State Cigarette Taxes, Smoking, and
Implications for the Educational Gradient in Mortality

INTRODUCTION

It is taken as a social fact that less educated people live shorter lives. But the association between educational attainment and mortality is not static. Educational disparities in mortality in the U.S. have widened in the past three decades (Montez 2012). For example, the educational gap in life expectancy at age 25 among whites has doubled for men and tripled for women since 1990. There has also been a dramatic divergence in mortality trends between states, due in large part to the premature mortality of individuals with low education (Montez et al. 2016). Concurrent with these changes, the U.S. has seen a rise in state's rights, divergence in state policies, and widespread use of state preemption. In this evolving political landscape, state-level policy is increasingly consequential for population health.

New research suggests that state policy is most consequential for individuals with low education (Beckfield and Bambra 2016; Krieger et al. 2014; Montez et al. 2016, 2017). This is because college graduates have personal resources that make them less dependent on context for health. Rich, educated people can "buy" their way into the determinants of health regardless of where they live (Chetty et al. 2016). This idea is consistent with Fundamental Cause Theory (FCT) (Link and Phelan 1995). According to FCT, increased educational attainment conveys flexible social resources, which can be marshaled to avoid health risks and access medical technology. Individuals with lower education, on the other hand, are more dependent on their local context. This is where variation between states becomes consequential for health. For example, an individual with less than a high school education has limited employment options and is less likely to receive adequate health insurance through an employer. For this reason, under the American model of employer-based health insurance, not finishing high school is associated with less access to health insurance (Farber and Levy 2000). But states differ in the extent to which they will offer public health insurance to low-income individuals. Thus, the same individual might qualify for health insurance through Medicaid in Illinois, but not in South Carolina. This is an example of a social mechanism by which state policy influences the strength of the low education→no health insurance association.

With this study, I contribute to a growing body of research that suggests state policy can disrupt the extent that educational attainment maps onto health resources, even when there is no change in social stratification by educational attainment (Beckfield and Bambra 2016; Cylus et al. 2015; Montez et al. 2019). I conceptualize educational attainment as a component of socioeconomic status and as a factor that has differential influence on mortality depending on state policy. I propose a Tobacco Control Transition model to conceptualize the multistage process of tobacco control policy and its corresponding impacts on smoking, smoking-related mortality, and the educational gradient in mortality. I draw on data from two nationally representative longitudinal surveys (The Panel Study of Income Dynamics and The National Social Life Health and Aging Project) to explore the potential for a specific state policy—the excise tax on cigarettes—to reduce smoking and moderate the educational gradient in mortality. My results suggest that higher state cigarette taxes weaken the educational gradient in mortality. Higher taxes have a stronger protective effect against mortality for the low educated, particularly for men. I find modest support for the hypothesis that state cigarette taxes reduce educational disparities in mortality directly by reducing smoking. But the negative association between cigarette tax level and smoking prevalence (and in turn, cigarette tax level and mortality) result from more than merely the direct effect of tax increases on smoking cessation. Drawing on my conceptual framework, I argue that cigarette taxes act as an indicator for progression along the Tobacco Control Transition. Thus, in addition to their direct effect on smoking, cigarette taxes differentiate states' overall progress in moving through the Tobacco Control Transition. State cigarette taxes may be especially representative of a state's policy regime, which facilitates or inhibits educational disparities in health via multiple policy domains. With this study, I highlight one way that the effects of a fundamental cause—in this case educational attainment—on health inequality are contingent on state policy.

BACKGROUND

Education differentiates social resources such that lower educated people, on average, experience less healthcare, more toxic exposures, more instability, more stress, worse nutrition, and worse health behaviors (Crimmins and Saito 2001; Kubanksy et al. 1999; Ross and Wu 1995). But what if people were assured quality healthcare, financial stability, and protection from toxic exposures regardless of their social resources? This is where states come into the picture. In today's America, states have unprecedented control over access to the social determinants of health (Nathan 2005). This is because decisions about public health insurance, public economic benefits, regulation of health risks, and environmental standards are made at the state level, and increasingly so. The American Federalist system has seesawed between giving more and less autonomy to states (Nathan 2005). Since the 1980s, more discretion to expand or limit public access to everything from education to clean air rests in the hands of the state government (Kondratas et al. 1998; Nathan 2005). State policies determine who is exposed to what and for how long and who gets access to protective resources ranging from healthcare to stable housing to paid sick leave. I should note that I follow convention in conceptualizing educational attainment not as a measurement of an individual's cognitive abilities, but as a component of and proxy for socioeconomic status (House 2002). More education is power; it is agency; it is the privilege of highly-educated individuals to move to any state and know that their health will be minimally impacted.

