

# US state cigarette tax increases and smoke-free legislation in relation to cigarette expenditure across household socio-economic circumstances: a quasi-experimental study

Summer Sherburne Hawkins<sup>1</sup> , Melissa Kull<sup>2</sup> & Christopher F. Baum<sup>1,3,4</sup> 

Boston College, School of Social Work, Chestnut Hill, MA, USA,<sup>1</sup> Chapin Hall at the University of Chicago, Chicago, IL, USA,<sup>2</sup> Department of Economics, Boston College, Chestnut Hill, MA, USA<sup>3</sup> and German Institute for Economic Research (DIW Berlin), Berlin, Germany<sup>4</sup>

## ABSTRACT

**Background and Aims** While research has focused on outcomes of tobacco control policies, less is known about the mechanisms by which policies may affect tobacco use. We estimated the associations of changes in cigarette taxes and smoke-free legislation with (1) any household cigarette expenditure and (2) the level of household expenditure on cigarettes, as well as (3) tested interactions with socio-economic circumstances. **Design** Difference-in-differences regression models to estimate the associations between changes in US state cigarette taxes and smoke-free legislation with changes in household expenditure on cigarettes. **Setting** Forty US states and District of Columbia. **Participants** From annual, cross-sectional surveys (with a longitudinal component) between 2000 and 2014, 128 138 households interviewed quarterly in the Consumer Expenditure Survey. **Measurements** Dependent measures included any household cigarette expenditure, expenditure in real dollars and budget share of cigarette expenditure. Policy measures included state cigarette taxes and 100% smoke-free legislation. Covariates included respondent age, race/ethnicity, sex; household education; poverty level; family structure; and number of children and adults. **Findings** Every \$1.00 cigarette tax increase was associated with a 1.5 percentage point (−0.028, −0.002) reduction in any cigarette expenditure and an increase of 0.1% (0.1%, 0.1%) budget share and \$10.11 (\$8.38, \$11.84) absolute expenditure. The association with absolute expenditure was stronger among smoking households above poverty level (\$10.73; \$8.94, \$12.51) than below (\$4.72; \$2.37, \$7.07). The enactment of smoke-free legislation was associated with \$2.33 (−\$4.56, −\$0.10) less expenditure, but not with any expenditure (0.1%; −1.6%, 1.8%) or budget share (−0.1%; −0.1%, 0.1%). The association with absolute expenditure was stronger among households above poverty level (−\$2.62; −\$4.95, −\$0.29) than below (−\$0.34; −\$4.27, \$3.58) **Conclusion** Cigarette tax increases in the United States between 2000 and 2014 may have reduced smoking prevalence due to an absolute and relative increase in household tobacco expenditure while smoke-free policies appear to have led to a reduction in expenditure. Although tax increases had a stronger impact on absolute expenditure among households above the poverty level, impact on relative expenditure was similar, and consequences for socio-economic inequalities in smoking will vary based on the broader financial situation of households.

**Keywords** Economics, household income, policy evaluation, smoke-free policy, smoking, taxes.

Correspondence to: SS Hawkins, Boston College, School of Social Work, McGuinn Hall, 140 Commonwealth Avenue, Chestnut Hill, MA 02467, USA.  
E-mail: summer.hawkins@bc.edu

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## INTRODUCTION

At the global level, from 2000 to 2010 the prevalence of tobacco smoking among men has declined in 72% of countries and among women in 87% of countries, although variation persists throughout regions [1]. From

2005 to 2015, the drop in the proportion of US adult smokers from 21 to 15% represents 8.6 million fewer smokers [2]. Reductions in smoking globally and in the United States are probably due, in part, to the success of tobacco control policy efforts and public health campaigns [3–6]. In particular, increases in cigarette excise taxes have

been hailed as one of the most notable achievements of anti-smoking efforts [5,7]. While the enactment of smoke-free legislation has been very effective at protecting non-smokers from secondhand smoke exposure, research has shown a less consistent effect on decreasing smoking prevalence [8,9]. Despite cigarette tax increases having a larger effect on low-income smokers who are more price-sensitive [5,10], 26% of US adults below the poverty line continue to smoke compared to 14% at or above the poverty line [2].

