



## Original article

## Effects of wages on smoking decisions of current and past smokers

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## ABSTRACT

**Purpose:** We used longitudinal data and instrumental variables (IVs) in a prospective design to test for the causal effects of wages on smoking prevalence among current and past smokers.

**Methods:** Nationally representative U.S. data were drawn from the 1999–2009 waves of the Panel Study of Income Dynamics. Our overall sample was restricted to full time employed persons, aged 21–65 years. We excluded part time workers and youths because smoking and wage correlations would be complicated by labor supply decisions. We excluded adult never smokers because people rarely begin smoking after the age of 20 years. IVs were created with state-level minimum wages and unionization rates. We analyzed subsamples of men, women, the less educated, the more educated, quitters, and backsliders. Validity and strength of instruments within the IV analysis were conducted with the Sargan-Hansen J statistic and F tests.

**Results:** We found some evidence that low wages lead to more smoking in the overall sample and substantial evidence for men, persons with high school educations or less (<13 years of schooling), and quitters. Results indicated that 10% increases in wages lead to 5.5 and 4.6 percentage point decreases in smoking for men and the less educated; they also increased the average chance of quitting among base-year smokers from 17.0% to 20.4%. Statistical tests suggested that IVs were strong and valid in most samples. Subjects' other family income, including spouses' wages, was entered as a control variable.

**Conclusions:** Increases in an individual's wages, independent of other income, decreased the prevalence of smoking among current and past smokers.

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## Introduction

Epidemiologists have long recognized that low income is associated with smoking in industrialized countries [1,2]. One view is that low income causes smoking. Another view—frequently espoused by economists—is that smoking causes low income or that some unmeasured “third variable” such as ability to delay gratification or self-efficacy is responsible for both smoking and low income [3]. Instrumental variables (IVs) analysis has been suggested to remove the bias from reverse causality and “third variables” [4]. Two sets of economic studies have used IV analysis. In the first, economists find evidence that smoking results in lower wages for full time workers [5,6]. The second finds that increases in the

Earned Income Tax Credit (EITC) lead to decreases in smoking for low-educated women [7–9].

Our study tests whether wages—the largest category of income for most working adults—are causally related to smoking prevalence among current and past smokers. We make several contributions. First, we use unique instruments that, to our knowledge, have not appeared in studies of the effects of wages on smoking: state-level minimum wages and unionization rates. In addition, we statistically test for the validity and strength of these instruments. Second, the influential studies that have considered wages (as opposed to all income) and smoking correlations test whether smoking reduces wages [5,6]; we test for the reverse. Third, we are not aware of any studies that specifically address the separate effects of an individual's wage versus all other family income. The possible negative effect on smoking may be especially strong for wages. Evidence suggests that low wages are associated with low self-esteem and depression that, in turn, predict smoking prevalence and cessation [10,11]. Moreover, focusing on wages is warranted given that there are specific policies affecting wages such as minimum wage laws and business firms' decisions regarding compensation of

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employees. Fourth, our investigation differs from the EITC studies: Our samples are broader than low-income mothers; we analyze men and women together and separately; and we analyze individuals with high school educations or less (<13 years of schooling) as well as individuals with some college or college degrees ( $\geq 13$  years). We stratify by education because our instruments are likely to be stronger predictors of wages for the less educated than the more educated. Fifth, separate analyses are conducted for quitters and backsliders in light of findings in an influential study suggesting different predictors for each [12]. Finally, we use longitudinal data from the Panel Study of Income Dynamics (PSID), a highly regarded data set widely used by social scientists but infrequently used by epidemiologists.

Our samples are restricted to people who either smoke now or used to smoke at younger ages (ever smokers), who are aged 21–65 years, and who are employed full time. We focus on ever smokers because roughly 90% of smokers in the United States begin smoking before the age of 18 years and 99% before 26 years [13]. Our focus on ever smokers follows Ayyagari and Sindelar [14] in their analysis of job stress on smoking. Our sample does not include youths because their inclusion would require a separate analysis of labor supply given that many youths do not work or work part time. Moreover, wage and smoking correlations may sharply differ for youths versus adults [15]. Finally, most studies on the predictors of wages—such as schooling or work experience—exclude youths and the majority focus on full time workers, in part, to minimize any bias imparted by labor supply decisions [16].

## Methods, data

The PSID is a longitudinal, representative U.S. sample of adults. It contains much information including subjects' wages, smoking status, and state of residence. We combine data on "household heads" and "wives" (including partners), if any, for six recent waves as follows: 1999, 2001, 2003, 2005, 2007, and 2009. We use lagged socioeconomic variables and wages to predict smoking; that is, for

example, socioeconomic variables in 1999 are used to predict wages in 2000, and wages in 2000 are used to predict smoking in 2001. The information on previous year wages is collected in every wave. Because the critical covariate is wages, we select employees and/or the self-employed working full time defined as 1750+ annual work hours and 49+ weeks per year. Even though our samples are restricted to full time workers, we divide annual earnings by annual hours to obtain wages-per-hour. Annual earnings are not pure measures of wages-per-hour because respondents may work 38 hours or more than 60 hours per week and may work 49 weeks or 52 weeks per year. The dependent variable is prevalence of smoking (yes or no). We exclude persons with missing data. Our largest overall sample contains 7029 person-years. "Ever smoker" refers to respondents who are current or past smokers. The PSID asked respondents: "Do you smoke cigarettes?" and for those who answered "no" the PSID asked "Did you ever smoke cigarettes?" We define respondents as "ever smokers" if a "1" is recorded for either question.

Six subsamples are considered. In the first four, men are separated from women and persons with high school or less education are separated from persons with some college or more. In the quitters subsample, persons who report that they were not smokers in base years are excluded. In the backsliders subsample, persons who report that they were smokers in base years are excluded. The quitter subsample consists of 2765 person-years, and the backslider subsample consists of 2196 person-years.

