



Full length article

## Smokers' behavioral intentions in response to a low-nicotine cigarette policy

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## ABSTRACT

**Introduction:** Evidence suggests that reducing the nicotine concentration in cigarettes to sub-addictive levels would reduce use. Until a low-nicotine cigarette policy is enacted, population-level effects are unknown. This study examines the behavioral intentions of current U.S. cigarette smokers if a low-nicotine policy were implemented.

**Methods:** Data were drawn from a nationally representative probability-based panel and opt-in panel. Weighted logistic regressions examined likelihood to (1) smoke lower nicotine cigarettes, (2) quit using tobacco, (3) use e-cigarettes, (4) illegally buy high-nicotine cigarettes, and (5) smoke cigars, cigarillos, or little cigars (CLCCs) among smokers, controlling for demographics, tobacco products used, dependence, and intentions to quit cigarettes. Latent class analyses (LCA) characterized patterns of behavioral intentions.

**Results:** If a low-nicotine policy were implemented, most participants indicated a likelihood to smoke low-nicotine cigarettes (78.4%) or quit tobacco (61.9%), followed by use e-cigarettes (46.5%). Individuals with greater dependence had greater odds of intending to smoke low-nicotine cigarettes, use e-cigarettes, and illegally buy high-nicotine cigarettes. Current e-cigarette or CLCCs users had higher odds of intending to use these products. LCA revealed that individuals would 1) use low-nicotine cigarettes with low intentions to use other tobacco products or 2) use multiple tobacco products, including low-nicotine cigarettes.

**Conclusions:** A reduced nicotine standard for all combustible tobacco products is needed given that many tobacco users would likely intend to continue to use tobacco products. Differences in intentions by tobacco use and demographic characteristics indicate a need for additional cessation support and education around the harms of continued use of combustible tobacco.

## 1. Introduction

In recent years, adult smoking rates have significantly decreased in the United States from 20.9% in 2005 to 14.0% in 2017. (Jamal et al., 2018) However, additional interventions are needed to further reduce smoking prevalence, given that 68.0% of U.S. adult smokers, or approximately 23 million U.S. adults, want to quit smoking but report limited success. (Babb et al., 2017). The 2009 Family Smoking Prevention and Tobacco Control Act (FSPTCA) granted the Food and Drug Administration (FDA) the authority to regulate the manufacture, distribution, and marketing of tobacco products – including regulation of the nicotine content in cigarettes to sub-addictive levels. (U.S. Congress, 2009) As a result, research efforts have examined the potential impact

of reducing nicotine levels (the primary addictive agent in cigarettes) to further reduce smoking rates and enhance cessation. (Benowitz, 2010; Hatsukami et al., 2010b; U.S. Department of Health and Human Services, 1988) In March 2018, the FDA issued an Advance Notice of Proposed Rulemaking (ANPRM) to solicit public comments on a proposal to establish a maximum nicotine level for cigarettes. (Food and Drug Administration, 2018) The ANPRM stated that the intention of this policy would be to make cigarettes minimally addictive or non-addictive to prevent future cigarette users from becoming addicted and facilitate cessation among current cigarette users. Recent research indicates that support for a policy requiring cigarette makers to lower the nicotine levels in cigarettes so that they are less addictive was high, with 80% of current smokers somewhat or strongly favoring such a

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policy.(Ali et al., 2019)

Several clinical trials conducted with smokers have examined the effects of reduced nicotine cigarettes on smoking-related outcomes. These studies demonstrate that use of cigarettes with reduced (e.g., < 0.1 mg) levels of nicotine was associated with smoking fewer cigarettes per day and making more frequent quit attempts compared to smokers who used conventional cigarettes (e.g., 0.8 mg).(Benowitz et al., 2012; Dermody et al., 2015; Donny et al., 2015; Hatsukami et al., 2010a, 2012, 2015) Further, there is little evidence to suggest that smokers using reduced nicotine cigarettes engaged in compensatory smoking behavior to increase nicotine intake.(Benowitz et al., 2012, 2015; Donny et al., 2015; Hatsukami et al., 2015, 2012) Clinical trial data also suggests that nicotine dependence among smokers who used lower nicotine cigarettes was either reduced in short-term clinical trials of 12 weeks or less, (Donny et al., 2015; Hatsukami et al., 2010a) or was not significantly different compared to smokers who used cigarettes with higher nicotine content, as seen in a 2-year follow up.(Benowitz et al., 2015) To date, only one clinical trial examined smoking-related outcomes in a simulated real-world tobacco marketplace, where smokers were randomly assigned to three conditions: 1) lower nicotine cigarettes plus access to non-cigarette combusted products (e.g., cigars, little cigars, cigarillos) and non-combusted tobacco products (e.g., smokeless tobacco and snus, electronic cigarettes, over-the-counter nicotine medications), 2) low-nicotine cigarettes plus access to non-combusted tobacco products only, and 3) normal nicotine cigarettes plus access to non-cigarette combusted and non-combusted tobacco products (e.g., current marketplace conditions).(Hatsukami et al., 2017) Researchers found that smokers assigned to both of the lower nicotine cigarette conditions had higher rates of cigarette smoking abstinence and were more likely to use alternative tobacco or nicotine products compared to those assigned to the normal nicotine cigarette condition.(Hatsukami et al., 2017) These results suggest that nicotine reduction regulations that cover all combustible products could maximally improve public health outcomes.

