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Yao, Tingting
Ong, Michael K
Max, Wendy
et al.

Research paper

Responsiveness to cigarette prices by different racial/ethnic groups of US adults

Tingting Yao,[1] Michael K Ong,[2,3] Wendy Max,[1] Courtney Keeler,[4] Yingning Wang,[1] Valerie B Yerger,[5] Hai-Yen Sung[1]

[1]Institute for Health & Aging, School of Nursing, University of California, San Francisco, California, USA
[2]Division of General Internal Medicine and Health Services Research, Department of Medicine, University of California, Los Angeles, California, USA
[3]VA Greater Los Angeles Healthcare System, California, Los Angeles, California, USA
[4]Department of Population Health Sciences, School of Nursing, University of San Francisco, San Francisco, California, USA
[5]Department of Social and Behavioral Sciences, School of Nursing, University of California, San Francisco, California, USA

Correspondence to
Dr Tingting Yao, Institute for Health & Aging, School of Nursing, University of California, San Francisco, 3333 California Street, Suite 340, San Francisco, CA 94118, USA;
tingting.yao@ucsf.edu

ABSTRACT

Objective To evaluate the impact of cigarette prices on adult smoking for four US racial/ethnic groups: whites, African–Americans, Asians and Hispanics.

Methods We analysed pooled cross-sectional data from the 2006/2007 and 2010/2011 Tobacco Use Supplement to the Current Population Survey (n=339 921 adults aged 18+) and cigarette price data from the Tax Burden on Tobacco. Using a two-part econometric model of cigarette demand that controlled for sociodemographic characteristics, state-level antismoking sentiment, local-level smoke-free air laws and monthly indicator, we estimated for each racial/ethnic group the price elasticities of smoking participation, smoking intensity and total demand for cigarettes.

Results Smoking prevalence for whites, African–Americans, Asians and Hispanics during the study period was 18.3%, 16.1%, 8.2% and 11.3%, respectively. The price elasticity of smoking participation was statistically significant for whites, African–Americans, Asians and Hispanics at −0.26, −0.10, −0.42 and −0.11, respectively. The price elasticity of smoking intensity was statistically significant among whites (−0.22) and African–Americans (−0.17). Overall, the total price elasticity of cigarette demand was statistically significant for all racial/ethnic groups: 0.48 for whites, −0.27 for African–Americans, −0.22 for Asians and −0.15 for Hispanics.

Conclusions Our results suggest that raising cigarette prices, such as via tobacco tax increases, would result in reduced cigarette consumption for all racial/ethnic groups. The magnitude of the effect and the impact on cessation and reduced smoking intensity differ across these groups.

INTRODUCTION

Cigarette smoking causes a tremendous burden of disease, preventable death and healthcare cost.[1–4] Globally and nationally, health policymakers continue to advocate for raising tobacco taxes to reduce smoking epidemic.[5–8] Previous US studies demonstrated that cigarette tax increases result in comparable or even larger increases in cigarette retail prices.[9–12] The resulting price increase provides smokers a financial incentive to quit or reduce consumption level and discourages smoking initiation.[4] The price-responsiveness of cigarette demand is commonly measured by price elasticity (ie, the percentage change in quantity demanded in response to a 1% change in price). Numerous studies have estimated the effects of cigarette prices on smoking.[13 14] Recently, a systematic and comprehensive review concluded that most US

studies estimated the price elasticity of total cigarette consumption for adults in the range of −0.2 to −0.6,[7 15] meaning that a 1% increase in cigarette prices would result in a 0.2%–0.6% reduction in the quantity of cigarette demanded.

Certain racial/ethnic minorities bear a disproportionate burden of smoking.[16 17] Eliminating tobacco-related disparities among racial/ethnic minorities has been identified as a critical goal for comprehensive tobacco control programmes that comprise coordinated efforts to implement evidence-based interventions such as raising tobacco taxes.[8 18] To assess whether this goal is met, research examining the effectiveness of tobacco tax increases on reducing smoking and hence the price-responsiveness of smoking across different racial/ethnic groups is needed.[19] A number of US studies on cigarette demand for adults have examined differential price-responsiveness among subpopulations stratified by gender,[20–26] age,[20 24 27–30] income[24 25 31 32] or education[29 32]; however, only two studies have examined price-responsiveness by race/ethnicity.[24 32] Farrelly and colleagues[24] pooled multiple waves of the National Health Interview Survey data between 1976 and 1993 and found that the total price elasticity was −0.93 for Hispanics, −0.35 for African–Americans and −0.23 for whites. Dinno and Glantz[32] used the Tobacco Use Supplement to the Current Population Survey (TUS-CPS) data in February 2002 and found no racial or ethnic difference in price-responsiveness of smoking prevalence and intensity, which is likely attributed to relying exclusively on cross-sectional variation in prices.