By March 2018 the average price of a pack of cigarettes was \$6.32 (range = \$4.56–10.48), including state and federal excise taxes [11]. While the majority of research has focused on the outcomes of tobacco control policies—measures of current smoking behaviors—less is known about the mechanisms by which policies may impact these behaviors. Based on economic theory, higher cigarette taxes would increase a household's tobacco cost burden due to continued consumption of a more expensive product, maintain expenditure with decreases in consumption or decrease the cost burden due to curtailed consumption or quitting smoking. Estimates suggest that the elasticity of demand for cigarettes is  $-0.3$  to  $-0.6$ , indicating that the demand for cigarettes is relatively insensitive to price (inelastic) [6,10] due to the highly addictive nature of tobacco [4]. Research has demonstrated a larger elasticity of demand for low-income smokers, indicating a greater response to tax increases [6]. Faced with higher prices, smokers often compensate by finding lower-priced cigarettes, including switching brands, purchasing online or crossing state borders [6]. Coady and colleagues found that the 2008 cigarette tax increase in New York City led to tax-avoidant purchasing behaviors, particularly among low-income smokers [12]. It is also well documented that the tobacco industry engages in various strategies to maintain low prices of tobacco products in response to tobacco control efforts, such as reductions in the size of packs and price discounts [13,14].

Currently, 35 US states and the District of Columbia (DC) have enacted 100% smoke-free restaurant legislation and 30 states and DC have enacted legislation in the workplace [15]. Comprehensive legislation in these venues may reduce the number of opportunities to smoke and, consequently, decrease a household's tobacco expenditure while still maintaining the behavior. Studies have not supported the initial concern that smoke-free policies would increase consumption in the home to 'replace' lost opportunities to smoke elsewhere [16,17]. However, recent reviews present conflicting conclusions about the impact of smoke-free legislation on cigarette consumption, indicating inconsistent evidence [8] or a positive benefit [9].

In order to examine the mechanisms by which strengthening tobacco control policies affects adult smoking behaviors, we analyzed a natural experiment

created by within and between state-level changes in cigarette taxes and smoke-free legislation. Our aims were to estimate the associations of changes in cigarette taxes and smoke-free legislation with (1) any household cigarette expenditure and (2) the level of household expenditure on cigarettes, as well as to (3) test interactions with socioeconomic circumstances.

## METHODS

### Design

We used repeated cross-sectional surveys (with a longitudinal component) of households from 40 US states and DC conducted annually to obtain data on household expenditure on cigarettes between 2000 and 2014. For each state, we collected monthly cigarette excise taxes and the enactment date of 100% smoke-free restaurant legislation in the year of the survey and merged with household data. We estimated difference-in-differences regression models to estimate the associations between tobacco control policies and household expenditure on cigarettes overall and, based on interactions, according to socioeconomic circumstances.

### Participants

The Consumer Expenditure Survey (CES), conducted by the US Bureau of Labor Statistics (BLS), is an annual rotating panel study that randomly selects a probability sample of households to assess household expenditure among the US civilian population [18]. Each year approximately 7000 new households are randomly selected to participate, in which households are asked to recall major expenditures during the past 3 months over the course of five quarters. The first interview for each household collects demographic data, with the following four consecutive quarterly interviews employing uniform questionnaires to capture expenditures during the past 3 months as well as changes in household characteristics, structure and employment. BLS estimates that up to 95% of total household expenditures may be identified in the interview panel survey [19].

We used 2000–14 CES data from the interview panel survey and stacked data to capture all observations (432 853) within households across calendar years (148 961). Households were excluded if they reported no expenditures (68), respondent was under the age of 16 years (8), there were no adults (72), state identifiers were missing (59 060) or the number of cases per state was fewer than 250 households across study years (326). The resulting sample size yielded 128 138 unique households that contributed 373 319 observations, and represented 40 states and DC. Observations across households were split almost equally from the second to fifth interviews

(second interview = 93 663; third interview = 92 621; fourth interview = 92 387; fifth interview = 94 648).

