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Supplement Article

Selective Reduction of Socioeconomic Disparities in the Experimental Tobacco Marketplace: Effects of Cigarette and E-cigarette Flavor Restrictions

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Abstract

Introduction: Cigarette smoking accounts for >30% of the socioeconomic gap in life expectancy. Flavored restrictions claim to promote equity; however, no previous studies have compared the effect of cigarette and e-cigarette flavor restrictions among individuals who smoke with *lower* and *higher socioeconomic status* (*SES*).

Aims and Methods: In a between-group within-subject design, individuals with *lower* (n = 155) and *higher* (n = 125) *SES* completed hypothetical purchasing trials in the experimental tobacco marketplace (ETM). Conditions were presented in a 2 × 2 factorial design (cigarette flavors restricted or unrestricted and e-cigarette flavors restricted or unrestricted) with increasing cigarette prices across trials.

Results: Results show (1) SES differences in cigarette, e-cigarette, and NRT purchases under unrestricted policies, with *lower SES* showing higher cigarette demand and lower e-cigarette and NRT substitution than *higher SES*, (2) cigarette restrictions decreased cigarette and increased NRT purchases among *lower SES*, but no significant changes among *higher SES*, (3) decreased SES differences in cigarette demand under cigarette restrictions, but persistence under e-cigarette restrictions or their combination, (4) persistence of SES differences in e-cigarette purchases when all restrictions were enforced, and (5) waning of SES differences in NRT purchasing under all restrictions.

Conclusions: Flavor restrictions differentially affected individuals based on *SES*. Within-group comparisons demonstrated restrictions significantly impacted *lower SES*, but not *higher SES*. Between-group comparisons showed SES differences in cigarette purchasing decreased under cigarette restrictions, but persisted under e-cigarette-restrictions or their combination. Additionally, *SES* differences in NRT substitution decreased under flavor restrictions. These findings highlight the utility of the ETM to investigate SES disparities.

Implications: With increasing trends of socioeconomic differences in smoking prevalence and cessation rates, smoking-related health disparities are expected to continue to widen. Restricting menthol flavor in cigarettes while enhancing the availability and affordability of NRT have the potential to alleviate SES disparities in tobacco use, therefore, positively impacting health equity. However, this effect may depend on flavor availability in other tobacco products.

Introduction

Cigarette smoking is a leading contributor to socioeconomic health disparities accounting for >30% of the socioeconomic gap in life expectancy.[1,2] Groups with lower socioeconomic status (SES) spend a greater portion of their income on cigarettes, smoke more heavily,[3,4] are less likely to achieve long-term abstinence from smoking[5,6] and have higher cancer incidence and death rates than more affluent groups.[7]

SES is a complex and contextualized sociopolitical construct associated with relative access to basic resources required to achieve and maintain good health.[8] Not surprisingly, SES is also associated with a wide variety of health behaviors, including addictive behaviors such as cigarette and other tobacco product use.[9] Members of lower SES groups are often marginalized from the central experiences of the dominant culture in which they live.[10] SES is commonly assessed with culturally relevant composite indices. In the United States, SES is often assessed with educational achievement and household income. Educational achievement is relevant to the acquisition of knowledge and skills, cultural literacy, and cognitive functioning,[11] while household income is relevant to access to material resources.8 Importantly, SES overlaps with other important marginalized social identities, including race,

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ethnicity, sex/gender, sexual orientation, mental and physical health, and disability.

Historically, the tobacco industry has advertised flavored tobacco products (eg, menthol cigarettes) to communities with a high proportion of individuals who are of lower SES.[12] Menthol allows the user to inhale more deeply by decreasing sensations of harshness and nicotine-evoked oral irritation,[13] and perhaps allowing smokers with restricted resources to optimize their use of a product. As a result, prominent socioeconomic differences exist in flavored tobacco product use.[14,15] Flavored tobacco and nicotine product use is associated with increased dependence and poorer cessation outcomes,[16] which might contribute to socioeconomic disparities in cigarette smoking. Therefore, flavor restrictions could potentially promote health equity by decreasing differences in tobacco use between the groups with *lower* and *higher SES*.

Recently, the U.S. Food and Drug Administration has taken multiple actions toward tobacco product flavor restrictions. In 2020, the Food and Drug Administration finalized an enforcement policy on unauthorized flavored (other than tobacco or menthol) cartridge-based-e-cigarette products including mint and fruit.[17] In 2022, the Food and Drug Administration proposed two new rules to prohibit menthol as a characterizing flavor in cigarettes and to prohibit all flavors (including menthol) in cigars.[18] These proposed rules aim to improve public health, by reducing initiation among youth and facilitating smoking cessation, and advance health equity.

One way to forecast the impact of these restrictions on tobacco product purchasing is through the experimental tobacco marketplace (ETM). The ETM, an online Amazon-like tobacco store,[19] provides a useful method to examine equity in the context of tobacco control. The ETM mirrors real-world purchase behaviors and permits estimation of the effect of SES on tobacco/nicotine product purchases under different policies. A priori estimates from the ETM may be utilized to determine the impact of such policies in reducing health disparities and improving public health.

In this context, this study explored the moderating role of SES on the effects of cigarette and e-cigarette flavor restriction policies on tobacco product purchasing (ie, cigarette, e-cigarette, smokeless tobacco, and nicotine replacement therapy - NRT) among individuals who use tobacco regularly. We hypothesize that unrestricted cigarette and e-cigarette flavor policies would reflect contemporary SES disparities, and the implementation of cigarette flavor restrictions would decrease the SES disparities in cigarette purchases. The effects of these flavor restrictions on alternative product purchasing are unknown. These findings are needed to determine the relative health equity impact of cigarette and e-cigarette flavor policies. By elucidating the differences in tobacco and nicotine product purchasing between SES groups in the face of flavor restrictions, policymakers may better understand the impact of potential policies on subgroups of tobacco users and avoid increasing an already widening socioeconomic gap in health.[20]

Methods

Participants

This secondary analysis of previously collected data included individuals who smoke cigarettes (N = 280) recruited by market research firms, Ipsos (iSay panel; social.i-say.com) and Innovate MR (innovatemr.com/panels/consumer-panel) during July and August 2021. To determine eligibility for the study, participants reported their age, smoking history, current smoking status, and preferred brand of cigarettes. Inclusion criteria included: (1) being[21] years of age or older, (2) currently smoking at least 10 cigarettes per day regardless of other tobacco product use, and (3) having smoked at least 100 cigarettes in their lifetime. Informed consent was implied through the completion of the survey. The parent study was registered on www.clinicaltrials.gov (NCT05110872) and approved by the Institutional Review Board at Virginia Polytechnic Institute and State University.