The two racial/ethnic-specific studies described above used data that predated the dramatic legislation and policy changes occurring in the late 2000s. Most importantly, effective 1 April 2009, the federal excise tax on cigarettes increased by an unprecedented 62 cents per pack,[4] representing a 159% increase from the old rate (39 cents per pack). This increase was substantial when compared with the national average of state cigarette excise tax rates ($1.20 per pack) on 1 April 2009.[33] As a result, cigarette prices jumped 22% from February to April 2009.[34] This change is very likely to affect smoking behaviours;[34] therefore, findings from studies based on earlier data may no longer be applicable. Furthermore, none of the prior studies estimated the price elasticity of smoking for Asian–Americans, who had the lowest adult smoking prevalence among racial/ethnic groups in the USA (7.0% in 2015).[35]

To fill these gaps, this study evaluates the impact of cigarette prices on adult smoking participation,

smoking intensity and cigarette demand using the most recently available data that cover the preperiod and postperiod of the 2009 federal tobacco tax increase for four major mutually exclusive racial/ethnic groups in the USA: non-Hispanic whites (hereafter referred to as whites), non-Hispanic African–Americans (hereafter African–Americans), non-Hispanic Asians (hereafter Asians) and Hispanics (regardless of race).

METHODS

Data source

We analysed data from the two recent waves (May and August 2006, January 2007; May and August 2010, January 2011) of the TUS-CPS. The TUS-CPS uses a multistage and stratified sampling design to collect individual's detailed history of cigarette smoking and use of other tobacco products. Each wave contains a nationally representative sample of over 50 000 households and approximately 240 000 civilian, non-institutionalised persons aged 15+ in the USA (data starting in 2007 are for persons aged 18+). About 64% of interviews were conducted by telephone and the rest were conducted in person. When the intended respondent was unavailable, proxy respondents were interviewed (about 20%). Proxy respondents were only eligible to answer a small portion of the survey items, such as current smoking status, but not detailed questions such as number of cigarettes smoked per day. Details about the TUS-CPS are available elsewhere.[36]

Dependent variables

Two dependent variables were examined: the decision to smoke or not (smoking participation) and smoking intensity. Smoking participation was defined dichotomously by assigning the value of 1 for current smokers and 0 otherwise. Current smokers were those who have smoked 100 cigarettes in their lifetime and now smoke cigarettes every day or some days. Smoking intensity was defined as the average number of cigarettes consumed per day (CPD). For current smokers who now smoke some days, their CPD was constructed by multiplying the number of days they smoked in the past 30 days by the number of cigarettes they usually smoked each day on their smoking days, and then dividing the product by 30.

Independent variables

Cigarette prices

State-specific retail prices were obtained from the Tax Burden on Tobacco (TBOT),[37] which contains federal and state excise taxes. The TBOT prices have been extensively used in many US studies of cigarette demand.[9 20 24 25 27 28 30–32] The TBOT reports prices as of November 1 for each year. Following a previous study,[38] we constructed monthly cigarette prices by first computing the net-of-tax price (ie, before state and federal taxes are added) as of November 1. Second, using linear interpolation, we calculated the net-of-tax prices for all the months between the consecutive pairs of November prices. Third, monthly cigarette prices were derived by adding the state and federal taxes in effect for each month to the corresponding interpolated monthly net-of-tax prices. Finally, these nominal prices were adjusted into real prices in January 2011 dollars using the consumer price index for all urban consumers, and merged into the TUS-CPS data by year, month and individual's state of residence.

Sociodemographic characteristics

Sociodemographic variables included gender (male and female), age (18–24, 25–34, 35–44, 45–54, 55–64 and 65+),

education (less than high school degree, high school graduate (including General Educational Development certificate), some college (including associate degree), and college degree and above), annual family income (<$25 000, $25 000–$49 999, $50 000–$99 999, ≥$100 000 and unknown), marital status (married, divorced/separated, widowed and never married) and employment status (employed, unemployed and not in labour force).

State antismoking sentiment

People living in places with strong attitude against smoking may be more likely to support tobacco tax policies and smoke-free air laws, and less likely to smoke.[39–41] To account for this potential confounder, we controlled for state antismoking sentiment using an index originally constructed by Decicca and colleagues[39] based on five questions asked in the TUS-CPS waves during 1992/1993, 1995/1996, 1998/1999, 2001/2002 and 2006/2007 regarding whether smoking should be allowed in restaurants, indoor work areas, bars and cocktail lounges, and indoor sporting events, as well as smoking rules inside the home. A greater value indicates stronger antismoking sentiment. This sentiment index was only constructed through 2006/2007 as only two of the five questions were asked in 2010/2011 TUS-CPS. We merged the 2006/2007 sentiment data with the TUS-CPS data by survey wave and state, and repeated the 2006/2007 sentiment index for 2010/2011.