The Institutional Review Board at Boston College reviewed this study and considered it exempt.

### State-level measures

We included three state-level measures capturing tobacco control policies and economic indicators. First, monthly data on state-level cigarette excise taxes were acquired from the Tax Burden on Tobacco [20] and translated into real dollars using the national consumer price index (2013–15 = 100) [21]. Secondly, the American Non-smokers' Rights Foundation reports the month/year in which 100% smoke-free legislation for work-places and restaurants was implemented across each state [15]. Given that 24 of 40 states and DC had smoke-free policies applying to both work-places and restaurants and only one state (PA) had smoke-free work-place but not restaurant legislation, we selected 100% smoke-free restaurants as a proxy for smoke-free legislation. Thirdly, we incorporated a state-level economic indicator to control for the potential effects of economic conditions on cigarette expenditure [22]. We drew seasonally adjusted unemployment data for each state-year from the BLS Local Area Unemployment Statistics Database to capture the monthly unemployment rate, defined as the index of the number of non-working adults seeking employment to the number of adults in the labor force between 2000 and 2014 [23].

### Measures of household cigarette expenditure

We created three measures of household cigarette expenditure. At each interview, respondents answered questions on household spending: 'Have you or any members of your household purchased cigarettes? What is the usual weekly expense?'. BLS derived summary cigarette expenditure variables corresponding to calendar quarters. First, we created a dichotomous indicator to identify households with cigarette expenditure as those that reported any spending on cigarettes. Secondly, for our measure of household cigarette expenditure, we summed these variables to indicate each household's total cigarette-related expenses during the 3-month reference periods, which were translated into real dollars (2013–15 = 100) [21] and top-coded to four standard deviations above the mean. Thirdly, we computed a measure of the budget share of cigarette expenditure by dividing total cigarette expenditure by total household expenditure.

In order to align the calendar quarter interviews with monthly policy and economic indicators, we linked each policy variable to correspond to the first month of households' calendar quarter interview and averaged each

economic indicator during the 3 months that captured respondents' retrospective reports of expenditures.

### Respondent and household socio-demographic characteristics

The primary respondent reported information on the socio-demographic characteristics of him/herself and their households. We included respondent age, race/ethnicity and sex. We coded highest level of educational attainment in the household. We also included measures of family structure and the number of adults and, separately, children. Household poverty level was derived using total expenditure as a proxy for household income [24]. We used the federal poverty guidelines, accounting for household income and household size, to compute a dichotomous indicator of economic status relative to the annual federal poverty level. These poverty guidelines were used to determine eligibility for means-tested federal programs; for example, a household of four living in the contiguous US states with a total expenditure of \$23 850 in 2014 was defined as below the poverty line [25].

### Analyses

Our analytical plan proceeded in two steps. First, we used difference-in-differences models to examine whether changes in state tobacco control policies were associated with changes in any household cigarette expenditure (yes/no), as well as changes in the level of household cigarette expenditure assessed by two measures: (1) cigarette expenditure (\$) and (2) budget share of cigarette expenditure (%). We used a logistic regression model to assess whether changes in state tobacco control policies were associated with changes in any household cigarette expenditure (yes/no). We used a zero-inflated negative binomial regression model to predict cigarette expenditure [preferred to negative binomial models based on the Akaike information criterion (AIC) and Bayes' information criterion (BIC)].

For the logistic regression model of any household cigarette expenditure (yes/no) we tested a model with state random effects, but received a result from the Hausman test [26], indicating that the asymptotic assumptions underlying the test were not satisfied. For the zero-inflated negative binomial model, we were not able to achieve convergence with a two-level nested model. We could not find an adequate multi-level version of the zero-inflated beta model. The inclusion of state and time fixed effects with other time-varying state-level effects, such as the unemployment rate and poverty threshold, should be sufficient to diminish the remaining state-level variation.

To examine the budget share of cigarette expenditure, we used a zero-inflated regression to account for the (0,1) bounded nature of the proportional budget share variable.