Study Design

In a between-group within-subject design (repeated measures), we employed a 2 × 2 factorial design to expose participants to four policy scenarios. The factors included cigarette flavor restricted versus unrestricted; and e-cigarette flavor restricted versus unrestricted.

Policy Scenarios

Cigarette Flavor Restricted

Only non-menthol cigarettes were available.

Cigarette Flavor Unrestricted

Non-menthol and menthol cigarettes were available.

E-cigarette Flavor Restricted.

Only tobacco e-cigarette flavors were available (ie, classic tobacco, cigar tobacco).

E-cigarette Flavor Unrestricted.

The following e-cigarette flavors were available: Blueberry, blueberry pie, cappuccino, cheesecake, cherry cheesecake, chocolate ice cream, cinnamon, cinnamon menthol, coffee, cotton candy, energy drink, menthol, peach, peach tobacco, red licorice, root beer, vanilla, and wintergreen menthol.

Flavors of other products were the same across conditions and included: Apple (dip), berry (snus, dip), cinnamon (gum), citrus (snus, dip) dry fruit (snus), fruit (gum), mint (gum, lozenge, snus, dip), straight (dip), tobacco (snus, dip), and wintergreen (snus, dip).

The ETM was tailored for each participant to include only preferred varieties of flavors and nicotine doses chosen from a provided list of products.

Procedures

Participants completed an online survey administered through Qualtrics survey software (Qualtrics, Provo, UT, United States). Assessments included: Cigarettes and e-cigarettes experience and flavor and nicotine dose choices, the heaviness of smoking index,[21] a timeline follow-back to report nicotine product use in the previous week (TLFB),[22] hypothetical tobacco purchases in the ETM, and demographics.

Experimental Tobacco Marketplace

Instruction Quiz

Before entering the ETM, participants were given instructions and asked to make the following assumptions during their decision-making: (1) they would make hypothetical purchases of tobacco and nicotine products for the next 7 days, (2) a new purchasing scenario began in every purchasing trial, (3) they had no access to other tobacco/nicotine products outside of the ETM, and (4) they could not give away or save products for longer than the next 7 days. A four-question instruction

quiz was implemented to ensure comprehension of the ETM instructions.[23] Individuals had up to seven chances to master the quiz before engaging in the ETM.

Hypothetical Account Balance

Participants were provided with an account balance calculated by multiplying the self-reported average number of tobacco products used per day during the past month by their respective median unit price, then summing the results for each product. This calculation is intended to mimic participants' budget constraints in the real world.[19]

Purchase Trials

A hypothetical account balance was provided in each trial to purchase tobacco products for 7 days. Participants were asked to assume they already had an e-cigarette device or that it was available for free. Cigarette prices increased across purchase trials according to the following multiplicative factors on a logarithmic scale: Market-price [MP]; 2 × MP, 4 × MP, 8 × MP. As in prior studies, individual units were available in the ETM and not full packages to increase measurement resolution.[24–26] Median prices by product type were computed using the NielsenIQ 2017 data to define MP in the ETM. MPs and units for each product were as follows: $0.30 per single cigarette, $0.51 per 1 mL of E-liquid, $7.15 per disposable e-cigarette, $3.34 per e-cigarette pod or cartridge, $0.22 per single snus pouch, $0.10 per single dip pouch, and $0.37 per single piece of gum or lozenge. Each product was displayed with the price along with an image and a brief description. For vaping products (ie, e-liquid, disposable e-cigarette, and e-cigarette pods or cartridges), participants were informed that one unit was approximately equivalent to 10 cigarettes and/or 100 puffs.

Measures

For all outcome measures, percent budget spent was used to normalize across the wide array of participant-derived budgets.

Own-Price Demand Curves for Cigarettes

For individual own-price demand data under each policy scenario, two parameters were empirically determined from the ETM purchases: Intensity—the percentage of budget spent at $0.30 cigarette price, and Omax—the highest observed percent budget spent. Empirically determined measures of demand were used instead of fitting a demand equation to include all participant data. Individual intensity and Omax data were square-root transformed[27] due to the data being positively skewed.

Cross-Price Substitution Curves for Alternative Products

Products available in the ETM were combined into three product categories: E-cigarettes, smokeless tobacco, and NRT. Individual demand for alternative products was fit using linear regression, and parameters were derived from ETM purchases: Y-intercept; intensity of substitution[27] and slope; substitutability. The Y-intercept represents the predicted percentage of budget spent on the alternative product(s) when a cigarette is free, and the slope represents the change in the percentage budget spent on alternative product(s) demand divided by the change in price. Intercepts and slopes were square-root or log-transformed to normalize and stabilize variance, when appropriate.

SES Groups

SES was categorized using a composite SES index based on reported income and education questions used by the 2020 U.S. Census Bureau. Household income was grouped into six categories, and educational level was grouped into four categories. Values were assigned to income level (lowest = 1 to highest = 6) and educational level (lowest = 1 to highest = 4). Income and education values were summed resulting in a discrete analogue SES scale ranging from 2 to 10 as in prior studies.[28,29] A median split on the SES scale determined a participant's assignment to the group with *lower SES* or *higher SES*.

Data Analysis

A total of 302 participants were eligible and completed the survey. However, due to missing or invalid data pertinent to this analysis, 22 participants were removed from this report, which resulted in a final analytical sample of 280.

Participant Characteristics

Demographic characteristics (eg, age, race, and income) and smoking-related assessments (eg, heaviness of smoking index) were described using mean, standard deviation, and percentages. These characteristics were compared among the two SES groups using *t*-tests and Fisher's exact test, where appropriate. See **Supplementary Table S1** for all measures.

