Published in final edited form as:

Epidemiology. 2017 November ; 28(6): 863–871. doi:10.1097/EDE.0000000000000736.

Longitudinal Associations of Local Cigarette Prices and Smoking Bans with Smoking Behavior in the Multi-Ethnic Study of Atherosclerosis (MESA)

Stephanie L. Mayne^a, Amy H. Auchincloss^a, Mark F. Stehr^b, David M. Kern^a, Ana Navas-Acien^c, Joel D. Kaufman^d, Yvonne L. Michael^a, and Ana V. Diez Roux^a

^aSchool of Public Health, Drexel University, Philadelphia, PA

^bSchool of Economics, Drexel University, Philadelphia, PA

^cSchool of Public Health, Columbia University, New York, NY

^dSchool of Public Health, University of Washington, Seattle, WA

Abstract

Background—Few studies have examined associations of geographically proximal cigarette prices with within-person changes in smoking outcomes, or assessed interactions between cigarette prices and smoking bans.

Methods—We linked neighborhood cigarette prices (inflation-adjusted) at chain supermarkets and drug stores and bar/restaurant smoking ban policies to cohort participants (632 smokers from the Multi-Ethnic Study of Atherosclerosis, 2001–2012, baseline mean aged 58) using geocoded retailer and participant addresses. We used fixed-effects models to investigate associations of within-person changes in price and ban exposures with within-person changes in five smoking outcomes: current smoking, heavy (≥ 10 cigarettes) smoking, cessation, relapse, and intensity (average number of cigarettes smoked per day, natural log-transformed). We assessed intensity associations among all smokers, and heavy (≥ 10 cigarettes per day) and light (<10) baseline smokers. Finally, we tested interactions between cigarette price and bans.

Results—\$1 increase in price was associated with a 3% reduction in risk of current smoking (aRR: 0.97, 95% confidence interval [CI]: 0.93, 1.0), a 7% reduction in risk of heavy smoking (aRR: 0.93, CI: 0.87, 0.99), a 20% increase in risk of smoking cessation (aRR 1.2, CI: 0.99, 1.4), and a 35% reduction in the average number of cigarettes smoked per day by heavy baseline smokers (ratio of geometric means: 0.65, CI: 0.45%, 0.93%). We found no association between smoking bans and outcomes, and no evidence that price effects were modified by the presence of bans.

Corresponding author: Amy H. Auchincloss, PhD, Department of Epidemiology and Biostatistics, School of Public Health, Drexel University, 3215 Market Street, 5th floor, Philadelphia, PA, 19104. aha27@drexel.edu.

Conflicts of interest: The authors have no conflict of interest with this paper.

Description of the process by which someone else could obtain the data and computing code required to replicate the results: MESA data are available to scientific colleagues [<http://www.mesahlbi.org>] however participant geocodes are not publically available and access to the pricing dataset would require buying data anew from the vendor. Computer code may be available to scientific colleagues who are attempting replication.

Conclusions—Results underscore the importance of local prices, but not hospitality smoking bans, in influencing older adults' smoking behaviors.

Keywords

Smoking; Smoke-Free Policy; Prices; Taxes; Tobacco; Socioeconomic Factors

Introduction

Cigarette smoking remains a major public health problem in the United States, resulting in approximately 480,000 deaths per year from chronic diseases.¹ Smoking prevalence has declined over time; however, an estimated 15% of U.S adults smoked as of 2015.² Reductions in smoking prevalence have been attributed in part to excise tax policies that increase cigarette prices³ and, consequently, the economic cost of smoking. "Excise taxes" are indirect taxes levied on tobacco producers/vendors under the assumption that additional costs will be passed to consumers. In the U.S., excise taxes have been levied at the federal, state, and local level and have increased over time. Prior studies found that excise taxes encourage smoking cessation and reduce cigarette consumption,³ with price elasticities of -0.1 to -0.6 indicating that a 10% increase in price would reduce per capita tobacco consumption between 1% and 6%.³⁻⁷

Most prior studies of cigarette prices/taxes and smoking outcomes have used repeat cross-sectional data such as nationally representative surveys to assess price elasticity or changes to smoking prevalence.⁵⁻¹² However, longitudinal cohorts are better suited to examine associations of cigarette prices with within-person changes in smoking behavior. In addition, few studies have used data at a smaller geographic scale to assess associations of prices with individual smoking behavior. Most prior studies have used state-level average cigarette prices or taxes to examine associations with smoking.^{5,8,9,11-13} However, several prior studies found substantial variation in cigarette prices within states and counties.¹⁴⁻¹⁶ In addition, prior work suggests geographically proximal exposures may be important determinants of smoking behavior- for example, individuals who lived closer to stores licensed to sell tobacco were less likely to quit smoking than those living farther away.^{17,18} Thus, the tobacco retail environment near peoples' homes may have a meaningful impact on their smoking behavior, and local cigarette prices may better reflect the prices to which they are exposed than state-level averages.

Tobacco tax increases are only one of several macro-level tobacco control strategies that have been implemented in the U.S. Legislation banning smoking in indoor public places, such as bars and restaurants, has become increasingly common.^{1,19} Smoking bans in hospitality venues may reduce smoking by both limiting the social situations in which people smoke and by changing social norms related to smoking.²⁰ While prior studies have found that smoking bans reduced smoking prevalence among U.S. adults,²¹⁻²⁴ these studies often included only a single city.^{21,22,24} In addition, few studies have examined whether there is a synergistic interaction between cigarette prices and smoking ban policies.²⁵ This is an important question as policymakers are increasingly turning to multi-component, comprehensive tobacco control strategies.^{21,22,24}

To address these knowledge gaps, we linked a commercial dataset of cigarette prices from chain grocery and drug stores to longitudinal individual-level data from the Multi-Ethnic Study of Atherosclerosis (MESA) to evaluate the association of geographically proximal cigarette price exposures with smoking outcomes. Specifically, we assessed the association of changes in cigarette price with within-person change in the risk of current smoking, heavy smoking, cessation, relapse, and change in the number of cigarettes smoked per day. Finally, we examined the main effect of bar and restaurant smoking ban legislation in this cohort and assessed whether price associations differed by exposure to bans.

Methods

Price Data

Cigarette pricing data came from Information Resources Inc.'s (IRI, Symphony Technology Group, Chicago, IL) Academic Dataset, a panel of large chain supermarkets and drug stores covering 41 states and 47 U.S. market regions.²⁶ The current study includes 896 stores in 19 states. IRI compiled weekly prices and sales data for cigarette products from 2001–2011. While cigarette prices were available for all Universal Produce Codes sold at each store, we restricted the sample to the most frequently sold items in order to reduce variation in price due to varying cigarette lengths and package sizes: single packs of king-sized and long-sized cigarettes (comprising 99% of sales). Cigarette prices included excise taxes but not sales tax.