Wages are calculated as subjects' annual earnings from work divided by annual work hours both measured in the year before the interview. Wages capture all earnings, including wages-per-hour, salary, second jobs, self-employment, bonuses, overtime, tips, and commissions. "Other family income" includes income to the subject from government transfers, interest, rent, dividends, capital gains, and alimony as well as wage and nonwage income from any spouse. The Consumer Price Index is used to adjust for inflation and our data are in 1999 dollars [17].

Table 1 lists means and SDs (continuous variables only) for all variables derived from the overall sample as well as the six subsamples.

**Table 1**  
Descriptive statistics: means (SDs for continuous variables)

Variables, covariates, and instruments	Overall sample	Male	Female	<13 y of school	13+ y of school	Smokers in base years	Nonsmokers in base years
Sample size	7029	4316	2713	3906	3123	2765	2196
<b>Key variables</b>							
Whether currently smokes	0.52	0.51	0.52	0.58	0.44	0.83	0.13
Wages, in 1999 dollars	\$14.92 (12.37)	\$16.47 (13.92)	\$12.46 (8.88)	12.30 (8.09)	18.21 (15.61)	13.99 (11.22)	17.62 (14.54)
Other family income, in 1999 dollars (divided by 10,000)	2.5371 (4.4139)	2.3003 (4.4567)	2.9139 (4.3193)	2.0803 (2.8075)	3.1084 (5.7803)	2.0795 (3.0283)	2.9985 (6.0851)
<b>Covariates</b>							
Male	0.61	—	—	0.63	0.59	0.65	0.67
Age	39.29 (10.77)	39.53 (10.99)	38.89 (10.36)	38.92 (10.49)	39.76 (11.07)	38.74 (9.95)	42.6751 (10.49)
White, non-Hispanic	0.64	0.65	0.61	0.59	0.68	0.62	0.68
African-American, non-Hispanic	0.26	0.23	0.32	0.31	0.21	0.30	0.20
Hispanic	0.05	0.07	0.03	0.07	0.04	0.04	0.07
Others	0.05	0.05	0.04	0.03	0.07	0.04	0.05
Married, spouse present	0.61	0.69	0.50	0.61	0.62	0.58	0.71
Years of schooling	12.69 (2.23)	12.60 (2.37)	12.84 (1.97)	11.26 (1.57)	14.49 (1.51)	12.39 (1.99)	13.06 (2.37)
Self-employed	0.09	0.10	0.07	0.09	0.09	0.07	0.10
Northeast	0.14	0.14	0.15	0.12	0.16	0.13	0.14
South	0.41	0.40	0.42	0.44	0.38	0.44	0.39
Midwest	0.28	0.28	0.28	0.27	0.28	0.30	0.25
West	0.17	0.13	0.15	0.17	0.18	0.13	0.22
State cigarette tax, cents per pack	0.53 (0.45)	0.53 (0.44)	0.54 (0.45)	0.51 (0.42)	0.57 (0.47)	0.51 (0.45)	0.59 (0.46)
State unemployment rate	4.90 (1.11)	4.89 (1.12)	4.90 (1.11)	4.87 (1.13)	4.93 (1.09)	4.89 (1.12)	5.04 (1.08)
Tobacco-control funding per capita, in 1999 dollars	2.64 (2.66)	2.61 (2.63)	2.68 (2.71)	2.72 (2.78)	2.54 (2.51)	2.65 (2.71)	2.68 (2.52)
Number of smoke-free laws	3.04 (1.73)	3.07 (1.73)	2.99 (1.73)	2.94 (1.75)	3.17 (1.70)	2.87 (1.76)	3.29 (1.72)
<b>Instruments</b>							
State minimum wage, in 1999 dollars	\$4.89 (0.56)	\$4.90 (0.57)	\$4.87 (0.53)	\$4.87 (0.55)	\$4.91 (0.56)	\$4.81 (0.52)	\$4.94 (0.61)
State unionization percentage	12.91 (6.07)	12.92 (6.10)	12.92 (6.01)	12.56 (5.96)	13.36 (6.18)	12.36 (6.00)	13.29 (6.10)

The dependent variable is binary and measures whether the person smokes in the current year (yes = 1); the mean is 52% for the overall sample, indicating that, on average, 52% of the sample smokes in any given year (but not that 52% were continuously smoking across all years). Mean real wages-per-hour are \$14.9 (1999 dollars) for all years combined. In the regressions, wages are logged. Mean “other family income” is \$25,371 (1999 dollars). State unemployment rates are from the Bureau of Labor Statistics [18]; state cigarette taxes are from Orzechowski and Walker [19]; measures of numbers of smoke-free air laws within states and inflation-adjusted per capita funding for tobacco control programs within states are from ImpacTeen (2015) [20,21]; state minimum wages, from the Department of Labor [22]; state percent of the workforce unionized, from UnionStats [23]. The measures of laws and funding are available from the second author.

## Methods, models

To minimize bias resulting from reverse causality (low wages cause smoking) and unmeasured “third variables,” we first exploit the longitudinal character of our data and second apply an IVs approach. We measure wages in base years and smoking in subsequent years. This means, for example, that wages from 2000 are used to predict smoking status in 2001; wages from 2002 are used to predict smoking status in 2003, and so on. This prospective approach likely suffers less reverse causality bias than a contemporaneous approach whereby wages and smoking are measured in the same year.

For the IV approach, two regressions, corresponding to “two stages,” are estimated. The first predicts wages and the second, smoking. Our instruments include variables unique to the wage regression and that do not appear in the smoking regression: state minimum wages and state percent of the workforce unionized. Numerous labor economics studies indicate that minimum wages and unionization rates are positive predictors of wages [24,25]. All monetary values are expressed in 1999 dollars to eliminate any bias that would have resulted from inflation from 1999 to 2007.

