## Title

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# Differential Price-Responsiveness of Smoking Behaviors among Non-Hispanic African Americans and Non-Hispanic Whites in the U.S.

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**Abstract**

**Background and aims**: Non-Hispanic African Americans (African Americans) smoke fewer cigarettes per day (CPD) and are more likely to be nondaily smokers than non-Hispanic Whites (Whites). Little is known about how changes in cigarette prices might contribute to these differences. This study aimed to measure the price-responsiveness of smoking participation, nondaily smoking among current smokers, and smoking intensity among daily or nondaily smokers for African Americans and compare the price-responsiveness estimates with those for Whites.

**Design:** Analyzed data from the 2009-2014 National Adult Tobacco Surveys and cigarette price data from the Tax Burden on Tobacco report.

**Setting:** United States of America

**Participants:** 19,232 African American and 197,939 White adults aged 18+.

**Measurements:** We used a three-part econometric model of cigarette demand to estimate the price-responsiveness of smoking participation, daily vs. nondaily smoking, and smoking intensity. The model controlled for secular variation, state-level anti-smoking sentiment and smoke-free air laws, and socio-demographics.

**Findings**: In 2009-2014, 20.2% of African Americans and 17.7% of Whites identified as current smokers; 70.2% of African American smokers and 81.4% of White smokers smoked daily. The price elasticity of smoking participation was significant for Whites at -0.16 (95% CI=-0.23,-0.09), indicating that a 10% increase in prices would reduce smoking participation by 1.6%, but not statistically significant for African Americans, and this racial/ethnic differential price responsiveness was not statistically significant. The price elasticity of smoking intensity was statistically significant for African American daily smokers at -0.29 (95% CI= -0.42,-0.16), but not statistically significant for White daily smokers, and this racial/ethnic differential price-responsiveness was statistically significant. The price elasticity of daily vs. nondaily smoking among current smokers, and the price elasticity of smoking intensity among nondaily smokers were not statistically significant for either racial/ethnic group.

**Conclusion:** In the United States of America, cigarette price increases may have stronger effects on decreasing daily smokers' consumption among African Americans than among non-Hispanic Whites.

## Introduction

After years of tobacco control efforts, adult smoking prevalence for non-Hispanic African Americans is slightly lower than that for non-Hispanic Whites in the U.S. (14.6% vs.15.0% in 2018) (1). In addition, cigarette consumption patterns among current smokers have changed with increases in nondaily and light smoking (1-4), and this trend is more apparent among non-Hispanic African American ("African Americans") than non-Hispanic White ("White") smokers (5, 6). During 1992-2011, the proportion of nondaily and light smokers (≤5 cigarettes per day) among current smokers increased by 7.8% among African Americans and by 4.3% Whites (5). Despite African Americans smoking at a slightly lower rate, less frequently and fewer cigarettes than Whites (7-9), they suffer disproportionately from smoking-caused morbidity and mortality (9, 10). For example, African Americans have disproportionately higher lung cancer incidence and lower survival rates (11, 12). These outcomes underline the existence of smoking-related health disparities for African Americans as a major public health concern.

Raising cigarette taxes has been regarded as one of the most effective tobacco control policies (13, 14) to reduce smoking and improve public health (15-17). In the U.S., cigarettes are taxed by federal, state, and local governments. During 2009-2014, 25 states and the District of Columbia (DC) increased their cigarette taxes 31 times (18), and the federal cigarette tax increased in 2009 by $0.62 per pack. The state cigarette tax rates averaged $1.82 per pack as of June 2020, and varied considerably from $0.17/pack in Missouri to $4.50/pack in DC, which contributed to wide state-to-state variation in cigarette retail prices (19). A large body of literature has consistently estimated that a 10% increase in cigarette prices would reduce adults' demand for cigarettes by 2%-6% (i.e., price elasticity -0.2 to -0.6), with half of the effect on smoking prevalence and half on cigarette consumption (16, 17).

Only a few studies (20-22) have assessed the impact of cigarette prices on smoking behavior for African Americans. Using the 1976 – 1993 National Health Interview Surveys , one study found that African Americans were more price-responsive than Whites in reducing smoking prevalence (price elasticity of -0.20 vs. -0.08), but their price-responsiveness of smoking intensity was the same as Whites' (price elasticity of -0.15 vs. -0.15) (20). Using the last panel of the 2001/02 wave of the Tobacco Use Supplement to the Current Population Survey (TUS-CPS), one study (21) found no differential price effects on smoking between Blacks and Whites regardless of Latino ethnicity. Using all panels of the 2006/07 and 2010/11 waves of the TUS-CPS, another study found that African Americans were less price-responsive than Whites in both smoking participation (price elasticity of -0.10 vs -0.26) and intensity (price elasticity of -0.17 vs -0.22). (22) The inconsistent findings from these studies may result from the different study periods explored and different data sources used. More research is needed to better understand the price-responsiveness of smoking behaviors among African Americans. Furthermore, the impact of cigarette prices on daily vs. nondaily smoking behaviors among African Americans remains underexplored. One study found that raising cigarette prices not only decreased smoking prevalence, but also increased the proportion of nondaily smoking among current smokers (23). However, that study did not examine the price effects for racial/ethnic sub-groups. Given the different trends in nondaily and light smoking for American Africans and Whites, it is important to understand how price changes have contributed to these differences.