In all analyses, we adjusted for respondent and household socio-demographic characteristics, state-level unemployment rate, month/year and state of residence. The state-level unemployment rate was not associated with any measure of cigarette expenditure (results not shown). The inflate option of the latter two regression models included respondent and household socio-demographic characteristics, month/year and state. All models included month/year and state fixed effects to account for calendar effects and time-invariant state-level differences, respectively. For these models, although all households were included in analyses, we present marginal effects only for households with cigarette expenditure, as non-smoking households have zero expenditure on cigarettes. To aid in the interpretation of coefficients, we present average marginal effects indicating the change in cigarette expenditure due to a \$1.00 increase in cigarette taxes or the implementation of smoke-free legislation.

Secondly, considering the known disparities in smoking [2], we examined whether associations between tobacco control policies and household cigarette expenditure varied across socio-economic circumstances. For these analyses, we tested interactions using an adjusted Wald test between each policy and household poverty and, separately, education.

Analyses were conducted using Stata version 14.1 statistical software, including cluster robust standard errors to cluster by household, except for the logistic regression model to examine any household cigarette expenditure, which was clustered by state.

## RESULTS

By December 2014, 30 of 40 states and DC had 100% smoke-free restaurant legislation and there was a 230% average increase in cigarette taxes over the study period (Table 1).

Overall, 26.5% of households had any expenditure on cigarettes. There was no evidence for differential associations between tobacco control policies and any household cigarette expenditure according to household poverty (Table 2) or education (Supporting information, Table S1) (both  $P > 0.05$ ). Every \$1.00 increase in cigarette taxes was associated with a 1.5 percentage point reduction in household cigarette expenditure [ $-0.015$ ; 95% confidence interval (CI) =  $-0.028$ ,  $-0.002$ ] (Table 2). In contrast, there was no association between the enactment of smoke-free legislation and household cigarette expenditure.

As there were significant interactions between cigarette taxes and household expenditure on cigarettes ( $P = 0.002$ ) and budget share ( $P = 0.057$ ) by poverty level (Table 3), but not education (Supporting information, Table S2) (both  $P > 0.05$ ), results were stratified. From 2000 to

2014, among smoking households at or above the poverty level, mean quarterly expenditure on cigarettes decreased from \$344.82 to 317.17 and the mean quarterly budget share of cigarette expenditure was 3.5% during the study period. Among smoking households below the poverty level, mean quarterly expenditure on cigarettes decreased from \$220.00 to 185.22 and the mean budget share of cigarette expenditure was 6.0% during the study period.

Differences in household expenditure revealed that, among smoking households at or above the poverty level, every \$1.00 increase in cigarette taxes was associated with \$10.73 (95% CI = \$8.94, \$12.51) per quarter higher expenditure on cigarettes and 0.11% (95% CI = 0.09%, 0.14%) higher budget share of cigarette expenditure (Table 3). Additionally, the enactment of smoke-free legislation was associated with \$2.62 (95% CI =  $-\$4.95$ ,  $-\$0.29$ ) less expenditure on cigarettes and 0.03% (95% CI =  $-0.06\%$ ,  $< 0.00\%$ ) lower budget share.

Among smoking households below the poverty level, every \$1.00 increase in cigarette taxes was associated with \$4.72 (95% CI = \$2.37, \$7.07) per quarter higher cigarette expenditure and 0.14% (95% CI = 0.07%, 0.21%) higher budget share of cigarette expenditure. We found no evidence that smoke-free legislation was associated with either measure of cigarette expenditure among households below the poverty level.

We repeated our analyses without California, as nearly 12% of observations were from that state alone and had the highest proportion of observations across all states. The pattern of results was consistent throughout all models (results not shown).