Implementation of an IV analysis with our data presents two challenges: our dependent variable, smoking, is binary and our data are longitudinal. To address these challenges, we run two models: linear IV regression with random effects and the Wooldridge IV Probit [26]. The linear model has the advantages that the IV, or two-stage least squares estimator, can be implemented conveniently with transformed instruments and consistent estimates can be obtained [27,28]. Random effects account for the lack of independence among observations from the same subject across different years that are associated with longitudinal data. But the linear model has a drawback: Predicted values of the binary dependent variable may fall outside the 0-to-1 interval. Wooldridge [29] and Angrist and Pischke [30] nevertheless suggest running linear models that include IVs, especially in large samples like ours.

We are not aware of any logistic model that simultaneously allows for IVs and longitudinal data. Wooldridge [26] adapted the Probit model to include IVs using longitudinal data. The Wooldridge model requires time averages of the exogenous variables in both first- and second-stage regressions [31,32]. The Wooldridge model estimates the effect of changes in independent variables holding time averages constant. The effects for variables with little variation over time (such as education) would not be well estimated in the Wooldridge model. State minimum wages and state percent of the workforce unionized, on the other hand, display variation over time and therefore are well suited for the Wooldridge model. The Probit model has the disadvantage that estimated coefficients are not easily interpreted. We therefore calculate marginal effects that are

similar to linear regression coefficients. The formula used to calculate the marginal effect for the Probit model is,

$$\frac{1}{N} \sum_{i=1}^N \left( \frac{\partial \Phi(x'_{ij}\beta_j)}{\partial x_{ij}} \right),$$

where  $\Phi()$  is the cumulative distribution function of the standard normal distribution. The marginal effect is calculated as the average of the marginal effect for individual  $i$ .  $\beta_j$  is the coefficient of variable  $j$ . The Stata command we use is “margins.”

Both the first- and second-stage regressions in both the linear and Probit models include these exogenous variables: age, age squared, race or ethnicity, gender, marital status, years of schooling, indicators for three of four broad regions, state cigarette taxes, state measure of number of smoke-free air laws, state inflation-adjusted per capita funding for tobacco control programs, and state unemployment rates. Selection of these exogenous covariates is based on our reading of the separate literature on predictors of wages and smoking [2,3,5–9,12,14–16,24,25,33–37]. We also include indicator (dummy) variables for four of five years. Even though we use data from 6 years, 1999, 2001, ..., 2009, we effectively analyze only 5 years because we do not predict smoking in 1999. We use cluster robust standard errors at the state level to account for any within state correlations in the IV Probit regressions. This clustering also accounts for the correlation within the same individual over time.

For both the linear and Probit models, in the second stage, we predict smoking using wages, the residual from the first stage, and all exogenous variables listed in the previous paragraph. For the Probit models, we also use time averages for covariates. The residual,  $u$ , is the difference between  $\ln wage$  and the predicted value ( $\ln wage$ ) in the first-stage regression. We view the residual as representing unobserved factors that influence wages and potentially affect smoking decisions. This viewpoint allows us to test whether wages are endogenous by testing the null hypothesis that the coefficient of  $u = 0$  [29]. The wage variable is endogenous because wages could be correlated with unobserved individual characteristics that predict smoking or because smoking could reduce wages. Therefore, any observational survey measure of wages (without IV adjustment) will not provide an unbiased estimate of the effects of wages on smoking status.

We also perform tests for the strength and validity of instruments. Strength is assessed with an  $F$  test of the joint contribution of our two instruments in predicting wages: percent unionized and level of state minimum wages. Strong instruments require first-stage  $F$  statistics to exceed 10; values less than 10 are problematic and values of 5 or less are weak and indicate finite-sample bias [38]. Validity (sometimes called overidentification or OIR) tests help to determine whether our instruments are exogenous, that is, in our case, whether there is any correlation between percent unionized and minimum wages on the one hand and state smoking prevalence on the other that is not due to variation in wages. Validity tests rely on the Sargan-Hansen  $J$  statistic for the OIR test for the linear model [39]. Stata did not provide the  $J$  statistic for the Probit model. Finally, the first regressions we report in the tables in the next section are linear with random effects and do not apply the IV technique; they are useful for comparison to the IV results.

## Results

Table 1 lists descriptive statistics. Males have higher wages than females (\$16.5 vs. \$12.5) but lower other family income (\$23,003 vs. \$29,139). The better educated (some college or college graduate, 13+ years of schooling) have higher wages than the less educated

(high school graduate or less: <13 years; \$18.2 vs. \$12.3). On average, 58% of the less educated smoke in the given interview year, whereas 44% of the better educated smoke. Among smokers in base years, 17% quit in current years. Among nonsmokers in base years, 13% relapse in current years. Nonsmokers in base years have higher wages than smokers in base years (\$17.6 vs. \$14.0). Nonsmokers have more years of schooling (13.6 vs. 12.4) and higher percentages are married (71% vs. 58%). First-stage IV regressions are available in the [Appendix Table 6](#).

**Table 2** lists overall sample results from the linear regression without IV as well as the second stage results from the linear regression with IV and Probit with IV. For the wage variable, statistical significance at the 5% level, two-tailed test, is achieved in all three regressions. Marginal effects are larger in the IV than the non-IV models. In the linear IV and Probit IV regressions, 10% increases in wages are associated with 3.8 and 3.7 percentage point reductions in smoking prevalence. These reductions correspond to changes from mean smoking prevalence of 52.0%–48.3%. But for the linear regression without IV, the marginal effect is only a 0.6 percentage point reduction in smoking. In the linear regression without IV, other family income is negative and statistically significant at ( $P < .05$ ), but the magnitude is small: A \$10,000 increase in other family income is associated with a reduction in smoking probability by .002. In the IV models, other family income is statistically insignificant.