Statistical Analysis

For each of the product categories in the ETM, we sought to determine (1) if differences in purchasing and substitution under the unrestricted flavor policies were observed across SES groups; (2) how the policy restrictions impact purchasing in the group with *lower SES* and *higher SES*; and (3) whether differences in purchasing across SES groups persisted or changed under the policy restrictions. To evaluate these questions, we fit a hierarchical linear regression to estimate purchasing behavior that included an interaction term between SES and cigarette policy, an interaction term between SES and e-cigarette policy, and a random effect for the participant. Additionally, heaviness of smoking index scores, age, and gender were included as covariates after SES group differences were observed. Despite observed SES differences in e-cigarette use, we opted to not include this variable as a covariate, because the goal of the present study is to identify SES disparities independent of the potential driving mechanism. For cigarettes, purchasing behavior was evaluated using intensity and O_{max}; for alternative product categories, purchasing behavior was evaluated using intercept and slope. Custom contrasts to test the previously described hypotheses were performed. Specifically, groups with *lower SES versus higher SES* in unrestricted conditions, restricted versus unrestricted conditions in the group with *lower SES*, restricted versus unrestricted conditions in the group with *higher SES*, and groups with *lower SES versus higher SES* in restricted conditions. Contrasts were adjusted for multiple comparisons using the Sidak method.[30] We opted not to include cigarette flavor since significant differences in menthol preference were not observed between SES groups. We sought to understand the policy implications at the population level instead of the individual level. Moreover, we did not perform model selection since we were specifically interested in understanding the moderating role of SES

under each of these policies; in an exploratory data analysis, a significant interaction between cigarette and e-cigarette policy was not observed. R software Version 3.5.1 was used for all data analysis.[31] All statistical tests were considered significant at the <.01 level.

Results

Participant Characteristics

Overall, our sample was 49.53 (±13.66) years old, majority male (50.7%), white (90.0%), non-Hispanic (86.6%), with an annual income of less than $50 000 (61%), a plurality with some college or associate degree (37.8%), reported smoking 17.78 (±8.11) cigarettes per day, and scored 3.34 (±1.55) on the heaviness of smoking index. A total of 45% of participants reported smoking menthol cigarettes with no significant differences observed between groups (p = .1190). Demographics (eg, age, education, race) and tobacco-related measures by SES group are shown in Supplementary Table S1.

SES Differences in Cigarette Purchasing and Product Substitution Under Unrestricted Flavor Policies

SES-dependent differences in percent budget spent under the unrestricted flavor policy environment were explored (Figure 1, Table 1). The group with *lower SES* showed significantly higher intensity of cigarette demand (t(274) = −4.142, p = .0004) compared to the group with *higher SES participants*. These SES-dependent differences continue with the groups with *higher SES* exhibiting higher intensity of e-cigarette substitution (t(274) = 3.877, p = .0011), and NRT substitution (t(274) = 3.833, p = .0013) than the group with lower SES. Significant differences in intensity of smokeless tobacco substitution and in slope of substitution for all alternative products were not observed.

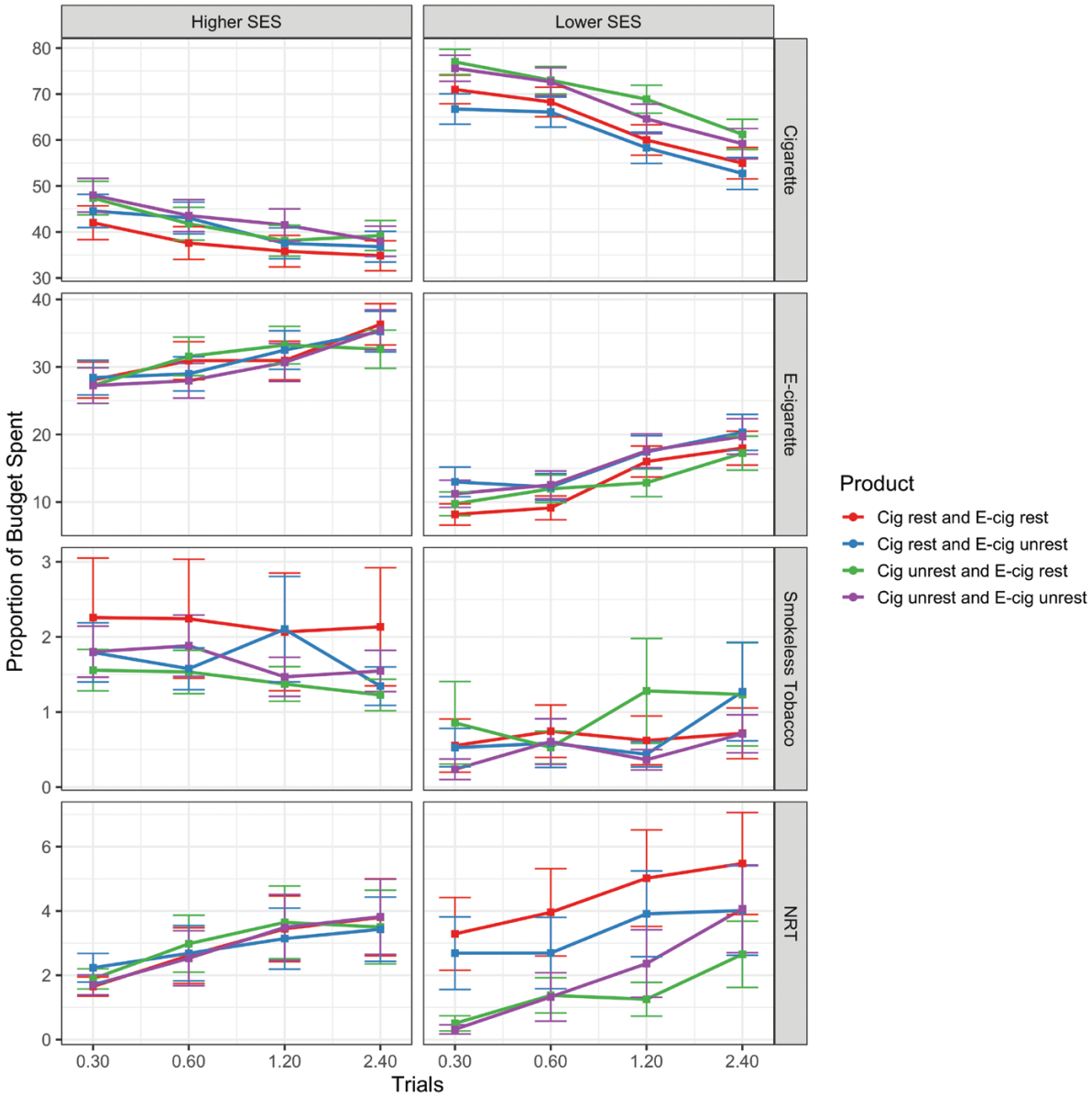

Figure 1. Proportion of total budget spent per product category across trials in each policy scenario.