Adapting methods developed by others,²⁷ dollar and unit sales were aggregated from Universal Product Codes to standardized brand names at each store location. Brand-level dollar and unit sales were used to create weights reflecting the proportion of sales made up by each brand at that store over the entire study period. These weights were used to calculate the weighted average price of a pack of cigarettes at each store in each week, accounting for varying sale volumes of different brands. All prices were inflated to 2010 dollars based on the US Bureau of Labor and Statistics Consumer price index.²⁸

Study Population

The study population was the Multi-Ethnic Study of Atherosclerosis, a longitudinal cohort of 6,814 adults aged 44–84 and free of cardiovascular disease at enrollment. Participants were sampled from six U.S. sites (Los Angeles, CA, Manhattan and Bronx, NY, St. Paul, MN, Chicago, IL, Baltimore, MD, and Forsyth County, NC) and the baseline exam was conducted in 2000–2002. Four follow-up exams were conducted between 2002 and 2012 (retention rates: 92% at year 2, 89% at year 3, 87% at year 5, and 76% at year 10). The Institutional Review Board at each site approved the study, and all participants provided informed consent. The MESA Neighborhood Study was an ancillary study to MESA that included 6,191 participants (91% of the baseline sample). All residential addresses from baseline through year 10 were geocoded. We excluded participants who were missing data on smoking outcomes (N=53) and key covariates (N=33) and with low geocoding accuracy (not at street-level or zip+4 centroid level, N=23). In addition, we included only participants who had at least one store from the IRI dataset within a 3-mile buffer of their residence at a given exam (N=4,884). A 3-mile buffer was chosen because prior research indicates smokers are willing to travel up to 3 miles in order to save \$1 on a pack of cigarettes.²⁹ Similarly,

food and alcohol purchasing studies indicate that 2–3 miles is a typical distance people travel to purchase these products.^{30–33} Using a 3-mile buffer retained a high proportion of the study population (>70%) and did not drastically alter the demographic composition of the study sample (eTable 1). We included data from all five exams, and included all person-years of data meeting eligibility criteria (e.g., if a participant had a store from the dataset within the 3-mile buffer for exams 1–2 but then moved to an area with no included stores for exams 3–5, only their data from exams 1–2 would be included). In addition, we confirmed that results were generally insensitive to alternate buffer sizes (5 miles and 2 miles, eTable 2).

In this analysis, we focused on longitudinal models examining smoking behavior changes in the cohort. As such, we included only those participants who reported smoking at some point during follow-up, as only these participants had the opportunity to have a smoking behavior change. This resulted in a final sample size of 632 participants with 2,342 exam years.

Linkage of Cigarette Prices to MESA Participants

We linked cigarette prices to MESA participants using the following steps: First, all stores in the IRI dataset within a 3-mile radius of each MESA participant's residence at each exam date were identified. Then, for each participant at each exam, we calculated a 12-month exposure period that ended on the exam date. For each participant at each exam, we calculated the average cigarette pack price at each store by extracting weekly prices from all weeks in that 12-month exposure period and calculating the average. At each exam, each participant was assigned a price value reflecting the average price of a pack of cigarettes across all stores within a 3-mile buffer of their residence.

Outcomes

Outcomes included current smoking, cessation, relapse, and intensity. Smoking status was assessed using the following questions: “Have you smoked at least 100 cigarettes in your lifetime?” and “Have you smoked cigarettes in the last 30 days?”^{34,35} We dichotomized smoking status to current smoker versus non-current smoker. We then defined *smoking cessation* as reporting being a non-smoker at a later exam subsequent to reporting current smoking at the last exam. *Smoking relapse* was defined as former smokers reporting current smoking at a later exam subsequent to reporting not currently smoking at an earlier exam. *Smoking intensity* was assessed by asking “On average, how many cigarettes a day do/did you smoke?” We coded intensity to 0 at exams where participants reported not currently smoking. Smoking intensity was evaluated as a natural log-transformed continuous variable due to a skewed distribution. In addition, smoking intensity was dichotomized to at least half a pack (10 of cigarettes per day i.e. ‘heavy’ smoking) versus less than 10 cigarettes per day. This threshold aligned with the distribution of the data (mean was approximately 10), facilitated interpretation of interactions, and has been used by others to indicate heavier smoking in older populations.^{36,37}

Other Variables of Interest

Time-invariant covariates included gender, race/ethnicity (White, African American, Hispanic, Chinese), and education (categorized as high school or less, some college/technical school/Associate's degree, Bachelor's degree or higher). Time-varying covariates collected at each exam included years of follow-up since baseline, age, marital status (married/living with partner versus unmarried), employment status (employed versus unemployed/retired), alcohol use (current versus non-current/never) and income (converted from a 13-category item with categories ranging from <\$5,000 to >\$100,000 to a continuous variable based on the midpoint of each category). Income was inflated to 2010 U.S. dollars and divided by the number of members of the household to reflect inflation-adjusted per capita income. We tested sensitivity to the inclusion of an index that accounted for both income and wealth, and results were the same.

Area-level variables included state of residence and neighborhood socioeconomic status (SES), which was evaluated at each exam as a composite measure created by summing z-scores from several census variables: log median housing value, percent with a high school education, percent with a bachelor's degree, percent in a managerial occupation, log median household income, and percent with interest/dividend income.³⁸ A higher score indicated higher neighborhood SES.

Smoking Ban Exposures

Local, county, and state smoking ban laws came from the American Non-Smokers Rights Foundation (ANRF) Local Ordinance Database,³⁹ a comprehensive dataset of all state, county, and city-level 100% smoking bans in the U.S. "100% smoking ban" indicated that legislation prohibited smoking in a given venue category with no exceptions. We focused on laws prohibiting smoking in restaurants and bars because survey data indicates that many non-hospitality workplaces voluntarily banned indoor smoking well in advance of legislation banning smoking in all non-hospitality workplaces.⁴⁰

Participants were assigned to smoking ban exposure status at each MESA exam date based on their current census block group of residence. State-county-block group Federal Information Processing Standard (FIPS) codes were assigned to census place names (via the Missouri Census Data Center's MABLE/Geocorr Geographic Correspondence⁴¹) and then place names and state/county FIPS codes were linked to state, county, and city smoking bans in the ANRF database. We assigned smoking ban exposure status (exposed versus unexposed) based on a 1-year lag to ensure that policy changes preceded outcome measurement.