First-stage  $F$  statistics for the two instruments are calculated to test for strength.  $F$  statistics are 14.25 and 15.59 for the linear IV and Probit IV regressions, suggesting instruments are strong in the overall sample. The state percentage unionized variable has statistically significant effects on wages ( $P < .05$ ). The minimum wage variable does not achieve statistical significance by itself, but does contribute to sizable  $F$  statistics—especially for the less-educated subsample. The validity (overidentification) test yields the Sargan-Hansen statistic of 2.44 with  $P$ -value of .118 and indicates that we fail to reject the null hypothesis that the instruments are valid. Finally, we test whether wages are endogenous, that is, whether the residuals from the first-stage regression have any predictive power in the smoking equation. The  $P$ -value for this test

is .069, implying that wages are endogenous, thereby justifying use of the IV.

**Table 3** lists results for men and women. Again, three regressions are reported: linear without IV, linear with IV, and Probit with IV. For the male subsample, we find statistical significance at the 5% level, two-tailed test, for wages in all three regressions. The coefficients for men suggest that 10% increases in wages result in reductions in smoking from 51% prevalence to 44.4% and 45.5% for the linear IV and Probit IV, respectively. For the female subsample, we find statistical significance only in the linear regression, but not in either IV regressions. We find other family income is statistically insignificant in five of six regressions. Regarding the strength of instruments, the  $F$  statistics from the first-stage regressions are 10.06 and 9.18 for men and 5.58 and 7.31 for women for the linear IV and Probit IV regressions, respectively. Regarding the validity of instruments, the OIR test does not reject the validity of instruments for men ( $P$ -value = .944) but does reject validity for women ( $P$ -value = .023).

**Table 4** lists results by education. We find statistical significance ( $P < .05$ ) for wages in the less than 13-year group. The coefficients for the less than 13-year group suggest that 10% increases in wages result in reductions in the prevalence of smoking from 58.0% to 49.8% and 53.4% for the linear IV and Probit IV regressions, respectively. The instruments are both strong and valid for the less-educated group (first stage  $F = 8.30$  and  $9.30$ , OIR  $P$ -value = .848). The test for endogeneity of wages ( $P$ -value = .058) suggests wages are endogenous for the less educated. For the better-educated group, we did not find statistical significance ( $P < .10$ ) for wages using either the linear IV or Probit IV regressions. We also encounter weak instruments (with first-stage  $F$  statistics around 6 and validity problems (OIR  $P$ -value = .065).

**Table 5** lists results on quitters and backsliders. The dependent variable for quitters equals 1 for quit and 0 for current smoker; the dependent variable for backsliders equals 1 for current smoker (person relapses) and 0 otherwise. The same three regressions from previous tables are run. For the quitters subsample, statistical significance ( $P < .05$ ) is achieved for both linear IV and Probit IV. The

**Table 2**  
Effect of wages on smoking in overall sample

Variables	Random effects linear model	Random effects linear model with IV	Wooldridge IV Probit model
Log of wages	−0.055*** (.000)	−0.379* (.068)	−0.368** (.027)
Other family income (spouse labor income + other income)/10,000	−0.002** (.015)	−0.000 (.995)	−0.000 (.862)
Male	0.033** (.032)	0.119** (.037)	0.113** (.015)
Age	0.006 (.171)	0.020** (.029)	0.025** (.031)
Age squared	−0.000*** (.006)	−0.000*** (.002)	−0.000*** (.000)
African-American†	0.046** (.013)	−0.022 (.626)	−0.020 (.559)
Hispanic†	−0.114*** (.000)	−0.177*** (.000)	−0.199*** (.000)
Other races†	−0.006 (.831)	−0.038 (.303)	−0.011 (.820)
Married, spouse present	−0.089*** (.000)	−0.074*** (.000)	−0.044* (.084)
Years of schooling	−0.027*** (.000)	−0.001 (.952)	0.001 (.941)
Self-employed	−0.010 (.597)	−0.045 (.130)	−0.021 (.435)
Cigarette tax	0.006 (.742)	0.027 (.232)	−0.010 (.697)
State unemployment rate	−0.017** (.017)	−0.020*** (.005)	−0.031*** (.008)
Tobacco-control funding per capita, in 1999 dollars	−0.002 (.421)	−0.004 (.109)	−0.001 (.855)
Number of smoke-free laws	−0.011** (.014)	−0.009* (.083)	0.017* (.075)
First-stage $F$ statistics ( $P$ -value)	—	14.25 (.001)	15.59 (.000)
OIR test statistics ( $P$ -value)	—	2.438 (.118)	—
Test of endogenous wage ( $H_0: \nu = 0$ )	—	—	3.31 (.069)
Sample size	7029	7029	7029

Notes: \*\*\* $P < .01$ , \*\* $P < .05$ , \* $P < .1$ . All are two-tailed tests. Each cell contains coefficient and  $P$ -value in parentheses. In the last column (IV Probit model), marginal effects are presented. Each regression also included indicator variables for four of the 5 years and three of the four regions (Northeast, South, and Midwest). All control variables are from the previous wave (2 years ago) because they are used to predict wages from the previous year (1 year ago). For IV Probit, the first stage predicts wages using all control variables and their averages and the two instruments minimum wages and percent of the labor force unionized. The second stage predicts smoking status using wages, the residual from the first stage, all control variables, and their averages [26].

† Omitted category is white, non-Hispanic.