States vary in the degree that educational attainment predicts health. If we imagine a spectrum with complete decoupling of the educational inequality/health association on one end and complete coupling of the educational inequality/health association the other end, states are distributed at different positions along this spectrum. Two general strategies will, in theory, reduce the educational gradient in mortality: 1) reduce educational inequality (i.e. compulsory schooling laws, mandated school desegregation); or 2) decouple educational inequality from health and mortality (House 2002; Phelan et al. 2010). The second strategy, decoupling educational inequality from health and mortality, requires investment in non-education sectors. It may seem counterintuitive, but it takes investment in policy domains other than education to decouple educational inequality from health. For example, mandatory seat belt laws reduce motor vehicle fatalities (Rivera et al. 1999) and mandatory seat belt laws have a stronger effect on seat belt use among those with less education (Harper et al. 2013). Interestingly, the differential impact of seat belt laws by education was larger for states that transitioned from no law directly to primary enforcement (drivers can be stopped and ticketed for failing to use seat belts alone), instead of upgrading from secondary (drivers can be ticketed for no seat belt when stopped for something else) to primary enforcement (Harper et al. 2012).

There are various theoretical perspectives on the educational/health inequality association. This study draws heavily on Fundamental Cause Theory. According to Fundamental Cause Theory, educational/SES gradients in health and mortality emerge as a result of advances in scientific knowledge and medical interventions (Clouston et al. 2016; Phelan et al. 2010). When we first learn how to intervene in a disease process, people with more education, money, and social privilege will benefit disproportionately. As the better educated use their social resources to avoid a particular disease outcome, a gap in health emerges (Clouston et al. 2016). In the time it takes for less educated, poorer people to gain access to the new treatment or knowledge for disease prevention, the gap widens. When this inequality-producing process occurs across multiple health outcomes, the result is a steep educational gradient in mortality.

State policies with the best chance of flattening educational gradients in health and mortality are those that ensure public access to things that highly educated people have in abundance or that protect populations against harmful exposures to materials, toxins, or lifestyle factors (e.g., zoning to prevent toxic exposures, occupational safety regulations, investment in public transportation, etc.). Policies that ensure universal or uniform access to a determinant of health should contribute to a decoupling of educational inequality and health (Phelan et al. 2010). For example, laws mandating universal access to vaccination, fluoride, clean indoor air, and minimum wages reduce the channels through which educational inequality can shape health (Gostin and Gostin 2009; Hodge and Gostin 2001). Investment in roads, more generous unemployment insurance, and increased regulations to protect worker safety will also help decouple the link between low education and poor health/shorter life (Cylus et al. 2015; McKinlay 1979; Viscusi 1986).

While it is relatively easy to list policies that should, in theory, result in a weakening of the educational gradient in health and mortality, it is much more difficult to find empirical evidence of this effect. Here are some of main challenges to empirical work of this sort. First, and most obvious, social policies constrain health in complex ways so it is difficult to isolate the effect of a single policy on the educational gradient in mortality. Yet, standard methods of causal inference in quantitative research rely on isolating treatment effects and minimizing bias. Second, policy changes can have gradual influence that is detectable only at the aggregate level, often many years after exposure. The lagged nature of most social policy effects on disease and mortality means that there are countless opportunities for intervening mechanisms to transform the treatment effects over the life course. Third, although social policies initiate causal chains, they are often several causal steps away from measurable health outcomes. Because medical research traditionally focuses on proximal, visible causes at the individual level, it is easy to underestimate the role of social policy variables in producing health inequalities. Their distal or upstream position in a causal relationship makes their effects "invisible" with standard research methods. Worse yet, we erroneously attribute their effects to other downstream variables. Fourth, exposure to policies is often uneven across the population. Of particular concern are situations where privileged individuals are exempted from regulations or laws, or can opt-out of exposure to a social policy. Fifth, social policies hang together and often have their effect in concert with each other. In this sense, efforts to isolate the effect of a single social policy on health may be misguided because social policy (particularly state policy) may have the majority of its influence as a "package deal." These are just some of the challenges to studies that aim to demonstrate the causal influence of social policies on trends in population health.