This study aims to fill the research gaps by examining the price-responsiveness of smoking participation, nondaily smoking among current smokers, and smoking intensity among daily or nondaily smokers for African Americans and comparing the price-responsiveness estimates with those for Whites. We hypothesize that cigarette price increases would decrease smoking prevalence, increase nondaily smoking, and decrease smoking

consumption among nondaily and daily smokers. We also hypothesize that the price responsiveness would differ between African Americans and Whites.

## Methods

### Data source

We analyzed data from three waves of the National Adult Tobacco Survey (NATS): Wave 1 (October 2009 to February 2010), Wave 2 (October 2012 to July 2013), and Wave 3 (October 2013 to October 2014). The NATS is conducted by the Centers for Disease Control and Prevention's Office on Smoking and Health and administered to a nationally representative sample of non-institutionalized adults (aged 18+) residing in all 50 states and DC. It collects information about individual's sociodemographic characteristics, cigarette smoking, other tobacco use, nicotine dependence, risk perceptions, and exposure to tobacco marketing and promotion (24). The NATS is a stratified telephone survey utilizing a dual-frame random-digit dialing method, with independent samples drawn from landline and cell phone frames. The total response rates in Waves 1-3 were 62.3%, 44.9% and 36.1%, respectively (24).

### Dependent variables

The dependent variables include the following smoking behaviors: cigarette smoking participation (i.e. being a current smoker), nondaily vs. daily smoking among current smokers, and smoking intensity separately for daily and nondaily smokers. Current smokers were those who reported smoking ≥ 100 cigarettes in their lifetime and now (i.e., at the time of interview) smoke cigarettes every day or some days. Daily (nondaily) smokers were current smokers who smoked every day (some days). Smoking intensity was measured as the average number of cigarettes smoked per day (CPD). For nondaily smokers, we derived the mean number of CPD as the product of the number of days smoked in the past 30 days and the number of cigarettes smoked on those days, and then dividing by 30.

**Independent variables**

***State-level cigarette prices***

We obtained state-specific retail cigarette prices from the Tax Burden on Tobacco (TBOT) report (25), which publishes the average retail cigarette prices for every state and DC as of November 1 each year. TBOT prices are inclusive of federal and state excise taxes on cigarettes but do not include local sales taxes (25). TBOT prices have been extensively used in U.S. studies of demand for cigarettes (20, 26-29). However, since the TBOT prices were measured as of November 1, and the NATS was conducted over several months for each wave, we interpolated prices for other months following the approach employed by previous studies (22, 30). We first computed the net-of-tax price (i.e., the price before state and federal taxes are added) as of November 1, and then calculated the net-of-tax prices for all the months between the consecutive pairs of November prices using linear interpolation. Finally, monthly retail prices were derived by adding the actual state and federal taxes in effect for each month to the corresponding interpolated monthly net-of-tax prices. To account for the impact of inflation over time, nominal values were converted to October 2014 constant dollars using the Consumer Price Index for All Urban Consumers (31), and then merged into the NATS data by year, month and state.

***Other state-level factors***

We controlled for two state-level factors which are also determinants of smoking: anti-smoking sentiment and smoke-free air laws.

States with stronger public attitudes against smoking would have stricter tobacco control regulations, and were more likely to have lower smoking rates (29, 32, 33). Therefore, not accounting for this potential confounder may overestimate the price effect on cigarette demand. To measure the unobserved anti-smoking sentiment, we adopted a method originally developed by Decicca and colleagues (33) to construct a state-level index by wave

based on the following two questions asked in the NATS: "Not counting motorcycles, in the vehicles that you or family members who live with you own or lease, is smoking always allowed, sometimes allowed in at least one vehicle, or never allowed in any vehicle?" and "Not counting decks, porches, or garages, inside your home, is smoking always allowed, allowed only at some times or in some places, or never allowed?" We ran a factor analysis, estimated the first factor for every respondent, and calculated the state-level average of the estimated first factor across all respondents in each state by wave to create the state anti-smoking sentiment index (29, 33). Larger values of the index indicated stronger anti-smoking sentiment. This index was standardized to have a mean of zero across all waves, hence allowing comparisons across waves and states. The derived index showed a general upward trend over time and a reasonable pattern across states. For example, the highest indices were in states with the lowest smoking rates — Utah and California, while the lowest indices were in tobacco-producing states such as Kentucky. The derived indices were merged into the NATS data by year and state.

Based on data collected in January of 2009, 2012, and 2013 from the American Nonsmokers' Rights Foundation (34), we constructed a smoke-free air law index. For each state and wave, we calculated the mean percentage of state population covered by 100% smoke-free air laws in: 1) workplaces, 2) restaurants, and 3) bars. The derived mean values were used as our state-level smoke-free air law indices, which were then merged into the NATS data by wave and state.

***Individual's sociodemographic characteristics***

Individual's characteristics included age (18–24, 25–34, 35–44, 45–54, 55–64, and 65+), gender (male, and female), education (less than high school degree, high school graduate (including General Educational Development certificate), some college (including associate degree), college degree, and post graduate), marital status (married, living with partner,

divorced, widowed, separated, and single/never married), and annual family income (<$20,000, $20,000-29,999, $30,000-39,999, $40,000-49,999, $50,000-69,999, $70,000-99,999, $100,000-149,999, ≥$150,000, and unknown). We included those adults who did not report their annual family income as "unknown", due to the concern of non-random missing values.

