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Original Investigation

Cigarette Pack Price and Its Within-Person Association With Smoking Initiation, Smoking Progression, and Disparities among Young Adults

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Abstract

Background: There is a dearth of research on within-person relationships between tobacco price and cigarette smoking initiation and progression in young adulthood. This project examines the within-person association between cigarette pack price and smoking initiation and progression between age 18 and 21/22, focusing on differences across subgroups.

Methods: Data came from the longitudinal Monitoring the Future (MTF) project. MTF examines drug use behaviors with nationally representative samples of 12th graders annually. Subsamples of 12th graders are annually selected and followed longitudinally. Among 12th graders from baseline years 2000–2014, we examined past 30-day cigarette smoking initiation among baseline never smokers (N = 15 280) and progression to daily smoking among youth who were not daily smokers at baseline (N = 26 998). We used hierarchical logistic regression and interaction terms to assess differences across sex, race/ethnicity, and parental education.

Results: The within-person relationship between pack price and smoking indicated that a one-dollar increase in pack price corresponded with a 72% decrease in the odds of initiation (AOR = 0.28, 95% CI = 0.18, 0.44) and 70% decrease in the odds of progression to daily smoking (AOR = 0.30, 95% CI = 0.21, 0.44). There was a linear age trend for both smoking initiation and progression. There were no statistically significant interactions between price and demographics, making it difficult to disentangle differences across subgroups.

Conclusions: Exposure to increased cigarette prices during young adulthood was associated with lower odds of cigarette smoking initiation and progression. Additional policies and programs beyond cigarettes prices could help reduce tobacco-related disparities in smoking initiation and progression among young adults.

Implications: There is a strong, within-person relationship between cigarette prices and smoking initiation and progression during the transition to young adulthood: higher prices are associated with decreased odds of both initiation and progression. Cigarette taxation can help to prevent smoking initiation and progression among youth, but it is less clear how taxes are associated with disparities in smoking experienced by certain subgroups. We could not draw definitive conclusions about the impact of cigarette prices on tobacco-related disparities. Tobacco taxes should be increased on a regular basis to ensure young adults experience within-person increases in prices, and complementary programs geared toward reducing tobacco-related disparities among young adults should be promoted.

Introduction

Despite declines in cigarette smoking,[1,2] cigarette smoking initiation and progression to regular smoking is increasingly occurring in young adulthood (between ages 18 and 21).[3–7] Moreover, e-cigarette use among youth has reach epidemic proportions, and e-cigarette use is associated with future combustible cigarette use, even among youth with no intention of future cigarette smoking.[8–11] Preventing smoking initiation and progression in young adulthood is now a pressing public health concern, as smoking in young adulthood can lead to prolonged use and long-term health consequences.[5] Research is particularly needed on policies that reduce the likelihood of smoking initiation and progression among young adults (YA).[12]

Smoking trajectories among YAs differ by sex, race/ethnicity, and socioeconomic status (SES),[1,13,14] leading certain subgroups to be disproportionately affected by the tobacco epidemic.[10] Specifically, YA males, non-Hispanic White YAs, and low-SES YAs are important subgroups to examine. Males are more likely to initiate smoking and progress to daily smoking in young adulthood relative to females.[1,4] Non-Hispanic Whites are also more likely to progress to more frequent smoking in young adulthood compared with non-Hispanic Black YAs.[1,4,14,15] In terms of SES, YAs whose parents had lower levels of education are more likely to progress to more frequent smoking compared with YAs whose parents had higher levels of education.[4,14,16] Mechanisms for these disparities include stress, access to health information, differential levels of human capital, neighborhood effects, and the influence of social networks.[10] Research is needed to evaluate whether policies are likely to exacerbate or reduce tobacco-related disparities among YAs.

One policy that continues to have a major impact on cigarette smoking is tobacco taxation and price.[17,18] However, there is a dearth of research on tobacco prices that has examined *within-person* association between pack price and smoking during the critical age range from adolescence into young adulthood when smoking initiation and progression is increasingly likely to occur. Within-person associations are important because individuals may be exposed to new prices relative to their "typical" price level, and because prices can increase or decrease from an individuals' typical price exposure due to policy changes. Yet we know more about between-person associations (eg, price elasticity) regarding price changes than within-person associations.

Moreover, limited research has examined how within-person relationships vary across YA subgroups.[12,14] Research is needed on how tobacco taxes may prevent smoking initiation and progression among YAs,[5,12] particularly among certain subgroups. Cigarette taxation can help to prevent smoking initiation and progression among youth,[19] but taxes may not be effective at reducing disparities in smoking experienced by certain subgroups.[12,20] Additionally, there are few nationally representative and longitudinal studies conducted since 2000 that have examined the impact of price on smoking initiation and progression in young adulthood.[4,5,12] Most research has used data from before the 1997 Master Settlement Agreement (MSA), which is before the MSA prohibited the targeting of youth by tobacco companies,[21] or used repeated cross-sectional analyses compared with longitudinal analyses of within-person price change.