## DISCUSSION

Our study provides insights into the mechanisms by which tobacco control policies may influence adult smoking rates by examining household expenditure on cigarettes. Overall, we found that cigarette tax increases, but not smoke-free legislation, reduced household cigarette expenditure by 1.5 percentage points. During the study period, smoking households at or above the poverty level spent 3.5% of their expenditure on cigarettes compared to 6.0% in smoking households below the poverty level. We found that households' expenditure varied across household poverty as a result of stronger tobacco control policies. Households at or above the poverty level spent nearly \$11 more per quarter on cigarettes in response to a \$1.00 cigarette tax increase. In contrast, households below the poverty level spent only \$5 more per quarter on cigarettes in response to the same tax increase. We also found that the enactment of smoke-free restaurant legislation decreased cigarette expenditure only among households at or above the poverty level. As governments are recommended to raise taxes and enact smoke-free policies [5,7], it is essential to continually

**Table 1** Household smoking and tobacco control policies by state (*n* = 128 138 households).

	No. households	%	Mean % Any cigarette expenditure <sup>a</sup>	Mean cigarette expenditure per quarter (\$) <sup>b</sup>	Mean budget share of cigarette expenditure per quarter (%) <sup>b</sup>	12/2014 Cigarette tax <sup>c</sup>	2000–14 Tax % change	100% Smoke-free restaurants
Alabama	1915	1.5	32.7	312.05	4.3	\$0.42	85%	
Alaska	1985	1.6	33.8	376.36	3.7	\$1.99	43%	
Arizona	3587	2.8	26.4	315.46	3.9	\$1.99	147%	5/1/2007 <sup>d</sup>
California	15 129	11.8	20.0	263.17	2.9	\$0.87	–28%	1/1/1998
Colorado	2111	1.6	30.0	268.95	3.2	\$0.84	201%	7/1/2006
Connecticut	1704	1.3	25.7	345.00	3.5	\$3.39	387%	10/1/2003
Delaware	326	0.3	27.8	313.98	3.7	\$1.59	378%	11/27/200 <sup>d</sup>
DC	381	0.3	25.2	191.09	3.2	\$2.89	220%	1/1/2007 <sup>d</sup>
Florida	8286	6.5	25.2	301.39	3.9	\$1.33	183%	7/1/2003 <sup>d</sup>
Georgia	4497	3.5	25.2	252.69	3.7	\$0.37	121%	
Hawaii	1785	1.4	24.4	320.20	3.4	\$3.19	129%	11/16/200 <sup>d</sup>
Idaho	1349	1.1	25.5	262.99	3.8	\$0.57	46%	7/1/2004
Illinois	5857	4.6	27.9	331.02	4.0	\$1.97	145%	1/1/2008 <sup>d</sup>
Indiana	1831	1.4	31.4	308.65	4.5	\$0.99	360%	7/1/2012 <sup>d</sup>
Kansas	648	0.5	30.9	289.82	3.2	\$0.79	136%	7/1/2010 <sup>d</sup>
Kentucky	1758	1.4	42.5	339.97	5.3	\$0.60	1333%	
Louisiana	2748	2.1	29.0	288.02	4.0	\$0.36	29%	1/1/2007 <sup>d</sup>
Maine	514	0.4	32.3	399.28	5.3	\$1.99	94%	1/1/2004 <sup>d</sup>
Maryland	2809	2.2	23.3	301.55	3.3	\$1.99	117%	2/1/2008 <sup>d</sup>
Massachusetts	3055	2.4	25.8	377.38	4.5	\$3.50	231%	7/5/2004 <sup>d</sup>
Michigan	3658	2.9	31.7	356.84	4.3	\$1.99	91%	5/1/2010 <sup>d</sup>
Minnesota	1978	1.5	29.0	302.66	3.5	\$3.33	399%	10/1/2007 <sup>d</sup>
Missouri	2546	2.0	32.1	285.59	3.7	\$0.17	–28%	
Nebraska	1402	1.0	30.3	287.33	4.0	\$0.64	35%	6/1/2009 <sup>d</sup>
Nevada	1543	1.2	32.7	299.88	3.5	\$0.80	64%	12/8/2006 <sup>d</sup>
New Hampshire	458	0.4	26.2	374.55	4.1	\$1.77	145%	9/17/2007
New Jersey	4054	3.2	22.3	359.35	3.5	\$2.69	142%	4/15/2006 <sup>d</sup>
New York	8228	6.4	20.4	328.11	4.1	\$4.34	466%	7/24/2003 <sup>d</sup>
North Carolina	434	0.3	27.1	281.15	3.6	\$0.45	545%	1/2/2010
Ohio	4760	3.7	33.0	321.58	4.1	\$1.25	273%	12/7/2006 <sup>d</sup>
Oklahoma	618	0.5	31.8	286.51	4.0	\$1.03	221%	
Oregon	2329	1.8	30.0	282.43	3.6	\$1.31	38%	1/1/2009 <sup>d</sup>
Pennsylvania	6931	5.4	32.0	330.61	4.2	\$1.59	270%	
South Carolina	2703	2.1	32.7	275.92	4.4	\$0.57	483%	
Tennessee	1448	1.1	35.2	320.04	4.7	\$0.62	242%	
Texas	10 007	7.8	30.3	286.11	3.6	\$1.41	146%	
Utah	1911	1.5	9.5	296.34	3.0	\$1.69	137%	1/1/1995 <sup>c</sup>
Vermont	323	0.3	35.1	360.06	4.5	\$2.74	348%	9/1/2005 <sup>c</sup>
Virginia	4155	3.2	26.1	292.33	3.5	\$0.30	760%	
Washington	2636	2.1	25.0	322.97	3.5	\$3.02	163%	12/8/2005 <sup>c</sup>
Wisconsin	3741	2.9	27.7	312.02	3.9	\$2.51	206%	7/5/2010 <sup>c</sup>