**Table 3**  
Effect of wages on smoking by gender

Gender Variables	Male			Female		
	Random effects linear model	Random effects linear model with IV	Wooldridge IV Probit model	Random effects linear model	Random effects linear model with IV	Wooldridge IV Probit model
Log of wages	-0.054*** (.000)	-0.660** (.014)	-0.550*** (.008)	-0.049*** (.007)	-0.142 (.529)	-0.187 (.532)
Other family income/10,000	-0.002** (.049)	0.001 (.663)	-0.000 (.806)	-0.002 (.103)	-0.002 (.665)	-0.000 (.955)
Age	0.001 (.884)	0.030** (.025)	0.028** (.048)	0.013* (.083)	0.022** (.019)	0.033 (.110)
Age squared	-0.000 (.132)	-0.000*** (.005)	-0.000*** (.001)	-0.000** (.022)	-0.000*** (.003)	-0.000** (.021)
African-American†	0.084*** (.001)	-0.083 (.279)	-0.037 (.499)	0.003 (.926)	-0.020 (.524)	-0.032 (.427)
Hispanic†	-0.138*** (.000)	-0.247*** (.000)	-0.237*** (.000)	-0.035 (.514)	-0.068 (.342)	-0.081 (.388)
Other races†	-0.018 (.649)	-0.105* (.068)	-0.057 (.293)	0.018 (.694)	0.069 (.172)	0.067 (.199)
Married, spouse present	-0.094*** (.000)	-0.046 (.156)	-0.056 (.114)	-0.074*** (.001)	-0.094*** (.000)	-0.028 (.592)
Years of schooling	-0.024*** (.000)	0.024 (.283)	-0.002 (.860)	-0.036*** (.000)	-0.031 (.145)	0.010 (.407)
Self-employed	0.005 (.817)	-0.028 (.381)	-0.009 (.781)	-0.033 (.326)	-0.062 (.354)	-0.024 (.666)
State cigarette tax	0.042* (.079)	0.094*** (.009)	0.032 (.283)	-0.045* (.094)	-0.029 (.412)	-0.087** (.042)
State unemployment rate	-0.025*** (.005)	-0.025** (.016)	-0.029*** (.003)	-0.001 (.931)	-0.006 (.653)	-0.024 (.259)
Tobacco-control funding per capita, in 1999 dollars	-0.001 (.616)	-0.007* (.086)	0.001 (.772)	-0.002 (.537)	-0.004 (.307)	0.001 (.897)
Number of smoke-free laws	-0.017*** (.004)	-0.018*** (.009)	0.015 (.198)	-0.002 (.824)	-0.002 (.744)	0.017 (.291)
First-stage F statistics (P-value)	—	10.06 (.007)	9.18 (.000)	—	5.58 (.062)	7.31 (.000)
OIR test statistics (P-value)	—	0.005 (.944)	—	—	5.19 (.023)	—
Test of endogenous wage (H <sub>0</sub> : ν = 0)	—	—	5.35 (.021)	—	—	0.20 (.623)
Sample size	4316	4316	4316	2713	2713	2713

Notes: \*\*\*P < .01, \*\*P < .05, \*P < .1. All are two-tailed tests. Each cell contains coefficient and P-value in parentheses. In the last column (IV Probit model), marginal effects are presented. Each regression also included indicator variables for four of the 5 years and three of the four regions (Northeast, South, and Midwest). All control variables are from the previous wave (2 years ago) because they are used to predict wages from the previous year (1 year ago). For IV Probit, the first stage predicts wages using all control variables and their averages and the two instruments minimum wages and percent of the labor force unionized. The second stage predicts smoking status using wages, the residual from the first stage, all control variables, and their averages [26].

† Omitted category is white, non-Hispanic.

coefficient and marginal effect estimate suggest that 10% increases in wages are associated with 3.0 and 3.4 percentage point increases in the chances of quitting smoking. This can be interpreted an increase in the quit rate from 17% to 20%. The instruments are both strong and valid (F = 12.14 and 7.97, OIR P-value = .65) and wages are endogenous (P-value = .086). For the backsliders subsample, wages are not statistically significant at the 5% level in the IV regressions but are significant in the linear regression without IV. In the backslider

regressions, we detect some weak instruments (first stage F = 9.95 and 6.38), but no validity problems (OIR P = .187). Wages likely reduce the chances of quitting but do not affect backsliding.

Finally, overall, wages garner significance (P < .05) in 15 of 21 regressions in Tables 2–5, whereas other family income garners significance in only 4 of 21 regressions. Although not reported in the tables, we also run regressions with only unionization as the instrument (a tactic that seems especially appropriate for the