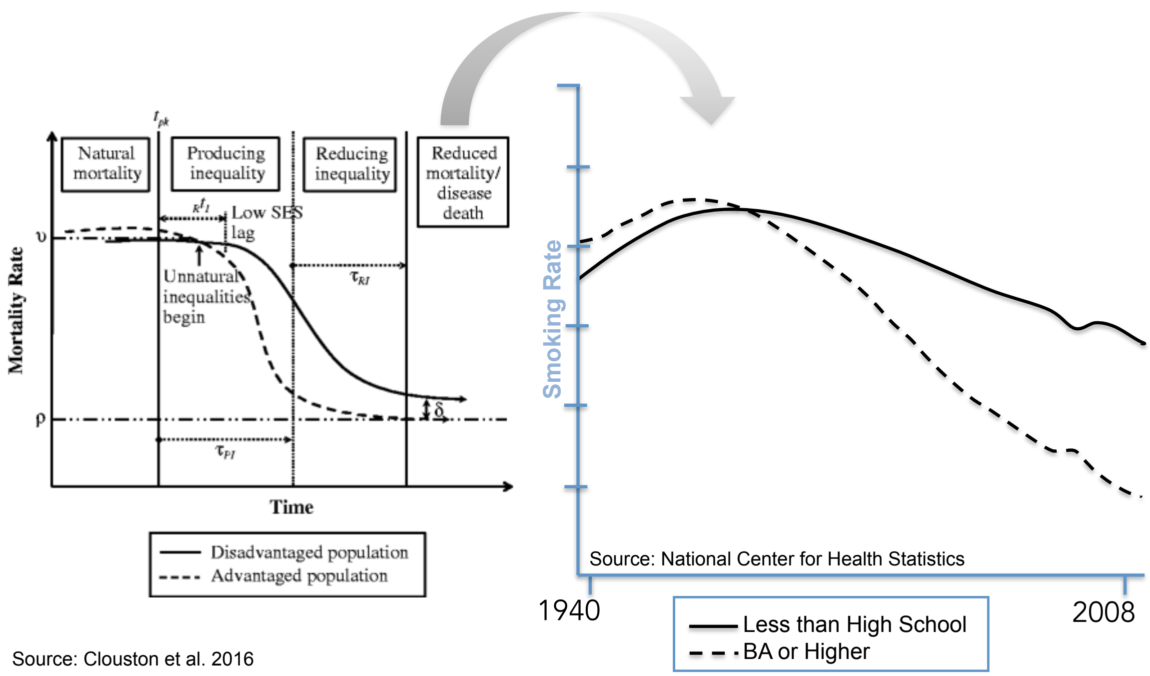
Despite these challenges, several recent studies have demonstrated that when localities or states adopt policies that promote universal access to the social determinants of health, educational inequalities in health are reduced. This evidence has come from studies that have attempted to isolate and quantify the impact of the Earned Income Tax Credit, paid family leave, access to WIC and foodstamps, and racial integration of schools on health inequalities (Alvarez et al. 2015; Cylus et al. 2015; Hamad et al. 2018a; Hamad et al. 2018b; Liu et al. 2012).

Other scholars have taken a more holistic approach to show that regional context or state political regime can influence health and moderate health inequalities. A team of researchers led by Jennifer Karas Montez has identified five domains of state context that are consequential for mortality disparities between states: economic output, income inequality, adoption of the Earned Income Tax Credit, Medicaid program quality and expansion, and tobacco policy environment (Montez et al. 2016).

