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## Adolescent menthol cigarette use and risk of nicotine dependence: Findings from the national Population Assessment on Tobacco and Health (PATH) study

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### Abstract

**Background:** Menthol cigarettes appeal to adolescents because they mask the harsh taste and sensation of tobacco smoke thereby making it easier to inhale the smoke. As a result, menthol cigarette users expose themselves to higher levels of nicotine relative to non-menthol cigarettes and increase their risk for developing nicotine dependence. We examined whether adolescent menthol smokers (vs. non-menthol smokers) reported higher nicotine dependence.

**Methods:** Data were from adolescent past 30-day cigarette smokers participating in Wave 2 of the Population Assessment of Tobacco and Health survey (n = 434). Nicotine dependence was assessed using eight items from the Wisconsin Inventory of Smoking Dependence Motives corresponding to individual subscale constructs. Linear regression models evaluated the association of past 30-day menthol (vs. non-menthol) cigarette use with each dependence outcome in separate models, adjusting for age, gender, race, and other tobacco product use.

**Results:** 49.5% of past 30-day youth cigarette smokers reported smoking menthol cigarettes. In adjusted models, menthol smokers (vs. non-menthol smokers) reported significantly higher nicotine dependence for three constructs: craving (p = 0.005), affiliative attachment (p = 0.005), and tolerance (p = 0.003). No differences for menthol vs. non-menthol smokers were observed for loss of control, negative reinforcement, cognitive enhancement, automaticity, or social environment after correction for multiple comparisons.

**Conclusions:** Findings suggest that menthol cigarette smokers are not just more physically dependent on nicotine but also experience increased emotional attachments to cigarettes compared

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#### Contributors

Ms. Sam Cwalina formulated the research question, conducted statistical analyses, interpreted the results, wrote and edited the manuscript, and approved the manuscript as submitted. Ms. Majmundar conducted statistical analyses, interpreted the results, contributed to editing the manuscript, and approved the manuscript as submitted. Drs. Unger, Barrington-Trimis, and Pentz contributed to formulating the research question, interpretation of results, and to editing the manuscript, and approved the manuscript as submitted.

#### Declaration of Competing Interest

No conflict declared.

#### Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.drugalcdep.2019.107715>.

to their non-menthol smoking peers. Because adolescents are vulnerable to developing nicotine dependence, tobacco control policies that restrict youth access to menthol cigarettes are urgently needed.

## Keywords

Menthol; Cigarettes; Nicotine dependence; Youth; PATH study; WISDM

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## 1. Introduction

The US Food and Drug Administration's (FDA) Tobacco Control Act of 2009 (Administration, 2009) banned all characterizing cigarette flavors except menthol. The purpose of this prohibition was to deter adolescents and young adults from early experimentation with cigarettes, given the appeal of flavored tobacco to this age group and the ability of flavor additives to mask the otherwise unpleasant taste of cigarette smoke (Carpenter et al., 2005; McKemy et al., 2002). Although excluded from the flavor ban legislation, menthol cigarettes similarly mask the aversive physiological effects of smoking with their perceived "cooling" effects and may increase exposure to nicotine compared to non-menthol cigarettes (Ha et al., 2015; McKemy et al., 2002; Yerger, 2011).

Further, menthol may slow the metabolism of nicotine, allowing for prolonged elevation of blood cotinine levels (Benowitz et al., 2004; Fagan et al., 2016). Preclinical data also suggests that menthol enhances the reinforcing properties of nicotine in key brain regions (Biswas et al., 2016; Henderson et al., 2017; Zhang et al., 2018), providing evidence for menthol's capacity to facilitate nicotine dependence. These unique properties of menthol may collectively lead to a disproportionate increase in the risk of dependence among users of menthol cigarettes relative to those using non-mentholated cigarettes (Fagan et al., 2010; Garten and Falkner, 2004; Hoffman and Simmons, 2011).

Despite sound mechanistic data suggesting an association between menthol cigarette use and increased nicotine dependence, relative to non-menthol cigarette use, empirical data to support this association have been inconclusive, especially among adolescents (Curtin et al., 2014). One study found that adolescent menthol users were more likely to smoke their first cigarette of the day immediately after waking, but there were no significant differences between menthol and non-menthol users on overall scores from the Fagerstrom Test of Nicotine Dependence (FTND) (Collins and Moolchan, 2006). Another study compared differences in associations of nicotine dependence between menthol and non-menthol users measured with three different scales: FTND, Wisconsin Inventory of Smoking Dependence Motives (WISDM), and the Nicotine Dependence Syndrome Scale (NDSS); associations varied considerably among different constructs within each scale (Fagan et al., 2015). The discrepancies reported in previous studies may be explained by a complex range of smoking motivations, such as menthol smokers typically smoking less cigarettes per day than non-menthol smokers (Fagan et al., 2010). Subscales within the full-length WISDM represent distinct smoking motivation constructs (Adkison et al., 2016), but these subscales have not yet been directly compared between menthol and non-menthol cigarettes smokers among adolescents.