Table 1. SES-Dependent Differences in Cigarette, E-cigarette, Smokeless Tobacco, and NRT Purchasing

	Cigarette and e-cigarette flavors unrestricted	Cigarette flavor restricted only	E-cigarette flavor restricted only	Cigarette and e-cigarette flavors restricted
Cigarettes (intensity)	**$t = -4.142$ $p = .0004$**	$t = -2.543$ $p = .0886$	**$t = -4.940$ $p < .0001$**	**$t = -4.155$ $p = .0003$**
Cigarettes (Omax)	**$t = -3.187$ $p = .0127$**	$t = -1.657$ $p = .5645$	**$t = -3.827$ $p = .0013$**	**$t = -2.881$ $p = .0337$**
E-cigarettes (intercept)	**$t = 3.877$ $p = .0011$**	**$t = 3.993$ $p = .0007$**	**$t = 4.507$ $p = .0001$**	**$t = 4.648$ $p < .0001$**
E-cigarettes (slope)	$t = -1.331$ $p = .8038$	$t = -1.635$ $p = .5814$	$t = -1.231$ $p = .8619$	$t = -1.176$ $p = .8895$
Smokeless tobacco (intercept)	$t = 2.592$ $p = .0777$	$t = 2.871$ $p = .0348$	$t = 1.580$ $p = .6249$	$t = 1.911$ $p = .3753$
Smokeless tobacco (slope)	$t = -1.636$ $p = .5810$	$t = -1.379$ $p = .7729$	$t = -1.824$ $p = .4364$	$t = -0.730$ $p = .9934$
NRT (intercept)	**$t = 3.833$ $p = .0013$**	$t = 1.232$ $p = .8618$	$t = 2.834$ $p = .0388$	$t = 0.187$ $p = 1.0000$
NRT (slope)	$t = -0.892$ $p = .9762$	$t = -0.339$ $p = 1.000$	$t = -0.380$ $p = .9999$	$t = 0.166$ $p = 1.0000$

Degrees of freedom = 274. Contrasts were performed as *higher SES* minus *lower SES*.
Bold values indicate significant differences ($p < .05$) between higher and lower SES.

Impact of Cigarette Policy Restrictions on Groups With *Lower and Higher SES*

The effect of cigarette policy restriction on product purchasing within each SES was explored (Figure 2, Table 2). The cigarette policy restriction resulted in decreased intensity of cigarette demand ($t(824) = 4.555$, $p < .0001$) and increased Omax ($t(824) = 5.009$, $p < .0001$) among the group with *lower SES*. In addition, a significant increase in the intensity of NRT substitution was observed ($t(824) = -4.334$, $p = .0001$). All other indices were non-significant in the group with *lower SES*. Significant differences in product purchasing for cigarettes and each of the alternative products were not observed in the group with *higher SES*.

Impact of E-cigarette Policy Restrictions on Groups With *Lower and Higher SES*

The effect of e-cigarette policy restriction on product purchasing was explored within each SES group (Figure 2, Table 2). No significant differences in cigarette demand and alternative product substitution indices were observed in product purchases within the groups with *higher and lower SES* (Figure 1, Table 2).

SES Differences in Cigarette Purchasing and Product Substitution Under Proposed Product Flavor Bans

The persistence of SES-dependent disparities under each policy restriction was explored (Table 1). In the presence of the cigarette policy restriction, significant SES-dependent differences in cigarette purchases were no longer observed ($t(274) = -2.543$, $p = .0886$). However, the persistence of these SES-dependent differences in cigarette purchasing was observed for the e-cigarette policy restriction ($t(274) = -4.940$, $p < .0001$) and the combination of cigarette and e-cigarette policy restrictions ($t(274) = -4.155$, $p = .0003$), with the group with *lower SES* exhibiting higher intensity of cigarette demand compared to the group with *higher SES*. Significant differences in O_{max} were observed under the e-cigarette flavor restrictions ($t(274) = -3.827$, $p = .0013$) with the group with *lower SES* indicating higher O_{max}.

Significant differences in the intensity of e-cigarette substitution continued throughout all three flavor policy restriction conditions (Table 1). Interestingly, the decrease in intensity of NRT substitution in the group with *lower SES* compared to the group with *higher SES* did not persist under the cigarette flavor restriction ($t(274)=1.232$, $p=.8618$), the e-cigarette flavor restriction ($t(274) = 2.834$, $p = .0388$), or the dual flavor restriction conditions ($t(274) = 0.187$, $p = 1.0000$). While none of the policy restrictions created new disparities between SES groups, the e-cigarette flavor restriction increased disparities (ie, larger effect sizes) between the groups with *lower* and *higher SES*.

Discussion

The present study sought to investigate the role of SES in moderating the effects of cigarette and e-cigarette flavor restrictions on hypothetical tobacco and nicotine product purchasing. Five main findings were observed: (1) unrestricted flavor policies reflected SES disparities in cigarette purchasing, e-cigarette, and NRT substitution with increased cigarette purchases and decreased e-cigarette and NRT substitution among the group with *lower SES* when compared to the group with *higher SES*, (2) cigarette flavor restrictions significantly decreased cigarette demand and increased NRT substitution in the group with *lower SES*, but did not significantly change product purchasing in the group with *higher SES*, (3) cigarette flavor restrictions significantly decreased differences in cigarette purchasing between the groups with *lower* and *higher SES;* however, differences persisted under e-cigarette flavor restrictions or the combination of cigarette and e-cigarette flavor restrictions, (4) SES-dependent differences in e-cigarette purchasing persisted under all flavor restrictions, and (5) SES-dependent differences in NRT purchasing waned under all flavor restrictions. These findings and implications are discussed below.