DC = District of Columbia. <sup>a</sup>Households with any expenditure on cigarettes, drawn from earliest recorded observation. <sup>b</sup>Among households with cigarette expenditure. <sup>c</sup>Translated into real dollars using the national consumer price index (2013–15 = 100). <sup>d</sup>States with 100% smoke-free work-places by December 2014.

monitor the purchasing patterns of individuals and households in response to these policies and, particularly, those with limited financial resources.

Previously, Busch and colleagues used 1995–2001 CES data and found that smoking households spent 4% of their total expenditure on cigarettes [27]. In our CES sample nearly a decade later, we found that households at or above

the poverty level spent on average 3.5% of their total expenditure on cigarettes while households below the poverty level spent 6.0% on cigarettes. Differences in estimates may be due to the considerable changes in adult smoking rates [2] as well as the strengthening of tobacco control policies [4,5], including that only two states had enacted 100% smoke-free restaurant legislation

**Table 2** Marginal effects of the association between state tobacco control policies and any cigarette expenditure (yes/no) by poverty level ( $n = 128\ 138$  households).

	<i>Any cigarette expenditure</i>	<i>Marginal effect of coefficient</i>	<i>P-value</i>
Overall ( $n = 128\ 138$ )			
Mean %	26.5%		
Cigarette excise tax (\$1.00) (95% CI) <sup>a</sup>		-0.015 (-0.028, -0.002)	0.026
100% Smoke-free restaurants (yes/no) (95% CI) <sup>a</sup>		0.001 (-0.016, 0.018)	0.933
Above poverty level ( $n = 111\ 281$ )			
Mean %	26.7%		
Cigarette excise tax (\$1.00) (95% CI) <sup>a</sup>		-0.015 (-0.028, -0.002)	0.027
100% Smoke-free restaurants (yes/no) (95% CI) <sup>a</sup>		0.001 (-0.015, 0.017)	0.898
Below poverty level ( $n = 16\ 857$ )			
Mean %	25.1%		
Cigarette excise tax (\$1.00) (95% CI) <sup>a</sup>		-0.015 (-0.032, 0.003)	0.104
100% Smoke-free restaurants (yes/no) (95% CI) <sup>a</sup>		-0.002 (-0.028, 0.024)	0.889

CI = confidence interval. Models adjusted for the following covariates: respondent age, race/ethnicity and sex, household education, poverty level, number of adults and children in the household, family structure, state-level unemployment rate, month/year and state. <sup>a</sup>Standard errors are clustered by state; confidence interval based on White-robust standard errors.

prior to 2001 compared to 35 states and DC at the present time [15].