Statistical Analysis

We examined the distribution of cigarette prices, smoking outcomes, and socio-demographic characteristics of the study sample over the 10-year study period. To estimate the association of an increase in cigarette prices with within-person changes in smoking behaviors, we used longitudinal models with participant fixed effects. Fixed-effects models treat each individual as his/her own control by including the individual as a stratum in the model.^{42–44} Estimates are then averaged across individuals to estimate the association of within-person change in

an exposure with within-person change in the outcome. This approach uses only within-person variation to estimate associations and thus controls for all time-stable individual-level characteristics, both observed and unobserved.⁴² For the four binary outcomes (current smoking, heavy smoking, quitting, and relapse), we used conditional modified Poisson fixed-effects models to estimate the relative risk of these outcomes associated with a \$1 increase in cigarette price. We chose modified Poisson over logistic regression because odds ratios may provide biased estimates of relative risk when the outcome is not rare.⁴⁵ Conditional fixed-effects models condition on the individual and include only participants who have a change in the exposure and outcome during follow-up,^{42,46} thus, the number of participants included in the model differed for each outcome (current smoking: N=578; heavy smoking: N=344, cessation: N=238, relapse: N=109). For smoking intensity, we used linear fixed-effects models to estimate the average change in ln(number of cigarettes smoked per day) associated with a \$1 increase in cigarette price. Regression coefficients were then exponentiated to facilitate interpretation and reflected the percent change in the average number of cigarettes per day. We examined this outcome in all smokers (N=632), and then separately in heavy baseline smokers (those who reported smoking 10 cigarettes per day at their first exam, N=326) and light baseline smokers (<10 cigarettes per day, N=306) to assess whether associations differed by level of baseline smoking intensity.

Fixed-effects model building followed recommended practice.⁴² Fixed-effects models control for measured and unmeasured time-invariant covariates through the subject fixed effects, thus, we adjusted models for time-varying covariates only: marital status, employment status, income, alcohol use, and neighborhood SES. For all adjusted analyses, results were virtually identical before and after adjustment for SES thus main results include neighborhood SES (eTable 3). In a sensitivity analysis, we also adjusted for the number of stores each participant had in their neighborhood in each year, and found results to be unchanged. Secular time trends were adjusted for by including time since baseline (years) to the model. As descriptive analysis indicated potential nonlinearity in cessation and relapse over time, we also considered a quadratic term (years-squared) in all models to provide more robust control for secular trends. This term was retained for cessation and relapse ($p<0.001$), but not for other outcomes as results were unchanged with inclusion of the quadratic term. In sensitivity analyses, we used dummy variables for exam year rather than a linear time trend to explore more robust adjustment for secular trends in smoking (eTable 4). Interactions between time-invariant characteristics (sex, race, study site) and time were tested and retained if p -for interaction ≤ 0.05 .⁴² Race*time interactions were retained in models for quitting, and sex*time interactions were retained in heavy smoking and smoking intensity models. Standard errors were clustered by participant. In sensitivity analyses, we considered clustering at higher levels (census tract, county, state) and found results to be similar, so only results where standard errors were clustered by participant are reported.

Subsequently, we repeated these models and added time-varying smoking ban exposure (exposed versus unexposed) as an independent variable to determine the independent associations of price and smoking ban policy exposures with outcomes. In these models, the effective sample size was smaller than for the price models as fewer participants had a change in both exposure and outcome (current smoking: N=313; heavy smoking: N=185; cessation: N=152; relapse: N=62). To evaluate whether cigarette prices had a stronger

association with smoking outcomes in combination with bar and restaurant smoking ban policies, we tested interactions between cigarette price and smoking ban exposure in addition to examining stratification by exposure status. All analyses were completed using Stata version 13.1 (StataCorp, College Station, TX).

Results

Table 1 describes characteristics of the study population over 10 years of follow-up (mean follow-up length: 7.0 years). The average number of cigarettes smoked per day declined from 11.4 to 8.1. The percent of smokers quitting since the past exam increased from 12% in year 2 to 22% in year 10. The average price of a pack of cigarettes at stores in a 3-mile buffer of participants' residences was \$4.74 at baseline (range \$3.28 to \$5.82) and \$6.74 (range \$4.18 to \$11.09) at year 10 (Table 2). An overall \$2 average inflation-adjusted increase aligns with other reports.^{47,48} The number of stores within the buffer remained fairly constant over time (median 4 or 5, range 1–34). Prices varied both within and between study sites; the ranges were typically widest in year 10. At baseline, 15% of participants lived in areas with a bar/restaurant smoking ban, which increased to 96% by year 10.

Longitudinal Associations of Cigarette Pack Price

In adjusted fixed-effects models (Table 3), a \$1 increase in cigarette price over the follow-up period was associated with a weak reduction in the risk of current smoking (3% reduction; risk ratio (RR): 0.97, 95% CI: 0.93, 1.0), adjusted for time-varying socio-demographic characteristics and neighborhood socioeconomic status. Stronger associations were found for heavy smoking and cessation: a \$1 increase in price over the follow-up period was associated with a 7% reduction in the risk of heavy smoking (RR: 0.93, 95% CI: 0.87, 0.99), and with a 20% increase in the likelihood of smoking cessation RR: 1.2, 95% CI: 0.99, 1.4). There was no clear association of price increase with smoking relapse (RR: 0.90, 95% CI: 0.62, 1.3). Adjustment for smoking bans had little impact on these estimates.

Among all smokers, the average change in $\ln(\text{number of cigarettes smoked per day})$ associated with a \$1 increase in price was -0.21 (95% CI: $-0.49, 0.06$) in the fully adjusted model (Table 4). The exponentiated coefficient reflects the ratio of geometric means (0.81, 95% CI: 0.61, 1.1) and can be interpreted as a 19% reduction in the average number of cigarettes smoked per day per \$1 increase. We found a stronger association among heavy baseline smokers (ratio of geometric means: 0.65, 95% CI: 0.45, 0.93) indicating a 35% reduction.

Bar and Restaurant Smoking Bans-Independent and Interactive Associations

The only outcome for which the smoking ban association was in the expected direction was heavy smoking, although the confidence interval was wide (Table 3, RR: 0.95, 95% CI: 0.82, 1.1). For the other outcomes, the association was in the opposite direction (Table 3–4) and all estimates had extremely wide confidence intervals, reflecting considerable uncertainty. In addition, there was no evidence of an interaction between cigarette prices and bans for any outcome (eTable 6).

Discussion

In a large cohort of U.S. adults, a \$1 increase in cigarette price was associated with an increase in smoking cessation, as well as a reduction in current smoking, heavy smoking, and the average number of cigarettes smoked per day by heavy baseline smokers. There were no clear associations of bar and restaurant smoking bans with smoking behavior changes, and confidence intervals were wide. We found no evidence of interactions between cigarette prices and bar/restaurant smoking ban policies on smoking outcomes.