While clinical trials provide some evidence that lowering the nicotine content in cigarettes is a viable strategy to reduce the burden of tobacco use, many of these studies report small sample sizes and may not be representative of adult smokers, limiting the generalizability of the results. Additionally, only a handful of clinical trials have examined differences in outcomes by demographic characteristics, highlighting a gap in understanding of how smokers' responses to nicotine reduction vary by race/ethnicity, income, and education level.(Faulkner et al., 2018; Higgins et al., 2017; Tidey et al., 2016) More importantly, these studies are also limited in their ability to reflect the complexity of the tobacco marketplace wherein multiple tobacco and nicotine products would be available to consumers alongside lower nicotine cigarettes. The potential behavioral response of smokers to the proposed FDA regulation is largely unknown and needs to be considered to estimate the public health impact of such a regulation. Since actual behavioral response to policy implementation cannot be determined until the regulation is enacted, behavioral intentions provide valuable insights to possible precursors of behavioral expression.(Ajzen, 1985, 1991) Previous research on behavioral intentions related to tobacco policies include examining the potential impact of a menthol ban policy and restricting smoking in restaurants and bars.(Biener and Siegel, 1997; D'Silva et al., 2015) To our knowledge, only one study has explored behavioral intentions in response to a nicotine reduction policy; a hypothetical scenario was presented to a convenience sample of young adults (18–29 year-olds) wherein only low-nicotine combustible cigarettes and electronic cigarettes (e-cigarettes) were sold.(Pacek et al., 2019) Researchers found that dual cigarette and e-cigarette users were more likely to report that they would increase e-cigarette use and reduce or quit smoking versus increasing or maintaining their current smoking behavior.(Pacek et al., 2019) The current study builds off this work by examining tobacco use behavioral intentions in response to a nicotine reduction policy among a large, nationally representative

sample of adult cigarette smokers ages 18–54. Additionally, this study explores how intentions may vary based on demographic characteristics and tobacco use patterns.

## 2. Methods

### 2.1. Data source

Data were drawn from the probability-based AmeriSpeak panel and weighted to be nationally representative. This panel includes 30,000 households and leverages the NORC National Sampling Frame, which covers over 97% of all U.S. households.(Dennis, 2018) A subsample of respondents were also recruited through an online opt-in panel to ensure sufficient sample of younger tobacco users. Responses from the AmeriSpeak panel were used to adjust for potential sampling and non-sampling biases in the opt-in panel. Data were collected between March 22, 2018 and April 17, 2018. Survey participants were English or Spanish speaking adult tobacco users between 18 and 54 years old and non-users between 18 and 24 years old; each panelist had the opportunity to complete the survey online or by phone (n = 1746). Participant recruitment and survey administration were conducted by NORC at the University of Chicago. The study sample was further restricted to only include current cigarette smokers (n = 1156) to investigate behavioral intentions in response to a low-nicotine cigarette policy. Participants were considered current cigarette smokers if they smoked at least 100 cigarettes in their lifetime and now smoked cigarettes every day or some days. Complete case analyses were conducted and missing data were listwise deleted, resulting in analytic sample of n = 917. Sensitivity analyses using listwise deletion per behavioral intention (not shown) to address potential biases from complete case analyses did not show any significant differences. This study was approved by Advarra IRB (Protocol number: Pro00024529).

### 2.2. Measures

#### 2.2.1. Sociodemographics

Study demographics included age (categorized as 18–24, 25–34, 35–54 years old), race/ethnicity (White non-Hispanic, Black non-Hispanic, Other non-Hispanic, Hispanic), gender (male, female), education (high school/GED equivalent or less, some college, BA or above), and annual household income (< \$35,000, \$35,000–\$74,999, \$75,000–\$99,999, > 100,000).

#### 2.2.2. Other Tobacco Use

E-cigarettes were defined for participants as “e-cigarettes, e-cigs, vape pens, vape tanks, JUUL devices, hookah pens, or e-hookahs.” Current e-cigarette and current cigar, cigarillo, or little cigar (CLCC) use was defined by whether participants had ever used the product and now used the products every day or some days. Non-current users consisted of participants who had never used the products or no longer used the product every or some days.