During a 1-year period, our findings suggest that among smoking households at or above the poverty level, cigarette tax increases lowered any expenditure on cigarettes by 1.5 percentage points, but increased annual expenditure on cigarettes by approximately \$43. In contrast, cigarette tax increases had no effect on any expenditure among households below the poverty level, but increased annual expenditure by \$19. These trade-offs highlight the challenges of balancing economic ramifications of reduced household income with potential health benefits accrued by reducing smoking and exposure of secondhand smoke. Research from behavioral economics has demonstrated that hypothetical changes in cigarette prices would elicit positive behavior change. Ross and colleagues found that a hypothetical 50% higher cigarette price increased the likelihood of adult smokers considering quitting or reducing the consumption of cigarettes, independent of the current price of cigarettes [28]. In a sample of low-income adults, Guillaumier and colleagues found that in response to higher hypothetical price increases, respondents increasingly endorsed trying to quit smoking [29]. While smokers in both studies reported price minimization strategies to maintain their addiction [28,29], the authors were not able to examine whether smokers actually changed their behavior when faced with higher prices. The CES does not capture information on quantity or type of cigarettes or other tobacco product purchased, so we could not determine whether participants engaged in any price minimization strategies in response to actual raises in cigarette taxes [6,30]. While a \$19–43 annual increase in household cigarette expenditure may not be large, these funds could be spent from budgets for essential household items.

We have shown that while smoking households below the poverty level spent a higher proportion of their household expenditure on cigarettes compared to households at or above the poverty level, the marginal effect of a cigarette tax increase was the same across household poverty levels. Furthermore, cigarette tax increases and smoke-free legislation had significant, albeit small, effects on the budget share of cigarette expenditure. However, the ethical ramifications of cigarette tax increases due to their financial burden continue to be debated [31,32]. While taxes have been shown to reduce socio-economic disparities in adult smoking [33], smokers are more likely to report financial strain than non-smokers [34] and low-income smokers are at particular risk [35]. In cross-sectional studies it is not possible to test for directionality and rule out that stress related to financial instability induces smoking as a coping mechanism. In a longitudinal study, Kendzor and colleagues found that smokers who reported financial strain at baseline had lower smoking cessation rates 26 weeks post-quit [36]. These findings demonstrate that the success of cigarette tax increases may be to the detriment of increasing financial strain. Martire and colleagues estimated that cigarette price increases would decrease income inequalities in smoking rates, but if smokers with financial stress were less price-sensitive, then the overall reduction would be smaller [37]. As these findings highlight, results may vary according to costs of basic expenditures and substitution of other tobacco products, suggesting that more research is needed on the financial implications of cigarette tax increases across income strata.

Furthermore, we found evidence that the enactment of smoke-free legislation was associated with expenditure only among households at or above the poverty level. In response to smoke-free policies these households spent, on average,

**Table 3** Marginal effects of the associations between state tobacco control policies among households with cigarette expenditure by poverty level ( $n = 33\,977$  households) on (a) cigarette expenditure and (b) budget share of cigarette expenditure.

	(a) Cigarette expenditure per quarter (\$)		(b) Budget share of cigarette expenditure per quarter (%)	
	Marginal effect of coefficient	P-value	Marginal effect of coefficient	P-value
Overall ( $n = 33\,977$ )				
Mean (SD)	\$308.33 (293.31)		3.8% (0.04)	
Cigarette excise tax (\$1.00) (95% CI) <sup>a</sup>	10.11 (8.38, 11.84)	< 0.001	0.12% (0.09, 0.14)	< 0.001
100% Smoke-free restaurants (yes/no) (95% CI) <sup>a</sup>	-2.33 (-4.56, -0.10)	0.040	-0.03% (-0.06, < 0.01)	0.063
Above poverty level ( $n = 29\,745$ )				
Mean (SD)	\$323.26 (299.19)		3.5% (0.04)	
Cigarette excise tax (\$1.00) (95% CI) <sup>a</sup>	10.73 (8.94, 12.51)	< 0.001	0.11% (0.09, 0.14)	< 0.001
100% Smoke-free restaurants (yes/no) (95% CI) <sup>a</sup>	-2.62 (-4.95, -0.29)	0.027	-0.03% (-0.06, < 0.00)	0.040
Below poverty level ( $n = 4232$ )				
Mean (SD)	\$198.34 (215.95)		6.0% (0.07)	
Cigarette excise tax (\$1.00) (95% CI) <sup>a</sup>	4.72 (2.37, 7.07)	< 0.001	0.14% (0.07, 0.21)	< 0.001
100% Smoke-free restaurants (yes/no) (95% CI) <sup>a</sup>	-0.34 (-4.27, 3.58)	0.863	0.02% (-0.14, 0.10)	0.743