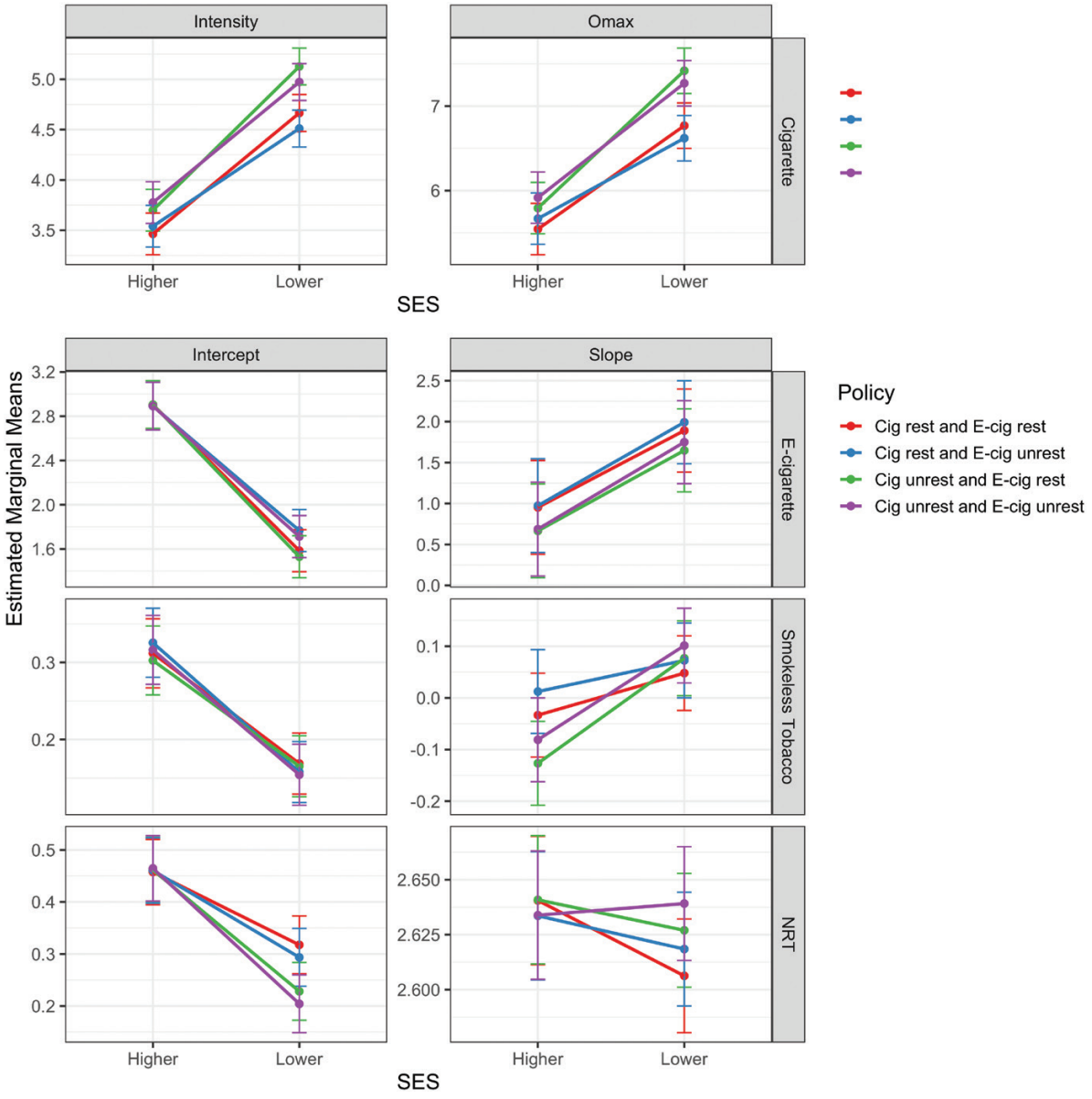

Figure 2. Estimated marginal means and standard errors of cigarette demand and alternative product substitution indices across policy scenarios.

First, our findings of socioeconomic differences in tobacco and nicotine product purchasing under unrestricted flavor policies are consistent with previous literature. Numerous factors are associated with tobacco use among individuals of lower SES,[5,32] including tobacco industry targeted marketing,[33] reduced access to affordable smoking cessation,[34] social factors such as greater tobacco use and reduced support for quitting among friends,[35] and greater exposure to stress and adversity.[32] We speculate that our findings of reduced e-cigarette and NRT substitution in the group with lower SES might be because of individuals of lower SES being more price sensitive and e-cigarettes and NRT being more costly than comparable units of combustible cigarettes.[36] Individuals of lower SES also may not be aware of the potential benefits of switching to NRT and may not have the same access to NRT as more affluent individuals. Several possible policy changes that may help to increase familiarity with NRT products and address concerns individuals may have about the use of NRT include: (1) requiring the sale of NRT at every point of sale of cigarettes, (2) promoting quitting cigarettes using NRT or referral to a state smoker's quitline at places where people either smoke or buy cigarettes, and (3) having more educational materials about the benefits of quitting or distributing free NRT in communities of *lower SES*.

Second, flavor restrictions significantly changed tobacco product purchasing in the group with *lower SES*, but not in the group with *higher SES*. This finding is consistent with a previous study suggesting that approximately 75% of individuals of *lower SES* who live in public housing would quit smoking under a menthol cigarette ban.[37] Additionally, more affluent groups purchased more alternative tobacco products under unrestricted flavor policies, suggesting they may have more experience or are more willing to try new products than individuals of *lower SES*. As with NRT, this finding might reflect greater access or exposure to alternative tobacco products. These findings suggest flavor restrictions are likely to have a minimal effect on tobacco product use among groups with *higher SES*.