Local-level smoke-free air law coverage

Because restrictions on where smoking is allowed are associated with decreased cigarette consumption and state clean indoor air laws (CIALs) are often weaker than local-level CIALs,[10 42] we controlled for local-level smoke-free air law coverage using an American Nonsmokers' Rights Foundation database of city or county CIALs, which were coded from the detailed text of the law including date of passage, date of implementation, stringency of the law and venues covered by the law (private workplaces, restaurants and bars) from 1996 to 2011.[43] Following previous studies,[44 45] we calculated the weighted percentage of county population covered by 100% CIALs, defined as prohibiting smoking indoors without exceptions, as of July 1 for each year separately for workplaces, restaurants and bars using the weight from the population of each jurisdiction.[46] Then, an average CIAL coverage index was calculated by taking the mean of all three weighted percentages for workplaces, restaurants and bars. Finally, we merged this index with the TUS-CPS data by year, state and county. Because only one-third of counties in the TUS-CPS data have county identifiers,[40] we calculated the average of the CIAL coverage index within the remaining two-thirds of counties for each state and used it as a proxy measure for these counties.

Monthly indicator

For each survey month, a dummy variable was created.

Study sample

This study focused on self-respondents because the dependent variable CPD can only be answered by self-respondents. The pooled TUS-CPS data contained 343 388 self-respondents aged 18+. There were no missing values for sociodemographic variables except income. After excluding those who did not report smoking status (n=1591) or CPD (n=1876), the final study sample consisted of 339 921 adults.

Statistical analysis

We used a two-part econometric model[47] to first estimate the effect of cigarette prices on smoking participation and then the effect of cigarette prices on smoking intensity conditional on being a current smoker. In the first part of the model, a multivariable logistic regression was used to estimate the probability of being a current smoker as a function of cigarette prices and other independent variables among all adults. In the second part of the two-part model, a multivariable linear regression was used to estimate the CPD as a function of cigarette prices and other independent variables among current smokers. Since the distribution of the CPD was skewed to the right, the CPD was logarithmically transformed. The cigarette price variable was also logarithmically transformed so that the price elasticity of smoking intensity is simply equal to the estimated coefficient for the cigarette price variable from the second part model.[48] The price elasticity of smoking participation was derived by multiplying the estimated coefficient for the cigarette price variable from the first part model by (1 – smoking prevalence rate).[48 49] Based on this two-part model specification, the total price elasticity of cigarette demand can be derived as the sum of these two price elasticities.[7 24 48 50] The formulas for calculating the SEs of these price elasticities are available elsewhere.[50]

The two-part models were estimated separately for each of the four racial/ethnic groups (whites, African–Americans, Asians and Hispanics). To test whether the price elasticities differ across racial/ethnic groups, we ran a two-part model on the combined sample of all four racial/ethnic groups by adding two additional independent variables: (1) race/ethnicity and (2) an interaction term between cigarette prices and race/ethnicity. The p value for the interaction term gave a significance test for the difference in price elasticities by race/ethnicity.

All analyses were estimated with the TUS-CPS self-response weights, which adjust for unequal probabilities of sample selection and non-response and for items that can only be answered by self-respondents.[36] Using the self-response weight makes the results representative of the national population.[36] SEs and 95% CIs were estimated using the published TUS-CPS replicate weights with Fay's balanced repeated replication to account for the complex survey design.[51 52] All analyses were carried out using Stata V.14. A two-tailed p value <0.05 was considered to be statistically significant.

Sensitivity analysis

We conducted a sensitivity analysis to estimate price elasticities from the two-part model that excluded antismoking sentiment, smoke-free air law coverage and monthly indicator. We also conducted a sensitivity analysis by adding a time fixed-effects variable, which equals 0 for the 2006/2007 wave and 1 for the 2010/2011 wave, in the two-part model.

RESULTS

Among 339 921 adults, 16.8% were current smokers who consumed an average of 13.5 cigarettes per day (table 1). Among whites, African–Americans, Asians and Hispanics, the smoking prevalence was 18.3%, 16.1%, 8.2% and 11.3%, respectively; the average CPD was 14.9, 10.0, 9.0 and 7.8 cigarettes, respectively.