#### 2.2.3. Time-to-first cigarette (TTFC)

TTFC was used as an established measure of nicotine dependence.(DiFranza et al., 2013; Heatherton et al., 1991) Current smokers were asked how soon after first waking they had their first cigarette. TTFC was categorized with: ≤ 5 min, 6–30 minutes, 31–60 minutes, after 60 min.(Heatherton et al., 1991)

#### 2.2.4. Intention to quit

Intention to quit was measured by a single item: “Are you planning to stop smoking cigarettes within the next 30 days?” (yes/no).

#### 2.2.5. Behavioral intentions outcomes

Responses to a low-nicotine cigarette policy were measured among current smokers. Participants were told, “The federal government may

require tobacco companies to significantly reduce the level of nicotine in cigarettes.” Participants were then asked the following questions: “If lower nicotine cigarettes were the only cigarettes available for legal purchase, how likely would you be to...?” (1) Smoke lower nicotine cigarettes, (2) Quit using tobacco products altogether, (3) Use e-cigarettes, (4) Try to buy cigarettes with higher levels of nicotine, even if it was illegal to do so and, (5) Smoke cigars, cigarillos or little cigars. Participants responded to each of the 5 behaviors and responses were dichotomized (very/somewhat likely vs. very/somewhat unlikely).

### 2.3. Analysis

Analyses were conducted in SAS Enterprise Guide and Mplus. (Muthén and Muthén, 2019; SAS Institute Inc, 2017) Probability sample data were weighted using base and sample-specific post-stratification weights to produce estimates representative of U.S. adult tobacco users. After probability samples weights were determined, the non-probability sample was calibrated to probability samples using auxiliary variables. (Gupta et al., 2011, 2019; Schonlau and Couper, 2017) Unweighted frequencies and weighted proportions of sample characteristics are presented.

Bivariate analyses and separate weighted multivariable logistic regression models examined the association between each behavioral intention outcome (1–5) and sociodemographic characteristics, current other tobacco use, TTFC, and intention to quit. Current e-cigarette use was not included in the model for intending to smoke CLCCs; likewise, current CLCC use was not included in the model for intending to use e-cigarettes, due to sample size restrictions.

To further characterize patterns of behavioral intentions as a response to a low-nicotine policy, latent class analyses (LCA) were conducted using unweighted data. Commonly used statistical fit indices including the Bayesian Information Criterion (BIC) (Collins and Lanza, 2010), entropy (Celeux and Soromenho, 1996) and the Lo-Mendell-Rubin likelihood ratio test (Lo et al., 2001) were used to identify the optimal model. All behavioral intentions excluding “Quit using tobacco products altogether” were included in the latent class analyses, as the behavioral intention of quitting was seen as separate from behavioral intentions to continue using tobacco products.

### 3. Results

The majority of the sample were 35–54 years old (60.1%), non-Hispanic white (68.7%), and male (55.2%). Less than half of participants had a high school/GED (38.8%), and an income of less than \$35,000 a year (42.1%) (Table 1). Fewer than half were also current CLCC users (40.9%) or current e-cigarette users (41.6%). Over half of the sample reported a TTFC of  $\leq 5$  or 6–30 minutes (61.3%), and approximately one-third were planning to quit smoking in the next 30 days (36.0%).

A large proportion of the sample reported that they were very likely or somewhat likely to smoke low-nicotine cigarettes (78.4%) or quit tobacco altogether (62.5%) if only lower nicotine cigarettes were available for sale. Almost half of the sample were very likely or somewhat likely to use e-cigarettes (46.4%) and about one third endorsed that they would illegally buy high-nicotine cigarettes (34.7%) or smoke CLCCs (30.4%). The bivariate analyses demonstrate significant differences in behavioral intention outcomes by sociodemographic characteristics and tobacco use behaviors (Table 1).

Results from weighted adjusted logistic regression models are presented in Table 2. Compared to individuals who reported a TTFC greater than 60 min, individuals with a TTFC of 6–30 minutes (adjusted odds ratio (aOR) = 2.31, 95% confidence interval (CI): 1.32–4.02) and a TTFC  $\leq 5$  min (aOR = 3.35, CI: 1.63–6.89) had greater odds of endorsing that they were very likely or somewhat likely to smoke low-nicotine cigarettes. Similarly, women (aOR = 1.82, CI: 1.11–3.00) and individuals with annual income \$35,000–\$74,999 (aOR = 1.95,

CI:1.08–3.51) or over \$100,000 (aOR = 3.05, CI: 1.25–7.44) had greater odds of intending to smoke low-nicotine cigarettes compared to men and those with lower annual income less than \$35,000, respectively.

Participants who intended to quit smoking cigarettes in the next 30 days had higher odds of endorsing that they would quit tobacco products altogether if only lower nicotine cigarettes available compared to those who did not intend to quit (aOR = 2.61, CI:1.65–4.13). Additionally, those with a bachelor’s degree or higher had greater odds of intending to quit tobacco altogether compared to those with a high school education or less (aOR = 2.10, CI:1.13–3.89).

