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Response by Adults to Increases in Cigarette Prices by Sociodemographic Characteristics

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Cigarette excise taxes are widely viewed by health economists as an effective tool to reduce cigarette consumption. However, those opposed to increasing cigarette excise taxes often state that the taxes unfairly target certain segments of the population, notably the poor and minorities. Some of this opposition may have been fueled by a lack of understanding of how the tax will affect the health and welfare of various demographic groups of interest. This article provides guidance to policy makers by estimating price elasticities among adults by gender, income, age, and race or ethnicity. Women, adults with income at or below the median income, young adults, African-Americans, and Hispanics are most responsive to cigarette price increases. For example, adults with income at or below the median are more than four times as price-responsive as those with income above the median.

1. Introduction

The prevalence of cigarette smoking among high school seniors increased more than 30% between 1992 and 1997 (Monitoring the Future 1998). In response to this recent increase, federal, state, and local initiatives have been proposed and enacted to curb smoking, especially among teenagers. These initiatives include increasing cigarette excise taxes. Increasing these taxes effectively discourages smoking among both teenagers and adults (Chaloupka and Grossman 1996; CDC 1998; Evans and Farrelly 1998; Evans and Huang 1998). Those opposed to increased cigarette excise taxes argue that these taxes are regressive and hit "hardest those least able to afford them" (Tobacco Institute 1998). In addition, increases in cigarette prices may impose a disproportionate financial burden on racial and ethnic minority groups and the poor. If these same groups were the most responsive to taxes, however, then the regressive effects of the tax would be mitigated by above-average decreases in smoking.

It is important to understand the sociodemographic characteristics of smokers who are responsive to tax changes and those who are not. Previous studies have found that certain sociodemographic groups are more price-responsive than others. For example, Chaloupka and Grossman (1996), Evans and Farrelly (1998), Evans and Huang (1998), and Tauras and Chaloupka (1999) showed that young adults are more price-responsive than older adults. The results of studies by Evans and Huang (1998) and Chaloupka and Pacula (1999) suggest that, among

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high school seniors, nonwhites are more price-responsive than whites. It is not known whether cigarette price increases differentially affect adults of different races and ethnicities. Only one study, conducted in Britain, has examined price elasticities by income group (Townsend, Roderick, and Cooper 1994). These authors found that people in lower socioeconomic groups are more price-responsive than those in higher socioeconomic groups. Nor is it known whether the poor (young or old) are more or less price-responsive than the rich. To answer these questions, we evaluated the effect of cigarette price increases by gender, income, age, and race or ethnicity with a nationally representative sample of more than 350,000 adults. This article also elaborates on work presented in an earlier, brief summary of results from similar models (CDC 1998).

2. Data

We pooled data from 14 years (1976–1980, 1983, 1985, and 1987–1993) from the National Health Interview Survey (NHIS). The NHIS is a nationally representative multistage probability sample of the civilian, noninstitutionalized U.S. population age 18 and older.[1] The NHIS obtains information about the amount and distribution of illness, disability, and chronic impairments and about the kinds of health services respondents receive. In supplements to the NHIS before 1992, respondents were asked, "Have you smoked 100 cigarettes in your entire life?" and "Do you smoke cigarettes now?" In 1992 and 1993, participants were asked, "Do you now smoke cigarettes every day, some days, or not at all?" We define current smokers as those who reported having smoked at least 100 cigarettes during their lifetimes and who reported currently smoking cigarettes either every day or some days. Current smokers were asked, "On average, how many cigarettes do you smoke per day?" We define cigarette demand as the number of cigarettes smoked per day, conditional on the respondent's being a current smoker. Information on gender, income, age, race or ethnicity, and other sociodemographic factors was obtained from the core NHIS questionnaire.

Average annual cigarette prices were obtained for each state from the Tobacco Institute's *The Tax Burden on Tobacco* (1998). Prices were adjusted for inflation (constant 1982–1984 dollars) and merged into the NHIS by year and state of residence.[2] Combined, the 14 cross-sections of the NHIS consisted of 367,106 respondents; of those, complete sociodemographic and price data were available for 354,228 (approximately 25,000 respondents per year).