This paper investigates the association of menthol cigarette use (vs. non-menthol cigarette use) and dimensions of nicotine dependence derived from the WISDM, using data from adolescent past 30-day cigarette smokers participating in Wave 2 of the Population Assessment of Tobacco and Health (PATH) survey.

## 2. Materials and Methods

### 2.1. Participants

Data were derived from Wave 2 of the Youth PATH survey public use files (Services et al., 2017). The Youth survey was administered to randomly selected U.S. adolescents aged 12–17 years from October 2014 through October 2015. The present analyses were restricted to adolescents who had used menthol ( $n = 215$ ) or non-menthol ( $n = 219$ ) cigarettes in the past 30 days. Respondents were excluded from analyses if they reported smoking any flavored cigarette other than menthol in the past 30 days ( $n = 30$ ). Additional information on the selection of the analytic sample appears in Fig. 1 in Supplementary material.

### 2.2. Measures

**2.2.1. Menthol cigarette use**—Respondents were first asked whether they had smoked any flavored cigarettes in the past 30 days; if participants responded “yes,” they were prompted with a follow-up question about which specific flavors they had smoked (including menthol). Respondents who indicated that they smoked menthol cigarettes in the past 30 days were classified as menthol cigarette smokers, and respondents who indicated that they did not smoke any flavored cigarettes in the past 30 days were classified as non-menthol cigarette smokers; respondents who indicated that they smoked cigarettes in a flavor other than menthol were excluded from analyses ( $n = 30$ ).

**2.2.2. Outcome measures of nicotine dependence**—The PATH questionnaire assessed nicotine dependence with individual survey items from several different validated scales, such as the WISDM (Piasecki et al., 2011; Piper et al., 2004), FTND (Fagerstrom and Schneider, 1989), and Hooked on Nicotine Checklist (MacPherson et al., 2008). Of the twelve nicotine dependence survey items included, eight conform most closely to WISDM subscale constructs (Piasecki et al., 2011) and were included in analyses; survey items from the FTND and HONC were excluded from analysis.

Each WISDM subscale in the full-length instrument includes several questions related to its corresponding overarching construct, and each construct emphasizes a distinct dimension of smoking motivations (Piasecki et al., 2011) (referred to as ‘dimensions of nicotine dependence’ from hereon). Rather than including eight full-length subscales, the PATH survey design team selected one item from each subscale to represent eight separate constructs, thus, each of the eight survey items were examined separately in the current analysis. The eight dimensions of nicotine dependence included: Craving, Tolerance, Automaticity, Loss of Control, Negative Reinforcement, Cognitive Enhancement, Affiliative Enhancement, and Social Environment; survey question text can be found in Table 1. Respondents were asked how strongly they agreed with each statement on a Likert scale from 1 to 5, with higher scores representing higher agreement.

There were two main reasons for excluding the FTND and HONC items from analyses. First, the dimensions of nicotine dependence were scored consistently with five levels of agreement and similar question structure. Therefore, scores of only the WISDM items are more readily interpretable compared to scores that would need to adjust for two-level variables (HONC) and a five-level variable (FTND) that is not on a comparable agreement scale. Second, two WISDM-derived items closely resemble the three excluded FTND- and HONC-derived items: “I frequently crave tobacco” and “I usually want to use tobacco right after I wake up.”

**2.2.3. Covariates**—The PATH public use data files included a three-level race variable (White, Black, Other), two-level gender (Male, Female), two-level age during interview (12–14 years, 15–17 years), dichotomous past 30-day use of other combustible tobacco products (traditional cigars, cigarillos, filtered cigars, pipe tobacco, hookah, bidis, and kreteks; Yes, No), and dichotomous past 30-day use of non-combustible tobacco products (e-cigarettes, smokeless tobacco, snus, and dissolvable tobacco; Yes, No).

### 2.3. Data analysis

All analyses utilized survey weights generated by the PATH study team that adjusted for oversampling and nonresponse (Services et al., 2017). Weighted frequencies and percentages were calculated using the SURVEYFREQ procedure in SAS for all five covariates by past 30-day menthol cigarette use. A weighted multivariate logistic regression model was used to assess any significant associations between covariates and past 30-day menthol cigarette use.