Current Study

This project utilizes longitudinal data (from 12th graders at modal age 18 in 2000–2014) from the Monitoring the Future (MTF) project.[22,23] We expand on a previous research project,[12] which examined how pack price at age 18 was prospectively associated with smoking initiation and progression at age 19/20. This previous research focused strictly on between-person differences in pack price, and it did not examine within-person/time-varying associations across the critical age range of 18–21/22. In order to address the gap in research on within-person associations between pack price and initiation and progression during the transition to young adulthood, in the current study, we examine how within-person change in the (state-level) cigarette prices to which young adults are exposed are related to change in cigarette smoking initiation and progression between ages 18 and 21/22 among a national sample. We focus on ages 18–21/22 because initiation and changes in smoking trajectories are most likely to occur before age 22 and therefore policies during this age could have a large impact on smoking. We also examine whether the within-person relationship between cigarette prices and smoking initiation and progression in young adulthood differs by sex, race/ethnicity, and parental education.

Methods

Data and Sample

Data came from the Monitoring the Future (MTF) study, which is a national, repeated cross-sectional and prospective study of drug use with nationally representative samples of 12th graders from the contiguous United States. For the prospective study, half of participants were randomly selected for follow-up that begins 1 year after 12th grade (modal age 19); they are surveyed biennially through modal age 29. The other half of the participants are surveyed 2 years after 12th grade (modal age 20); they are then surveyed biennially through modal age 30. We examined participants who were eligible to participate in the MTF longitudinal study for three waves, and only include data from baseline to follow-up 2 (baseline, modal age 19/20, and modal age 21/22). More details about the MTF study design are provided in previous publications.[2,22,23] Approximately 2450 students are selected annually from each 12th-grade sample to complete follow-up surveys, and substance users are oversampled.[23] The current study uses data from participants who participated in

baseline years of 2000–2014. We restricted our sample in two ways for the analyses: for cigarette smoking initiation analyses, we examined baseline never smokers (no smoking reported in lifetime); for smoking progression, we examined participants who were not daily smokers at baseline (never [56.8], previous/not current [30.7%], and current nondaily smokers [12.5%]).

Cigarette Smoking Outcomes

For smoking initiation, we examined past 30-day smoking (0 = no vs 1 = smoked at least one cigarette), and for daily smoking, we examined smoking at least one cigarette per day (0 = none or nondaily smoking vs 1 = smoked at least 1 cigarette per day).[12]

Cigarette Pack Price

Cigarette price was based on average cost per cigarette pack, in constant dollars (adjusted for inflation), by state.[24] These data were updated by extrapolating and imputing data for years after 2016. Because MTF surveys are collected in the spring and average pack prices are measured on November 1, we used an average before and after each respondent's survey. We use cigarette prices instead of taxes because they are the focus of consumer behavior and because the impact of taxes tends to depend on whether cigarette prices actually change in response to taxes.[25,26] We focus on within-person change in pack price, and include a measure that captures pack price on a given year (ie, baseline, follow-up 1, follow-up 2). We also include an average price measure at the individual level that captures average price across the study period (see Analytic Strategy).

Modal Age/Follow-up Number

Analyses included a measure for the modal age/follow-up number (0 = baseline, 1 = modal age 19/20 or follow-up 1, 2 = modal age 21/22 or follow-up 2), which assessed the age trend.

Demographic Characteristics

Demographics included baseline self-reported sex (male = 1, female = 0), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, non-Hispanic Asian, and non-Hispanic Other), and parental education (highest education of either parent: high school/GED or less, some college, or college degree or more). We also included a time-varying measure of whether participants were full-time students or not (1 = full-time student, 0 = other). These were the main demographics of interest that were available in the MTF study.

Covariates

We included census region, and state percent of non-Hispanic Black, Hispanic, and living below the poverty line. There are potential regional differences in smoking and tobacco policy.[27] Replicating previous research with national data,[28] four census regions were included as time-varying dummy variables (Northeast, Midwest, South, and West). Time-varying percent Black and Hispanic populations for each state were calculated using Survey of Epidemiology and End Results (SEER) population estimates.[29] To control for the tobacco policy environment, we included baseline percentage of residents covered by smoke-free workplace and hospitality laws at the county level using data from the American Nonsmokers' Rights Foundation.[30] Additional covariates (eg, unemployment rate) were not included due to multicollinearity.