Price elasticities

Table 2 shows a significantly negative coefficient for logged prices in the smoking participation model for whites, African–Americans, Asians and Hispanics at −0.32, –0.12, −0.46 and −0.12, respectively. According to the smoking participation model for the combined racial/ethnic groups (data not shown), the interaction term between prices and race/ethnicity indicated that Asians were significantly more price-responsive than African–Americans (p<0.001) and Hispanics (p<0.001), but not significantly different from whites (p=0.062), and that whites were significantly more price-responsive than African–Americans (p<0.001) and Hispanics (p<0.001). Table 2 also shows that antismoking sentiment was negatively associated with smoking prevalence among all four racial/ethnic groups. The association between the CIAL coverage and smoking prevalence was significantly negative among African–Americans and Hispanics, but significantly positive among Asians.

Table 3 shows that the coefficient for logged prices in the smoking intensity model was statistically significantly negative for whites (−0.22) and African–Americans (−0.17), but not statistically significant for Asians and Hispanics. According to the smoking intensity model for the combined racial/ethnic groups (data not shown), the interaction term between prices and race/ethnicity indicated that white smokers were significantly more price-responsive than African–American (p<0.01), Asian (p<0.01) and Hispanic (p<0.001) smokers, and that African–American smokers were significantly more price-responsive than Hispanic smokers (p=0.012). Table 3 also shows that antismoking sentiment was negatively associated with smoking intensity for all four racial/ethnic groups. The association between the CIAL coverage and smoking intensity was statistically positive for African–Americans.

The price elasticity estimates from the main analysis were summarised in table 4. The price elasticity of smoking participation was −0.26 for whites, −0.10 for African–Americans, −0.42 for Asians and −0.11 for Hispanics. The price elasticity of smoking intensity was −0.22 for whites and −0.17 for African–Americans but not statistically significant for Asians and Hispanics. The total price elasticity of cigarette demand was statistically significantly negative for all groups: −0.48 for whites, −0.27 for African–Americans, −0.22 for Asians and −0.15 for Hispanics.

Sensitivity analysis

Without controlling for antismoking sentiment, smoke-free air laws and monthly indicator in the model, the price elasticity of smoking participation was statistically significant for all four racial/ethnic groups: −0.36 for whites, −0.27 for African–Americans, −0.40 for Asians and −0.16 for Hispanics (table 4). The price elasticity of smoking intensity was statistically significant for whites (−0.36) and African–Americans (−0.20), but not significant for Asians and Hispanics. The total price elasticity of cigarette demand was statistically significant for whites (−0.72), African–Americans (−0.48) and Hispanics (−0.26), but not statistically significant for Asians.

When adding a time fixed-effects variable in the model, the price elasticity of smoking participation became insignificant for whites and significantly positive for African–Americans and Hispanics, while the price elasticity of smoking intensity became insignificant for African–Americans and significantly positive for Asians and Hispanics. For whites, the total elasticity reduced to −0.15, which was much lower than the estimates from our main analysis and the literature. For African–Americans and Hispanics, the total elasticity was statistically significant and positive at 0.15 and 0.89, respectively. These unstable results could be caused by the strong correlation between cigarette prices and the time

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Table 1 Sample size, smoking prevalence among adults and smoking intensity (ie, cigarettes per day) among current smokers by sociodemographic characteristics and other factors, based on 2006/2007 and 2010/2011 TUS-CPS data

	Adults		Current smokers	
	N	Smoking prevalence (%)*	N	Mean cigarettes per day*
Total	339 921	16.8	57 236	13.5
Gender				
Male	148 808	18.8	27 813	14.4
Female	191 113	14.9	29 423	12.4
Age				
18–24	27 800	18.6	5437	10.4
25–34	56 109	19.8	11 486	11.5
35–44	62 438	18.1	11 846	13.9
45–54	68 315	20.0	13 947	15.2
55–64	57 394	15.9	9232	15.7
65+	67 865	7.6	5288	14.4
Education				
<High school graduate	42 652	22.2	9717	14.4
High school graduate	102 589	22.3	22 894	14.5
Some college	96 045	17.9	17 482	12.9
College degree and above	98 635	7.2	7143	10.6
Family income				
<$25 000	79 595	23.7	19 125	13.3
$25 000–$49 999	87 984	19.3	16 967	13.7
$50 000–$99 999	99 329	14.1	14 099	13.5
≥$100 000	52 609	8.2	4293	12.2
Unknown	20 404	13.8	2752	15.0
Marital status				
Married	189 533	13.0	24 566	14.2
Divorced/separated	51 307	26.9	14 058	14.9
Widowed	27 271	11.2	3046	14.4
Never married	71 810	20.4	15 566	11.5
Employment status				
Employed	209 800	16.9	35 741	13.2
Unemployed	15 070	28.9	4584	12.6
Not in labour force	115 051	14.6	16 911	14.5
Race/ethnicity				
White	255 154	18.3	45 149	14.9
African–American	30 525	16.1	4930	10.0
Asian	11 872	8.2	1044	9.0
Hispanic	33 747	11.3	3835	7.8
Others	8623	25.2	2278	12.9
Monthly indicator				
January	123 600	16.4	20 554	13.2
May	123 702	17.1	21 110	13.5
August	92 619	16.8	15 572	13.8
Antismoking sentiment index (mean=0.25)				
Low (index=−0.12 to 0.18)	118 147	20.0	23 322	14.8
Moderate (index=0.19–0.35)	114 775	15.8	18 513	12.9
High (index=0.36–0.58)	106 999	13.1	15 401	11.5
CIAL coverage index (mean=0.33)				
Low (index=0.00–0.05)	113 687	18.5	20 681	14.1
Moderate (index=0.06–0.67)	148 067	17.2	25 733	13.8
High (index=0.68–1.00)	78 167	13.2	10 822	11.3