Figure 1 illustrates the consistent differences in the prevalence of cigarette smoking among non-Hispanic African-Americans, Hispanics, and non-Hispanic whites[3] from 1976 through 1993 (data are interpolated for 1981, 1982, 1984, and 1986). The prevalence of smoking dropped more rapidly for nonwhites than for whites (38% vs. 30%). During this period, the real price

[1] To the extent that the institutionalized population is more/less price responsive to changes in cigarette prices, our results will be somewhat biased.

[2] In preparing these data for public release, the National Center for Health Statistics (NCHS) removed all direct identifiers that might lead to the identification of the survey respondents, including recoding the primary sampling unit (PSU) codes that identify the location of each respondent. We reached an agreement with NCHS that allowed us to identify the state of residence of each respondent while maintaining the confidentiality of his or her PSU. For a small percentage of observations, we were unable to identify states of residence for reasons of confidentiality; these observations were deleted from the sample. In addition, because we did not have information on the county of residence, we were not able to control for differential price elasticities for those living near the borders of low-price cigarette states.

[3] Hereafter referred to as African-Americans, Hispanics, and whites.

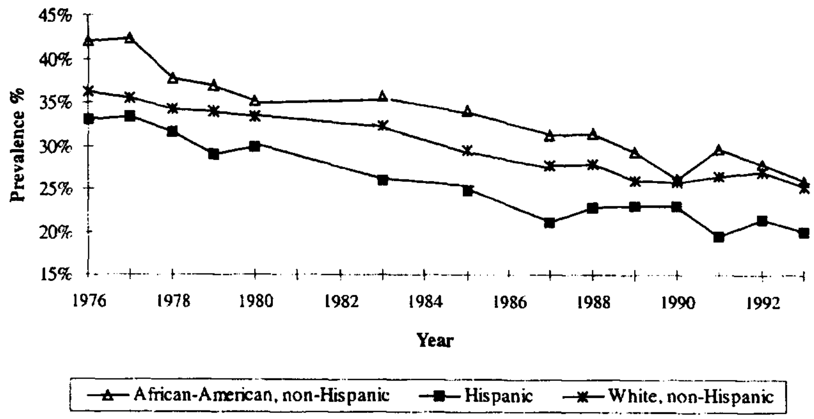

Figure 1. Prevalence of Smoking by Race/Ethnicity

of cigarettes increased by 48%. Determining differential price effects for African-Americans, Hispanics, and whites may explain some of these differences in smoking prevalence.

Table 1 presents summary statistics for the entire 1976–1993 NHIS database. During this period, a mean of 29% of the sample smoked, and smokers consumed a mean of 20 cigarettes per day. Ten percent of the sample was African-American, 6% was Hispanic, and 81% was white. The average age of the respondents was 44 years, and almost 75% had at least a high school degree.

3. Methods

The two-part estimation procedure has been used extensively in health economics to model the demand for medical care (Duan et al. 1982, 1984; Manning et al. 1987), drinking (Manning, Blumburg, and Moulton 1995), and cigarette smoking (Wasserman et al. 1991; Grossman et al. 1993; Chaloupka and Wechsler 1997; Chaloupka, Tauras, and Grossman 1997). Using this two-part framework, we model separately the decision to smoke and the quantity of cigarettes smoked. In the first stage of the two-part estimation, a probit equation is used to model the probability of smoking. In the second stage, cigarette demand for only the smokers is estimated with ordinary least squares regression. Our specification for both the probit and the linear model is

$$Y_i = F(X_i\beta_0 + P_{ST}\beta_1 + v_S + e_i), \quad (1)$$

where Y_i is the indicator for a current smoker (number of cigarettes smoked) and $F(\cdot)$ is the standard normal cumulative density function (CDF) (identity function) for the probit model (linear regression). X_i is a set of demographic covariates, including age, age squared, real family income (replaced with zero when missing), 1 indicator for whether income is missing, family size, indicators for state of residence, 13 year indicators, 2 indicators for city size, 3 indicators for race or ethnicity, 4 indicators for educational level, 4 indicators for marital status, and 1 indicator for gender. P_{ST} is the price of cigarettes in state S in year T, v_S is a state-specific fixed effect, and e_i is an individual-level error term.