In this study, I chose to focus on cigarette taxes as a case for studying how state level policy can moderate the educational gradient in mortality. The general consensus in the literature is that cigarette taxes reduce smoking prevalence, with the strongest effects seen in young people. This reduction in smoking is achieved through deterring smoking initiation and through encouraging smoking cessation. Because we know so much about the effect of cigarette taxes on smoking behavior (Bush et al. 2012; Chaloupka et al. 2012; Hill et al. 2014; MacLean et al. 2015), it is a useful case for testing the potential for state policy to modify educational disparities in mortality. Additional reasons why cigarette tax policy is ideal for exploring the potential for state policy to moderate the educational gradient in mortality are that: 1. Unlike policies such as paid family leave, state cigarette taxes have been implemented since the 1920s so there are many years of data which allows for the possibility to look between and within states for effects. 2. Smoking accounts for half of the recent increase in the educational gap in mortality for white women and much of it for white men (Ho and Fenelon 2015); and 3. Smoking-related morality explains 60 percent of the mortality disadvantage of Southern states compared with other regions (Fenelon 2013). Smoking is an especially important driver of the educational gradient in later-life mortality because over half of today's older adults were smokers at some point, but consistent with FCT, the more educated individuals quit (Fenelon and Preston 2012; Phelan et al. 2010).

Indeed, smoking is a compelling example of FCT in action (Link and Phelan 2009). Before the health risks of smoking were publicized in the 1964 Surgeon General's Report on Smoking and Health, there was no educational gap in smoking. Then, as knowledge spread about the health risks of smoking, a large educational gap in smoking emerged (See *Figure 1*). College educated people quit or never started smoking. But without the same access to knowledge or resources to quit, low-educated people kept smoking. This resulted in the large educational disparities in smoking and smoking-related mortality that we see today. Among today's older adults, the college educated are more likely to be former smokers instead of current smokers (Link and Phelan 2009). It is important to note that although cigarette taxes are thought to be most effective at preventing and reducing smoking among young people (Lewit and Coate 1982), studies have also shown significant reductions in smoking among older adult smokers in response to cigarette taxes (DiCicca and McLeod 2008; MacLean et al. 2015; Stevens et al. 2017). This tax-induced smoking cessation in later life may be especially likely to result in detectable reductions in mortality in the short-term since a large literature suggests smoking cessation even later in life reduces morbidity and increases longevity (DiCicca and McLeod 2008).

Figure 1. Smoking Trends as Example of Fundamental Cause Theory



The public health crusade to reduce smoking is now over a half century underway in the U.S. State cigarette excise taxes, which began as a tool for revenue generation, became a key strategy for tobacco control. The causal effect of cigarette tax increases on smoking has been thoroughly studied by economists. The general consensus in the literature is that cigarette taxes reduce smoking, with the strongest effects being on young people. Because we know so much about this mechanism, it is useful for testing the potential for state policy to modify educational disparities in mortality.