**Table 4**  
Effect of wages on smoking by education

Variables	High school or less than high school educated (<13 y of schooling)			Some college, college or more than college educated (13+ y of schooling)		
	Random effects linear model	Random effects linear model with IV	Wooldridge IV Probit model	Random effects linear model	Random effects linear model with IV	Wooldridge IV Probit model
Log of wages	-0.061*** (.000)	-0.817** (.035)	-0.458** (.025)	-0.047*** (.003)	0.258 (.472)	-0.332 (.224)
Other family income/10,000	-0.007*** (.006)	0.003 (.577)	-0.006 (.120)	-0.001 (.182)	-0.002 (.276)	0.001 (.255)
Male	0.030 (.156)	0.231** (.030)	0.131** (.032)	0.032 (.159)	-0.046 (.626)	0.109 (.147)
Age	0.009 (.138)	0.040** (.023)	0.038*** (.009)	0.004 (.565)	-0.009 (.599)	0.017 (.295)
Age squared	-0.000*** (.005)	-0.001*** (.005)	-0.001*** (.000)	-0.000 (.270)	0.000 (.857)	-0.000** (.032)
African-American†	0.020 (.401)	-0.130 (.117)	-0.047 (.255)	0.067** (.024)	0.126* (.095)	-0.012 (.816)
Hispanic†	-0.149*** (.000)	-0.288*** (.001)	-0.246*** (.000)	-0.033 (.462)	0.019 (.809)	-0.158** (.041)
Other races†	-0.004 (.946)	-0.027 (.676)	-0.080 (.219)	0.007 (.838)	0.051 (.431)	0.036 (.523)
Married, spouse present	-0.093*** (.000)	-0.066** (.016)	-0.068* (.082)	-0.079*** (.001)	-0.099*** (.002)	-0.022 (.596)
Years of schooling	-0.016*** (.008)	0.026 (.261)	0.013 (.506)	-0.033*** (.000)	-0.058* (.051)	0.004 (.757)
Self-employed	-0.001 (.971)	-0.086 (.127)	-0.042 (.289)	-0.014 (.622)	0.014 (.751)	-0.008 (.882)
State cigarette tax	0.025 (.326)	0.051 (.146)	0.039 (.301)	-0.019 (.458)	-0.041 (.263)	-0.063** (.039)
State unemployment rate	-0.021** (.024)	-0.036*** (.008)	-0.034*** (.007)	-0.010 (.335)	-0.010 (.349)	-0.030* (.060)
Tobacco-control funding per capita, in 1999 dollars	-0.000 (.902)	-0.005 (.254)	-0.001 (.746)	-0.004 (.167)	-0.003 (.399)	-0.002 (.691)
Number of smoke-free laws	-0.012* (.051)	0.001 (.926)	0.012 (.262)	-0.010 (.120)	-0.012* (.097)	0.020 (.173)
First-stage F statistics (P-value)	—	8.30 (.016)	9.30 (.000)	—	5.37 (.068)	6.34 (.002)
OIR test statistics (P-value)	—	0.037 (.848)	—	—	3.400 (.065)	—
Test of endogenous wage (H <sub>0</sub> : ν = 0)	—	—	3.58 (.058)	—	—	0.99 (.321)
Sample size	3906	3906	3906	3123	3123	3123

Notes: \*\*\*P < .01, \*\*P < .05, \*P < .1. All are two-tailed tests. Each cell contains coefficient and P-value in parentheses. In the last column (IV Probit model), marginal effects are presented. Each regression also included indicator variables for four of the 5 years and three of the four regions (Northeast, South, and Midwest). All control variables are from the previous wave (2 years ago) because they are used to predict wages from the previous year (1 year ago). For IV Probit, the first stage predicts wages using all control variables and their averages and the two instruments minimum wages and percent of the labor force unionized. The second stage predicts smoking status using wages, the residual from the first stage, all control variables, and their averages [26].

† Omitted category is white, non-Hispanic.

**Table 5**  
Wage effect on cigarette quitting and relapsing behavior

Variables	Smokers in previous waves; quit = 1 or continues smoking = 0			Nonsmokers in previous waves; resume smoking = 1 or continues not smoking = 0		
	Random effects linear model	Random effects linear model with IV	Wooldridge IV Probit model	Random effects linear model	Random effects linear model with IV	Wooldridge IV Probit model
Log of wages	0.050*** (.002)	0.301* (.090)	0.336** (.048)	-0.037** (.011)	-0.051 (.790)	-0.107 (.463)
Other family income/10,000	-0.001 (.515)	-0.007 (.171)	-0.001 (.606)	-0.001** (.015)	-0.001 (.463)	-0.003 (.315)
Male	-0.009 (.657)	-0.080 (.103)	-0.095** (.046)	-0.004 (.834)	-0.003 (.951)	-0.004 (.921)
Age	0.001 (.901)	-0.012 (.139)	0.020* (.074)	-0.004 (.613)	-0.005 (.568)	0.021* (.079)
Age squared	-0.000 (.820)	0.000 (.242)	0.000* (.068)	-0.000 (.725)	-0.000 (.921)	-0.000 (.465)
African-American <sup>†</sup>	0.008 (.702)	0.048 (.123)	0.057** (.033)	0.029 (.301)	0.025 (.564)	0.013 (.681)
Hispanic <sup>†</sup>	0.059 (.203)	0.096** (.027)	0.089** (.010)	-0.072** (.041)	-0.071 (.157)	-0.074* (.088)
Other races <sup>†</sup>	-0.007 (.879)	0.008 (.868)	0.019 (.694)	-0.048 (.249)	-0.050 (.204)	-0.044 (.293)
Married, spouse present	0.047** (.012)	0.019 (.311)	0.081** (.049)	-0.058** (.011)	-0.052** (.018)	-0.082* (.051)
Years of schooling	0.009** (.040)	-0.012 (.433)	-0.011 (.644)	-0.009** (.023)	-0.008 (.622)	-0.008 (.686)
Self-employed	0.019 (.539)	0.059* (.096)	0.043 (.431)	0.013 (.603)	0.009 (.773)	0.037 (.140)
State cigarette tax	-0.004 (.881)	-0.023 (.430)	0.024 (.516)	0.010 (.645)	0.011 (.714)	0.005 (.904)
State unemployment rate	0.006 (.546)	-0.002 (.825)	0.017 (.335)	-0.012 (.266)	-0.010 (.309)	-0.018 (.242)
Tobacco-control funding per capita, in 1999 dollars	0.001 (.773)	0.001 (.716)	0.001 (.736)	0.001 (.692)	0.001 (.724)	0.003 (.533)
Number of smoke-free laws	0.004 (.521)	0.003 (.673)	-0.020* (.056)	-0.001 (.839)	-0.002 (.782)	0.008 (.541)
First-stage F statistics (P-value)	—	10.14 (.006)	7.97 (.000)	—	9.95 (.007)	6.38 (.002)
OLR test statistics (P-value)	—	0.226 (.645)	—	—	1.744 (.187)	—
Test of endogenous wage (H <sub>0</sub> : $\nu = 0$ )	—	—	2.96 (.086)	—	—	0.24 (.627)
Sample size	2765	2765	2765	2196	2196	2196

Notes: \*\*\* $P < .01$ , \*\* $P < .05$ , \* $P < .1$ . All are two-tailed tests. Each cell contains coefficient and  $P$ -value in parentheses. In the last column (IV Probit model), marginal effects are presented. Each regression also included indicator variables for four of the 5 years and three of the four regions (Northeast, South, and Midwest). All control variables are from the previous wave (2 years ago) because they are used to predict wages from the previous year (1 year ago). For IV Probit, the first stage predicts wages using all control variables and their averages and the two instruments minimum wages and percent of the labor force unionized. The second stage predicts smoking status using wages, the residual from the first stage, all control variables, and their averages [26].