Current e-cigarette users had over six times higher odds of intending to use e-cigarette given a low-nicotine cigarette policy compared to non-current e-cigarette users (aOR = 6.61, CI:4.11–10.62), while individuals 35–54 years old had much lower odds of intending to use of e-cigarettes compared to individuals 18–24-year-olds (aOR = 0.32, CI: 0.16–0.64). Black, non-Hispanic adults had higher odds of intending to use e-cigarettes (AOR = 2.05; CI: 1.12–3.73) than White adults. Additionally, those with an annual income of \$35,000–\$74,999 (aOR = 2.32, CI:1.30–4.15) or over \$100,000 (aOR = 2.85, CI: 1.42–5.72) had greater odds of intending to use e-cigarettes compared to those with an annual income less than \$35,000. Current CLCC users had over eight times higher odds of reporting that they were very likely or somewhat likely to smoke CLCCs if a low-nicotine cigarette policy were in place compared to non-current CLCC users (aOR = 8.85, CI: 4.84–15.05).

Participants with a TTFC of  $\leq 5$  min (aOR = 4.33, CI: 2.23–8.41) or between 6–30 minutes (aOR = 2.55, CI: 1.43–4.53) had greater odds of intending to illegally buy high-nicotine cigarettes if only lower nicotine cigarettes were available compared to those with a TTFC of greater than 60 min. Additionally, participants with a TTFC of  $\leq 5$  min (aOR = 1.97, CI: 1.04, 3.75) or between 6–30 minutes (aOR = 2.45, CI: (1.44, 4.16) had greater odds of intending to use e-cigarettes if only lower nicotine cigarettes were available compared to those with a TTFC of greater than 60 min. Participants 35–54 years old had much lower odds of intending to buy high-nicotine cigarettes compared to participants 18–24 years old (aOR = 0.36, CI: 0.19–0.70).

Class enumeration results (presented in Table 3) showed that an LCA with a two-class solution had the most parsimonious fit to the data. Sample adjusted BIC = 4260.094, entropy = 0.79 and Lo-Mendell-Rubin LRTs provided evidence that 2 classes provided a better fit than 1 class or 3 classes ( $p < 0.001$ ,  $p = 0.094$ , respectively). These results indicate that individuals are likely to intend to either 1) use low-nicotine cigarettes with low intentions to use other tobacco products (labeled “low-nicotine cigarette adopters”,  $n = 651$ ) or 2) use multiple tobacco products, including low-nicotine cigarettes, but also e-cigarettes, CLCC, or illegally purchase high-nicotine cigarettes (labeled “multiple product users”,  $n = 266$ ). The probability of belonging to the “low-nicotine cigarette adopters” was 0.71, while the probability of belonging to the “multiple product users” class was 0.29. Fig. 1 presents the conditional probability estimates for each of behavioral intention by latent class.

### 4. Discussion

Findings from this study indicate significant variation in behavioral intentions to a reduced nicotine policy. While almost two-thirds (62%) of respondents indicated they would quit tobacco use altogether, many also intended to use combustible products, including high-nicotine cigarettes, and CLCCs if only low-nicotine cigarettes were available. In addition, our latent class analysis revealed that approximately one quarter intend to use multiple combustible and non-combustible tobacco products. While findings do indicate some level of potential population health benefit with intended use of low-nicotine cigarettes and potential increased quitting, our findings also suggest that smokers intend to seek out other tobacco alternatives which may attenuate the

**Table 1**  
Frequencies and weighted proportions of study sample by total and by behavioral intention outcome (n = 917).