Analytic Sample, Missing Data, and Weights

The unweighted sample sizes at baseline for initiation and progression analytic samples were, respectively, 15 280 and 26 998. Due to attrition, the sample sizes for initiation at modal age 19/20 and 21/22 were 8291 and 7633, respectively; and 13 816 and 12 641 for progression analytic sample (see Figure 1). The attrition rate for initiation and progression samples were, respectively, 50.1% and 53.2%. There were two sources of missing data: person-level sample attrition and item-level missing data on covariates. List-wise deletion was used for item-level missing data. No covariate had more than 5% item-level missing data, and less than 10% of the sample was removed due to missing data on covariates for both initiation and progression samples. Attrition weights are recommended for accounting for person-level sample attrition in the MTF longitudinal study, as MTF attrition weights take into account predictors of attrition and key outcomes, as well as the complex survey design.[31–33]

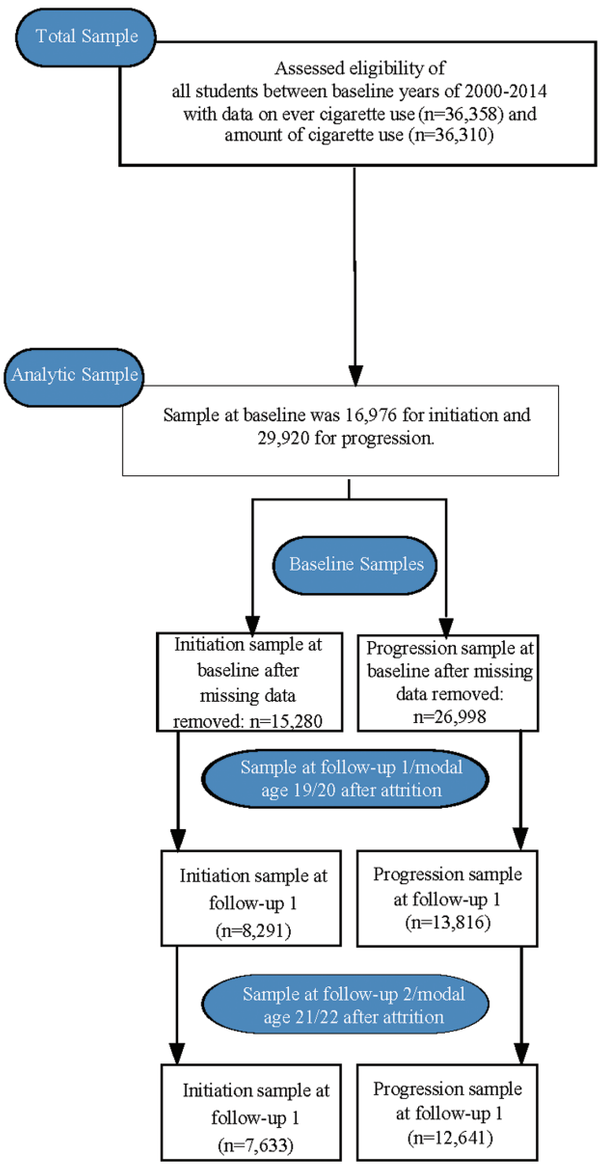

Figure 1. Diagram for longitudinal sample.

Other methods for addressing nonresponse bias, such as full information maximum likelihood and multiple imputation, are not independently sufficient for adequately addressing nonresponse bias in the longitudinal MTF study. Attrition weights were calculated as the inverse of the probability of participation at a given follow-up based on covariates measured at age 18: gender, race/ethnicity, college plans, truancy, high school grades, number of parents in the home, religiosity, parental education, substance use, region, cohort, and sampling weight. The weight also adjusted for oversampling of age 18 substance users.

In sum, we accounted for the weighting and complex sample design using design-based pseudo-maximum likelihood estimators for multistage generalized linear mixed models[34]; first-stage individual weights were given by each individual's baseline weight (accounting for initial participation), whereas conditional wave-level weights (accounting for dropout) were computed by dividing case weights by each individual's baseline weight. Consequently, analyses accounted for attrition and nonresponse bias, and the complex stratified survey design of the MTF study.[6,12,23] Analyses also allowed for partial data.

Analytic Strategy

We used hierarchical logistic regression models.[35] The purpose of the two-level hierarchical models was to assess change in odds of smoking in relation to within-person change in cigarette prices. Our primary interest was in the within-person relationship between pack price and smoking initiation and progression, and these methods allowed us to obtain an estimate that strictly captured within-person change in pack price.

Overall Model Specification

Hierarchical models account for multiple observations per person as nested data points, primarily by allowing for residual variance at both levels of observation (time and individuals) and by analyzing time and individuals as separate levels of data.[35] Our hierarchical models included within-person and between-persons equations, estimated simultaneously. The following equation represents the within-person models used in our analysis:

$$Y_{ij} = \beta_{0,i} + \beta_{1,i}T_{ij} + \beta_{2,i}X_{ij} + \beta_{3,i}X_{ij} + \ldots + r_{ij}$$

where i is the subscript for individual persons, j is the index for observations. $\beta_{0,i}$ is the intercept for individual i, and r_{ij} corresponds to unexplained variance. T is a measure of time and $\beta_{1,i}$ indicates the overall age trend for smoking (modal age/follow-up). X is a time-varying explanatory variable—for example, $\beta_{2,i}X_{ij}$ represents the within-person association between pack price and smoking. All subsequent coefficients represent the association for time-varying covariates, which included student status, census region, and state demographic information. The individual-level parameters from the within-person model serve as dependent variables for the between-person model, generating separate equations for each parameter:

$$\begin{aligned}\beta_{0,i} &= \gamma_{0,0} + u_{0,i}\\ \beta_{1,i} &= \gamma_{1,0}\\ \beta_{2,i} &= \gamma_{2,0} + u_{2,i}\\ &\ldots\end{aligned}$$