<sup>†</sup> Omitted category is white, non-Hispanic.

female and higher educated subsamples for which the minimum wage variable does not have a large effect). We do not find any notable differences from our main results: Wages are not statistically significant for the female and higher educated subsamples, but wages are significant for the male, lower-educated, and quitter subsamples.

## Discussion

The preponderance of evidence in Tables 2–5 is that rising wages are associated with lower smoking prevalence among full-time employed ever smokers. The strongest associations are found for men (Table 3), persons with less than 13 years of schooling (Table 4), and quitters (Table 5). Modest associations are found in the overall sample (Table 2) that combines sexes, education groups, quitters, and backsliders. In the IV models, 10% increases in wages are associated with 5.5–6.6 percentage point reductions in smoking prevalence for men, 4.6–8.2 percentage point reductions for persons with less education, and 3.0–3.4 percentage point increases in quitting. We include other family income as a control variable. We do not create an IV for other family income and therefore do not claim any causal finding regarding other family income [1,2].

Our results are consistent with IV studies on the EITC suggesting that higher income leads to less smoking for low-income persons. They are also consistent with those in Van Ours [6] and Huisman et al. [2] suggesting that wage (or income) and smoking correlations are stronger for men than women. There are explanations for these correlations. Stuber et al. [40] suggest social stigma is associated with smoking among higher income groups. Binkley [41] suggests that “the poor have less to look forward to” (p.982) and therefore more inclined to continue smoking, risking premature death than high-income smokers. Binkley’s hypothesis derives from Becker and Mulligan’s [42] argument that increasing income and wealth will result in lowering time preferences, leading to less smoking.

Our finding that wages are better predictors for men than women might be due to the tendency of men more than women to tie their self-worth to pay. Adelman [43] finds strong associations between “personal income” from work on the one hand and happiness and self-confidence on the other among men, but not women; and self-esteem predicts smoking cessation [11]. Our findings are also consistent with broad literature demonstrating that low income predicts poor health and health habits [1,44,45]. Finally, our findings for larger IV marginal effects than non-IV effects are consistent with the IV literature. Grossman [46] suggests larger IV estimates result from the following: variation in who is most affected by the instruments; spillover effects; and measurement error. Spillover effects refer to the effects of smokers and nonsmokers on fellow workers. One worker who quits may, indirectly, encourage other workers to quit and the per-worker productivity and wages for the team of workers may rise by more than the increase because of only the original worker’s decision to quit.

There are advantages to the instruments we selected. First, geographic variables are frequently used in IV analysis because they are less likely than other variables such as subjects’ characteristics to be under the influence of individuals [47,48]. Second, numerous studies use state minimum wages and percent of the workforce unionized to predict wages [24,25]. Moreover, these studies find that the effects of minimum wages and unionization are greatest for low-wage, low-education workers, consistent with our findings. These findings also suggest that the gaps between the non-IV estimates and the IV estimates may result from wage effects being larger for low-wage and less-educated workers who are most affected by the instruments. Third, our statistical tests for strength and validity are favorable in most cases; in fact, in all cases involving the subsamples for men only, persons with less than 13 years of schooling, and quitters.

There are additional strengths. Our prospective approach measures independent variables—including wages—in earlier years and smoking in later years. Second, data are highly regarded,

longitudinal from 1999 to 2009, and nationally representative. Third, we control for numerous independent variables—including other family income—that might confound associations between wages and smoking. Fourth, results on other independent variables appear reasonable and consistent with the literature: men smoke more than women [49,50]; the less educated smoke more than the more educated [51]; married persons smoke less than others [50]; southerners smoke more than nonsoutherners [50]. Our results for smoking coincide with those from Ruhm [37] who found that higher state-level unemployment was associated with less smoking. Our smoking findings may be the result of our unique samples of only full time workers. The increase in state unemployment rates may have resulted from employers laying off less productive employees and retaining more productive ones. Some evidence suggests that a disproportionate number of less productive employees are smokers [5,6]. Because observations that did not have full time employment are dropped from our sample, the pool of workers that remain in the sample would be disproportionately nonsmokers. Finally, results from the first-stage regressions (Appendix) are also consistent with the literature: for example, increasing age, more schooling, being male, and married predict higher wages [16]. The fact that so many of our results on control variables are consistent with the literature augers well for our data and method.

The first possible limitation is that smoking is self-reported. However, self-reported smoking has high validity compared to biological measures [52]. Second, attrition might bias our findings and we might be underestimating the effects of wages. It is likely that disproportionate numbers of persons in low-wage jobs or those who smoked had died over these years or dropped out of the labor market. Had there been no premature death or dropping out, the number of respondents in lower wage jobs would have increased and the estimated prevalence of smoking within those lower wage jobs would have been higher.

A different possible limitation involves unemployment. Some workers in our samples may have experienced some unemployment. For any given year, our samples included only respondents with full time employment. For example, if a respondent was fully employed in 2001, 2003, 2007, and 2009, but not in 2005, then data from this respondent were included only for 2001, 2003, 2007, and 2009. This respondent may therefore have experienced some unemployment in 2005. In this case, and similar ones, it could be that the new jobs confound the effect of the new wages. In partial response to this possible limitation, we reanalyzed with stricter conditions that required respondents to be continuously employed from 1999 through 2009. Our sample sizes were reduced by approximately 40%. Our results on the overall sample were very similar to those reported in Table 2, but for the subsamples (Tables 3–5) wages became statistically insignificant, which may be due to smaller samples. We prefer the first samples that did not require continuous employment, however, as these contained significantly more respondents. There is a second response to this potential limitation: our IVs are based on statewide influences on individuals' wages, not specific jobs. Economic evidence indicates that increases in state minimum wages and percentages of the workforce in unions lead to increases in average wages for jobs (especially low-wage jobs) available in the state, without any distinction between “old” or “new” jobs [24,25]. An analysis of the effects of job changes on smoking prevalence, nevertheless, may be a fruitful area for future research.