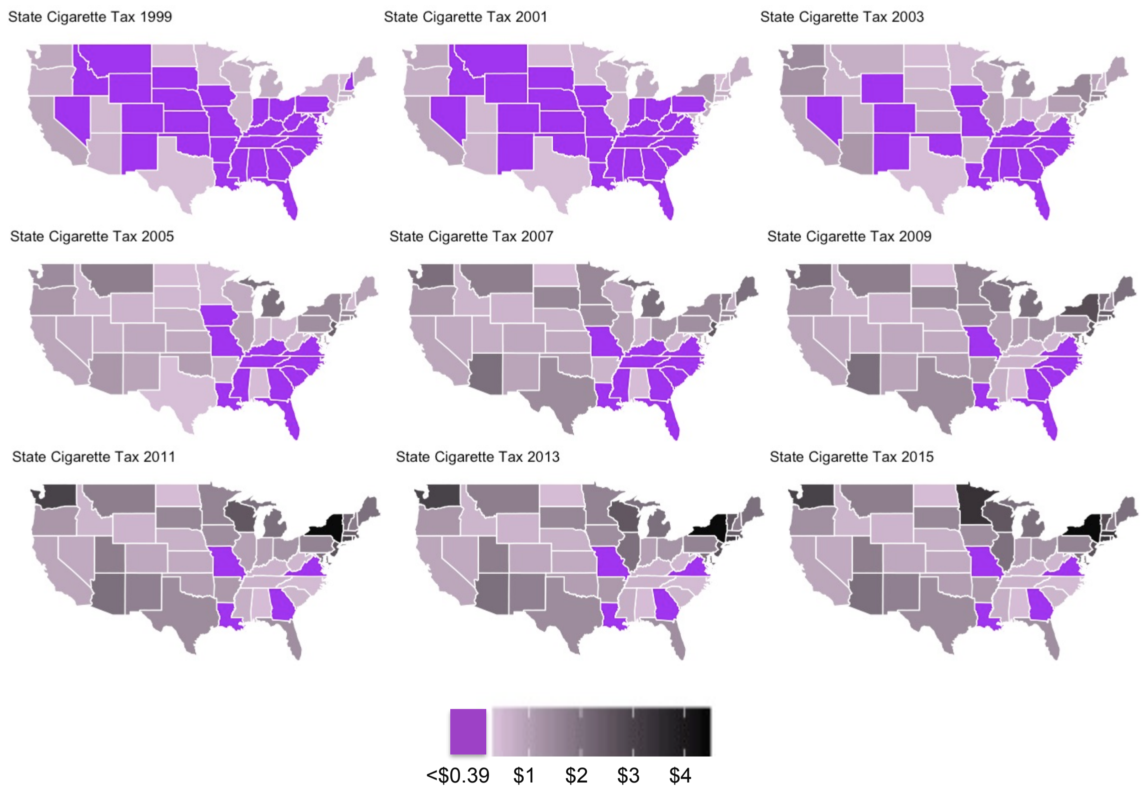
Tobacco control efforts shape trends in smoking initiation, smoking prevalence, and smoking-related mortality in patterned ways in line with what I refer to as the Tobacco Control Transition. In the following section, I propose a model (The TCT) that I use as a conceptual framework to guide my expectations about the interplay between cigarette taxes, smoking, death, and disparities.

Conceptual Framework: The Tobacco Control Transition

To make sense of the complex dynamics between tobacco-control strategies such as cigarette excise taxes, and smoking behavior, mortality, and mortality inequalities, I propose a model I call "The Tobacco Control Transition" (TCT). The Tobacco Control Transition describes the population health consequences of the adoption of a suite of strategies intended to reduce smoking and prevent tobacco use. In the model, tobacco control refers to taxation of cigarettes, laws to regulate indoor air, laws to restrict tobacco advertising, and campaigns to educate the public about the health risks of smoking. It also involves the contemporaneous shifts in culture and norms around smoking in public and private spaces. All of these variables shift at the contextual level, and through their mass influence on individual behavior, they have consequences for population-level trends in smoking and mortality.

States have been taxing cigarettes since 1921. Cigarette taxes were used to generate revenue for states. Cigarette taxes remained relatively low until the late-1990s. There has been a divergence in state-level cigarette taxes in the last two decades (See *Figure 2*), with the range between the highest and lowest state tax widening from $2.43 in 2005 to $4.18 in 2015. States in the Northeast are the leaders in high cigarette taxes, while the Southern states consistently have the lowest cigarette taxes. On average, states in the South saw a $0.35 increase in cigarette tax levels from the 2001-05 average to the 2011-15 average, whereas states in the Northeast saw a $1.58 increase over the same period. Few states increased cigarette taxes in the 2011-15 period. This may be because there was a $0.62 increase in the federal excise tax in April 2009, which is something I do not explore in this analysis but may consider in future work.

Figure 2. State Cigarette Taxes 1999 through 2015



Although they were not initially part of tobacco control efforts during the 1970s and 1980s, cigarette excise taxes are now a central pillar of a state's tobacco control program (Gorovitz et al. 1998). In every state during my study period, smoking prevalence is highest among individuals with low education (Farrelly et al. 2012). This means that every state has progressed to at least Stage 2 of the TCT. And of great relevance to my current investigation, cigarette taxes have been shown effective at not just furthering reductions in smoking prevalence and initiation, but at reducing the educational gap in smoking (Chaloupka et al. 2012). Much of the controversy surrounding cigarette taxes stems from concern that they punish poor smokers economically. But because cigarette taxes effectively deter smoking and promote smoking cessation, there is a compelling argument that by having a stronger effect on the poor and less educated, they promote equity in smoking-related mortality (Chaloupka et al. 2012).