In our models, the γ parameters represent average levels of the respective parameters from the within-person models, including individual-level intercepts, age trend, and effects for time-varying explanatory variables. The errors terms associated with the between-persons model ($u_{0,i}$ and $u_{2,i}$) treats $\beta_{0,i}$ and $\beta_{2,i}$ as random effects. Our models included error terms that allowed for random variation in the form of individual differences in smoking and the relationship between time-level pack price and the odds of smoking (random intercepts and slopes). In our final models we included time-invariant variables at level 2 (predicting intercepts), which included sex, race/ethnicity, and parental education, and covariates for other tobacco policies.

Since our outcomes are binary smoking measures, we used two-level hierarchical logistic models. Consequently, the within-person equation reflects the log-odds of smoking in a given survey year. Between-person coefficients also therefore reflect average values of logistic coefficients. Since the logistic model is inherently probabilistic, the within-person model does not include an error term. The equations presented here therefore still accurately depict our between-person equation even with the logistic within-person equation.

Within-Person Estimates

We separated the within- and between-person pack price by (1) group-mean centering the within-person pack price measure (included at the time level, capturing total within-person association) and (2) including average pack price across the study period at the individual level (and including average pack price at the individual level, capturing total between-person association).[35] Values for pack price in previous equations represent deviations from each individual's mean in pack price across the study period ($X*_{ij} = X_{ij} - \overline{X}_i$), and the individual mean in pack price was included in the level 2 equation ($\beta_{0,i} = \gamma_{0,0} + \gamma_{0,1}\overline{X}_i + u_{0,i}$).

We used a univariate model,[36] as we were interested in the subject-level means for the three time points in the current study and sample (within-person prices for YAs, adjusting for their observed mean). We did not envision additional factors impacting the observed mean, and the cluster size is larger than cutoffs needed for reducing bias; thus, centering based on the observed mean has potential error, but it fits our research questions.[36]

We first ran models to examine smoking initiation and progression and the within-person relationship with pack price, controlling for covariates. We then examined multiplicative interaction terms between pack price at the time level and time-invariant sex, race/ethnicity, and parental education in separate models, adjusting for all covariates. For parental education and race/ethnicity, we examined interactions using joint F tests. We further tested interaction effects on the additive scale by predicting marginal probabilities with covariates at their measured values.[37]

Finally, we also conducted multiple secondary analyses. These analyses included three separate models each for smoking initiation and progression that (1) controlled for cohort year at baseline, (2) examined interactions between time-level pack price and whether participants' baseline year was before or after 2009, and (3) examined an interaction between time-level pack price and whether participants' baseline year was 2006, 2007, or 2008. Secondary analyses assessed the interaction with baseline year to test whether the within-person relationship between pack price and smoking depended on whether baseline year was before or after the Tobacco Control Act, and the interaction with baseline years 2006, 2007, or 2008 (vs all other baseline years) tested whether the within-person relationship depended on whether individuals were surveyed during Tobacco Control Act implementation (eg, baseline year 2006 was followed up in 2008 and 2010).

All analyses were conducted in Stata V.16. This project adheres to the ethical procedures in the Declaration of Helsinki and the University of Minnesota's IRB deemed this project exempt, and data collection was approved by the University of Michigan's IRB.

Results

Table 1 presents descriptive statistics for both initiation and progression samples. The time-level pack price across all waves was on average $5.58 for the initiation sample and $5.47 for the progression sample; the average pack price across the study period at the individual level is presented in Table 1. At baseline, cohorts experienced different prices ranging from $4.36 in 2000 to $6.45 in 2014. Approximately 12% and 15% of the initiation and progression samples, respectively, experienced an increase (within-person change) of over $1.00 during the study period. There was an average change of $0.20 across each follow-up period (for both initiation and progression samples). Across the entire study period, the average initiation to past 30-day cigarette use was 3.3% and progression to daily smoking was 3.6%.

Past 30-Day Cigarette Initiation

Within-Person Relationships

Hierarchical logistic regression models showed a linear increase in the odds of smoking initiation demonstrated by the age trend (Table 2). The within-person relationship between pack price and smoking initiation indicated that a one-dollar increase in pack price corresponded to a 72% decrease in the odds of smoking initiation (AOR = 0.28, 95% CI = 0.18, 0.44), adjusting for covariates.