N=unweighted sample size; *weighted estimates.
CIAL, clean indoor air law; TUS-CPS, Tobacco Use Supplement to the Current Population Survey.

Table 2 Estimated multivariable logistic regression model on smoking participation among each racial/ethnic group of adults, based on 2006/2007 and 2010/2011 TUS-CPS data

Independent variables	White (N=255 154) Coefficient (SE)	African–American (N=30 525) Coefficient (SE)	Asian (N=11 872) Coefficient (SE)	Hispanic (N=33 747) Coefficient (SE)
Intercept	0.02 (0.03)	−1.35 (0.08)***	−0.99 (0.15)***	−1.54 (0.07)***
Real price of cigarettes (log)	−0.32 (0.02)***	−0.12 (0.04)**	−0.46 (0.08)***	−0.12 (0.04)**
Gender (REF=male)				
Female	−0.17 (0.01)***	−0.55 (0.02)***	−1.33 (0.04)***	−0.67 (0.02)***
Age (REF=18–24)				
25–34	0.50 (0.01)***	0.69 (0.03)***	0.60 (0.07)***	0.37 (0.03)***
35–44	0.36 (0.01)***	0.81 (0.03)***	0.58 (0.07)***	0.42 (0.03)***
45–54	0.31 (0.01)***	1.16 (0.03)***	0.39 (0.09)***	0.63 (0.03)***
55–64	−0.05 (0.01)***	0.87 (0.04)***	0.28 (0.09)**	0.45 (0.04)***
65+	−1.19 (0.02)***	−0.19 (0.04)***	−0.25 (0.09)**	−0.25 (0.05)***
Education (REF=less than high school)				
High school graduate	−0.34 (0.01)***	−0.30 (0.02)***	−0.08 (0.06)	0.05 (0.02)*
Some college	−0.69 (0.01)***	−0.52 (0.03)***	−0.32 (0.07)***	−0.03 (0.02)
College degree and above	−1.63 (0.01)***	−1.28 (0.04)***	−0.95 (0.07)***	−0.71 (0.04)***
Family income (REF=<$25 000)				
$25 000–$49 999	−0.22 (0.10)***	−0.31 (0.02)***	−0.09 (0.05)	−0.18 (0.02)***
$50 000–$99 999	−0.55 (0.10)***	−0.66 (0.03)***	−0.18 (0.05)**	−0.32 (0.03)***
≥$100 000	−0.91 (0.01)***	−0.90 (0.05)***	−0.58 (0.07)***	−0.42 (0.04)***
Unknown	−0.58 (0.10)***	−0.47 (0.04)***	−0.13 (0.07)	−0.49 (0.05)***
Marital status (REF=married)				
Divorced/separated	0.71 (0.10)***	0.38 (0.02)***	0.83 (0.06)***	0.71 (0.02)***
Widowed	0.16 (0.10)***	0.21 (0.04)***	−0.16 (0.11)	0.44 (0.06)***
Never married	0.32 (0.10)***	0.36 (0.02)***	0.54 (0.05)***	0.47 (0.02)***
Employment status (REF=employed)				
Unemployed	0.45 (0.10)***	0.46 (0.03)***	0.69 (0.06)***	0.48 (0.03)***
Not in labour force	−0.02 (0.01)**	0.17 (0.02)***	−0.10 (0.06)	−0.07 (0.02)**
Monthly indicator (REF=January)				
May	0.03 (0.10)***	0.11 (0.02)***	−0.04 (0.04)	0.07 (0.02)***
August	0.03 (0.01)***	0.03 (0.02)	−0.07 (0.05)	0.00 (0.02)
Antismoking sentiment index (continuous)	−0.51 (0.02)***	−0.78 (0.07)***	−0.34 (0.10)**	−1.22 (0.07)***
CIAL coverage index (continuous)	−0.02 (0.01)	−0.10 (0.03)***	0.32 (0.05)***	−0.13 (0.03)***