The key variable of interest is the price of cigarettes, which is measured at the state level and reported by the Tobacco Institute in *The Tax Burden on Tobacco.* Most price differences

Table 1. Summary Statistics for the NHIS 1976–1993 (N = 367,106)

Variable	Mean	Standard Deviation
Prevalence of smoking (%)	29.3	46.2
Cigarettes per day for smokers[a] (number)	20.2	12.32
Real price of cigarettes (cents)	98.7	19.8
Gender (%)		
Male	46.6	49.9
Female	53.4	49.9
Age (years)	43.9	17.7
Race or ethnicity (%)		
White, non-Hispanic	81.2	39.1
African-American, non-Hispanic	10.4	30.5
Hispanic	6.1	23.7
Other race, non-Hispanic	2.3	15.5
Educational level (%)		
High school dropout	26.4	44.1
High school graduate	37.8	48.5
Some college	18.3	38.7
College graduate	9.9	29.9
Postgraduate	7.2	25.9
Real family income ($)	25,784.2	18,670.0
Income missing indicator (%)	11.3	31.7
Metropolitan statistical area (MSA) (%)		
City resident	43.3	49.6
City center resident	30.0	45.8
Non-MSA	26.7	44.2
Family size (number of members)	2.94	1.69
Marital status (%)		
Married	66.7	47.1
Separated	2.3	14.9
Widowed	7.6	26.5
Never married	17.0	37.6
Divorced	6.4	24.4

across states are driven by state excise taxes. For example, in 1993, excise taxes ranged from $0.025 in Virginia to $0.65 in Washington, D.C. However, in regressions of cigarette consumption on cigarette prices and excise taxes, the price or excise tax may be correlated with unobserved state-level variation, which is captured in our model by v_S. For example, some states are tobacco-producing states and are likely to have relatively low cigarette excise taxes and high rates of smoking. Other states may have a strong antismoking sentiment (and low smoking rates) and pass higher cigarette excise taxes. Comparisons of prices and excise taxes and smoking rates across these two classes of states would conclude that higher taxes lead to decreased smoking rates. While this observation may be true, some of the differences in smoking rates have less to do with differential prices and excise taxes than with differences in the population characteristics of each state.

To effectively control for this possibility, we include state-specific effects to compare the variation in cigarette excise taxes over time within a state with changes in smoking behavior over time within that state. If, for example, the cigarette excise tax is increased in California and the rate of smoking in California drops accordingly, this model will show a negative correlation between taxes and smoking. Although this approach may not address all concerns of endogeneity, it is a stronger test of the effect on smoking behavior of changing cigarette taxes than are models with regional controls because it controls for time-invariant characteristics in each state (e.g., tobacco-producing states).

We first estimate a probit model that includes all respondents with complete sociodemographic information from all years. We then estimate a conditional demand model of the quantity of cigarettes smoked by current smokers. These two models produce, respectively, a smoking participation price elasticity and a conditional demand price elasticity. The participation elasticity is calculated as the marginal effect on the price variable multiplied by the mean price and divided by the sample mean of the response variable (i.e., indicator variable for smoker). The marginal effect for the probit model's *j*th variable is calculated as $\beta_j\Phi(z)$, where β_j is the probit coefficient, Φ is the standard normal probability density function, and $z = \Phi^{-1}(S)$, where Φ^{-1} is the inverse of the standard normal cumulative density function and S is the sample mean prevalence of smoking. The conditional demand elasticity is the coefficient of price multiplied by the mean price and divided by the sample mean number of cigarettes smoked per day among smokers. The total elasticity is the sum of the participation and conditional demand elasticities.

In addition to the basic model, we use the demographic data from the NHIS to examine the differential effect of cigarette price changes on the prevalence of smoking and on daily cigarette consumption by gender, real family income (equal to or below the median income, above the median), age (18–24, 25–39, 40 and older), and race and ethnicity (African-American, Hispanic, white).