Covariates

The average individual-level pack price showed that higher pack price was associated with lower past 30-day smoking initiation (AOR = 0.84, 95% CI = 0.70, 1.01), but the relationship was nonsignificant. Current student status was associated with lower odds of smoking initiation (AOR = 0.35, 95% CI = 0.25, 0.50), and males had higher odds of smoking initiation than females (AOR = 2.09, 95% CI = 1.54, 2.83). There were two statistically significant differences for race/ethnicity: non-Hispanic Black (AOR = 0.56, 95% CI = 0.33, 0.94) and Hispanic (AOR = 0.41, 95% CI = 0.23, 0.74) YAs had lower odds of smoking initiation than non-Hispanic White YAs. Individuals in the South had lower odds of smoking initiation compared with YAs in the Northeast (AOR = 0.52, 95% CI = 0.27, 0.98). County-level percent of smoke-free workplaces at baseline was associated with lower odds of smoking initiation (AOR = 0.48, 95% CI = 0.27, 0.86). In terms of variance components, the vast majority of variance in any past 30-day smoking initiation occurred at the individual level (intraclass correlation coefficient = .80).

Table 1. Weighted Descriptive Statistics for Smoking Initiation and Progression Analyses

	Initiation sample		Progression sample	
Variables	% or mean (SE)			
Within-person, time-varying cigarette pack price*	5.58	(0.01)	5.47	(0.01)
Between-person average cigarette pack price*	5.74	(0.01)	5.63	(0.01)
Modal age/follow-up number	0.78	(0.01)	0.76	(0.01)
Past 30-day smoking	3.3%	(0.1)	~	~
Daily smoking	~	~	3.6%	(0.0)
Current student	86.0%	(0.2)	83.7%	(0.2)
Sex				
Male	48.8%	(0.3)	51.7%	(0.2)
Female	51.2%	(0.3)	48.3%	(0.2)
Race/ethnicity				
Non-Hispanic White	60.6%	(0.3)	62.1%	(0.3)
Non-Hispanic Black	17.5%	(0.3)	15.3%	(0.2)
Hispanic	14.6%	(0.2)	15.8%	(0.2)
Non-Hispanic Asian	5.1%	(0.1)	4.3%	(0.1)
Other	2.1%	(0.1)	2.6%	(0.1)
Parental education				
High school degree or less than high school	27.3%	(0.3)	28.9%	(0.2)
Some college	19.8%	(0.3)	20.6%	(0.2)
College degree or more	52.8%	(0.3)	50.5%	(0.2)
Census region				
Northeast	19.3%	(0.2)	19.0%	(0.2)
Midwest	26.3%	(0.3)	26.4%	(0.2)
South	33.3%	(0.3)	33.8%	(0.2)
West	21.1%	(0.2)	20.8%	(0.2)
% workplaces covered by smoke-free laws	40.7%	(0.3)	36.9%	(0.2)
% hospitality venues covered by smoke-free laws	50.5%	(0.3)	46.5%	(0.2)
% of state that is African American/Black	12.7%	(0.1)	12.7%	(0.0)
% of state that is Hispanic	14.3%	(0.1)	14.3%	(0.0)
% of state below poverty	13.5%	(0.0)	13.4%	(0.0)

Unweighted N for initiation sample = 15 280; unweighted N for progression sample = 26 998. Attrition weights were used to generate estimates, which account for the complex survey design of the Monitoring the Future study, oversampling of drug users, and attrition; SE are in parentheses; pairwise deletion was used for missing data. "~" indicates that particular variable was not included in analyses.

*This metric is in $, adjusted for inflation.

Table 2. Hierarchical Logistic Regression Results for Smoking Initiation and Progression Among Monitoring the Future Longitudinal Sample (Baseline Years 2000–2014)

	Initiation results		Progression results	
Variables	AOR	(95% CI)	AOR	(95% CI)
Within-person, time-varying cigarette pack price	0.28***	(0.18, 0.44)	0.30***	(0.21, 0.44)
Between-person average cigarette pack price	0.84+	(0.70, 1.01)	0.70***	(0.59, 0.82)
Modal age/follow-up number	8.71***	(6.93, 10.95)	7.13***	(5.90, 8.61)
Current student	0.35***	(0.25, 0.50)	0.11***	(0.08, 0.15)
Male (vs female)	2.09***	(1.54, 2.83)	1.57***	(1.22, 2.03)
Race/ethnicity (vs Non-Hispanic White)				
Non-Hispanic Black	0.56*	(0.33, 0.94)	0.30***	(0.18, 0.50)
Hispanic	0.41**	(0.23, 0.74)	0.34***	(0.20, 0.57)
Non-Hispanic Asian	0.61	(0.31, 1.22)	0.73	(0.38, 1.38)
Other	0.67	(0.23, 1.92)	1.58	(0.81, 3.08)
Parental education (vs high school grad or less)				
Some college	0.96	(0.60, 1.55)	0.97	(0.66, 1.43)
College degree or more	1.14	(0.77, 1.68)	0.97	(0.71, 1.32)
Census region (vs Northeast)				
Midwest	1.19	(0.72, 1.97)	0.68+	(0.45, 1.04)
South	0.52*	(0.27, 0.98)	0.43**	(0.25, 0.72)
West	0.92	(0.49, 1.72)	0.41**	(0.25, 0.69)
% workplaces covered by smoke-free laws	0.48*	(0.27, 0.86)	0.72	(0.42, 1.24)
% hospitality venues covered by smoke-free laws	1.52	(0.86, 2.70)	0.72	(0.43, 1.20)
% of state that is African American/Black	1.02	(0.99, 1.05)	1.02	(1.00, 1.04)
% of state that is Hispanic	1.00	(0.98, 1.01)	1.00	(0.98, 1.01)
% of state below poverty	1.02	(0.96, 1.09)	0.99	(0.94, 1.04)
Level-2 variance components				
Individual-level variance	13.10***		15.47***	
Pack price slopes	2.13*		2.47***	