Contributions of our study include the high spatial and temporal resolution in our data, thus enabling examination of small area price variation as well as within-person changes among the same people over time. In general, our findings corroborate prior work regarding prices and smoking outcomes. Most prior studies have used state-level prices (or taxes) and either individual-level repeat cross-sectional or aggregate time-series data to examine associations of price with smoking.⁵⁻¹² Our findings are consistent with those reported using less robust data and study designs; namely, that higher cigarette prices are associated with reductions in current smoking^{5,7-12,49} and reductions in smoking intensity.^{5-7,9-11,50} If we convert the results of our longitudinal models into price elasticities, the elasticities for current smoking and heavy smoking are -0.14 and -0.34, which fall on the lower end of the range reported by previous studies (-0.1 to -0.6).^{5-8,10-12,49} Only two longitudinal studies have previously examined the association of cigarette prices with smoking relapse.^{51,52} Those studies found higher prices were negatively associated with relapse, in contrast to our findings.

Our findings regarding the independent associations of cigarette prices and smoking bans in hospitality venues differ from a recent study by Vuolo et al (2016) where data from the National Longitudinal Survey of Youth (NLSY), a longitudinal cohort of young adults (aged 19-31 years) in the U.S., was linked to excise taxes and smoking ban policies.⁵³ In that study, taxes were negatively associated with heavy smoking but not current smoking, while we found negative associations between cigarette prices and both outcomes, although the association with heavy smoking was stronger. In the NLSY, smoking bans were negatively associated with current smoking (but not heavy smoking) while our study found no impact of bans on within-person change in smoking outcomes. The lack of hospitality ban associations in our study may be explained by differences in the age distributions of the study populations. Young adults frequent bars and restaurants more than older adults (MESA population aged 44-94),⁵⁴ leading to a higher level of exposure to bar/restaurant smoking bans. In addition, smoking behavior is likely more stable among older populations. Prior studies have found that older adults have lower rates of smoking behavior changes such as cessation and relapse compared to younger adults.⁵⁵⁻⁵⁷ Thus, changes to norms brought about by smoking bans may have less of an influence on older smokers than the economic pressures of cigarette price increases. It is also possible that smoking bans operate primarily through changing cultural norms related to smoking rather than through individual exposure. If this is the case, the stable unit-treatment value assumption (that individuals' outcomes depend only upon their own exposure)⁵⁸ may be violated, which is also a possible explanation for the null result. Finally, the relatively small number of participants with changes in both smoking ban exposure and smoking outcomes limited our power to detect associations and likely contributed to the imprecision of results.

As tobacco control strategies are often multi-faceted, it is important to identify whether policies have a synergistic effect in order to anticipate impact and inform future policy directions. Few studies have examined interactions between cigarette prices and smoking bans, limiting opportunities for comparison with our results. Using the previously described young adult sample, Vuolo et al (2016) found that cigarette excise taxes were negatively associated with current smoking only in cities without bar/restaurant smoking bans.⁵³ In our older adults sample we found no interaction for any outcome. Our results suggest that price is an important determinant of smoking behavior in this population, but the presence or absence of a smoking ban does not influence this association.

Strengths of this study include the longitudinal study design that enabled examination of within-person behavior change, a long follow-up period (10 years), a diverse sample with detailed covariate information including neighborhood SES, and the use of actual prices from stores geographically proximal to participants (rather than state average prices/taxes). However, this study had several limitations. First, the price dataset included only chain grocery and drug store prices. We were unable to include prices from other venues where people buy cigarettes including convenience stores or gas stations. However, prior research suggests that the difference in price between convenience stores and large chain stores is likely to be small.¹⁵ Second, small sample size may have limited our power to detect interactions between cigarette prices and smoking ban exposures. Third, it is possible that selection bias may have influenced results, as participants with less education and lower income were more likely to be lost to follow-up, and these individuals are more likely to smoke and to live in areas with lower cigarette prices. Fourth, smoking outcomes were based on self-report which might have led to underreporting due to recall and social desirability biases. However, prior validation work in MESA has indicated that self-reported smoking is a reliable measure consistent with serum and urinary cotinine concentrations.⁵⁴ Fifth, smoking was relatively uncommon in MESA given the study enrolled older adults who were free of cardiovascular disease (baseline smoking prevalence was 11% compared to 17% among 45–64 year olds and 8% of individuals 65 years or older in a representative survey of the U.S. population).² This limited the number of participants with changes to smoking outcomes over follow-up. Sixth, as the fixed-effects models for binary outcomes only include individuals with changes in exposure and outcome, results may not generalize to all individuals. While fixed-effects models reduce bias by controlling for all time-invariant characteristics, including those not measured, an important limitation of these models is loss of precision due to the reduction in sample size of including only participants with within-person change.⁵⁹ Finally, prior research suggests stricter tobacco policies may be more likely to be passed in areas with lower smoking rates,⁶⁰ leading to concerns about reverse causation. However, this is less of a concern with individual-level data, as an individuals' decision to smoke is unlikely to influence policymakers' decisions to enact tobacco control policies in a given area.^{61,62}

Conclusions

Among older U.S. adults, cigarette price increases over time were associated with reduced risk of current smoking and heavy smoking, a reduction in the number of cigarettes smoked per day by heavy baseline smokers, and an increase in smoking cessation. While both

smoking bans and cigarette excise taxes are increasingly common tobacco control tools, we found no evidence that smoking bans influenced behavior change in this population, or that the two policies had a synergistic effect. Results reinforce the importance of higher prices as a smoking deterrent among older adults.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors take sole responsibility for all data analyses, interpretation, and views expressed in this paper. Any errors in the manuscript are the sole responsibility of the authors, not of Information Resources Inc. (IRI, who supplied the pricing dataset). The authors thank the other investigators, the staff, and the participants of the Multi-Ethnic Study of Atherosclerosis (MESA) study for their valuable contributions. A full list of participating MESA investigators and institutions can be found at <http://www.mesa-nhlbi.org>. In addition, we thank Kari Moore for help with data preparation and Loni Philip Tabb for suggestions for the statistical analysis.

Funding: This research was partially supported by P60 MD002249-05 (from U.S. Department of Health and Human Services, National Institutes of Health [NIH], National Institute of Minority Health and Health Disparities) and R01 HL071759 (NIH, National Heart, Lung, and Blood Institute [NIH NHLBI]). Funding for the MESA parent study came from NIH NHLBI contracts: HHSN268201500003I, N01-HC-95159 through 95169 and from grants UL1-TR-000040 and UL1-TR-001079 (NIH, National Center for Research Resources).