Multivariate linear regression models were used to estimate associations of past 30-day menthol cigarette use with each of the eight nicotine dependence constructs in separate models. Regression models were adjusted for self-reported race, gender, age, and other tobacco product use. Interaction models were used to determine whether the association of menthol cigarette use with each dependence construct differed by each covariate (race, gender, age, and other tobacco product use) by inclusion of a product interaction term (menthol cigarette use x covariate) in each model. Benjamini-Hochberg corrections were used to account for multiple comparisons (Benjamini, 2010). SAS V 9.4 was used for all analyses. Assumptions of linear regression were assessed, and no obvious concerns were found.

## 3. Results

### 3.1. Sample characteristics

Approximately half the analytic sample reported use of menthol cigarettes in the past 30 days (49.5 %) (Supplemental Table 1). The analytic sample was evenly balanced by gender. The majority of respondents were White (80.6 %) and aged 15–17 years (85.7 %). Lastly, 29.3 % and 45.6 % of respondents reported using combustible and non-combustible tobacco products (excluding cigarettes) in the past 30 days, respectively. There were no significant differences between menthol and non-menthol use by any demographic characteristics included in the regression models (all  $p > 0.05$ ). However, compared to non-menthol smokers, menthol smokers were more likely to have already smoked 100 lifetime cigarettes

( $p = 0.07$ ) and smoke on more days in the past 30 days (13.6 for menthol and 9.8 for nonmenthol;  $p < 0.001$ ).

### 3.2. Association of menthol cigarette use with nicotine dependence

Menthol cigarette use was positively associated with greater nicotine dependence for three dimensions: craving ( $p = 0.005$ ), affiliative attachment ( $p = 0.005$ ), and tolerance ( $p = 0.003$ ), after adjustment for race, gender, age, and other tobacco product use, and after the Benjamini-Hochberg correction (Table 1). Menthol cigarette smokers reported a higher mean craving value of 2.4 (95 % CI: 2.2, 2.6), compared to non-menthol smokers, who reported a mean craving score of 1.9 (95 % CI: 1.8, 2.1), resulting in an approximate 0.5 score difference (95 % CI: 0.15, 0.82;  $p = 0.0005$ ). Similar results were observed for affiliative attachment and tolerance. Menthol cigarette smokers reported a higher mean affiliative attachment value of 1.6 (95 % CI: 1.5, 1.8), compared to non-menthol smokers, who reported a mean craving score of 1.3 (95 % CI: 1.2, 1.4), resulting in an approximate 0.3 score difference (95 % CI: 0.10, 0.57;  $p = 0.0005$ ). Mean tolerance value has also higher among menthol cigarette smokers, 3.1 (95 % CI: 2.8, 3.3), compared to non-menthol smokers, with a mean craving score of 2.4 (95 % CI: 2.1, 2.7), resulting in an approximate 0.7 score difference (95%CI: 0.26, 1.21;  $p = 0.0005$ ). The association of menthol use with nicotine dependence did not differ by any covariates (all interaction  $p$ -values  $> 0.05$ ).

## 4. Discussion

Roughly half of youth surveyed in the PATH study who were past 30-day cigarette smokers reported smoking menthol cigarettes (49.5%), which is consistent with other estimates (Cohn et al., 2019). Past 30-day menthol cigarette smokers reported higher dependence scores for three constructs: craving, affiliative attachment, and tolerance. There were no significant differences between menthol and non-menthol users for the remaining dependence dimensions (loss of control, negative reinforcement, cognitive enhancement, automaticity, and social environment) after employing the Benjamini-Hochberg correction. However, loss of control and cognitive enhancement were significant prior to correction ( $p = 0.04$  and  $p = 0.03$ , respectively).

Craving and tolerance are both considered Primary Dependence Motives (PDM) within the WISDM which are thought to relate more closely to physical symptoms of nicotine dependence (Tarantola et al., 2017). The target construct for craving is described as smoking in response to craving or experiencing intense or frequent urges to smoke, and tolerance is described as the need to smoke increasing amounts over time to experience the desired effects of the ability to smoke large amounts without acute toxicity. Elevated scores for craving and tolerance constructs are consistent with physiological evidence of the synergistic effect of menthol and nicotine. Affiliative attachment is considered a Secondary Dependence Motive (SDM), which measures comparatively more ancillary smoking motivations. The target construct for affiliative attachment is described as a strong emotional attachment to smoking and cigarettes (Adkison et al., 2016). SDMs are strongly related to pleasure and relief derived from smoking (Tarantola et al., 2017).