Unweighted N for initiation model = 15 280; unweighted N for progression model = 26 998; 95% confidence intervals are in parentheses; county-level controls are measured at baseline; % workplaces and hospitality venues covered by smoke-free laws are measured at the county level. Initiation analyses examined past 30-day smoking among baseline never smokers; progression analyses examined daily smoking among baseline never, previous, and nondaily smokers. Pack price is in US dollars adjusted for inflation.

Statistical significance indicators are ***$p < .001$; **$p < .01$; * $p < .05$; +$p < .10$.

Interaction Results

Table 3 shows multiplicative and additive interaction results. No multiplicative interaction results between time-level pack price and individual-level sex, race/ethnicity, and parental education were statistically significant. Likewise, none of the tests for the additive terms were statistically significant, indicating no observed effect modification of the price/initiation association by sex, race/ethnicity, or parental education.

Progression to Daily Cigarette Smoking

Within-Person Relationships

There was a linear increase in the odds of smoking progression between ages 18 and 21/22 demonstrated by the age trend (Table 2). A one-dollar increase in pack price corresponded to a 70% decrease in the odds of progression to daily smoking (AOR = 0.30, 95% CI = 0.21, 0.44), adjusting for covariates.

Covariates

Regarding the average pack price, each one-dollar increase in price was associated with a decreased odds of progression to daily smoking by a factor of 0.70 (95% CI = 0.59, 0.82). Current student status was associated with lower odds of progression to daily smoking (AOR = 0.11, 95% CI = 0.08, 0.15), and males had higher odds of progression than females (AOR = 1.57, 95% CI = 1.22, 2.03). Non-Hispanic Black (AOR = 0.30, 95% CI = 0.18, 0.50), and Hispanic (AOR = 0.34, 95% CI = 0.20, 0.57) YAs had lower odds of progression than non-Hispanic White YAs. Living in the South and West compared with the Northeast was associated with lower odds of progression to daily smoking (respectively, AOR = 0.43, 95% CI = 0.25, 0.72; AOR = 0.41, 95% CI = 0.25, 0.69). The vast majority of variance in progression to daily smoking occurred at the individual level (intraclass correlation coefficient = .82).

Interaction Results

Shown in Table 3, no multiplicative interaction results for the interaction between time-level pack price and individual-level sex ($p = .74$), race/ethnicity (joint F test = 2.27, $p = .69$), and parental education (joint F test = 0.96, $p = .62$) were statistically significant. Likewise, there were no statistically signification interaction terms on the additive level (see Table 3).

Secondary Analyses

We found that, for both smoking initiation and progression, adjusting for cohort/baseline year did not substantially change results for the within-person relationship between pack price and smoking; the age trend also did not change. For both smoking initiation and progression, there were no significant interactions found between pre-2009 versus post-2009 baseline year and time-level pack price, as well as no significant interactions between baseline year of 2006, 2007, or 2008 (vs all other baseline years) and time-level pack price.

Table 3. Partial and Interaction Effects for Initiation and Progression among Monitoring the Future Longitudinal Sample (Baseline Years 2000–2014)