There is an additional limitation involving full time workers. Our sample of women is less typical of all employed women than our sample of men. In 2003 (a middle year of our analysis), approximately 72.1% of employed women were working full time (which the Bureau of Labor Statistics defines as 35+ hours per week), whereas approximately 86.8% of men were working full time [53].

Differences across race and ethnicity, however, are less pronounced than between the sexes [54].

Our findings have several implications. Given well-known associations between smoking and health insurance premiums as well as between smoking and work productivity, employers have incentives to reduce smoking prevalence among employees. Some employers pay for smoking cessation programs, whereas others offer financial incentives to quit [55]. Whereas wage increases are unlikely to be as cost effective for employers as either smoking cessation programs or specific financial incentives, our findings, especially for the large wage effects on the propensity to quit, suggest that the benefits of paying higher wages include reductions in smoking prevalence. Our results suggest that employers might consider these benefits in wage negotiations. These benefits on smoking cessation are consistent with other studies showing increasing wages can lead to lower turnover and absenteeism, improved productivity, enhanced customer service, and fewer disciplinary problems [56–58]. Similarly, our results suggest indirect benefits of unionization and higher minimum wages include reductions in smoking prevalence among employed persons. Our findings, finally, are consistent with studies demonstrating the benefits of unions for expanding health insurance coverage, paid sick leave, and pensions as well as the benefits of hikes in minimum wages for reducing obesity [59,60].

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**Appendix**

**Table 6**

First stage of IV estimation; dependent variable is log wages

Variables	Overall	Male	Female	High school or less	Some college, college, or more	Smokers in previous waves	Nonsmokers in previous waves
Sample size	7029	4316	2713	3906	3123	2765	2196
Other family income/10,000	0.006*** (.010)	0.005* (.086)	0.008** (.015)	0.013*** (.002)	0.004** (.033)	0.011** (.041)	0.006* (.068)
Male	0.263*** (.000)	—	—	0.265*** (.000)	0.259*** (.000)	0.263*** (.000)	0.242*** (.000)
Age	0.039*** (.000)	0.044*** (.000)	0.031*** (.000)	0.040*** (.000)	0.041*** (.000)	0.037*** (.000)	0.038*** (.000)
Age squared	-0.000*** (.000)	-0.000*** (.000)	-0.000*** (.002)	-0.000*** (.000)	-0.000*** (.000)	-0.000*** (.000)	-0.000*** (.000)
African-American	-0.202*** (.000)	-0.271*** (.000)	-0.114*** (.000)	-0.201*** (.000)	-0.197*** (.000)	-0.160*** (.000)	-0.201*** (.000)
Hispanic	-0.169*** (.000)	-0.161*** (.000)	-0.213*** (.002)	-0.191*** (.000)	-0.174*** (.007)	-0.143*** (.004)	-0.182*** (.004)
Other races	-0.102** (.011)	-0.140** (.013)	-0.046 (.395)	-0.041 (.584)	-0.150*** (.002)	-0.151*** (.013)	-0.041 (.548)
Married, spouse present	0.057*** (.000)	0.082*** (.000)	0.015 (.542)	0.035 (.113)	0.070*** (.002)	0.026 (.249)	0.048* (.088)
Years of schooling	0.080*** (.000)	0.079*** (.000)	0.084*** (.000)	0.056*** (.000)	0.081*** (.000)	0.080*** (.000)	0.075*** (.000)
Self-employed	-0.100*** (.004)	-0.049 (.238)	-0.205*** (.002)	-0.113** (.022)	-0.093* (.063)	-0.122** (.021)	-0.079 (.200)
State cigarette tax	0.032 (.171)	0.047 (.137)	0.005 (.895)	0.008 (.816)	0.050 (.122)	-0.015 (.648)	0.057 (.150)
State Unemployment rate	-0.015** (.049)	-0.006 (.494)	-0.028** (.029)	-0.024** (.013)	-0.006 (.618)	-0.006 (.598)	-0.013 (.322)
Tobacco-control fund per capita	-0.005** (.029)	-0.006* (.064)	-0.004 (.230)	-0.006* (.067)	-0.004 (.347)	-0.003 (.387)	-0.005 (.226)
Number of smoke-free laws	0.009* (.061)	0.003 (.686)	0.018** (.023)	0.013** (.046)	0.003 (.707)	0.011 (.124)	-0.002 (.817)
State minimum wages (instrument)	0.013 (.467)	0.009 (.710)	0.025 (.410)	0.017 (.536)	0.005 (.852)	0.030 (.288)	-0.014 (.616)
State percent unionized (instrument)	0.008*** (.001)	0.009*** (.003)	0.007** (.038)	0.008** (.011)	0.008** (.024)	0.009*** (.007)	0.012*** (.002)
First-stage joint test for instruments (P-value)	14.25 (.0008)	10.06 (.007)	5.58 (.062)	8.30 (.016)	5.37 (.068)	10.14 (.006)	9.95 (.007)

Notes: \*\*\**P* < .01, \*\**P* < .05, \**P* < .1. All are two-tailed tests. Each cell contains coefficient and *P*-value in parentheses. These are the first-stage regression estimates for the IV estimation. The dependent variable is log of wages. Each regression also included indicator variables for four of the 5 years and three of the four regions (Northeast, South, and Midwest).