When estimating price elasticities for gender, income, age, and race or ethnicity, we need to take into account the available degrees of freedom. Because we include state-level fixed effects in all models, we need a larger sample size to identify any price effects with a reasonable degree of precision. To ensure sufficient degrees of freedom when estimating price elasticities by age, race or ethnicity, and interactions between age and race or ethnicity, we imposed the constraint that all covariates except price had the same coefficient across all groups. We estimated models for these groups in which we relaxed this constraint and found that our estimated price effects were essentially unchanged. For the gender and income results, we had sufficient observations to estimate models with state-level fixed effects, so we allowed all coefficients to vary across groups.

4. Results

As shown in Table 2, the full model for all respondents with complete sociodemographic data yields a total price elasticity of −0.28 (−0.13 for participation elasticity and −0.15 for conditional demand elasticity). (The coefficients for all covariates from both the probit and ordinary least squares models are reported in the Appendix.) This total elasticity suggests that increasing the price of cigarettes by 100% leads to a decrease in total cigarette consumption by 28%. This elasticity should be considered a short-term response to an increase in price because it does not explicitly include the long-term consequences of tobacco addiction. Becker and Murphy (1988), Becker, Grossman, and Murphy (1991), and Chaloupka (1991) include past, current, and future consumption of cigarettes in rational addiction models, and their models show larger price elasticities. For a review of other analyses of cigarette demand, see Viscusi (1992) and Chaloupka and Warner (2000).

Table 2. Cigarette Price Elasticities by Gender, Income, Age, and Race or Ethnicity

		Probit Model			Conditional Demand Model			Total Elasticity	
Sample	*N*	Prevalence of Smoking (%)	Probit Coefficient	Participation Elasticity	Mean No. of Cigarettes	Ordinary Least Squares Coefficient	Conditional Demand Elasticity	With All Results	With Only Statistically Significant Results
All respondents	354,228	29.3	−0.10 (±0.09)	−0.13	19.74	−3.09 (±0.8)	−0.15	−0.28	−0.28
Gender (separate models by gender)									
Male	151,287	32.4	−0.03 (+0.14)	−0.03	21.75	−3.92 (±2.3)	−0.18	−0.21	−0.18
Female	202,941	26.8	−0.15 (±0.13)	−0.19	17.92	−2.31 (±1.9)	−0.13	−0.32	−0.32
Real family income[a] (separate models by income)									
≤ Median income	154,192	31.7	−0.17 (±0.14)	−0.21	19.00	−4.02 (±2.2)	−0.22	−0.43	−0.43
≥ Median income	156,572	27.5	0.00 (±0.14)	0.01	20.67	−2.26 (±2.4)	−0.11	−0.10	0.00
Age (years) (price × age interactions)									
18–24	46,379	29.4	−0.23 (±0.11)	−0.30	16.19	−4.09 (±2.0)	−0.25	−0.55	−0.55
25–39	119,328	34.0	−0.22 (±0.11)	−0.25	19.57	−5.37 (±1.8)	−0.28	−0.53	−0.53
40 and older	188,521	26.1	−0.01 (±0.10)	−0.02	20.87	−1.16 (±1.5)	−0.06	−0.08	0.00
Race or ethnicity[b] (price × race or ethnicity interactions)									
African-American	43,141	32.6	−0.17 (±0.12)	−0.20	13.88	−2.01 (±1.2)	−0.15	−0.35	−0.35
Hispanic	21,926	24.4	−0.36 (±0.14)	−0.62	13.81	−3.92 (±1.2)	−0.31	−0.93	−0.93
White	281,482	29.2	−0.06 (±0.10)	−0.08	21.16	−3.22 (±2.3)	−0.15	−0.23	−0.15

95% confidence intervals are in parentheses.

[a] 43,464 respondents did not report income.

[b] 7,679 respondents are categorized as "other" and are not reported.