	Initiation results		Progression results	
Variables	AOR	(95% CI)	AOR	(95% CI)
Model 1				
Within-person, time-varying cigarette pack price	0.24***	(0.14, 0.40)	0.28***	(0.18, 0.46)
Male (vs female)	2.17***	(1.59, 2.97)	1.60***	(1.24, 2.08)
Time-varying cigarette pack price × sex	1.27	(0.81, 2.00)	1.17	(0.78, 1.76)
Significance test for interactions	*F* value	*p*	*F* value	*p*
Multiplicative	~	.30	~	.74
Additive	0.18	.67	0.10	.76
Model 2				
Within-person, time-varying cigarette pack price	0.29***	(0.18, 0.46)	0.31***	(0.22, 0.45)
Race/ethnicity (vs Non-Hispanic White)				
Non-Hispanic Black	0.53*	(0.31, 0.91)	0.29***	(0.17, 0.48)
Hispanic	0.39**	(0.21, 0.70)	0.33***	(0.20, 0.55)
Non-Hispanic Asian	0.65	(0.32, 1.32)	0.78	(0.40, 1.51)
Other	0.75	(0.25, 2.30)	1.48	(0.73, 3.01)
Time-varying cigarette pack price × race/ethnicity				
× Non-Hispanic Black	0.63	(0.26, 1.49)	0.61	(0.24, 1.55)
× Hispanic	0.68	(0.31, 1.46)	0.78	(0.34, 1.78)
× Non-Hispanic Asian	1.58	(0.41, 6.18)	1.50	(0.48, 4.67)
× Other	2.48	(0.32, 19.24)	0.66	(0.16, 2.69)
Overall significance test for interactions	*F* value	*p*	*F* value	*p*
Multiplicative	3.36	.50	2.27	.69
Additive	2.54	.64	1.43	.84
Model 3				
Within-person, time-varying cigarette pack price	0.23***	(0.12, 0.44)	0.33***	(0.19, 0.59)
Parental education (vs high school grad or less)				
Some college	1.03	(0.63, 1.67)	0.94	(0.64, 1.39)
College degree or more	1.17	(0.78, 1.73)	0.96	(0.70, 1.32)
Time-varying cigarette pack price × parental education				
Some college	1.88	(0.77, 4.59)	0.74	(0.39, 1.43)
College degree or more	1.21	(0.65, 2.25)	0.93	(0.54, 1.61)
Overall significance test for interactions	*F* value	*p*	*F* value	*p*
Multiplicative	1.97	.37	0.96	.62
Additive	2.10	.35	0.91	.63

Unweighted *N* for initiation model = 15 280; unweighted *N* for progression model = 26 998; 95% confidence intervals are in parentheses; all models also include all covariates included in Table 2 (not shown): sex, race/ethnicity, parental education, census region, % workplaces and hospitality venues covered by smoke-free laws are measured at the county level, % of state that is African American/Black, Hispanic, and below poverty. Model 1 includes only the interaction for sex, Model 2 only includes the interaction for race/ethnicity, and Model 3 only includes the interaction for parental education. Initiation analyses examined past 30-day smoking among baseline never smokers; progression analyses examined daily smoking among baseline never, previous, and nondaily smokers.
*$p < .05$; **$p < .01$; ***$p < .001$.

Discussion

We observed a within-person relationship between cigarette prices and smoking initiation and progression during the transition to young adulthood, where higher price was associated with decreased odds of both initiation and progression. Previous research on cross-sectional and prospective relationships indicated higher state pack prices were similarly associated with lower initiation and progression among youth[12,20]; however, that research did not parse out the within-person relationships between pack price and change in the odds of smoking among YAs. Generally, the effect sizes found in the current project for pack price were larger compared with previous research that has used cross-sectional or prospective approaches, and this primarily stems from the current approach of estimating strictly within-person associations (i.e., effectively allowing each individual to serve as their own control). Previous studies have not examined within-person change in experienced price, particularly among YAs aged 18 to 21/22 who were never smokers or not daily smokers at age 18.

The within-person associations were strong for a few reasons. Rather than strictly comparing between-person policy differences across states, within-person price differences had a wider range since individuals could move between states with dramatically different price levels in addition to individuals experiencing price increases due to policy change. For instance, YAs in the current study could experience increased prices across age because they consistently lived in states where large tax increases were implemented (eg, Massachusetts, New York, Utah, Rhode Island).[38] Participants could also experience dramatic increases in prices because they moved from low-price states (eg, Missouri had an average price of <$4.20) to high-price states (eg, New York had an average of >$8.25). Due to within-person fluctuations because of moves and policy change, in addition to the specific sample and outcome of current smoking (a within-person binary measure compared with, for example, a between-person continuous measure of the percentage of smokers in a given state), our models generated large within-person effect sizes

with no effect size from previous studies to which we could directly compare.

The between-person associations were also not directly comparable to previous research since they were estimates that excluded within-person information, but our between-person associations generally corresponded with previous research.[12,20] The between-person associations were in the expected direction, with comparable effect sizes relative to previous research. It is important to note that the between-person relationship between average pack price and smoking initiation had a p-value of <.10, but this association was sensitive to model specification, as it was significant ($p < .05$) in other models not included in the current analyses that did not include other tobacco policy covariates.

We extend the prior research by demonstrating that higher pack prices are associated with decreased smoking initiation and progression between ages 18 and 21/22, even after accounting for stable, between-person differences. These findings on cigarette prices have important implications for curbing the current trend in the United States of increasing rates of smoking initiation in young adulthood. Young adulthood is increasingly a period when nonsmokers initiate and escalate combustible cigarette use,[5,7] threatening progress made in the substantial reductions in youth initiation and smoking rates over the past two decades. The current findings demonstrate that increases in pack price that YAs experience are substantially associated with lower odds of smoking initiation and progression.