Table 2. Policy-Dependent Differences in Purchasing Across SES

	Higher SES		Lower SES	
	Cigarette restrictions	E-cigarette restrictions	Cigarette restrictions	E-cigarette restrictions
Cigarettes (intensity)	t = 2.083 p = .2635	t = 0.673 p = .9962	**t = 4.555** **p < .0001**	t = –1.522 p = .6669
Cigarettes (Omax)	t = 1.719 p = .5132	t = 0.855 p = .9815	**t = 5.009** **p < .0001**	t = –1.141 p = .9042
E-cigarettes (intercept)	t = –0.086 p = 1.000	t = –0.587 p =.9985	t = –0.439 p = .9998	t = 1.731 p = .5037
E-cigarettes (slope)	t = –0.823 p = .9855	t = 0.061 p = 1.0000	t = –0.775 p = .9901	t = 0.323 p = 1.0000
Smokeless tobacco (intercept)	t = –0.094 p = 1.0000	t = 0.342 p = 1.0000	t = 0.554 p = .9990	t = –1.633 p = .5806
Smokeless tobacco (slope)	t = –1.121 p = .9126	t = 0.548 p = .9991	t = 0.384 p = .9999	t = 0.329 p = 1.0000
NRT (intercept)	t = 0.069 p = 1.0000	t = –0.067 p = 1.0000	**t = –4.334** **p = .0001**	t = –1.738 p = .4978
NRT (slope)	t = 0.013 p = 1.0000	t = –0.322 p = 1.0000	t = 1.064 p = .9338	t = 0.626 p = .9977

Degrees of freedom = 824. Contrasts were performed as unrestricted minus restricted.
Bold values indicate significant differences (p < .01) between unrestricted and restricted policy environments.

Third, comparing the groups with *lower* and *higher SES* showed that cigarette flavor restrictions only reduced socioeconomic differences in cigarette purchasing. However, socioeconomic differences persisted under e-cigarette flavor restrictions and the combination of cigarette and e-cigarette flavor restrictions. One potential explanation for this finding is that under a menthol cigarette ban, individuals who smoke menthol cigarettes may switch to flavored e-cigarettes. On the other hand, a flavored e-cigarette ban may shift current e-cigarette purchases to cigarette purchases increasing disparities, as observed by the greater differences under this policy scenario. When in combination, flavor restrictions in both cigarettes and e-cigarettes eliminate each product's best-flavored alternative and substitute with similar behavior topography, respectively.[19] Dual restrictions may hinder substitution across product types and, instead, promote substitution of the tobacco-flavored product of an individual's preferred type. As multiple studies have shown, characterizing flavors evokes the perception of mildness and reduces the tobacco taste and unpleasant mouth feel of tobacco products, therefore, increasing nicotine appeal, reinforcing value and abuse potential.[13] Further understanding of the importance of characterizing flavors in tobacco products relative to other reinforcing agents, such as nicotine itself or non-nicotine aspects of tobacco use, can help understand this finding. Importantly, however, these findings show that cigarette substitution is highly dependent on what other products are available in the tobacco marketplace.

Fourth, our findings showed that the group with *lower SES* spends a smaller percentage of their budget on e-cigarettes than the group with *higher SES*, regardless of the policy. This result highlights that factors other than flavor drive individuals of *lower SES*' decisions to purchase e-cigarettes. In addition to the economic and cost factors discussed above, individuals with *lower SES* may simply have less exposure to or understanding of e-cigarettes and therefore be less likely to purchase them. A systematic review found evidence of greater e-cigarette awareness and use associated with higher levels of educational attainment.[38] Others have also cited lower exposure to e-cigarette advertising among individuals with *lower SES* because of the tobacco industry targeting individuals with *higher SES* with e-cigarette advertising.[39]

Fifth, SES-dependent differences in NRT purchasing waned under flavor restrictions, such that the group with *higher SES* were no longer more likely to spend a higher proportion of their budget on NRT than the group with *lower SES*. SES differences in motivation for NRT use might explain this finding. Previous research suggests that flavor is an important cigarette feature for individuals of *lower SES*.[14,15] Individuals of *lower SES* may be more likely to use NRT as a substitute for their preferred flavored tobacco product. The availability of flavored gums and lozenges, instead of nicotine patches, may have favored the substitutability of these products among individuals of *lower SES*. Whereas individuals of *higher SES* may be more likely to use NRT for quitting, as a harm-reduction strategy or to get to their usual nicotine level.[40] Further investigation is needed into the impact of preference for flavored tobacco products and NRT availability as moderators of the relationship between flavor restrictions and NRT purchasing.

This study has limitations that warrant mention. First, the majority of participants were white, non-Hispanic, or Latinx and had at least completed high school. Importantly, the fact that tobacco use varies by race and ethnicity is widely known. As this sample lacked great racial diversity, examination of how flavor restrictions impact this healthy equity dimension can not be performed. Thus, the generalizability of the findings may be limited to predominantly White populations.[41] Future investigations are needed in a more diverse sample. Second, online data collection can induce social desirability bias.[42] Nevertheless, previous laboratory and online studies (with appropriate data quality) have shown comparable results.[43,44] Third, hypothetical and not real purchases may represent a threat to external validity. However, several previous investigations have demonstrated that hypothetical tobacco purchasing is correlated with real-world use,[45] including ETM

purchases.[46] Therefore, the validity and reliability of the hypothetical ETM to assess tobacco product purchases have support in the literature. Fourth, the median split on SES to determine groups with *lower and higher SES* may not reflect actual SES categories. We acknowledge that different cutoffs may lead to different findings. Fifth, other forms of smoked tobacco (eg, cigars, cigarillos) were not included in this implementation of the ETM. Their exclusion was purposeful as their substitution could hide the substitutability of alternative noncombustible products.[47] Future studies could compare the substitutability of combustible and noncombustible products under these policies, including the recently announced ban on flavored cigars. Finally, our analysis did not include prior exposure to alternative products. While we recognize that prior experience with alternative products between SES groups may be a driving factor of differences in purchasing, our goal in this paper is to evaluate SES disparities. To better understand the mechanisms responsible for the observed SES disparities, further analyses that consider prior exposures, such as directed marketing or density of tobacco retailers, should be performed.

Historically, specific groups, such as those with *lower SES,* have been disproportionately affected by tobacco use.[48] This study's findings support previous research showing that current policies contribute to SES disparities in cigarette demand and e-cigarette or NRT substitution. With increasing trends of socioeconomic differences in smoking prevalence and cessation rates,[49] smoking-related health disparities are expected to continue to widen.[50] Policy interventions have the potential to alleviate SES disparities in cigarette smoking and, therefore, positively impact equity in cigarette smoking and other tobacco product use.[51]

This study adds timely evidence that flavor restrictions may decrease tobacco-related disease and death rates. Additionally, these findings highlight the need to evaluate the impact of a tobacco product restriction in the context of other tobacco control policies. Policymakers must consider how restrictions on isolated products or multiple products simultaneously may affect substitution with other products available in the tobacco marketplace. Collectively, this study's findings enhance the translational utility of the ETM in reflecting real-world SES disparities and forecasting the impact of various policies on tobacco users' behavior and resulting SES differences.