***Secular indicator***

To account for secular variation, a dummy variable was created for each survey wave.

**Participants**

The pooled 2009-2013 NATS data contained 254,006 adults aged 18+, including 19,232 African Americans and 197,939 Whites. After excluding those who did not report their smoking status, CPD, age, gender, education, or marital status, and those who resided in DC (smoke-free air law data were not collected), the final study sample contained 17,721 African American and 191,006 White adults.

**Statistical analysis**

We employed a three-part econometric model (23), an extension of the widely used two-part model in the economics literature that examines the effects of cigarette prices on demand for cigarette using individual-level survey data (16, 17, 20, 22, 35-37). The first part of the model (Part I), the smoking participation equation, estimates a discrete choice of being a current smoker or not. The second part of the model (Part II), the nondaily smoking equation, estimates a discrete choice of being a nondaily smoker conditional upon being a current smoker. The third part of the model (Part III), the smoking intensity equation, estimates CPD separately conditional upon being a nondaily or daily smoker. The overall demand for cigarettes can be obtained by multiplying the probability of being a current smoker by the conditional probability of being a nondaily smoker and by smoking intensity conditional upon being a nondaily or daily smoker. Each part was specified as a function of the cigarette

price variable, anti-smoking sentiment index, smoke-free air law index, and other independent variables described above. We estimated Parts I and II using a multivariable logistic regression, and estimated Part III using a multivariable linear regression. We transformed CPD using the natural logarithm to reduce the skewness from 14.15 to -0.43 and kurtosis from 344.95 to -0.02. We also logarithmically transformed the cigarette price to reduce the skewness from 1.19 to 0.75 and kurtosis from 1.14 to -0.002.

Based on the three-part model specification, we calculated three price elasticities as follows: (1) price elasticity of smoking participation was derived by multiplying the cigarette price coefficient from Part I by (1 – smoking prevalence rate) (35-37); (2) price elasticity of nondaily smoking was derived by multiplying the cigarette price coefficient from Part II by (1 – the proportion of nondaily smoking among current smokers); and (3) price elasticity of smoking intensity equaled the cigarette price coefficient from Part III due to the log-linear transformation (36, 37).

We estimated the three-part model separately for African Americans and Whites. To test whether the smoking behaviors respond differently to cigarette prices for African Americans and Whites, we first estimated an expanded three-part model which added an indicator for African Americans (=1 if African American; 0 otherwise), and the interaction terms between the African American indicator and all the independent variables with the combined sample of both racial/ethnic groups. Then, we re-ran this combined-sample model by excluding those statistically non-significant interaction terms between the African American indicator and independent variables other than cigarette price. Finally, the Wald statistic was used to determine whether the price-responsiveness of smoking behavior differed significantly between African Americans and Whites.

To assess the validity of our model, we also tested three hypotheses: (1) Are the smoking intensity equations equivalent for nondaily and daily smokers?; (2) Are the three-

part models equivalent for African Americans and Whites?; and (3) Is the price elasticity constant over the three survey waves? For hypothesis (1), we conducted a Chow test separately for African Americans and Whites. For hypothesis (2), we estimated the expanded three-part model specified above, and used the F statistics to test if coefficients of the interaction terms with all independent variables jointly equaling zero for the Part I&II, and a Chow test for the Part III. To test hypothesis (3), we added the interaction terms between cigarette price and wave indicators to the three-part model separately for African Americans and Whites; we used the F statistics to test if the interaction terms coefficients jointly equaling zero.

We conducted a sensitivity analysis to estimate the three-part model using the cigarette price variable without log-transformation.

The analysis was not pre-registered and the results should be considered exploratory. All analyses were estimated with the NATS national weights, which accounted for complex survey design, and were carried out using SAS 9.4. A two-tailed p-value <0.05 was considered to be statistically significant.

**Results**

During the study period, prevalence of current cigarette smoking was 20.2% (n=3,076) for African Americans and 17.7% (n=23,914) for Whites (Table 1). On average, CPD was 9.9 (SE=0.3) for African American smokers and 14.8 (SE=0.11) for White smokers. Among African American smokers, 70.2% (n= 2,165) were daily smokers with 12.4 CPD (SE=0.67), and 29.8% (n=911) were nondaily smokers with 4.2 CPD (SE=0.67). Among White smokers, 81.4% (n=19,306) were daily smokers, with 17.4 CPD (SE=0.11), and 18.6% (n=4,608) were nondaily smokers with 3.2 CPD (SE=0.14).

Table 2 shows the results from the three-part model for African Americans. The price-responsiveness of smoking participation, nondaily smoking, and nondaily smokers' smoking

intensity were not statistically significant. However, the Part III results indicated that daily smokers reduced CPD by 2.9% in response to a 10% price increase (price elasticity=–0.29; 95% CI=-0.42,-0.16). The result of anti-smoking sentiment (coef= -0.83, p=0.014), indicated that for a one unit increase in anti-smoking sentiment, the odds of smoking participation decreased by 56.4% (= (1–exp (–0.83))). There were no statistically significant associations of smoke-free laws with smoking behaviors.