Ensuring that state-level taxes remain high (ie, representing between-person differences in prices) is important as demonstrated by decades of research, but the current study also highlights that increases in prices implemented in regular intervals could be an additional policy to consider, as it would mimic within-person change estimated in the current analyses. Alternatively, minimum price floors across states could also be a policy to consider, as ensuring that YAs experience a large increase in the lowest possible price of cigarettes could mimic within-person increases YAs experienced in the current study (eg, by moving from a low-price state to a high-price state). In sum, higher cigarette pack prices across states and regular increases in price (or universal increases in minimum pack price) may serve as critical tools for preventing smoking initiation and escalation to regular smoking among YAs.

Although the main effects in the current study showed a marked impact of pack prices within and between individuals, these effects were less clear for different sociodemographic subgroups. Findings from the current study generally support previous research that found no major differences in the relationship between pack price and cigarette smoking and progression across key sociodemographic factors of sex, race/ethnicity, and parental education.[12,20] However, it is important to highlight that there was limited power to detect interactions, and therefore neither no interaction nor very large interactions could be excluded based on confidence intervals from the current results.

We discuss the results according to the nonsignificant findings. Recent cross-sectional and prospective research on tobacco taxes have demonstrated that tobacco taxes since 2000 have not disproportionately helped youth experiencing tobacco-related disparities, with notable exceptions.[19] In terms of differences across sex, Fleischer et al. and Parks et al. also used MTF data and found no differential relationships according to sex, but these studies examined cross-sectional associations and prospective associations between pack price and smoking initiation and progression.[12,20] Fleischer et al. and Parks et al. also found that cigarette prices were not differentially associated with initiation and progression by race/ethnicity in cross-sectional and prospective analyses.[12,20] Finally, Fleischer et al. and Parks et al. similarly found that pack price and smoking did not differ by parental education in cross-sectional and prospective research,[12,20] and these results contradict other research showing low-SES adults and adolescents can have a stronger response to price compared with higher SES counterparts.[13,39,40] Other research has shown that females might exhibit a stronger response to price compared with males,[19] but males have also been shown to be more price sensitive than females, indicating findings on differences by sex have been mixed.[26,41,42] Cigarette prices may reduce the disparities in smoking associated with race/ethnicity in young adulthood[19] or at older ages (eg, 25 or older),[43] but the current study among YAs (age 18–21/22) did not find that the within-person relationship between pack price and change in smoking varied according to race/ethnicity. It is important to note that all of these aforementioned studies that found differential effects of tobacco taxes across sex, race/ethnicity, and SES were conducted with data prior to the 1997 Master Settlement Agreement (MSA), or they did not examine within-person relationships with national samples of YAs.

Results from the current study suggest that cigarette prices can help to prevent overall smoking initiation and progression in young adulthood, but other tobacco control strategies could help to reduce smoking disparities. Evidence-based programs could complement the impact of taxes. In particular, programs that address risk factors during adolescence and young adulthood[44–46] and can be tailored to subpopulations in an effort to reduce smoking initiation, and implementing tailored programs in conjunction with tax increases may help reduce disparities.

Limitations

We did not include e-cigarette use in the current study. E-cigarette use started to increase among youth in 2014, although the most dramatic increase in the United States occurred at the end of the current study period.[2] In previous analyses, we did not find differences in the relationship between pack price and smoking initiation and progression according to baseline year,[12] and the nature of the analyses over time indirectly allow for any potential effects of e-cigarette use. Nevertheless, current results may not hold in more recent years due to increases in e-cigarette use.[2] Finally, we were not able to investigate how within-person e-cigarette use was associated with cigarette use due to sample size limitations and available survey items. It is important to note that YAs may use price-minimization strategies (eg, coupons) as such behaviors are present across all age groups[47–50] and are associated with smoking and price elasticities.[48] However, older age groups are more likely to receive coupons for cheaper cigarettes compared with younger age groups,[47] and there is no indication YAs are more or less likely to engage in price-minimization strategies compared with other age groups.[50] Pack price at the local level was not considered in this analysis, as data on actual price at point of sale was not available.

Conclusion

Higher cigarette prices during the transition from late adolescence to young adulthood are associated with lower odds of cigarette smoking initiation and progression to regular smoking, even after accounting for individual differences in cigarette prices. We were unable to detect statistically significant differences across sex, race/ethnicity, or parental education in the within-person relationship

between pack price and smoking initiation or progression. Given the wide confidence intervals for the interaction terms, it is difficult to draw definitive conclusions about the impact of price on disparities. Nonetheless, we conclude that tobacco prices should be increased on a regular basis and that complementary prevention programs geared toward reducing tobacco-related disparities among YA could be beneficial.

Supplementary Material

A Contributorship Form detailing each author's specific involvement with this content, as well as any supplementary data, are available online at https://academic.oup.com/ntr.

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Declaration of Interests

The authors have no conflicts of interest.

Data Availability

Data are available from the Monitoring the Future Project. Code for the analysis is available upon request.

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