	Total n (wt. %)	Behavioral intention outcome if only lower nicotine cigarettes were available (very/somewhat likely to)				
		Smoke low-nicotine cigarettes n (wt. %)	Quit tobacco altogether n (wt. %)	Use e-cigarettes n (wt. %)	Illegally buy high- nicotine cigarettes n (wt. %)	Smoke cigars, cigarillos, or little cigars n (wt. %)
<b>Overall</b>	917	704 (78.4)	582 (62.5)	453 (46.4)	345 (34.7)	332 (30.4)
<b>Age</b>						
18-24 years	212 (12.1)	145 (76.7)	141 (62.4)	<b>119 (69.4)***</b>	<b>93 (50.7)***</b>	<b>106 (42.8)***</b>
25-34 years	353 (27.8)	275 (77.6)	230 (70.1)	<b>193 (55.7)***</b>	<b>160 (49.7)***</b>	<b>156 (47.6)***</b>
35-54 years	352 (60.1)	284 (79.0)	211 (58.9)	<b>141 (37.4)***</b>	<b>92 (24.6)***</b>	<b>70 (19.9)***</b>
<b>Race/Ethnicity</b>						
White, non-Hispanic	548 (68.7)	<b>451 (81.7)*</b>	347 (60.0)	276 (44.8)	209 (32.6)	202 (29.3)
Black, non-Hispanic	149 (12.7)	<b>105 (67.7)*</b>	108 (77.1)	76 (54.1)	55 (38.6)	64 (37.0)
Hispanic	129 (11.1)	<b>81 (66.8)*</b>	73 (62.1)	57 (46.2)	44 (38.0)	41 (28.3)
Other, non-Hispanic	91 (7.5)	<b>67 (82.7)*</b>	54 (60.6)	44 (47.6)	37 (42.9)	25 (31.6)
<b>Gender</b>						
Male	352 (55.2)	280 (75.3)	242 (63.1)	207 (49.8)	<b>180 (39.3)*</b>	<b>179 (35.7)**</b>
Female	565 (44.9)	424 (82.2)	340 (61.6)	246 (42.2)	<b>165 (29.1)*</b>	<b>153 (23.8)**</b>
<b>Education</b>						
HS graduate/GED equivalent or less	314 (38.8)	231 (72.8)	<b>169 (53.7)*</b>	134 (40.9)	<b>127 (41.4)***</b>	106 (28.9)
Some college	365 (35.1)	265 (79.6)	<b>242 (66.2)*</b>	174 (46.5)	<b>103 (22.3)***</b>	117 (29.1)
BA or above	238 (26.1)	208 (84.9)	<b>171 (70.4)*</b>	145 (54.4)	<b>115 (41.6)***</b>	109 (34.2)
<b>Income</b>						
< 35k	410 (42.1)	<b>288 (70.7)*</b>	239 (58.3)	<b>167 (36.5)**</b>	140 (32.5)	137 (31.5)
35k - 74,999	287 (29.4)	<b>226 (83.8)*</b>	190 (66.8)	<b>149 (52.3)**</b>	103 (34.6)	98 (29.9)
75k - 99,999	112 (13.7)	<b>96 (80.3)*</b>	78 (67.4)	<b>65 (47.3)**</b>	57 (37.5)	53 (31.3)
> = 100k	108 (14.8)	<b>94 (87.5)*</b>	75 (61.1)	<b>72 (61.9)**</b>	45 (38.8)	44 (27.2)
<b>Current cigar, cigarillo, or little cigar use</b>						
No	479 (59.2)	366 (78.7)	290 (59.4)	<b>187 (37.5)***</b>	<b>116 (25.8)***</b>	<b>61 (12.1)***</b>
Yes	438 (40.9)	338 (77.8)	292 (66.9)	<b>266 (59.3)***</b>	<b>229 (47.6)***</b>	<b>271 (56.8)***</b>
<b>Current e-cigarette use</b>						
No	484 (58.4)	355 (79.0)	296 (63.4)	<b>138 (27.2)***</b>	<b>132 (27.2)***</b>	<b>107 (22.4)***</b>
Yes	433 (41.6)	349 (77.5)	286 (61.1)	<b>315 (73.4)***</b>	<b>213 (45.2)***</b>	<b>225 (41.6)***</b>
<b>Time to first cigarette</b>						
after 60 min	246 (28.7)	<b>165 (69.0)*</b>	164 (65.6)	<b>96 (36.1)**</b>	<b>49 (22.3)***</b>	62 (26.3)
31-60 min	116 (10.1)	<b>88 (78.0)*</b>	80 (64.5)	<b>58 (43.3)**</b>	<b>38 (22.1)***</b>	38 (20.0)
6-30 min	336 (36.2)	<b>272 (82.4)*</b>	208 (59.6)	<b>200 (57.6)**</b>	<b>146 (39.5)***</b>	140 (32.0)
≤5	219 (25.1)	<b>179 (83.3)*</b>	130 (62.2)	<b>99 (43.2)**</b>	<b>112 (47.1)***</b>	92 (36.8)
<b>Intention to quit smoking cigarettes (next 30 days)</b>						
No	532 (64.0)	416 (80.9)	<b>289 (54.2)***</b>	237 (42.9)	180 (34.8)	157 (28.9)
Yes	385 (36.0)	288 (73.9)	<b>293 (77.2)***</b>	216 (52.5)	165 (34.7)	175 (33.0)

wt.% = weighted percent.

\*p < 0.05.

\*\*p < 0.01.

\*\*\*p < 0.001.

impact. These results should be considered alongside the clinical trial data from previous studies showing that smokers given low-nicotine cigarettes and access to combustible and alternative tobacco products used these products more frequently compared to smokers given normal nicotine cigarettes.(Hatsukami et al., 2017) Together these findings suggest that reducing the nicotine content in cigarettes alone may not reduce combustible tobacco use, i.e., maintain the risk of developing tobacco-related diseases.(U.S. Department of Health and Human Services, 2014) Collectively, this evidence makes a compelling case for the FDA to implement a nicotine standard across all combustible tobacco products to prompt cessation and reduce exposure to the harmful chemicals present in combusted tobacco products.