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

Although the following activities/relationships do not create a conflict of interest pertaining to this manuscript, in the interest of full disclosure, Dr. Bickel would like to report the following: W. K. Bickel is a principal of HealthSim, LLC; BEAM Diagnostics, Inc.; and Red 5 Group, LLC. In addition, he serves on the scientific advisory board for Sober Grid, Inc.; and Ria Health; serves as a consultant for Boehringer Ingelheim International and Lumanity; and works on a project supported by Indivior, Inc. Dr. Tegge reports work on a project supported by Indivior, Inc. Dr. Shields reports that he has and continues to serve as a paid expert witness in litigation filed against cigarette manufacturers. The other authors report no conflict of interest.

Data Availability

Readers are encouraged to email wkbickel@vtc.vt.edu to obtain more data for this study.

References

1. Centers for Disease Control and Prevention (CDC). Cigarette smoking among adults--United States, 2006. *MMWR Morb Mortal Wkly Rep.* 2007;56(44):1157–1161. https://www.ncbi.nlm.nih.gov/pubmed/17989644.
2. Gregoraci G, van Lenthe FJ, Artnik B, *et al*. Contribution of smoking to socioeconomic inequalities in mortality: a study of 14 European countries, 1990-2004. *Tob Control.* 2017;26(3):260–268.
3. Siahpush M, Farazi PA, Maloney SI, *et al*. Socioeconomic status and cigarette expenditure among US households: results from 2010 to 2015 Consumer Expenditure Survey. *BMJ Open.* 2018;8(6):e020571e020571.
4. Ham DC, Przybeck T, Strickland JR, *et al*. Occupation and workplace policies predict smoking behaviors: analysis of national data from the current population survey. *J Occup Environ Med.* 2011;53(11):1337–1345.
5. Reid JL, Hammond D, Boudreau C, Fong GT, Siahpush M; ITC Collaboration. Socioeconomic disparities in quit intentions, quit attempts, and smoking abstinence among smokers in four western countries: findings from the International Tobacco Control Four Country Survey. *Nicotine Tob Res.* 2010;12(suppl 1):S20–S33.
6. Agrawal A, Sartor C, Pergadia ML, Huizink AC, Lynskey MT. Correlates of smoking cessation in a nationally representative sample of U.S. adults. *Addict Behav.* 2008;33(9):1223–1226.
7. Henley SJ, Jane Henley S, Thomas CC, *et al*. Vital signs: disparities in tobacco-related cancer incidence and mortality — United States, 2004–2013. *MMWR Morb Mortal Wkly Rep.* 2016;65(44):1212–1218.
8. Shavers VL. Measurement of socioeconomic status in health disparities research. *J Natl Med Assoc.* 2007;99(9):1013–1023. https://www.ncbi.nlm.nih.gov/pubmed/17913111.
9. Galea S, Vlahov D. Social determinants and the health of drug users: socioeconomic status, homelessness, and incarceration. *Public Health Rep.* 2002;117(suppl 1):S135–S145. https://www.ncbi.nlm.nih.gov/pubmed/12435837.
10. Hall JM, Carlson K. Marginalization. *ANS Adv Nurs Sci.* 2016;39(3):200–215.
11. Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey Smith G. Indicators of socioeconomic position (part 1). *J Epidemiol Community Health.* 2006;60(1):7–12.
12. Brown-Johnson CG, England LJ, Glantz SA, Ling PM. Tobacco industry marketing to low socioeconomic status women in the U.S.A. *Tob Control.* 2014;23(e2):e139–e146.
13. Patten T, De Biasi M. History repeats itself: role of characterizing flavors on nicotine use and abuse. *Neuropharmacology.* 2020;177:108162.

