Figure 8.Correlates of Smoking Cessation in PATH Wave 5 Among Non-Hispanic Black Adult Non-Menthol Smokers.

Discussion

Results of this study suggest that menthol does not increase the inherent dependence potential of cigarettes, nor does menthol impede smoking cessation. MAS and non-Hispanic Black AS exhibited lower cigarette dependence than NMAS. Menthol use was not a significant correlate of smoking cessation. Factors associated with lower odds of cigarette smoking cessation included older age, non-White race/ethnicity, daily smoking, and moderate to high cigarette dependence. In contrast, having a college degree or higher and planning to quit within a year were associated with increased odds of cessation. Although not statistically significant, non-Hispanic Black MAS had lower rates of smoking cessation than their non-menthol counterparts. Among all non-Hispanic Black AS, daily smoking and moderate

dependence were associated with lower odds of cessation, while moderate income ($50K-100K) and current use of smoke-free tobacco products were associated with greater odds of quitting.

These findings align with previous research demonstrating no impact of menthol on cigarette smoking dependence. Comprehensive reviews and meta-analyses have established that menthol cigarettes do not increase the likelihood of continued daily or non-daily smoking.[18][19][20] In addition, Villanti et al., 2021[1] found no association between first use of a menthol cigarette and past 30-day use, past 12-month use, or dependence symptoms among youth cigarette smokers.[20] Further, analyses of multiple national surveys have consistently shown that menthol smokers reported significantly fewer cigarettes per day than non-menthol smokers, with no differences in TTFC or HSI.[2] Consistent with this literature, the current study found that MAS had lower TDI and HSI scores than NMAS.

This study contributes to the mixed body of evidence on the relationship between menthol use, race/ethnicity, and smoking cessation. While some previous research has shown menthol use associated with lower cessation rates[21], this study and others found no significant impact of menthol on smoking cessation.[8] Consistent with previous research, we observed overall lower smoking cessation rates among non-Hispanic Black AS.[9] Among this group, barriers to cessation included daily cigarette smoking and moderate dependence, while facilitators included higher income and use of smoke-free products. Our findings align with previous research suggesting that using other smoke-free tobacco products, including e-cigarettes, can facilitate cigarette smoking cessation among non-Hispanic Black AS.[9][21]

Overall, the findings of this study suggest that menthol has no impact on cigarette dependence and a limited influence on smoking cessation. These results are consistent with prior research indicating that menthol does not alter the subjective or physiological effects of nicotine in humans.[22] Importantly, these findings underscore the need for effective strategies to support cigarette smoking cessation among MAS, particularly non-Hispanic Black MAS including accessible, FDA-authorized smoke-free alternatives to cigarettes, rather than reliance on prohibitive policy approaches such as menthol bans.[23]

Strengths and Limitations

This study had several strengths. The use of a nationally representative dataset with a large sample of AS enabled population-level inferences, including among subgroups of MAS and NMAS. The longitudinal design allowed for the examination of predictors of cigarette smoking cessation, including the influence of dependence level on cessation. However, limitations include the self-report nature of the data, which may

introduce bias, and the possibility that unmeasured confounders or omitted variables could influence cigarette smoking cessation outcomes.

Conclusion

These findings reinforce that menthol's role in cigarette dependence and cessation is minimal. Rather than focusing solely on product removal, efforts to support adult smokers – especially those from disproportionately impacted groups – may benefit more from expanding access to smoke-free alternatives and developing tailored cessation strategies. Such approaches may offer greater potential to reduce harm and improve public health outcomes.

Statements and Declarations

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Potential Competing Interests

All authors are employed by Altria Client Services LLC and declare that they have no additional competing interests.

Ethics approval and consent to participate

Not applicable. The study used de-identified, publicly available data only.

Consent for publication

Not applicable.

Data Availability

The datasets generated and/or analyzed during the current study are available at https://www.icpsr.umich.edu/icpsrweb/NAHDAP/studies/36498

Authors' contributions

PNL, LW, and ARV conceptualized and designed the study. PNL and LW acquired and analyzed the data and drafted the manuscript. ARV contributed to manuscript review and editing. All authors critically revised the manuscript for important intellectual content and approved the final version.

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