In addition to expressing intention to use other combustible

products, approximately 78% of participants also expressed intention to use low-nicotine cigarettes. Recent research conducted among smokers naïve to low-nicotine cigarettes found that the majority of smokers did not believe that low-nicotine cigarettes were less addictive or easier to quit than regular cigarettes.(Mercincavage et al., 2019) It is possible that misperceptions around low-nicotine cigarettes may contribute to smokers' reported intentions to use this product as a replacement for high-nicotine cigarettes. Alternatively, smokers may be informed about the less addictive nature of low-nicotine cigarettes and may see use of this product as a pathway to quitting tobacco use altogether, particularly given that 62% of smokers in this study expressed intention to quit using tobacco. More research is needed to understand smokers' knowledge and misperceptions of low-nicotine cigarettes compared to

**Table 2**  
Weighted adjusted logistic regression models of behavioral intention outcomes (very/somewhat likely) if only low-nicotine cigarettes were available (n = 917).

	Smoke low-nicotine cigarettes aOR (95% CI)	Quit tobacco altogether aOR (95% CI)	Use e-cigarettes aOR (95% CI)	Illegally buy high-nicotine cigarettes aOR (95% CI)	Smoke cigars, cigarillos, or little cigars aOR (95% CI)
<b>Age</b>					
18-24 years	REF	REF	REF <sup>†</sup>	REF <sup>†</sup>	REF <sup>†</sup>
25-34 years	0.94 (0.46, 1.91)	1.04 (0.54, 2.00)	0.52 (0.24, 1.10)	1.05 (0.53, 2.07)	1.47 (0.63, 3.39)
35-54 years	1.02 (0.48, 2.20)	0.71 (0.38, 1.31)	<b>0.32** (0.16, 0.64)</b>	<b>0.36** (0.19, 0.70)</b>	0.65 (0.29, 1.48)
<b>Race/Ethnicity</b>					
White, non-Hispanic	REF	REF	REF <sup>†</sup>	REF	REF
Black, non-Hispanic	0.58 (0.28, 1.22)	1.96 (0.99, 3.87)	<b>2.05* (1.12, 3.73)</b>	1.53 (0.78, 3.01)	0.72 (0.36, 1.46)
Hispanic	0.54 (0.28, 1.04)	1.08 (0.58, 2.03)	0.92 (0.43, 1.94)	1.51 (0.80, 2.86)	0.84 (0.31, 2.29)
Other, non-Hispanic	0.86 (0.36, 2.07)	0.90 (0.42, 1.90)	0.82 (0.37, 1.83)	1.65 (0.67, 4.07)	0.88 (0.37, 2.09)
<b>Gender</b>					
Male	REF <sup>†</sup>	REF	REF	REF	REF
Female	<b>1.82* (1.11, 3.00)</b>	0.98 (0.63, 1.52)	1.04 (0.67, 1.64)	0.82 (0.52, 1.29)	0.72 (0.42, 1.22)
<b>Education</b>					
HS graduate or equivalent or less	REF	REF <sup>†</sup>	REF	REF <sup>†</sup>	REF
Some college	1.63 (0.95, 2.80)	1.63 (0.99, 2.68)	1.18 (0.70, 2.01)	<b>0.42** (0.25, 0.71)</b>	1.47 (0.78, 2.74)
BA or above	1.98 (0.93, 4.22)	<b>2.10* (1.13, 3.89)</b>	1.43 (0.77, 2.66)	1.07 (0.60, 1.92)	1.42 (0.70, 2.88)
<b>Income</b>					
< 35k	REF <sup>†</sup>	REF	REF <sup>†</sup>	REF	REF
35k - 74,999	<b>1.95* (1.08, 3.51)</b>	1.46 (0.87, 2.47)	<b>2.32** (1.30, 4.15)</b>	1.43 (0.81, 2.50)	1.04 (0.53, 2.03)
75k - 99,999	1.77 (0.75, 4.18)	1.08 (0.50, 2.35)	1.44 (0.70, 2.93)	1.54 (0.77, 3.06)	0.97 (0.46, 2.04)
> = 100k	<b>3.05* (1.25, 7.44)</b>	1.12 (0.55, 2.31)	<b>2.85** (1.42, 5.72)</b>	1.47 (0.70, 3.08)	0.82 (0.31, 2.20)
<b>Current cigar, cigarillo, or little cigar use</b>					
No	REF	REF	XX	REF	REF <sup>†</sup>
Yes	1.30 (0.64, 2.65)	1.18 (0.71, 1.94)		1.55 (0.94, 2.54)	<b>8.53*** (4.84, 15.05)</b>
<b>Current e-cigarette use</b>					
No	REF	REF	REF <sup>†</sup>	REF	XX
Yes	0.82 (0.46, 1.48)	0.65 (0.40, 1.05)	<b>6.61*** (4.11, 10.62)</b>	1.52 (0.95, 2.43)	
<b>Time to first cigarette</b>					
after 60 min	REF <sup>†</sup>	REF	REF <sup>†</sup>	REF <sup>†</sup>	REF
31-60 min	1.32 (0.59, 2.95)	1.23 (0.68, 2.23)	0.95 (0.46, 1.93)	1.05 (0.47, 2.33)	0.57 (0.25, 1.29)
6-30 min	<b>2.31** (1.32, 4.02)</b>	0.88 (0.52, 1.50)	<b>2.45** (1.44, 4.16)</b>	<b>2.55** (1.43, 4.53)</b>	1.29 (0.71, 2.33)
≤5	<b>3.35** (1.63, 6.89)</b>	1.07 (0.54, 2.16)	<b>1.97* (1.04, 3.75)</b>	<b>4.33*** (2.23, 8.41)</b>	2.01 (0.96, 4.18)
<b>Intention to quit smoking cigarettes (next 30 days)</b>					
No	REF	REF <sup>†</sup>	REF	REF	REF
Yes	0.74 (0.45, 1.23)	<b>2.61*** (1.65, 4.13)</b>	1.12 (0.71, 1.78)	0.75 (0.48, 1.16)	0.84 (0.51, 1.39)