*Statistically significant at p<0.05, **statistically significant at p<0.01, ***statistically significant at p<0.001.
CIAL, clean indoor air law; N, unweighted sample size; TUS-CPS, Tobacco Use Supplement to the Current Population Survey.

fixed-effects variable (Spearman's correlation coefficient=0.57 (p<0.001)).

DISCUSSION

This study contributes to the limited empirical literature on price-responsiveness of adult smoking by race/ethnicity. Our results indicate that even after accounting for antismoking sentiment and smoke-free air laws, cigarette prices showed a significantly negative effect on cigarette demand for all four racial/ethnic groups; nevertheless, the magnitude of the effect and how the effect was manifested through changes in smoking participation and smoking intensity varied across these groups.

To our knowledge, no prior study has examined the impact of cigarette prices on smoking for Asians in the USA. This study found that Asians were more price-responsive to reduce smoking participation than African–Americans and Hispanics, but were not price-responsive to reduce smoking intensity. Although Asian–Americans had the lowest adult smoking prevalence among all major racial/ethnic groups in the USA,[35] they comprise many diverse subgroups with high variability in smoking prevalence

and acculturation.[53] Future research on the price-responsiveness among different Asian subgroups is needed.

This study found that whites were more price-responsive than African–Americans in both smoking participation (−0.26 vs −0.10) and smoking intensity (−0.22 vs −0.17) during 2006–2011. In contrast, the study by Farrelly and colleagues[24] found that, during 1976–1993, whites were less price-responsive than African–Americans in smoking participation (price elasticity: −0.08 vs −0.20), but had the same price elasticity of smoking intensity (−0.15) as for African–Americans. Our results seem consistent with the observation that smoking cessation rates were higher among whites than African–Americans in recent years (6.0% vs 3.3% in 2010).[54] Given that African–Americans suffer a disproportionate burden of smoking-attributable mortality and healthcare costs,[17] other non-price tobacco control programmes tailored to African–American smokers are needed to increase their cessation rates.

Our results that Hispanics were less price-responsive than whites in both smoking participation and smoking intensity are opposite to the findings by Farrelly and colleagues.[24] One possible reason might be that Hispanic population consists of

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Table 3 Estimated multivariable linear regression model on smoking intensity (ie, cigarettes per day) among each race/ethnicity group of current smokers, based on 2006/2007 and 2010/2011 TUS-CPS data