Table 3 shows the three-part model results for Whites. The price-responsiveness of smoking participation was significant (coef=-0.19, price elasticity=-0.16, 95% CI= -0.23,-0.09), indicating that smoking participation decreased by 1.6% in response to a 10% cigarette prices increase. The price-responsiveness of nondaily smoking, and smoking intensity were not significant. The results of anti-smoking sentiment index indicated that a one-unit increase in the index decreased the odds of smoking participation by 53.7% (=(1–exp(–0.77))), increased the odds of nondaily smoking by 150.9% (=(exp (0.92)–1)), and decreased daily smokers' CPD by 49%. There were no statistically significant associations of smoke-free laws with smoking behaviors.

Table 4 shows the three-part model results for the combined sample (full version can be found in Supplemental Table S5). The interaction term between the African American indicator and cigarette price was negative in daily smokers' smoking intensity equation, indicating that African American daily smokers were more price-responsive (coef= –0.27, p=0.035) in reducing their CPD than White daily smokers.

The Chow tests rejected hypothesis (1), and justified estimating the Part III equations separately for daily and nondaily smokers (African American smoker: F-value=94.2, p<0.001; White smokers: F-value=1027.2, p<0.001; the combined-sample: F-value=1092.9, p<0.001). The F-tests rejected hypothesis (2) for the Part I (F-value=5.8, p<0.001) and Part II (F-value=2.4, p<0.001) equations. In the Part III equation, the Chow test failed to reject the

hypothesis for nondaily smokers (F-value=1.2, p=0.189), but rejected it for daily smokers (F-value=26.4, p<0.001). These results justified estimating the model separately for African American and Whites. The F-test failed to reject the hypothesis that price elasticity is constant over time, for both African Americans and Whites (Supplemental Table S1).

Our sensitivity analysis results from using cigarette prices without log-transforming (Supplemental Tables S2-S4) indicate the robustness of our results.

**Discussion**

To our knowledge, this is the first study to examine the price-responsiveness of daily and nondaily smoking behaviors for African American and White smokers. We found that after adjusting for secular variation, anti-smoking sentiment, smoke-free air laws, and sociodemographic factors, neither African American nor White smokers were price-responsive in changing their smoking frequency. African American daily smokers significantly decreased their smoking intensity in response to cigarette prices' increase; this was not observed among White daily smokers.

Our results indicate that the price-responsiveness of smoking participation was significantly negative for Whites with price elasticity at –0.16 but was not significant for African Americans. Our estimates are different from a recent study which showed that the price elasticity of smoking participation was -0.10 for African Americans and -0.26 for Whites (22). Possible explanations include different data sources (NATS vs. TUS-CPS), different study periods (2009–2014 vs. 2006–2011), and different model specifications (state-level vs. county-level smoke-free air law coverage, and survey indicator vs. monthly indicator).

Our results also show that the price-responsiveness of smoking participation, smoking frequency, and smoking intensity among nondaily smokers were not significantly different between African Americans and Whites. We did observe a differential price-responsiveness

in smoking intensity among daily smokers for two groups. Therefore, by disaggregating current smokers into daily and nondaily smokers, our results provide new insights into how cigarette price increases change cigarette demand: by changing adults' decision to smoke or not, by changing smokers' decision to smoke daily or not, and/or by changing daily or nondaily smokers' smoking intensity. Understanding these pathways for different population groups is useful for evaluating whether and how policies, such as raising tobacco taxes, mitigate race-specific disparities in smoking burden.

The anti-smoking sentiment results for African Americans and Whites suggest that non-price tobacco control programs, such as health education or media campaigns which aim to de-normalize smoking and promote anti-smoking sentiment, might have different impacts for African Americans and Whites. Future studies are needed to further assess the effects of these tobacco control programs for African Americans and Whites to design targeted intervention approaches to reduce the disparity in tobacco burden for racial/ethnic minorities.

We did not find any evidence linking smoke-free air laws with smoking behaviors. A previous study, which compared the impacts of cigarette taxes and smoke-free air law policies on cigarette smoking, also found very limited impacts of smoke-free air law on smoking participation and nondaily smoking (23). This result could, at least in part, be due to the strong correlation between the cigarette price and smoke-free law variables (Pearson's correlation coefficient=0.58 ($p<0.001$) for African Americans, and 0.43 ($p<0.001$) for Whites).

This study has some limitations. First, our analyses were based on independently pooled cross-sectional data, so we could not analyze long-run price effects. Second, smoking status and CPD were self-reported and might be subject to recall bias; however, it has been shown that self-reported smoking status is a valid measure (38). Third, we used the state-level TBOT prices which do not reflect local cigarette taxes; therefore, the price effects may be

underestimated (39). Fourth, the NATS data were only available until 2014; therefore, our analysis may not be able to capture the changes since 2014, including changes in tobacco control regulation and the increasing popularity of e-cigarettes. Despite its increasing popularity among youth and young adults aged 18-24, e-cigarette prevalence has been relatively low and stable among African American and While adults aged 25+.(40, 41). Nevertheless, future research is needed that reflects the changing tobacco landscape and new tobacco control regulation.