These findings contribute to the rapidly growing body of scientific evidence demonstrating that menthol cigarettes may be more harmful to youth than non-menthol cigarettes, resulting from increased nicotine dependence which could adversely impact the incidence of tobacco-induced diseases. Further, findings suggest that menthol cigarette smokers are not just more physically dependent on nicotine but also experience increased emotional attachments to cigarettes compared to their non-menthol smoking peers, which should be considered in tobacco prevention campaigns and tobacco control policies. Although the FDA already has enacted policy that prohibits the sale of cigarettes to minors and has banned other flavored cigarettes, there are no additional federal regulations on menthol cigarettes. In light of this, and given the known adverse impact of menthol cigarettes on youth initiation, several cities and counties across the U.S. have implemented policies that prohibit the sale of all flavored tobacco products, including menthol cigarettes (Anon., 2018) but such measures are not yet widespread.

Several limitations of the present study should inform future analyses. Respondents were asked if they had smoked any flavored cigarettes in the past 30 days, so it is possible that a respondent who typically smoked non-menthol cigarettes happened to smoke a mentholated cigarette recently and was therefore classified as a menthol user; there was no question that explicitly confirmed preference for menthol or non-menthol, though the proportion of menthol smokers was consistent with prior estimates from national samples (Cohn et al., 2019). The PATH study protocol does not provide a standardized scoring method for the nicotine dependence items that are included in the questionnaire. It remains unclear whether analyzing each WISDM-derived item separately is the best assessment of nicotine dependence in youth, but there is some evidence to suggest that removing redundantly worded questions within individual subscales does not significantly compromise subscale reliability (Shenassa et al., 2009). Further to this point, the original WISDM scale has more expansive response options that range from 1 to 7 rather than 1–5 in the PATH survey. It is unclear how a condensed agreement scale could have impacted results, but it is possible that a lower range of scores contributed to the relatively low WISDM scores observed here. The PATH survey did not assess family history of smoking and did not provide adequate data on age of smoking initiation for all Wave 2 respondents, both of which could explain differences in nicotine dependence by menthol use, so present analyses were unable to control for these variables. Finally, low concentrations of menthol still appear in non-menthol cigarettes (Ferris Wayne and Connolly, 2004). Menthol concentrations that are typically observed in cigarettes advertised as non-menthol are sufficient to activate the receptor responsible for the “cooling” effects of mentholated tobacco smoke (Ai et al., 2016; Paschke et al., 2017; Richter et al., 2016), raising the possibility that the menthol cigarette use-dependence relationship found in the present study may be underestimated.

#### 4.1. Conclusions

Adolescent menthol cigarette smokers appear to experience stronger evidence of nicotine craving, tolerance, and affiliative attachment—three distinct aspects of nicotine dependence—compared to adolescents who only smoke non-mentholated cigarettes. This could place a disproportionate tobacco-related disease burden on menthol users in subsequent years. FDA should consider a federal ban on menthol as a characterizing flavor or cigarette additive and



place increased emphasis on menthol tobacco products in tobacco control campaigns and policies.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Association of menthol cigarette use with eight WISDM constructs.

Dimensions of nicotine dependence and corresponding survey question	Menthol		Non-Menthol	
	Weighted Mean (95% CI) <sup>a</sup>	Weighted Beta (95% CI) <sup>b</sup>	P	Weighted Mean (95% CI)
Craving I frequently crave cigarettes.	2.4 (2.2,2.6)	0.48 (0.15,0.82)	0.005*	1.9 (1.8,2.1)
Tolerance I usually want to smoke a cigarette right after I wake up.	3.1 (2.8,3.3)	0.73 (0.26,1.21)	0.003*	2.4 (2.1,2.7)
Automaticity I find myself reaching for cigarettes without thinking about it.	2.5 (2.3,2.7)	0.27 (-0.07,0.62)	0.12	2.2 (1.9,2.3)
Loss of control My cigarette use is out of control.	1.8 (1.6,2.0)	0.32 (0.02,0.63)	0.04	1.6 (1.4,1.8)
Negative reinforcement Smoking helps me feel better if I've been feeling down.	2.6 (2.4,2.8)	0.24 (-0.01,0.58)	0.15	2.4 (2.2,2.6)
Cognitive enhancement Smoking cigarettes helps me think better.	2.2 (1.9,2.4)	0.33 (0.03,0.62)	0.03	1.9 (1.7,2.1)
Affiliative attachment I would feel alone without my cigarettes.	1.6 (1.5,1.8)	0.34 (0.10,0.57)	0.005*	1.3 (1.2,1.4)
Social environment Most of the people I spend time with smoke cigarettes.	3.3 (3.2,3.6)	0.26 (-0.07,0.60)	0.12	3.0 (2.8,3.2)

<sup>a</sup>Weighted means and standard errors of WISDM scores (range = 1–5).

<sup>b</sup>Weighted linear regression coefficients and 95% confidence intervals, after adjustment for race, gender, age, and other tobacco product use.

\* p significant at 0.05 after Benjamini-Hochberg correction.