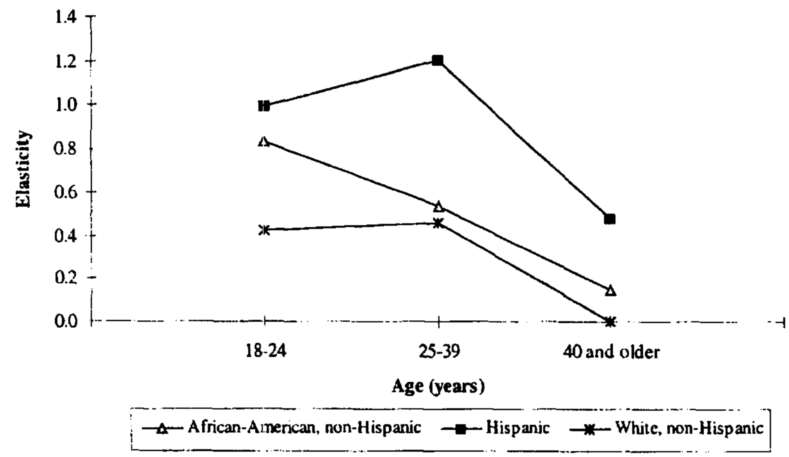

Figure 2. Estimated Cigarette Price Elasticity by Race/Ethnicity and Age

The last two columns of Table 2 show the total price elasticities. The penultimate column is the sum of the participation and conditional demand elasticities, including the few elasticities that are not statistically significant ($p > 0.10$). The final column repeats the sum of the elasticities but sets to zero those elasticities that are not statistically significant. Table 2 shows that women are more price-responsive than men (total elasticity of −0.32 for women and −0.18 for men). The total elasticity for men is due solely to reductions in daily consumption (−0.18), whereas for women, approximately half of the decline in smoking is from reduced consumption and half is from decreased participation in smoking. The difference between respondents of lower and higher incomes is even more pronounced: Those with income at or below the median income for this sample have a total elasticity of −0.43 and those with a higher income were not responsive at all (0.00) to price changes. Even if we accept the statistically imprecise elasticity measure for this higher income group, the lower income group is four times as price-responsive.

We estimate separate price elasticities by age and by race or ethnicity. The results for the three age groups and the three race and ethnicity groups are presented in Table 2. The major differences for the three age groups are between respondents age 40 and older (total elasticity of 0.00) and those under age 40 (total elasticity of −0.55 for 18–24-year-olds and −0.53 for 25–39-year-olds). As for racial and ethnic groups, African-Americans are more than two times as price-responsive (total elasticity −0.35) and Hispanics are more than six times as price-responsive (total elasticity −0.93) as whites (total elasticity −0.15).

Finally, we estimate price elasticities by interactions between age and race or ethnicity. Figure 2 shows that, for all age groups, African-Americans and Hispanics are more responsive to changes in prices than are whites. This graph also shows that price elasticities decline monotonically with age for African-Americans, that whites aged 18–24 have approximately the same price elasticity as whites aged 25–39, and that Hispanics aged 18–24 are less price-responsive than Hispanics aged 25–39. However, across all racial and ethnic groups, those aged 18–39 are more price-responsive than those aged 40 and older.

5. Discussion

Our results suggest that any increase in the price of cigarettes will have differential effects on smokers of different gender, income, age, and race or ethnicity. Women and men differ not only in the magnitude of their price response but also in the nature of their price response. Our results suggest that women are much more likely to quit smoking in response to a price increase, whereas men are much more likely to reduce their consumption of cigarettes than to quit smoking. This distinction suggests that price increases, combined with other policy tools, may be a mechanism for reducing the percentage of women who smoke. Given the health risks associated with smoking during pregnancy and the health risks unique to women, policy makers may be especially interested in reducing smoking among women.

The differential effect of cigarette price changes by income that we found is consistent with economic theory: Adults with lower income are more price-responsive than adults with higher income. This result suggests that price increases are an effective tool for reducing the prevalence of smoking among lower income adults—precisely the persons who can least afford the health consequences of smoking. Although cigarette excise taxes are regressive, lower income smokers are more likely to quit and decrease consumption in response to cigarette price increases. This is in contrast with smokers with incomes greater than the median, whose share of all cigarettes (and hence taxes paid) are likely to increase to similar cigarette price increases. Using the price elasticities from our model and data on aggregate national cigarette sales, we simulated the share of all cigarettes smoked by adults above and at or below the median income. We then simulated the change in this share in response to a 25% increase in cigarette prices. Before a price increase (using 1993 NHIS data), smokers with income above the median smoked 42% of all cigarettes sold in the United States. After the price increase, this share increased to 46%. Therefore, although lower income smokers have to pay a larger share of their income in the form of excise taxes, relatively more lower income smokers quit and their greater sensitivity to prices does shift some of the total tax burden to higher income groups.