XX not included in the model.

aOR = adjusted odds ratio; 95% CI: 95% Confidence interval.

\*p < 0.05.

\*\*p < 0.01.

\*\*\*p < 0.001.

† F test gives p < 0.05; overall effect of covariate is significant.

smokers' knowledge of other cessation methods.

This study, one of the first to examine demographic differences in behavioral intentions of adult smokers, also suggests that subgroups of individuals may have different intentions and thus may be differentially impacted if a low-nicotine cigarette policy were established. Overall, women and those with higher income had higher odds of intending to use low-nicotine cigarettes, and therefore continuing to use

combustible tobacco products, which may reflect beliefs and attitudes among women that lower nicotine cigarettes are less harmful. (Patel et al., 2013) Additionally, individuals with higher education levels are more likely to believe that low-nicotine cigarettes were less harmful. (O'Brien et al., 2017) Higher socioeconomic status smokers may be at a higher risk in the context of low-nicotine cigarettes, if they only switch to low-nicotine cigarettes, which are still combustible products and

**Table 3**  
Model fit information for LCA models with 1–6 latent classes.

Classes	Log Likelihood	Free parameters	AIC <sup>a</sup>	BIC <sup>b</sup>	Sample-size Adjusted BIC <sup>c</sup>	Entropy R <sup>2</sup>	LMR <sup>d</sup> LRT p-value for k – 1 classes
1	-2340.061	4	4688.123	4707.407	4694.704	-	-
2	-2099.352	9	4216.704	4260.094	4231.511	0.790	0.0000
3	-2090.597	14	4209.193	4276.689	4232.227	0.654	0.0939
4	-2087.043	19	4212.086	4303.687	4243.346	0.609	0.0486
5	-2087.043	24	4222.086	4337.793	4261.572	0.572	0.4839
6	-2087.043	29	4232.086	4371.899	4279.798	0.808	0.0105

<sup>a</sup> Akaike information criterion.

<sup>b</sup> Bayesian information criterion.

<sup>c</sup> Replace sample size (n) in BIC calculation with n\*[(n + 2) / 24].

<sup>d</sup> Lo-Mendell-Rubin likelihood ratio test.

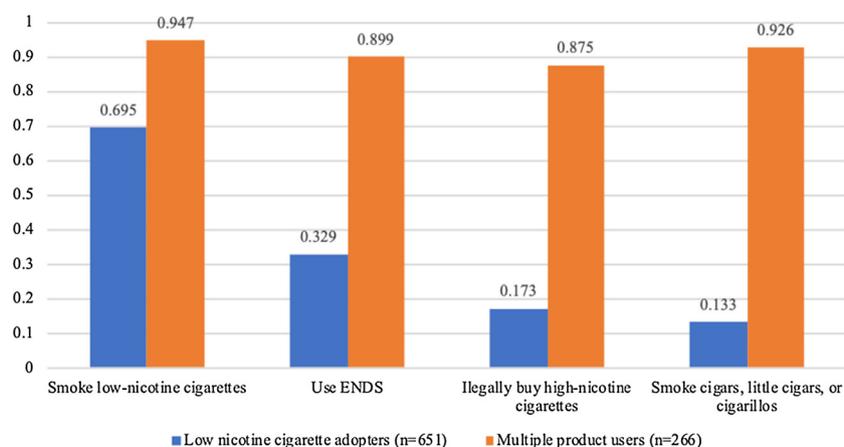


Fig. 1. Probability for somewhat/very likely behavioral intention if a low-nicotine cigarette policy were in place for two latent classes.

therefore still harmful, rather than quitting tobacco use or switching exclusively to e-cigarettes. Our study did find that higher income smokers were more likely to intend to use e-cigarettes. Although not approved as cessation devices, e-cigarettes have been marketed as “switching” devices (Jackler et al., 2019) and may have the potential to assist adult smokers in quitting combustible tobacco use, which may reduce their risk of adverse health outcomes, if used exclusively. (National Academies of Sciences Engineering and Medicine, 2018) Moreover, smokers with a college education had greater odds of intending to quit compared to those with a high school degree or less, consistent with prior evidence that more economically advantaged populations have greater quit intentions and success. (U.S. Department of Health and Human Services, 2014) Thus, it is important to be mindful of the differential impact of this policy on individuals with lower education attainment, who may need additional resources to reduce their consumption of combustible tobacco products.