Some studies have shown that individuals with lower socioeconomic status are more sensitive to cigarette tax increases (Siapush et al. 2009), although other studies have shown no increased sensitivity to tax among low income or low educated individuals (Borren and Sutton 1992). Regardless of differential sensitivity to cigarette taxes, as long as low educated individuals have a higher prevalence of smoking, smoking contributes more to mortality for the low educated. It follows that any reductions in smoking due to taxes should have a greater impact on mortality among the low educated. There need not be a differential responsiveness to cigarette taxes by education for cigarette taxes to reduce the educational gradient in mortality.

One of the challenges in studying the effects on cigarette taxes on smoking disparities is that states have increased cigarette taxes concurrently with other tobacco control strategies, such as labeling requirements for cigarette packaging, restrictions on tobacco advertising, and clean indoor air regulations. Some studies of cigarette taxes have tried to address this by controlling for the passage of smoking bans (For example, see MacLean et al. 2015). This helps somewhat, but the problem of confounding by general progression through the Tobacco Control Transition remains. The Tobacco Control Transition involves multiple strategies that impact smoking behavior as well as social norms around smoking. Cigarette taxes and clean indoor air regulations are just two of those strategies. Further, there may be feedback between cigarette taxes and smoking behavior such that as norms around smoking change, it becomes easier to pass larger increases in cigarette taxes. Because of this complexity, I consider the possibility that cigarette taxes act as signal for progression through the TCT. In this way, any detectable effect of base cigarette tax level on educational disparities in smoking and mortality may reflect the aggregate effect of all of the tobacco control efforts undertaken in addition to taxing cigarette. In other words, cigarette taxes may have their effects, in part, from the direct price increase, and in part, indirectly from what tax level signals about the progression along the Tobacco Control Transition.

The TCT depicts the expected consequences of tobacco-control strategies for population health, but there is great variation in the pace that states progress through the five stages of the transition. State differences in demographics, culture, economy, and politics make it such that certain states (i.e., California) have progressed quickly through the Tobacco Control Transition, while others (i.e, North Carolina) have stalled. For nearly three decades, California led the way in tobacco control (Rogers 2010). In 1989, California launched a $0.25 per pack tax on cigarettes as part of the state's larger strategy of tobacco control. Revenue generated through the tax was funneled back into other strategies for tobacco control (Roeseler and Burns 2010). In line with the National Cancer Institute's *Standards for Comprehensive Smoking Prevention and Control*, California's tobacco control program aimed to achieved comprehensive social norm change, which was believed to be more effective for smoking reduction that focusing on individual smokers (Roeseler and Burns 2010). This model of social norm change was disseminated widely and influenced tobacco control efforts in other states. But not all states have been receptive. Former tobacco producing states, such as North Carolina, have trailed behind in raising cigarette taxes and regulating smoking in public spaces. The lobbying against anti-smoking legislation and state preemption to block tobacco control by lower jurisdictions are also factors that have slowed the pace at which states proceed through the TCT.

While this policy variation across states is indicative of deeper differences in state political culture, it is useful for studying the effects of cigarette taxes on the educational gradient in mortality. Here, I conceptualize each state as a population with its own educational gradient in mortality that is dynamic over time in response to state policy and other factors that differ between states. I make the assumption that the meaning of educational attainment for social stratification is stable over my study period and across states. Thus, I interpret any variation in the educational gradient in mortality as indicative of changes in the extent to which education maps onto health, not changes in the extent to which education stratifies social resources. With that said, a recent study showed that the functional form of the educational gradient in mortality varies by region in the U.S. In the South, the form is consistent with the Human Capital Hypothesis (a linear association between years of schooling and mortality), whereas the other regions reflect the Credentialism Hypothesis (high school completion and college completion are marked by stepwise decreases in mortality) (Sheehan et al. 2018)[1]. Put simply, this suggests that a college degree does not mean the same thing for social status in one region as it does in another. It is possible that some of this variation is because states within these regions are at different stages of the TCT, but investigating the causes of interregional variation in the functional form of the educational gradient in mortality is beyond the scope of this study. I acknowledge it here as a reminder that my study observes states at different stages in the TCT and, in turn, with different educational gradients in mortality at the study baseline in 1999.