References

1. U.S. Department of Health and Human Services. A Report of the Surgeon General. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2014. The Health Consequences of Smoking -- 50 Years of Progress.
2. Jamal A, King BA, Neff LJ, Whitmill J, Babb SD, Graffunder CM. Current Cigarette Smoking Among Adults - United States, 2005–2015. *MMWR Morb Mortal Wkly Rep*. 2016; 65(44):1205–1211. [PubMed: 27832052]
3. Chaloupka FJ, Yurekli A, Fong GT. Tobacco taxes as a tobacco control strategy. *Tob Control*. 2012; 21(2):172–80. [PubMed: 22345242]
4. Gallus S, Schiaffino A, La Vecchia C, Townsend J, Fernandez E. Price and cigarette consumption in Europe. *Tob Control*. 2006; 15(2):114–9. [PubMed: 16565459]
5. Tauras JA. Smoke-free air laws, cigarette prices, and adult cigarette demand. *Economic Inquiry*. 2006; 44(2):333–342.
6. Yurekli AA, Zhang P. The impact of clean indoor-air laws and cigarette smuggling on demand for cigarettes: an empirical model. *Health Econ*. 2000; 9(2):159–70. [PubMed: 10721017]
7. Townsend J, Roderick P, Cooper J. Cigarette smoking by socioeconomic group, sex, and age: effects of price, income, and health publicity. *BMJ*. 1994; 309(6959):923–7. [PubMed: 7950662]
8. DeCicca P, McLeod L. Cigarette taxes and older adult smoking: evidence from recent large tax increases. *J Health Econ*. 2008; 27(4):918–29. [PubMed: 18178277]
9. Dinno A, Glantz S. Tobacco control policies are egalitarian: a vulnerabilities perspective on clean indoor air laws, cigarette prices, and tobacco use disparities. *Soc Sci Med*. 2009; 68(8):1439–47. [PubMed: 19282078]
10. Farrelly MC, Bray JW, Pechacek T, Woollery T. Response by adults to increases in cigarette prices by sociodemographic characteristics. *Southern Economic Journal*. 2001; 68(1):156–165.
11. Franz GA. Price effects on the smoking behaviour of adult age groups. *Public Health*. 2008; 122(12):1343–8. [PubMed: 18951594]
12. Stehr M. The effect of cigarette taxes on smoking among men and women. *Health Econ*. 2007; 16(12):1333–43. [PubMed: 17335102]

13. Song AV, Dutra LM, Neilands TB, Glantz SA. Association of Smoke-Free Laws With Lower Percentages of New and Current Smokers Among Adolescents and Young Adults: An 11-Year Longitudinal Study. *JAMA Pediatr.* 2015; 169(9):e152285. [PubMed: 26348866]
14. Brock B, Choi K, Boyle RG, Moilanen M, Schillo BA. Tobacco product prices before and after a statewide tobacco tax increase. *Tob Control.* 2015
15. Hanson A, Sullivan R. The incidence of tobacco taxation: evidence from geographic micro-level data. *National Tax Journal.* 2009:677–698.
16. Harding M, Leibtag E, Lovenheim MF. The heterogeneous geographic and socioeconomic incidence of cigarette taxes: Evidence from Nielsen Homescan Data. *American Economic Journal: Economic Policy.* 2012; 4(4):169–198.
17. Halonen JI, Kivimäki M, Kouvonen A, Pentti J, Kawachi I, Subramanian SV, Vahtera J. Proximity to a tobacco store and smoking cessation: a cohort study. *Tob Control.* 2014; 23(2):146–51. [PubMed: 23436138]
18. Reitzel LR, Cromley EK, Li Y, Cao Y, Dela Mater R, Mazas CA, Cofta-Woerpel L, Cinciripini PM, Wetter DW. The effect of tobacco outlet density and proximity on smoking cessation. *Am J Public Health.* 2011; 101(2):315–20. [PubMed: 21164089]
19. Centers for Disease C, Prevention. State smoke-free laws for worksites, restaurants, and bars-- United States, 2000–2010. *MMWR Morb Mortal Wkly Rep.* 2011; 60(15):472–5. [PubMed: 21508923]
20. Brown A, Moodie C, Hastings G. A longitudinal study of policy effect (smoke-free legislation) on smoking norms: ITC Scotland/United Kingdom. *Nicotine Tob Res.* 2009; 11(8):924–32. [PubMed: 19541947]
21. Coady MH, Jasek J, Davis K, Kerker B, Kilgore EA, Perl SB. Changes in smoking prevalence and number of cigarettes smoked per day following the implementation of a comprehensive tobacco control plan in New York City. *J Urban Health.* 2012; 89(5):802–8. [PubMed: 22544658]
22. Frieden TR, Mostashari F, Kerker BD, Miller N, Hajat A, Frankel M. Adult tobacco use levels after intensive tobacco control measures: New York City, 2002–2003. *Am J Public Health.* 2005; 95(6): 1016–23. [PubMed: 15914827]
23. Hahn EJ, Rayens MK, Butler KM, Zhang M, Durbin E, Steinke D. Smoke-free laws and adult smoking prevalence. *Prev Med.* 2008; 47(2):206–9. [PubMed: 18519154]
24. Kilgore EA, Mandel-Ricci J, Johns M, Coady MH, Perl SB, Goodman A, Kansagra SM. Making it harder to smoke and easier to quit: the effect of 10 years of tobacco control in New York City. *Am J Public Health.* 2014; 104(6):e5–8.
25. Bader P, Boisclair D, Ferrence R. Effects of tobacco taxation and pricing on smoking behavior in high risk populations: a knowledge synthesis. *Int J Environ Res Public Health.* 2011; 8(11):4118–39. [PubMed: 22163198]
26. Bronnenberg BJ, Kruger MW, Mela CF. Database paper - The IRI marketing data set. *Marketing Science.* 2008; 27(4):745–748.
27. Espinosa J, Evans WN. Excise taxes, tax incidence, and the flight to quality: evidence from scanner data. *Public Finance Review.* 2012 1091142112460724.
28. United States Department of Labor BoLS. [Accessed July 9, 2015] Consumer Price Index. <http://www.bls.gov/cpi/data.htm>
29. Chiou L, Muehlegger E. Crossing the Line: Direct Estimation of Cross-Border Cigarette Sales and the Effect on Tax Revenue. *B E Journal of Economic Analysis & Policy.* 2008; 8(1)
30. Drewnowski A, Aggarwal A, Hurvitz PM, Monsivais P, Moudon AV. Obesity and supermarket access: proximity or price? *Am J Public Health.* 2012; 102(8):e74–80. [PubMed: 22698052]
31. Fuller D, Cummins S, Matthews SA. Does transportation mode modify associations between distance to food store, fruit and vegetable consumption, and BMI in low-income neighborhoods? *Am J Clin Nutr.* 2013; 97(1):167–72. [PubMed: 23193006]
32. Michimi A, Wimberly MC. Associations of supermarket accessibility with obesity and fruit and vegetable consumption in the conterminous United States. *Int J Health Geogr.* 2010; 9:49. [PubMed: 20932312]
33. Pearce J, Day P, Witten K. Neighbourhood Provision of Food and Alcohol Retailing and Social Deprivation in Urban New Zealand. *Urban Policy and Research.* 2008; 26(2):213–227.