In conclusion, compared to White daily smokers, African American daily smokers were more price-responsive in reducing their daily cigarette consumption. We did not find differential price-responsiveness of smoking participation for the two groups. Therefore, raising cigarette tax could contribute to the reduction of health disparities in smoking between African Americans and Whites by having stronger impacts on decreasing daily smokers' consumption for African Americans than for Whites.

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**Table 1. Sample size and distribution by survey wave, sociodemographic characteristics, and smoking status among non-Hispanic African American and non-Hispanic White adults aged 18+: National Adult Tobacco Survey in 2009/10, 2012/13, and 2013/14**

| | Non-Hispanic African Americans | | Non-Hispanic Whites | |
|---|---|---|---|---|
| | n | w% | n | w% |
| All | 17,721 | 100.00 | 191,006 | 100.00 |
| Wave | | | | |
| Wave 1 | 8,203 | 34.08 | 94,050 | 33.72 |
| Wave 2 | 3,805 | 31.03 | 42,469 | 33.49 |
| Wave 3 | 5,713 | 34.89 | 54,487 | 32.79 |
| Age | | | | |
| 18-24 | 1,308 | 14.15 | 7,969 | 10.43 |
| 25-34 | 2,394 | 19.41 | 17,600 | 15.23 |
| 35-44 | 2,700 | 18.55 | 23,428 | 15.99 |
| 45-54 | 3,641 | 20.57 | 34,491 | 19.33 |
| 55-64 | 3,736 | 14.31 | 43,794 | 17.53 |
| 65+ | 3,942 | 13.01 | 63,724 | 21.49 |
| Gender | | | | |
| Male | 6,696 | 45.48 | 78,432 | 48.45 |
| Female | 11,025 | 54.52 | 112,574 | 51.55 |
| Education | | | | |
| Less than HS | 2,442 | 18.66 | 10,380 | 9.41 |
| HS | 4,612 | 31.70 | 42,754 | 29.05 |
| Some college | 5,599 | 31.87 | 56,276 | 31.70 |
| College | 2,874 | 11.39 | 45,668 | 17.86 |
| Post graduate | 2,194 | 6.37 | 35,928 | 11.99 |
| Marital Status | | | | |
| Married | 5,541 | 30.33 | 107,730 | 55.24 |
| Living with partner | 1,077 | 8.71 | 8,630 | 6.74 |
| Divorced | 2,574 | 11.88 | 22,250 | 10.74 |
| Widowed | 2,070 | 6.92 | 24,804 | 7.74 |
| Separated | 834 | 4.61 | 2,553 | 1.63 |
| Single/never married | 5,625 | 37.55 | 25,039 | 17.91 |
| Income | | | | |
| <$20,000 | 3,179 | 16.57 | 16,008 | 8.34 |
| $20,000-29,999 | 1,882 | 10.71 | 14,371 | 7.44 |
| $30,000-39,999 | 1,941 | 12.27 | 16,383 | 8.65 |
| $40,000-49,000 | 1,875 | 10.86 | 19,719 | 10.29 |
| $50,000-69,000 | 2,295 | 12.96 | 27,949 | 14.23 |
| $70,000-$99,999 | 1,739 | 9.24 | 29,360 | 15.20 |
| $100,000-150,000 | 1,056 | 5.32 | 22,307 | 11.76 |
| ≥$150,000 | 653 | 3.22 | 15,836 | 8.29 |
| Unknown | 3,101 | 18.84 | 29,073 | 15.80 |
| Smoking status | | | | |
| Current smokers | 3,076 | 20.21 | 23,914 | 17.68 |
| Non-smokers | 14,645 | 79.79 | 167,092 | 82.32 |
| Smoking frequency among current smokers | | | | |
| Nondaily | 911 | 29.79 | 4,608 | 18.55 |
| Daily | 2,165 | 70.21 | 19,306 | 81.45 |
| Cigarettes per day (CPD)* | | Mean (SE) | | Mean (SE) |
| Current smokers | 3,076 | 9.93 (0.30) | 23,914 | 14.75 (0.11) |
| Nondaily smokers | 911 | 4.21 (0.67) | 4,608 | 3.20 (0.14) |
| Daily smokers | 2,165 | 12.35 (0.67) | 19,306 | 17.38 (0.11) |

Note: SE=standard error. *Among the respectively listed smokers only.

**Table 2. Estimated results from the three-part model of cigarette demand for non-Hispanic African Americans: National Adult Tobacco Survey in 2009/10, 2012/13, and 2013/14**