Young adults (age 18–24) are clearly more responsive to increased prices than are older adults. These results are consistent with the common wisdom that older smokers are more likely to be addicted to cigarettes and therefore less able to cut back or quit their cigarette consumption. That at least half of the price response of adults under age 40 is due to the participation elasticity suggests that, in addition to decreasing the number of cigarettes smoked by these younger adults, price increases may also help to reduce the number of addicted smokers in the future by decreasing the prevalence of smoking among younger adults today. However, our results highlight as well the need for a comprehensive strategy to discourage smoking among those age 40 and older because this age group is not responsive to price changes.

Finally, African-Americans and Hispanics are much more likely than whites to decrease smoking in response to increases in cigarette prices. Specifically, the total price elasticity for African-Americans is −0.35, or 50% higher than for whites (−0.23). Because the conditional demand elasticities for whites and African-Americans are the same (−0.15), the differences come from differences in the participation elasticity. Hispanics are the most price-responsive, with larger conditional, participation, and total elasticities than both whites and African-Americans. Because our models controlled for income, African-Americans and Hispanics are more price-responsive, not because they have less money but for other unknown reasons.

Our results help to quantify the effects of cigarette price increases. These effects differ by gender, income, age, and race or ethnicity in ways that may increase the usefulness of cigarette price changes as a policy tool for public health. Further work is needed to help determine the long-run price elasticity of demand among these groups and to understand the effect of cigarette price increases on the consumption of other potentially harmful commodities such as alcohol or marijuana.

Appendix
Results from Probit and Ordinary Least Squares (OLS) Models for All NHIS Respondents

	Probit Coefficient (N = 354,228)	OLS Coefficient (N = 98,842)
Intercept	−1.303[a]	1.046
	(0.074)	(1.173)
Real price of cigarettes	−0.001[b]	−0.031[a]
	(0.000)	(0.008)
Real family income	−4.30E−06[a]	3.70E−06
	(1.67E−07)	(2.60E−06)
Incoming missing indicator	−0.133[a]	−0.039
	(0.008)	(0.128)
Age		
Age	0.056[a]	0.808[a]
	(0.001)	(0.015)
Age^2	−0.001[a]	−0.009[a]
	(0.000)	(0.000)
Race or ethnicity		
White, non-Hispanic	0.175[a]	5.731[a]
	(0.013)	(0.275)
African-American, non-Hispanic	0.091[a]	−2.007[a]
	(0.015)	(0.291)
Hispanic	−0.239[a]	−1.857[a]
	(0.013)	(0.315)
Educational level		
High school dropout	0.190[a]	0.888[a]
	(0.006)	(0.089)
Some college	−0.188[a]	−0.685[a]
	(0.006)	(0.101)
College graduate	−0.475[a]	−1.867[a]
	(0.009)	(0.152)
Postgraduate	−0.625[a]	−2.711[a]
	(0.010)	(0.189)
Family size	−0.022[a]	0.003
	(0.002)	(0.026)
Marital status		
Separated	0.316[a]	1.121[a]
	(0.013)	(0.180)
Widowed	0.167[a]	0.589[a]
	(0.010)	(0.165)
Never married	−0.049[a]	−0.297[a]
	(0.007)	(0.115)
Divorced	0.312[a]	1.403[a]
	(0.008)	(0.117)
Male	0.207[a]	3.846[a]
	(0.005)	(0.073)
Metropolitan statistical area		
City resident	0.068[a]	0.075
	(0.006)	(0.098)
Central city resident	0.121[a]	0.158
	(0.007)	(0.103)

95% confidence intervals are in parentheses. In both the probit and OLS models, we reject the null hypotheses that the state effects are jointly zero ($p > \chi^2 = 0.001$). The same is true for the year effects ($p > \chi^2 = 0.001$). The log likelihood for the probit model is −197,835.13, and the adjusted R^2 for the OLS model is 0.13.

[a] Statistically significant at $p \leq 0.01$.

[b] Statistically significant at $p \leq 0.05$.

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