34. Centers for Disease Control and Prevention. [Accessed June 22, 2016] National Health Interview Survey: Questionnaires, Datasets, and Related Documentation- Adult Tobacco Use Questions. http://www.cdc.gov/nchs/nhis/tobacco/tobacco_questions.htm
35. National Cancer Institute. [Accessed June 22, 2016] Health Information National Trends Survey- Tobacco Use. <http://hints.cancer.gov/question-details.aspx?qid=810>
36. Cohen-Mansfield J. Smoking and mortality among persons aged 75–94. *Prev Med.* 2013; 56(3–4): 185–9. [PubMed: 23274589]
37. Peters SA, Huxley RR, Woodward M. Smoking as a risk factor for stroke in women compared with men: a systematic review and meta-analysis of 81 cohorts, including 3,980,359 individuals and 42,401 strokes. *Stroke.* 2013; 44(10):2821–8. [PubMed: 23970792]
38. Diez Roux AV, Merkin SS, Arnett D, Chambless L, Massing M, Nieto FJ, Sorlie P, Szklo M, Tyroler HA, Watson RL. Neighborhood of residence and incidence of coronary heart disease. *N Engl J Med.* 2001; 345(2):99–106. [PubMed: 11450679]
39. American Nonsmokers Rights Foundation (ANRF). [Accessed February 12, 2017] US Tobacco Control Laws Database. ANRF website. <http://www.no-smoke.org/document.php?id=313>
40. Farrelly MC, Evans WN, Sfeekas AE. The impact of workplace smoking bans: results from a national survey. *Tob Control.* 1999; 8(3):272–7. [PubMed: 10599571]
41. Missouri Census Data Center. [Accessed February 12, 2017] MABLE/Geocorr[12], Version 1.2: Geographic Correspondence Engine. <http://mcdc.missouri.edu/websas/geocorr12.html>
42. Allison, PD. Quantitative Applications in the Social Sciences. 1. Vol. 160. Thousand Oaks, CA: SAGE Publications; 2009. Fixed Effects Regression Models.
43. Hajat A, Allison M, Diez-Roux AV, Jenny NS, Jorgensen NW, Szpiro AA, Vedal S, Kaufman JD. Long-term exposure to air pollution and markers of inflammation, coagulation, and endothelial activation: a repeat-measures analysis in the Multi-Ethnic Study of Atherosclerosis (MESA). *Epidemiology.* 2015; 26(3):310–20. [PubMed: 25710246]
44. Schinasi L, Horton RA, Guidry VT, Wing S, Marshall SW, Morland KB. Air pollution, lung function, and physical symptoms in communities near concentrated Swine feeding operations. *Epidemiology.* 2011; 22(2):208–15. [PubMed: 21228696]
45. Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol.* 2004; 159(7):702–6. [PubMed: 15033648]
46. Allison, PD. Fixed Effects Regression Methods for Longitudinal Data Using SAS. Cary, NC: SAS Institute; 2005.
47. Campaign for Tobacco-Free Kids. [Accessed January 26, 2017] Trends in Average State Cigarette Tax Rates. <https://www.tobaccofreekids.org/research/factsheets/pdf/0211.pdf>
48. Campaign for Tobacco-Free Kids. [Accessed January 27, 2017] Cigarette Tax Increases by State per Year 2000–2017. <https://www.tobaccofreekids.org/research/factsheets/pdf/0275.pdf>
49. Siahpush M, Wakefield MA, Spittal MJ, Durkin SJ, Scollo MM. Taxation reduces social disparities in adult smoking prevalence. *Am J Prev Med.* 2009; 36(4):285–91. [PubMed: 19201146]
50. Farrelly MC, Nimsch CT, Hyland A, Cummings M. The effects of higher cigarette prices on tar and nicotine consumption in a cohort of adult smokers. *Health Econ.* 2004; 13(1):49–58. [PubMed: 14724893]
51. Shang C. The effect of smoke-free air law in bars on smoking initiation and relapse among teenagers and young adults. *Int J Environ Res Public Health.* 2015; 12(1):504–20. [PubMed: 25584419]
52. Tabuchi T, Fujiwara T, Shinozaki T. Tobacco price increase and smoking behaviour changes in various subgroups: a nationwide longitudinal 7-year follow-up study among a middle-aged Japanese population. *Tob Control.* 2016
53. Vuolo M, Kelly BC, Kadowaki J. Independent and Interactive Effects of Smoking Bans and Tobacco Taxes on a Cohort of US Young Adults. *Am J Public Health.* 2016; 106(2):374–80. [PubMed: 26691133]
54. Pew Research Center. Eating More; Enjoying Less. Washington, D.C: Pew Research Center; 2006.
55. Quitting smoking among adults--United States, 2001–2010. *MMWR Morb Mortal Wkly Rep.* 2011; 60(44):1513–9. [PubMed: 22071589]

56. Husten CG, Shelton DM, Chrismon JH, Lin YC, Mowery P, Powell FA. Cigarette smoking and smoking cessation among older adults: United States, 1965–94. *Tob Control*. 1997; 6(3):175–80. [PubMed: 9396100]
57. Weinberger AH, Pilver CE, Mazure CM, McKee SA. Stability of smoking status in the US population: a longitudinal investigation. *Addiction*. 2014; 109(9):1541–53. [PubMed: 24916157]
58. Little RJ, Rubin DB. Causal effects in clinical and epidemiological studies via potential outcomes: concepts and analytical approaches. *Annu Rev Public Health*. 2000; 21:121–45. [PubMed: 10884949]
59. Kaufman JS. Commentary: Why are we biased against bias? *Int J Epidemiol*. 2008; 37(3):624–6. [PubMed: 18316349]
60. Carton TW, Darden M, Levendis J, Lee SH, Ricket I. Comprehensive indoor smoking bans and smoking prevalence: evidence from the BRFSS. *American Journal of Health Economics*. 2016; 2(4):535–556.
61. Chaloupka F. Clean Indoor Air Laws, Addiction and Cigarette-Smoking. *Applied Economics*. 1992; 24(2):193–205.
62. Wasserman J, Manning WG, Newhouse JP, Winkler JD. The effects of excise taxes and regulations on cigarette smoking. *J Health Econ*. 1991; 10(1):43–64. [PubMed: 10112149]