| | Part I | | | Part II | | | Part III | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Current smoking participation among all adults, n=17,721 | | | Nondaily vs. daily smoking among current smokers, n=3,076 | | | Smoking intensity among nondaily smokers, n=911 | | | Smoking intensity among daily smokers, n=2,165 | | |
| | Coef | SE | Pr > \|t\| | Coef | SE | Pr > \|t\| | Coef | SE | Pr > \|t\| | Coef | SE | Pr > \|t\| |
| Intercept | -2.42 | 1.18 | 0.040 | -4.71 | 2.25 | 0.036 | 1.98 | 1.96 | 0.312 | 4.06 | 0.84 | <.0001 |
| Ln(cigarette price) | 0.10 | 0.19 | 0.581 | 0.61 | 0.35 | 0.087 | -0.24 | 0.31 | 0.445 | -0.29 | 0.13 | 0.027 |
| Anti-smoking sentiment index | -0.83 | 0.34 | 0.014 | 0.12 | 0.61 | 0.850 | -0.97 | 0.54 | 0.070 | -0.25 | 0.20 | 0.224 |
| Smoke-free air law index | 0.00 | 0.00 | 0.810 | 0.00 | 0.00 | 0.216 | 0.00 | 0.00 | 0.894 | 0.00 | 0.00 | 0.144 |
| Wave (REF=Wave 1) | | | | | | | | | | | | |
| Wave 2 | 0.09 | 0.09 | 0.353 | 0.00 | 0.18 | 0.997 | 0.17 | 0.16 | 0.291 | -0.08 | 0.06 | 0.202 |
| Wave 3 | 0.23 | 0.08 | 0.006 | -0.17 | 0.16 | 0.288 | 0.01 | 0.17 | 0.931 | -0.11 | 0.06 | 0.043 |
| Age (REF=18-24) | | | | | | | | | | | | |
| 25-34 | 0.83 | 0.13 | <.0001 | 0.10 | 0.26 | 0.709 | 0.01 | 0.21 | 0.956 | 0.11 | 0.10 | 0.294 |
| 35-44 | 0.79 | 0.14 | <.0001 | -0.35 | 0.26 | 0.187 | -0.41 | 0.22 | 0.062 | 0.23 | 0.10 | 0.018 |
| 45-54 | 1.06 | 0.13 | <.0001 | -0.45 | 0.25 | 0.071 | -0.08 | 0.23 | 0.741 | 0.27 | 0.10 | 0.005 |
| 55-64 | 0.75 | 0.14 | <.0001 | -0.06 | 0.25 | 0.814 | -0.13 | 0.23 | 0.554 | 0.30 | 0.10 | 0.002 |
| 65+ | -0.27 | 0.16 | 0.086 | 0.00 | 0.29 | 0.992 | -0.16 | 0.29 | 0.582 | 0.22 | 0.11 | 0.047 |
| Gender (REF=female) | | | | | | | | | | | | |
| Male | 0.53 | 0.06 | <.0001 | 0.26 | 0.12 | 0.030 | 0.27 | 0.12 | 0.030 | 0.11 | 0.04 | 0.013 |
| Education (REF=less than HS) | | | | | | | | | | | | |
| HS | -0.45 | 0.09 | <.0001 | 0.19 | 0.17 | 0.255 | 0.18 | 0.15 | 0.227 | -0.10 | 0.06 | 0.103 |
| Some college | -0.69 | 0.09 | <.0001 | 0.13 | 0.17 | 0.441 | 0.12 | 0.16 | 0.443 | -0.09 | 0.06 | 0.124 |
| College | -1.48 | 0.12 | <.0001 | 0.44 | 0.23 | 0.053 | -0.38 | 0.20 | 0.061 | -0.05 | 0.08 | 0.558 |
| Post graduate | -1.52 | 0.17 | <.0001 | 0.40 | 0.29 | 0.169 | -0.44 | 0.36 | 0.220 | -0.21 | 0.10 | 0.042 |
| Marital Status (REF=married) | | | | | | | | | | | | |
| Living with partner | 0.85 | 0.12 | <.0001 | -0.12 | 0.21 | 0.579 | 0.13 | 0.21 | 0.530 | 0.03 | 0.07 | 0.691 |
| Divorced | 0.38 | 0.10 | 0.000 | 0.32 | 0.20 | 0.115 | 0.43 | 0.24 | 0.077 | -0.07 | 0.07 | 0.317 |
| Widowed | 0.35 | 0.14 | 0.011 | 0.57 | 0.24 | 0.019 | 0.04 | 0.24 | 0.870 | -0.02 | 0.08 | 0.857 |
| Separated | 0.45 | 0.14 | 0.002 | 0.14 | 0.27 | 0.587 | -0.06 | 0.22 | 0.797 | -0.20 | 0.12 | 0.086 |
| Single/never married | 0.39 | 0.09 | <.0001 | 0.08 | 0.16 | 0.638 | -0.01 | 0.16 | 0.946 | 0.03 | 0.05 | 0.635 |
| Income (REF=<$20,000) | | | | | | | | | | | | |
| $20,000-29,999 | -0.12 | 0.11 | 0.284 | -0.10 | 0.19 | 0.602 | -0.06 | 0.19 | 0.769 | 0.01 | 0.06 | 0.889 |
| $30,000-39,999 | -0.41 | 0.11 | 0.000 | -0.12 | 0.20 | 0.566 | -0.05 | 0.19 | 0.785 | -0.08 | 0.08 | 0.343 |
| $40,000-49,000 | -0.33 | 0.12 | 0.004 | -0.18 | 0.21 | 0.402 | 0.09 | 0.25 | 0.711 | 0.11 | 0.07 | 0.116 |
| $50,000-69,000 | -0.63 | 0.12 | <.0001 | -0.02 | 0.22 | 0.930 | -0.11 | 0.21 | 0.595 | 0.00 | 0.08 | 0.989 |
| $70,000-$99,999 | -0.78 | 0.14 | <.0001 | -0.01 | 0.26 | 0.967 | 0.06 | 0.22 | 0.772 | 0.07 | 0.07 | 0.340 |
| $100,000-150,000 | -1.20 | 0.21 | <.0001 | -0.08 | 0.40 | 0.847 | -0.45 | 0.33 | 0.169 | 0.00 | 0.14 | 0.996 |
| ≥$150,000 | -1.04 | 0.25 | <.0001 | 0.37 | 0.44 | 0.394 | -0.28 | 0.39 | 0.472 | -0.11 | 0.27 | 0.686 |
| Unknown | -0.52 | 0.10 | <.0001 | -0.20 | 0.19 | 0.291 | -0.28 | 0.20 | 0.166 | 0.06 | 0.07 | 0.420 |
| Price elasticity* | 0.08 (-0.10,0.268) | | | 0.42 (0.07,0.78) | | | -0.24 (-0.56,0.07) | | | -0.29 (-0.42,-0.16) | | |