Independent variables	White (n=45 149) Coefficient (SE)	African–American (n=4930) Coefficient (SE)	Asian (n=1044) Coefficient (SE)	Hispanic (n=3835) Coefficient (SE)
Intercept	2.75 (0.02)***	2.15 (0.07)***	1.56 (0.16)***	1.10 (0.11)***
Real price of cigarettes (log)	−0.22 (0.01)***	−0.17 (0.05)***	0.20 (0.09)	−0.04 (0.06)
Gender (REF=male)				
Female	−0.19 (0.01)***	−0.08 (0.02)***	−0.16 (0.06)**	−0.09 (0.03)**
Age (REF=18–24)				
25–34	0.17 (0.01)***	0.06 (0.03)	−0.02 (0.07)	0.00 (0.05)
35–44	0.42 (0.01)***	0.32 (0.03)***	0.17 (0.08)*	0.37 (0.06)***
45–54	0.52 (0.01)***	0.26 (0.03)***	0.44 (0.07)***	0.64 (0.05)***
55–64	0.54 (0.01)***	0.19 (0.03)***	0.83 (0.08)***	0.82 (0.05)***
65+	0.34 (0.01)***	0.08 (0.04)	0.19 (0.12)	0.69 (0.07)***
Education (REF=less than high school)				
High school graduate	−0.14 (0.01)***	−0.04 (0.02)*	−0.09 (0.07)	0.13 (0.03)***
Some college	−0.33 (0.01)***	−0.17 (0.02)***	−0.27 (0.07)***	0.10 (0.04)**
College degree and above	−0.78 (0.01)***	−0.31 (0.04)***	−0.45 (0.06)***	−0.15 (0.06)**
Family income (REF=<$25,000)				
$25 000–$49 999	0.04 (0.01)***	0.01 (0.02)	0.14 (0.06)*	−0.12 (0.02)***
$50 000–$99 999	0.00 (0.01)	−0.14 (0.03)***	−0.02 (0.06)	−0.07 (0.04)
≥$100 000	−0.14 (0.01)***	−0.05 (0.05)	−0.43 (0.09)***	−0.05 (0.05)
Unknown	0.08 (0.01)***	0.21 (0.03)***	0.40 (0.07)***	−0.01 (0.06)
Marital status (REF=married)				
Divorced/separated	0.04 (0.01)***	−0.04 (0.02)	0.24 (0.06)***	0.23 (0.03)***
Widowed	−0.02 (0.01)	−0.18 (0.04)***	0.27 (0.10)**	0.10 (0.06)
Never married	−0.07 (0.01)***	−0.15 (0.03)***	0.07 (0.05)	0.29 (0.03)***
Employment status (REF=employed)				
Unemployed	0.06 (0.01)***	−0.02 (0.02)	−0.44 (0.07)***	0.08 (0.05)
Not in labour force	0.04 (0.01)***	0.01 (0.02)	−0.07 (0.05)	0.30 (0.03)***
Monthly indicator (REF=January)				
May	0.01 (0.01)*	0.02 (0.02)	0.08 (0.05)	0.15 (0.03)***
August	0.06 (0.01)***	0.11 (0.02)***	0.11 (0.05)*	0.04 (0.03)
Antismoking sentiment index (continuous)	−0.53 (0.02)***	−0.41 (0.07)***	−0.59 (0.15)***	−1.08 (0.09)***
CIAL coverage index (continuous)	−0.01 (0.01)	0.12 (0.03)***	−0.05 (0.06)	0.03 (0.04)

*Statistically significant at p<0.05, **statistically significant at p<0.01, ***statistically significant at p<0.001.
CIAL, clean indoor air law; N,unweighted sample size; TUS-CPS, Tobacco Use Supplement to the Current Population Survey.

diverse subgroups, including Central Americans, South Americans, Mexicans and Cubans, who have different smoking patterns probably due to different levels of acculturation.[55 56] Because the make-up of the Hispanic population may have changed since the Farrelly et al study, which used data about 23–40 years ago, the Hispanic population's price-responsiveness of smoking participation and intensity may have changed since then. However, further studies are needed to verify our findings.

Racial/ethnic minorities usually have lower socioeconomic status (SES) than whites.[57] Therefore, our results that African–Americans and Hispanics were less price-responsive than whites implied that lower SES people were less price-responsive than higher SES people. This seems inconsistent with the literature showing that lower income smokers were more price-responsive than higher income smokers.[24 25 32] However, our findings take into account SES through a variety of measures, so these differences are related to other factors or unmeasured aspects of SES. Additionally, a US study found no significant difference in the price elasticity of smoking participation between lower and higher income adults during 1997–2004.[31] Another study that used the 2006/2007 and 2010/2011 TUS-CPS data

also found no significant difference in the total price elasticity of cigarette demand between low-income and high-income adults.[58]

State-level antismoking sentiment has been shown as a more useful measure than state-fixed effect variables to control for unobservable factors, which may jointly influence both smoking behaviours and tobacco policies.[39] We found that compared with the model without controlling for antismoking sentiment, smoke-free air laws and monthly indicator, the price elasticity estimates from the main analysis were much lower (table 4), and the main driving force was the inclusion of antismoking sentiment variable (data not shown). This is consistent with Decicca et al,[39] who reported that after controlling for antismoking sentiment, the cigarette prices impact on youth smoking became weaker or statistically insignificant compared with the model without controlling for antismoking sentiment.

This study showed mixed results for the association of smoke-free air laws with smoking participation and smoking intensity depending on racial/ethnic groups. In contrast, previous studies showed that CIALs have a negative impact on cigarette demand,[23] smoking prevalence[59] and smoking intensity,[59 60] although one