The prevalence and popularity of e-cigarette use among youth and young adults likely accounts for younger individuals (18–24) to report they would use e-cigarettes as compared to older adults if a low-nicotine cigarette policy were in place. (Vallone et al., 2018; Wang et al., 2018) This finding highlights that older adults may need comprehensive public education efforts on the role of nicotine, combusted tobacco products, dependence, cessation, and alternative tobacco products in relation to health consequences. Race/ethnicity may also impact intentions to use e-cigarettes in response to a low-nicotine policy. We found that Black, non-Hispanic smokers were more likely to intend to use e-cigarettes compared to White, non-Hispanic smokers. While e-cigarette use is generally less common among African Americans compared to Whites, (Wang et al., 2018) African Americans smokers, particularly menthol cigarette smokers, have greater difficulty quitting compared to White smokers despite making more quit attempts. (Delnevo et al., 2011; Trinidad et al., 2010) A low-nicotine policy may benefit this population if exclusive use of e-cigarettes becomes an established pattern of tobacco product use among this subgroup.

Patterns of tobacco use also appear to impact intentions, with dual users indicating intention to use one of their current products as an option should low-nicotine cigarettes be introduced. Similar to prior research with young adult dual cigarette and e-cigarette users, current smokers who also used e-cigarettes reported greater intentions to use e-cigarettes. (Pacek et al., 2019) Smokers who used CLCCs also had greater odds of intending to use cigar products, reinforcing the need to reduce nicotine content across all other combustible products to realize the largest population-level public health benefit. Smokers with higher levels of dependence had higher odds of intending to use a variety of products including low-nicotine cigarettes, illegal combustible cigarettes, and e-cigarettes. However, intentions to quit did not differ by levels of dependence, which likely reflects their need to maintain their

current levels of nicotine consumption. To help prompt cessation of combustible products, increased cessation resources are critical as well as extending the reduced-nicotine policy to all combusted tobacco products.

There are several limitations of this study. Because behavioral intentions are the outcomes measured in this study, definitive conclusions cannot be drawn about how individuals would behave if a low-nicotine cigarette policy were implemented. Although research on smoking behaviors indicates that behavioral intentions and behavior moderately covary, behavioral intentions are important precursors to behavioral change. (Topa and Moriano, 2010) Nonetheless, measuring behavioral intentions in a population based study, rather than observed behavior in a simulation study, allows for an exploration of potential policy impacts. A second limitation of this study was that participants were not asked about the frequency of use for each other tobacco product. Although we controlled for dependence among smokers through time-to-first cigarette, it is possible that those who use CLCCs or e-cigarettes may have varying levels of dependence and may express different intentions about the products should a low-nicotine cigarette policy be implemented. Another limitation is that this study cannot predict nor account for changes in the tobacco product marketplace. Therefore, future changes to the marketplace may change the context in which smokers make decisions about the products they use, which could impact behavioral intentions. Additionally, this study does not examine behavioral intentions of individuals in underserved populations, such as those who identify as LGBTQ or individuals with psychiatric conditions due to small sample size and survey limitations. Given the high rates of tobacco use in these subpopulations (U.S. Department of Health and Human Services, 2014), a low-nicotine policy may have a different impact on the behavioral intentions of those who identify as LGBTQ or those with mental health conditions compared with the general population. A final limitation is that no information was provided about the extent to which nicotine levels may be reduced as a result of the policy the FDA is considering. It is possible that respondents may have interpreted the question differently depending on the extent to which they interpreted nicotine levels will be reduced. However, the FDA had not yet proposed a specific maximum nicotine level; thus, the information provided to participants was kept broad. (Food and Drug Administration, 2018)

## 5. Conclusion

As FDA policies are being proposed, studies like this allow us to examine potential behavioral impacts of policy implementation at the population level. Our study showed that behavioral intentions varied by both demographics and tobacco use variables, indicating that a reduced nicotine cigarette policy could have some positive impact on

population-level health. However, our research also indicates that most current cigarette smokers intend to continue using tobacco products and more research is needed to understand how vulnerable sub-populations may respond to this change in the tobacco landscape. These findings suggest a reduced-nicotine standard should be implemented across all combustible tobacco products to fully realize the optimal impact of a low-nicotine product policy.

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### Contributors

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### Declaration of Competing Interest

All authors declare no conflict of interest.

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