Characteristics of Participants in the Analytic Sample, Smokers from The Multi-Ethnic Study of Atherosclerosis 2000–2012 (N=632 total)^a

Table 1

	Year 0, Exam 1	Year 2, Exam 2	Year 3, Exam 3	Year 5, Exam 4	Year 10, Exam 5
N	458	530	525	477	352
Demographic Characteristics					
Mean age (SD)	57.7 (9.1)	58.9 (8.7)	60.5 (8.8)	62.0 (8.9)	65.2 (8.0)
Gender (%)					
Male	248 (54)	279 (53)	278 (53)	254 (53)	182 (52)
Female	210 (46)	251 (47)	247 (47)	223 (47)	170 (48)
Race (%)					
White	163 (36)	207 (39)	212 (40)	196 (41)	143 (41)
Chinese	38 (8)	42 (8)	39 (8)	31 (7)	18 (5)
Black/African American	117 (25)	131 (25)	137 (26)	121 (25)	91 (26)
Hispanic	140 (31)	150 (28)	137 (26)	129 (27)	100 (28)
Education (%)					
High school graduate or less	186 (41)	199 (38)	195 (37)	173 (36)	125 (35)
Some college	170 (37)	196 (37)	193 (37)	178 (37)	133 (38)
Bachelor's or Graduate degree	102 (22)	135 (25)	137 (26)	126 (27)	94 (27)
Currently employed (%)	274 (60)	325 (61)	302 (58)	263 (55)	179 (51)
Mean per capita household income, \$10k (SD) ^b	2.5 (2.1)	2.5 (2.0)	2.4 (1.9)	2.4 (1.8)	2.3 (1.6)
Currently married (%)	261 (57)	303 (57)	317 (60)	293 (61)	201 (57)
Health Behaviors					
Current Alcohol Use (%)	317 (69)	335 (63)	318 (61)	285 (60)	199 (57)
Smoking Status (%)					
Current smoker	400 (87)	426 (80)	406 (77)	343 (72)	205 (58)
Former smoker	49 (11)	103 (20)	118 (23)	134 (28)	147 (42)
Never smoker	9 (2)	1 (0)	1 (0)	0 (0)	0 (0)
Mean number of cigarettes smoked per day (SD)	11.4 (10.1)	9.2 (9.1)	9.5 (9.7)	8.5 (9.3)	8.1 (20.4)
Heavy smokers (10 cigarettes per day)	236 (52)	254 (48)	242 (46)	192 (40)	106 (30)

	Year 0, Exam 1	Year 2, Exam 2	Year 3, Exam 3	Year 5, Exam 4	Year 10, Exam 5
Quit since last exam (% of ever smokers) ^c	---	63 (12)	56 (11)	61 (13)	78 (22)
Smoking relapse (% of ever smokers) ^d	---	23 (4)	33 (6)	32 (7)	23 (7)
Area-level Characteristics					
Mean neighborhood socioeconomic score (SD)	-1.3 (6.1)	-0.7 (5.9)	0.2 (5.4)	1.3 (4.7)	0.4 (4.2)
Baseline Study Site					
North Carolina	52 (11)	63 (12)	62 (12)	57 (12)	43 (12)
New York	108 (24)	111 (21)	99 (19)	94 (20)	84 (24)
Maryland	35 (8)	57 (11)	57 (11)	52 (11)	35 (10)
Minnesota	133 (29)	147 (28)	147 (28)	137 (29)	105 (30)
Illinois	46 (10)	49 (9)	58 (11)	51 (10)	36 (10)
California	84 (18)	103 (19)	102 (19)	86 (18)	49 (14)

^a Only participants who lived within a 3-mile radius of a store in the Information Resources Inc. Academic Dataset were included in the analytic sample for each exam year. Other inclusion criteria included reporting being a current smoker during at least one exam, and complete data on main outcomes, exposures, and covariates.

^b Income adjusted for inflation to 2010 US Dollars

^c Quitting defined as being a non-smoker at the current exam and a current smoker at the previous exam

^d Relapse defined as being a current smoker at the current exam and a former smoker at the previous exam

Table 2

Participant Exposure to Cigarette Prices at Stores and Bar/Restaurant Smoking Ban Policies, The Multi-Ethnic Study of Atherosclerosis 2000–2012 (N=632)^{a, b}

	Year 0	Year 2	Year 3	Year 5	Year 10
Exposure to Stores^b					
Median # stores (range)	5 (1–34)	5 (1–34)	4 (1–34)	5 (1–34)	5 (1–34)
Mean price of pack of cigarettes across all stores nearby participant residences (SD)	\$4.74 (\$0.59)	\$5.10 (\$1.04)	\$4.82 (\$1.11)	\$5.14 (\$1.02)	\$6.74 (\$1.64)
Range	\$3.28–\$5.82	\$3.12–\$7.65	\$2.98–\$7.37	\$3.12–\$7.71	\$4.18–\$11.09
By Baseline Study Site:					
North Carolina- Mean (SD)	\$3.78 (\$0.45)	\$3.78 (\$0.43)	\$3.53 (\$0.45)	\$3.74 (\$0.42)	\$4.96 (\$0.51)
Range	\$3.28–\$4.58	\$3.12–\$4.67	\$2.98–\$4.25	\$3.12–\$4.38	\$4.31–\$5.76
New York- Mean (SD)	\$5.16 (\$0.22)	\$6.69 (\$0.61)	\$6.44 (\$0.59)	\$6.30 (\$0.59)	\$8.06 (\$2.06)
Range	\$4.18–\$5.49	\$5.88–\$7.65	\$5.58–\$7.37	\$5.44–\$6.97	\$5.21–\$11.09
Maryland- Mean (SD)	\$4.64 (\$0.28)	\$4.89 (\$0.24)	\$4.72 (\$0.16)	\$4.60 (\$0.14)	\$6.98 (\$0.65)
Range	\$3.95–\$5.16	\$4.56–\$5.34	\$4.44–\$5.06	\$4.12–\$4.87	\$6.27–\$7.95
Minnesota- Mean (SD)	\$4.32 (\$0.10)	\$4.29 (\$0.14)	\$3.78 (\$0.07)	\$4.73 (\$0.42)	\$6.01 (\$0.14)
Range	\$4.13–\$4.73	\$3.88–\$4.70	\$3.57–\$3.92	\$3.88–\$5.40	\$5.54–\$6.12
Illinois- Mean (SD)	\$5.52 (\$0.31)	\$5.65 (\$0.24)	\$5.79 (\$0.41)	\$6.74 (\$0.42)	\$8.83 (\$0.70)
Range	\$4.50–\$5.82	\$4.89–\$5.98	\$4.29–\$6.62	\$5.44–\$7.71	\$7.21–\$9.44
California- Mean (SD)	\$5.08 (\$0.31)	\$5.22 (\$0.24)	\$5.06 (\$0.23)	\$4.81 (\$0.32)	\$5.82 (\$0.57)
Range	\$4.49–\$5.70	\$4.75–\$5.63	\$4.47–\$5.58	\$4.09–\$5.44	\$5.01–\$7.24
Exposure to Smoking Ban Policies^c					
Exposed to bar/restaurant smoking ban (%)	68 (15)	102 (19)	165 (31)	178 (37)	338 (96)