Table 4 Price elasticities of cigarette demand by race/ethnicity based on different model specifications, 2006/2007 and 2010/2011 TUS-CPS data

| Race/ethnicity | Main analysis | | | Sensitivity analyses | | | | | |
| | | | | Exclude antismoking sentiment, smoke-free air law and monthly indicator from the model | | | Add a time fixed-effects variable in the model | | |
	Participation elasticity (95% CI)	Intensity elasticity (95% CI)	Total elasticity (95% CI)	Participation elasticity (95% CI)	Intensity elasticity (95% CI)	Total elasticity (95% CI)	Participation elasticity (95% CI)	Intensity elasticity (95% CI)	Total elasticity (95% CI)
White	−0.26*** (−0.29 to −0.23)	−0.22*** (−0.25 to −0.19)	−0.48*** (−0.52 to −0.44)	−0.36*** (−0.39 to −0.34)	−0.36*** (−0.38 to −0.34)	−0.72***(−0.76 to −0.69)	−0.04 (−0.08 to 0.00)	−0.12*** (−0.15 to −0.08)	−0.15*** (−0.21 to −0.10)
African–American	−0.10** (−0.17 to −0.04)	−0.17*** (−0.26 to −0.08)	−0.27*** (−0.38 to −0.16)	−0.27*** (−0.34 to −0.21)	−0.20*** (−0.29 to −0.12)	−0.48*** (−0.59 to −0.37)	0.15*** (0.07 to 0.23)	−0.00 (−0.11 to 0.11)	0.15* (0.02 to 0.28)
Asian	−0.42*** (−0.56 to −0.29)	0.20 (−0.02 to 0.39)	−0.22* (−0.46 to −0.02)	−0.40*** (−0.54 to −0.27)	−0.17 (−0.02 to 0.36)	−0.23 (−0.47 to 0.01)	−0.23* (−0.42 to −0.05)	0.42*** (0.19 to 0.65)	0.18 (−0.12 to 0.49)
Hispanic	−0.11** (−0.18 to −0.03)	−0.04 (−0.16 to 0.07)	−0.15* (−0.29 to −0.01)	−0.16*** (−0.24 to −0.09)	−0.10 (−0.21 to 0.02)	−0.26*** (−0.41 to −0.12)	0.37*** (0.28 to 0.46)	0.52*** (0.36 to 0.68)	0.89*** (0.70 to 1.08)

*Statistically significant at p<0.05, **statistically significant at p<0.01, ***statistically significant at p<0.001.
TUS-CPS, Tobacco Use Supplement to the Current Population Survey.

study found that more restrictive smoke-free air laws had little impact on smoking prevalence.[60] The mixed results from our study could be due to the correlation between smoke-free air law coverage and the antismoking sentiment variable (Spearman's correlation coefficients=0.37 for Asians (p<0.001) and 0.33 for African–Americans (p<0.001)).

This study has some limitations. First, the analysis was based on pooled cross-sectional data, so our estimates may not capture the long-run price effects. Second, smoking status and CPD were based on self-report and might be subject to recall bias. However, self-reported smoking status has been shown to be a validated measure of smoking.[61] Third, this study used the state-level cigarette prices collected by the TBOT. A study that conducted a careful examination of the cigarette price data suggested that the state price measures in TBOT reflect average local taxes.[38] Another study compared six different measures of cigarette prices and found that the total price elasticity was statistically significant when the cigarette price was measured at the local level (eg, by county), but not statistically significant for state-level price measures perhaps because they are not as effective in capturing the variation in the local tax environment.[58] . The inclusion of the average local taxes in the state price measures would result in even more measurement error in the price because for people living in parts of the state with no local taxes, the average price measure overstates the price they face; for those living in parts of the state with high local taxes, the average price measure understates the price they face.[38] Therefore, using the state-level TBOT prices is likely to bias our price elasticity estimates towards zero.

In conclusion, we found that increasing cigarette prices has a significant effect on reducing smoking prevalence for whites, African–Americans, Asians and Hispanics. These results suggest that raising cigarette prices, such as via tobacco tax increases, is an effective tool to reduce smoking prevalence for all four racial/ethnic groups, but the magnitude of the effects would differ across these groups. We also found that white and African–American smokers reduce their smoking intensity in response to higher prices. Taken together, all four racial/ethnic groups respond to cigarette price increases by reducing their total cigarette demand. Non-price tobacco control strategies, particularly those targeting less price-responsive population subgroups, should be coupled with tobacco tax initiatives to ensure that all racial/ethnic groups benefit equally from the reduction in tobacco use.

What this paper adds

- ► This is the first study to examine racial/ethnic differences in the impact of cigarette prices on adult cigarette demand in the USA using the most recently available data that covered the preperiod and postperiod of the 2009 federal tobacco tax increase.
- ► This is the first study to estimate the price-responsiveness of cigarette demand among Asian adults in the USA. We found that Asians had the highest price elasticity of smoking participation among all four racial/ethnic groups, but were not price-responsive to reduce smoking intensity.

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Responsiveness to cigarette prices by different racial/ethnic groups of US adults

Tingting Yao, Michael K Ong, Wendy Max, Courtney Keeler, Yingning Wang, Valerie B Yerger and Hai-Yen Sung

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