Note: Coef=coefficient; HS=high school; SE=standard error. *Reported the point estimate and 95% confidence interval. Price elasticity of smoking participation = (the coefficient of Ln(cigarette price) in Part I) x (1 – smoking prevalence rate). Price elasticity of nondaily smoking = (the coefficient of Ln(cigarette price) in Part II) x (1 – proportion of nondaily smoking among smokers). Price elasticity of smoking intensity = the estimated coefficient of Ln(cigarette price) in Part III.

**Table 3. Estimated results from the three-part model of cigarette demand for non-Hispanic Whites: National Adult Tobacco Survey in 2009/10, 2012/13, and 2013/14**

| | Part I | | | Part II | | | Part III | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Current smoking participation among all adults, n=191,006 | | | Nondaily vs. daily smoking among current smokers, n=23,914 | | | Smoking intensity among nondaily smokers, n=4,608 | | | Smoking intensity among daily smokers, n=19,306 | | |
| | Coef | SE | Pr > \|t\| | Coef | SE | Pr > \|t\| | Coef | SE | Pr > \|t\| | Coef | SE | Pr > \|t\| |
| Intercept | 0.46 | 0.45 | 0.308 | -2.25 | 1.01 | 0.026 | 0.41 | 1.07 | 0.703 | 2.70 | 0.24 | <.0001 |
| Ln(cigarette price) | -0.19 | 0.07 | 0.006 | 0.13 | 0.16 | 0.415 | -0.02 | 0.17 | 0.924 | -0.04 | 0.04 | 0.304 |
| Anti-smoking sentiment index | -0.77 | 0.10 | <.0001 | 0.92 | 0.23 | <.0001 | -0.46 | 0.27 | 0.088 | -0.49 | 0.06 | <.0001 |
| Smoke-free air law index | 0.00 | 0.00 | 0.130 | 0.00 | 0.00 | 0.719 | 0.00 | 0.00 | 0.253 | 0.00 | 0.00 | 0.569 |
| Wave (REF=Wave 1) | | | | | | | | | | | | |
| Wave 2 | 0.02 | 0.03 | 0.498 | 0.09 | 0.07 | 0.211 | 0.08 | 0.08 | 0.315 | 0.03 | 0.02 | 0.086 |
| Wave 3 | 0.01 | 0.03 | 0.780 | -0.10 | 0.07 | 0.145 | 0.21 | 0.08 | 0.008 | 0.01 | 0.02 | 0.712 |
| Age (REF=18-24) | | | | | | | | | | | | |
| 25-34 | 0.62 | 0.05 | <.0001 | -0.49 | 0.10 | <.0001 | 0.01 | 0.10 | 0.911 | 0.10 | 0.03 | 0.000 |
| 35-44 | 0.42 | 0.05 | <.0001 | -0.67 | 0.11 | <.0001 | 0.27 | 0.12 | 0.021 | 0.28 | 0.03 | <.0001 |
| 45-54 | 0.31 | 0.05 | <.0001 | -0.85 | 0.10 | <.0001 | 0.41 | 0.11 | 0.000 | 0.34 | 0.03 | <.0001 |
| 55-64 | -0.09 | 0.05 | 0.090 | -0.69 | 0.10 | <.0001 | 0.44 | 0.11 | <.0001 | 0.34 | 0.03 | <.0001 |
| 65+ | -1.12 | 0.06 | <.0001 | -0.60 | 0.11 | <.0001 | 0.44 | 0.12 | 0.000 | 0.27 | 0.03 | <.0001 |
| Gender (REF=female) | | | | | | | | | | | | |
| Male | 0.25 | 0.02 | <.0001 | 0.02 | 0.05 | 0.709 | 0.13 | 0.06 | 0.026 | 0.20 | 0.01 | <.0001 |
| Education (REF=less than HS) | | | | | | | | | | | | |
| HS | -0.52 | 0.04 | <.0001 | 0.18 | 0.11 | 0.085 | -0.26 | 0.14 | 0.058 | -0.08 | 0.02 | <.0001 |
| Some college | -0.77 | 0.04 | <.0001 | 0.59 | 0.10 | <.0001 | -0.34 | 0.14 | 0.013 | -0.13 | 0.02 | <.0001 |
| College | -1.71 | 0.05 | <.0001 | 1.15 | 0.12 | <.0001 | -0.77 | 0.15 | <.0001 | -0.21 | 0.03 | <.0001 |
| Post graduate | -2.10 | 0.06 | <.0001 | 1.30 | 0.13 | <.0001 | -0.76 | 0.17 | <.0001 | -0.24 | 0.04 | <.0001 |
| Marital Status (REF=married) | | | | | | | | | | | | |
| Living with partner | 1.08 | 0.04 | <.0001 | -0.19 | 0.09 | 0.034 | 0.00 | 0.10 | 0.969 | 0.03 | 0.02 | 0.119 |
| Divorced | 0.81 | 0.04 | <.0001 | -0.14 | 0.08 | 0.070 | 0.16 | 0.10 | 0.086 | 0.03 | 0.02 | 0.127 |
| Widowed | 0.33 | 0.05 | <.0001 | -0.05 | 0.11 | 0.686 | 0.03 | 0.11 | 0.777 | 0.01 | 0.02 | 0.594 |
| Separated | 1.08 | 0.08 | <.0001 | -0.49 | 0.17 | 0.004 | -0.12 | 0.20 | 0.546 | -0.01 | 0.04 | 0.732 |
| Single/never married | 0.35 | 0.04 | <.0001 | 0.16 | 0.08 | 0.035 | 0.14 | 0.09 | 0.096 | -0.02 | 0.02 | 0.352 |
| Income (REF=<$20,000) | | | | | | | | | | | | |
| $20,000-29,999 | -0.12 | 0.05 | 0.016 | -0.01 | 0.11 | 0.933 | 0.00 | 0.13 | 0.972 | -0.01 | 0.02 | 0.612 |
| $30,000-39,999 | -0.22 | 0.05 | <.0001 | 0.12 | 0.11 | 0.295 | 0.10 | 0.13 | 0.431 | -0.01 | 0.02 | 0.608 |
| $40,000-49,000 | -0.40 | 0.05 | <.0001 | 0.12 | 0.11 | 0.254 | 0.06 | 0.12 | 0.646 | -0.02 | 0.03 | 0.446 |
| $50,000-69,000 | -0.53 | 0.05 | <.0001 | 0.04 | 0.10 | 0.704 | -0.07 | 0.12 | 0.573 | -0.02 | 0.02 | 0.390 |
| $70,000-$99,999 | -0.76 | 0.05 | <.0001 | 0.15 | 0.11 | 0.194 | -0.20 | 0.12 | 0.087 | 0.00 | 0.02 | 0.931 |
| $100,000-150,000 | -0.93 | 0.06 | <.0001 | 0.45 | 0.12 | 0.000 | -0.20 | 0.13 | 0.121 | -0.02 | 0.03 | 0.602 |
| ≥$150,000 | -1.12 | 0.07 | <.0001 | 0.67 | 0.14 | <.0001 | -0.29 | 0.15 | 0.060 | 0.00 | 0.05 | 0.978 |
| Unknown | -0.55 | 0.05 | <.0001 | 0.00 | 0.10 | 0.997 | -0.06 | 0.12 | 0.644 | -0.03 | 0.02 | 0.192 |
| Price elasticity* | -0.16 (-0.23,-0.09) | | | 0.10 (-0.05,0.26) | | | -0.02 (-0.18,0.15) | | | -0.04 (-0.08,0.00) | | |