14. Patel A, Hirschtick JL, Cook S, *et al*. Sociodemographic patterns of exclusive and dual use of ENDS and menthol/non-menthol cigarettes among US youth (Ages 15--17) using two nationally representative surveys (2013--2017). *Int J Environ Res Public Health*. 2021;18(15):7781. https://www.mdpi.com/1660-4601/18/15/7781.
15. Villanti AC, Mowery PD, Delnevo CD, *et al*. Changes in the prevalence and correlates of menthol cigarette use in the USA, 2004–2014. *Tob Control*. 2016;25(suppl 2):ii14–ii20.
16. Villanti AC, Collins LK, Niaura RS, Gagosian SY, Abrams DB. Menthol cigarettes and the public health standard: a systematic review. *BMC Pub Health*. 2017;17(1):983.
17. Food US, Adminstration D. FDA finalizes enforcement policy on unauthorized flavored cartridge-based e-cigarettes that appeal to children, including fruit and mint. 2020. Accessed October 10, 2022. https://www.fda.gov/news-events/press-announcements/fda-finalizes-enforcement-policy-unauthorized-flavored-cartridge-based-e-cigarettes-appeal-children
18. Office of the Commissioner. FDA Proposes Rules Prohibiting Menthol Cigarettes and Flavored Cigars to Prevent Youth Initiation, Significantly Reduce Tobacco-Related Disease and Death. U.S. Food and Drug Administration. Accessed October 4, 2022. https://www.fda.gov/news-events/press-announcements/fda-proposes-rules-prohibiting-menthol-cigarettes-and-flavored-cigars-prevent-youth-initiation
19. Bickel WK, Pope DA, Kaplan BA, *et al*. Electronic cigarette substitution in the experimental tobacco marketplace: a review. *Prev Med*. 2018;117:98–106.
20. Mattingly DT, Hirschtick JL, Meza R, Fleischer NL. Trends in prevalence and sociodemographic and geographic patterns of current menthol cigarette use among U.S. adults, 2005–2015. *Prev Med Reps*. 2020;20:101227.
21. Heatherton TF, Kozlowski LT, Frecker RC, Rickert W, Robinson J. Measuring the Heaviness of Smoking: using self-reported time to the first cigarette of the day and number of cigarettes smoked per day. *Addiction*. 1989;84(7):791–800.
22. Sobell LC, Sobell MB. Timeline follow-back. In: Litten RZ, Allen JP, eds. *Measuring Alcohol Consumption: Psychosocial and Biochemical Methods*. Humana Press; 1992:41–72.
23. Freitas-Lemos R, Tegge AN, Craft WH, *et al*. Understanding data quality: instructional comprehension as a practical metric in crowdsourced investigations of behavioral economic cigarette demand. *Exp Clin Psychopharmacol*. 2022;30(4):415–423.
24. Kaplan BA, Koffarnus MN, Franck CT, Bickel WK. Effects of reduced-nicotine cigarettes across regulatory environments in the experimental tobacco marketplace: a randomized trial. *Nicotine Tob Res*. 2020.
25. Freitas-Lemos R, Stein JS, Pope DA, *et al*. E-liquid purchase as a function of workplace restriction in the experimental tobacco marketplace. *Exp Clin Psychopharmacol*. 2021.
26. Pope DA, Poe L, Stein JS, *et al*. Experimental tobacco marketplace: substitutability of e-cigarette liquid for cigarettes as a function of nicotine strength. *Tob Control*. 2019;28(2):206–211.
27. Stein JS, Koffarnus MN, Stepanov I, Hatsukami DK, Bickel WK. Cigarette and e-liquid demand and substitution in e-cigarette-naïve smokers. *Exp Clin Psychopharmacol*. 2018;26(3):233–243.
28. Sheffer CE, Stitzer M, Landes R, *et al*. Socioeconomic disparities in community-based treatment of tobacco dependence. *Am J Public Health*. 2012;102(3):e8–16.
29. Varghese M, Sheffer C, Stitzer M, Landes R, Brackman SL, Munn T. Socioeconomic disparities in telephone-based treatment of tobacco dependence. *Am J Public Health*. 2014;104(8):e76–e84.
30. Šidák Z. Rectangular confidence regions for the means of multivariate normal distributions. *J Am Stat Assoc*. 1967;62(318):626–633.
31. R Core Team. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. 2018. https://www.R-project.org/.
32. Businelle MS, Kendzor DE, Reitzel LR, *et al*. Mechanisms linking socioeconomic status to smoking cessation: a structural equation modeling approach. *Health Psychol*. 2010;29(3):262–273.
33. Truth Initiative. Why Are 72% of Smokers from Lower-Income Communities? *Truth Initiative*; 2019. Accessed November 2, 2022. https://truthinitiative.org/research-resources/targeted-communities/why-are-72-smokers-lower-income-communities
34. Yingst JM, Veldheer S, Hrabovsky S, Sciamanna C, Foulds J. Reasons for non-adherence to nicotine patch therapy during the first month of a quit attempt. *Int J Clin Pract*. 2015;69(8):883–888.
35. Hitchman SC, Fong GT, Zanna MP, *et al*. Socioeconomic status and smokers' number of smoking friends: fndings from the International Tobacco Control (ITC) Four Country Survey. *Drug Alc Dep*. 2014;143:158–166.
36. Cheng KW, Shang C, Lee HM, *et al*. Costs of vaping: evidence from ITC Four Country Smoking and Vaping Survey. *Tob Control*. 2021;30(1):94–97.
37. Dearfield CT, Horn K, Crandell I, Bernat DH. Behavioural intentions in response to a potential menthol cigarette sales ban: a survey examining smokers in Washington, DC public housing. *BMJ Open*. 2022;12(7):e059821e059821.
38. Hartwell G, Thomas S, Egan M, Gilmore A, Petticrew M. E-cigarettes and equity: a systematic review of differences in awareness and use between sociodemographic groups. *Tob Control*. 2017;26(e2):e85–e91.
39. Simon P, Camenga DR, Morean ME, *et al*. Socioeconomic status and adolescent e-cigarette use: the mediating role of e-cigarette advertisement exposure. *Prev Med*. 2018;112:193–198.
40. Lucherini M, Hill S, Smith K. Potential for non-combustible nicotine products to reduce socioeconomic inequalities in smoking: a systematic review and synthesis of best available evidence. *BMC Pub Health*. 2019;19(1):1469.
41. Paolacci G, Chandler J. Inside the turk: understanding mechanical turk as a participant pool. *Curr Dir Psychol Sci*. 2014;23(3):184–188.
42. Chmielewski M, Kucker SC. An MTurk crisis? shifts in data quality and the impact on study results. *Soc Psychol Personal Sci*. 2020;11(4):464–473.
43. Paolacci G, Chandler J, Ipeirotis PG. Running Experiments on Amazon Mechanical Turk. Accessed March 30, 2022. https://papers.ssrn.com/abstract = 1626226
44. Suri S, Watts DJ. Cooperation and contagion in web-based, networked public goods experiments. *PLoS One*. 2011;6(3):e16836e16836.
45. González-Roz A, Jackson J, Murphy C, Rohsenow DJ, MacKillop J. Behavioral economic tobacco demand in relation to cigarette consumption and nicotine dependence: a meta-analysis of cross-sectional relationships. *Addiction*. 2019;114(11):1926–1940.
46. Wilson AG, Franck CT, Koffarnus MN, Bickel WK. Behavioral economics of cigarette purchase tasks: within-subject comparison of real, potentially real, and hypothetical cigarettes. *Nicotine Tob Res*. 2016;18(5):524–530.
47. Quisenberry AJ, Koffarnus MN, Hatz LE, Epstein LH, Bickel WK. The experimental tobacco marketplace i: substitutability as a function of the price of conventional cigarettes. *Nicotine Tob Res*. 2015.
48. Adler NE, Cutler DM, Fielding JE, *et al*. Addressing social determinants of health and health disparities: a vital direction for health and health care. In: NAM Perspectives. Discussion Paper. Washington, DC: National Academy of Medicine; 2016. doi:10.31478/201609t.
49. Bosdriesz JR, Willemsen MC, Stronks K, Kunst AE. Socioeconomic inequalities in smoking cessation in 11 European countries from 1987 to 2012. *J Epidemiol Community Health*. 2015;69(9):886–892.
50. Cavelaars AE, Kunst AE, Geurts JJ, *et al*. Educational differences in smoking: international comparison. *BMJ*. 2000;320(7242):1102–1107.
51. Smith CE, Hill SE, Amos A. Impact of population tobacco control interventions on socioeconomic inequalities in smoking: a systematic review and appraisal of future research directions. *Tob Control*. 2020.