^a All prices adjusted for inflation to 2010 U.S. dollars

^b Prices came from stores within 3 miles of participant residential addresses. Mean prices for each study site in years 2–10 calculated from only those participants who still lived in the counties from which participants were recruited in a given follow-up year (N=458 in year 0, 530 in year 2, 523 in year 3, 472 in year 5, 347 in year 10)

^c Participants were considered exposed smoking ban policies if they lived in a census block group within a state, county, or locality with legislation prohibiting smoking in all bars and restaurants without exceptions (“100% bar/restaurant bans”). Exposure was lagged by 1 year to ensure that smoking ban legislation preceded smoking outcome ascertainment.

Table 3

Associations of Cigarette Pack Price and Exposure to Bar/Restaurant Smoking Ban Policies (Yes/No) and Within-Person Change in Smoking Outcomes, The Multi-Ethnic Study of Atherosclerosis 2000–2012

Smoking Outcomes and Exposures	Adjusted Risk Ratio ^a (95% Confidence Interval)		
	Model 1	Model 2	Model 3
A. Current smoking (current versus not current). N=578			
\$1 increase in cigarette price	0.97 (0.93, 1.0)	---	0.97 (0.93, 1.0)
Smoking ban policy exposure (yes versus no) ^b	---	1.0 (0.92, 1.1)	1.0 (0.94, 1.1)
B. Heavy smoking (≥ 10 cigarettes per day versus <10). N=344			
\$1 increase in cigarette price	0.93 (0.87, 0.99)	---	0.94 (0.88, 0.99)
Smoking ban policy exposure (yes versus no) ^b	---	0.90 (0.78, 1.1)	0.95 (0.82, 1.1)
C. Smoking Cessation (versus not quitting) N=238			
\$1 increase in cigarette price	1.2 (0.99, 1.4)	---	1.2 (0.99, 1.4)
Smoking ban policy exposure (yes versus no) ^b	---	0.90 (0.54, 1.5)	0.90 (0.54, 1.5)
D. Relapse (versus no relapse). N=109			
\$1 increase in cigarette price	0.90 (0.62, 1.3)	---	0.89 (0.61, 1.3)
Smoking ban policy exposure (yes versus no) ^b	---	1.1 (0.50, 2.6)	1.2 (0.5, 2.6)

^aRisk ratios were estimated using fixed-effects Poisson models with robust variance estimates only including participants with a change in the outcome over the follow-up period. Secular time trend was adjusted for by including a term for time since baseline (in years) in all models, and a quadratic term (time-squared) for quitting and relapse. We also adjusted for time-varying income, marital status, employment status, current alcohol use, and time-varying neighborhood socioeconomic status. Additional adjustment included a sex*time interaction term in heavy smoking models and a race*time interaction in smoking cessation models; see Methods.

^bSmoking ban exposure was lagged by 1 year to establish temporality by ensuring that policy implementation preceded outcome measurement.

Table 4

Associations of Cigarette Pack Price and Exposure to Bar/Restaurant Smoking Ban Policies (Yes/No) and Within-Person Change in Smoking Intensity, The Multi-Ethnic Study of Atherosclerosis 2000–2012^a

Exposures	Model 1	Model 2	Model 3	Exponentiated Coefficient [Reflecting Ratio of Geometric Means] ^c (95% Confidence Interval)	Model 1	Model 2	Model 3
Among Participants Who Ever Smoked During Follow-up (N=632)							
\$1 increase in cigarette price	-0.21 (-0.49, 0.07)	---	-0.21 (-0.49, 0.06)	0.81 (0.61, 1.1)	---	---	0.81 (0.61, 1.1)
Smoking ban policy exposure	---	-0.06 (-0.76, 0.63)	0.08 (-0.60, 0.77)	---	0.94 (0.47, 1.9)	---	1.1 (0.55, 2.2)
Among Heavy Baseline Smokers (Smoked 10 cigarettes per day at baseline, N=326)							
\$1 increase in cigarette price	-0.37 (-0.74, 0.00)	---	-0.43 (-0.79, -0.07)	0.69 (0.48, 1.0)	---	---	0.65 (0.45, 0.93)
Smoking ban policy exposure	---	0.25 (-0.62, 1.1)	0.58 (-0.28, 1.4)	---	1.3 (0.54, 3.1)	---	1.8 (0.76, 4.2)
Among Light Baseline Smokers (Smoked <10 cigarettes per day at baseline, N=306)							
\$1 increase in cigarette price	-0.11 (-0.51, 0.29)	---	-0.10 (-0.50, 0.31)	0.90 (0.60, 1.3)	---	---	0.90 (0.61, 1.4)
Smoking ban policy exposure	---	-0.22 (-1.3, 0.82)	-0.16 (-1.2, 0.88)	---	0.80 (0.29, 2.3)	---	0.85 (0.30, 2.4)

^a Estimated using linear regression with subject fixed effects. Models adjusted for time since baseline (years) and time-varying income, marital status, employment status, current alcohol use, and neighborhood socioeconomic status. Model includes all participants who smoked at some point during the follow-up period. Smoking intensity coded as 0 at exams where these participants reported not being current smokers.

^b Smoking intensity (the number of cigarettes smoked per day by participants who ever reported smoking during follow-up) was natural log-transformed due to a skewed distribution. Baseline smoking level (heavy versus light) was based on each participant's self-reported smoking intensity at their first exam included in the analysis.

^c Exponentiated coefficient from fixed-effects model indicates the ratio of geometric means, interpreted as the % reduction in the mean number of cigarettes per day associated with a \$1 increase in cigarette price. E.g. a \$1 cigarette pack price increase was associated with a 19% reduction in the mean number of cigarettes smoked per day among all smokers.