CI = confidence interval; SD = standard deviation. Models adjusted for the following covariates: respondent age, race/ethnicity and sex, household education, poverty level, number of adults and children in the household, family structure, state-level unemployment rate, month/year and state. Inflate option included respondent age, race/ethnicity, and sex, household education, poverty level, number of adults and children in the household, family structure, month/year and state.

<sup>a</sup>Standard errors are clustered by state; confidence interval based on White-robust standard errors.

\$2.62 per quarter less on cigarettes. Despite conflicting conclusions of systematic reviews [8,9], our results suggest that eliminating opportunities to smoke through smoke-free policies probably reduces the number of cigarettes consumed. However, our results also showed no evidence that smoke-free legislation was associated with any household cigarette expenditure or expenditure on cigarettes among households below the poverty level. This is consistent with the review by Brown and colleagues, which found that smoke-free policies did not reduce socio-economic disparities in tobacco use [33]. While further research is needed to understand these relationships, the findings may reflect differences in access to smoke-free restaurants and work-places or addiction to tobacco products.

Despite detailed household expenditure data, there are a number of limitations of the CES. No information is collected on the type of cigarettes, other tobacco products, the number of people in the household who use cigarettes and the quantity and frequency of use. Cigarette expenditure is potentially subject to recall bias, particularly for non-daily smokers. If high cigarette taxes encourage substitution of alternative tobacco products, such as cigars, which could be cheaper in real terms, there may be no difference in the amount of nicotine or other chemicals consumed and no subsequent health benefits. We derived a proxy of household income based on total expenditure [24], which does not include savings and may underestimate total household income. As households above the poverty level probably have more savings and, thus, more total income than households below the poverty level, the difference in households' budget share of cigarette expenditure may be larger than estimated. While it was not possible to fit the optimal multi-level version of the zero-inflated model, we included state and time fixed effects, so this limitation is unlikely to have significantly affected the results. As state of residence was the lowest available geographic identifier, we were not able to capture local smoke-free policies in municipalities. Thus, our results are probably underestimates of the true effect of smoke-free legislation on household expenditure as residents living in a state with only local policies would be coded as not being covered by state-wide legislation.

Despite calls to continue increasing cigarette taxes and enacting smoke-free policies [4,5], considering tobacco control policy efforts within a social determinants of health framework can help to reduce tobacco use without widening health disparities [31,38]. Increases in cigarette taxes can be coupled with free smoking cessation medication and counseling, such as is offered through the Patient Protection and Affordable Care Act (ACA) [39]. Smoking cessation therapies for Medicaid recipients vary by state [40], and policymakers should be encouraged to provide benefits to the same level as the ACA. Further efforts to reduce disparities in adult smoking could include allocating funds from cigarette taxes to tobacco cessation efforts

among low-income smokers, such as subsidizing cessation therapies [31,33]. It is not enough to strive for national targets; we need to continually assess our progress by examining how and which individuals and households change their behavior to get us there.

#### Declaration of interests

None.

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### Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

**Table S1** Marginal effects of the association between state tobacco control policies and any cigarette expenditure (yes/no) by education ( $n = 128\ 138$  households).

**Table S2** Marginal effects of the associations between state tobacco control policies among households with cigarette expenditure by education ( $n = 33\ 977$  households) on a) cigarette expenditure and b) budget share of cigarette expenditure.