Note: Coef=coefficient; HS=high school; SE=standard error. *Reported the point estimate and 95% confidence interval. Price elasticity of smoking participation = (the coefficient of Ln(cigarette price) in Part I) x (1 – smoking prevalence rate). Price elasticity of nondaily smoking = (the coefficient of Ln(cigarette price) in Part II) x (1 – proportion of nondaily smoking among smokers). Price elasticity of smoking intensity = the estimated coefficient of Ln(cigarette price) in Part III.

**Table 4. Selected results* from the three-part model of cigarette demand for the combined sample of non-Hispanic African Americans and non-Hispanic Whites: National Adult Tobacco Survey in 2009/10, 2012/13, and 2013/14**

| | Part I | | | Part II | | | Part III | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Current smoking participation among all adults, n=208,727 | | | Nondaily vs. daily smoking among current smokers, n=26,990 | | | Smoking intensity among nondaily smokers, n=5,519 | | | Smoking intensity among daily smokers, n=21,471 | | |
| | Coef | SE | Pr > \|t\| | Coef | SE | Pr > \|t\| | Coef | SE | Pr > \|t\| | Coef | SE | Pr > \|t\| |
| Ln(cigarette price) | -0.19 | 0.07 | 0.007 | 0.20 | 0.15 | 0.199 | 0.02 | 0.16 | 0.893 | -0.04 | 0.04 | 0.289 |
| Ln(cigarette price) x AA | 0.25 | 0.16 | 0.120 | 0.15 | 0.32 | 0.631 | -0.38 | 0.29 | 0.191 | -0.27 | 0.13 | 0.035 |
| AA | -2.63 | 1.02 | 0.010 | -0.50 | 2.02 | 0.804 | 2.48 | 1.85 | 0.179 | 1.39 | 0.80 | 0.083 |

Note: AA=indicator for African Americans (=1 if African American; 0 otherwise); Coef=coefficient; SE=standard error. *In addition to the results shown in this table, the model also controlled for all the independent variables listed in the Methods section (including anti-smoking sentiment index, smoke-free air law index, survey wave indicators, age, gender, education, marriage status, and income), as well as all the statistically significant interaction terms between AA and aforementioned independent variables. The complete results from this three-part model are shown in Supplemental Table S5.