There are four population-level measures that show patterned trends as a consequence of the Tobacco Control Transition and its influence on individual smoking behavior within a population: 1) smoking initiation; 2) smoking prevalence; 3) smoking-related mortality; and 4) contribution from smoking to SES-inequalities in mortality such as the educational gradient in mortality. Similar to the Demographic Transition (Lee 2003), the Tobacco Control Transition can be conceptualized with five stages. The TCT model I introduce here is not the first attempt at modeling the complex relationship between smoking prevalence and smoking-related mortality. In 1994, Lopez and colleagues proposed a multistage model of the cigarette epidemic where they conceived of four stages and depicted trends in smoking prevalence by gender and smoking-related deaths by gender (Lopez et al. 1994). Thun and colleagues extended the Lopez model in 2012, updating it with recent data and extending it to the year 2020 (Thun et al. 2012). The aim of these models was to depict the long delay between widespread uptake of smoking in a population and its effects on mortality. The multistage TCT model I propose builds on these models, but is distinct in that the TCT also considers influence from tobacco-control efforts including cigarette taxes, and it depicts the consequences for the educational gradient in mortality as predicted by Fundamental Cause Theory.

<u>Stage 1. Pre-Transition.</u> Populations, in this case states, which have yet to undergo the Tobacco Environment Transition look like this:

1. HIGH Smoking Initiation
2. HIGH Smoking Prevalence
3. HIGH Smoking-related Mortality

[1] The human capital hypothesis and credentialism are the two main theories of how years of schooling relates to health and mortality (Sheehan et al. 2018). According to the human capital hypothesis, each additional year of schooling enhances human capital that manifests as reductions in mortality (Mirowsky and Ross 1998). According to credentialism, the relationship between educational attainment and health is not linear, but an incremental trichotomy with mortality reductions resulting from the earning of educational credentials, specifically, a high school diploma and a college degree (Backlund et al. 1999).

4. LOW Educational gradient in mortality (contribution from smoking)

Stage 2. Initiation. As a population initiates the Tobacco Control Transition, public awareness about the health risks of smoking grows through the publicizing of research and through anti-smoking campaigns. This first causes the more educated use their social resources to quit. Also, the context begins to restrict ease of smoking through regulations and cigarette excise taxes.

1. DECLINING Smoking Initiation
2. DECLINING Smoking Prevalence
3. HIGH Smoking-related Mortality
4. LOW Educational gradient in mortality (contribution from smoking)

Stage 3. Saturation. As a population proceeds through the Tobacco Control Transition, public awareness about the health risks of smoking reaches saturation through the publicizing of research, anti-smoking campaigns, and tobacco product labeling requirements. It is no longer just the most educated who are aware of the health risks of smoking. High cigarette taxes provide a strong incentive to quit or reduce smoking and a disincentive to initiate smoking. These influences combine to prevent smoking initiation among young people of all education levels. They also spurs reduction in smoking among people of all education levels, though the highly educated people are more successful at quitting because they have better access to medical and cultural resources to support their decision to quit. With reductions in smoking, smoking-related mortality begins to decline, but primarily among the highly educated since they were the first to quit smoking. Reflecting the early reductions in smoking among the highly educated, the educational gradient in mortality is increasing. This is consistent with evidence that educational disparities in mortality in the U.S. have widened in recent decades (Montez 2012).

1. Low Smoking Initiation
2. DECLINING Smoking Prevalence
3. DECLINING Smoking-related Mortality
4. INCREASING Educational gradient in mortality (contribution from smoking)

Stage 4. Completion. As a population completes the Tobacco Control Transition, public awareness about the health risks of smoking reaches saturation through the publicizing of research and through anti-smoking campaigns. It is no longer just the most educated who are aware of the health risks of smoking. High cigarette taxes provide a strong incentive to quit or reduce smoking and a disincentive to initiate smoking. These influences combine to prevent smoking initiation among young people of all education levels. They also spurs reduction in smoking among people of all education levels, though the highly educated people are more successful at quitting because they have better access to medical and cultural resources to support their decision to quit. With reductions in smoking, smoking-related mortality begins to decline, but primarily among the highly educated since they were the first to quit smoking. Reflecting the early reductions in smoking among the highly educated, the educational gradient in mortality is high.

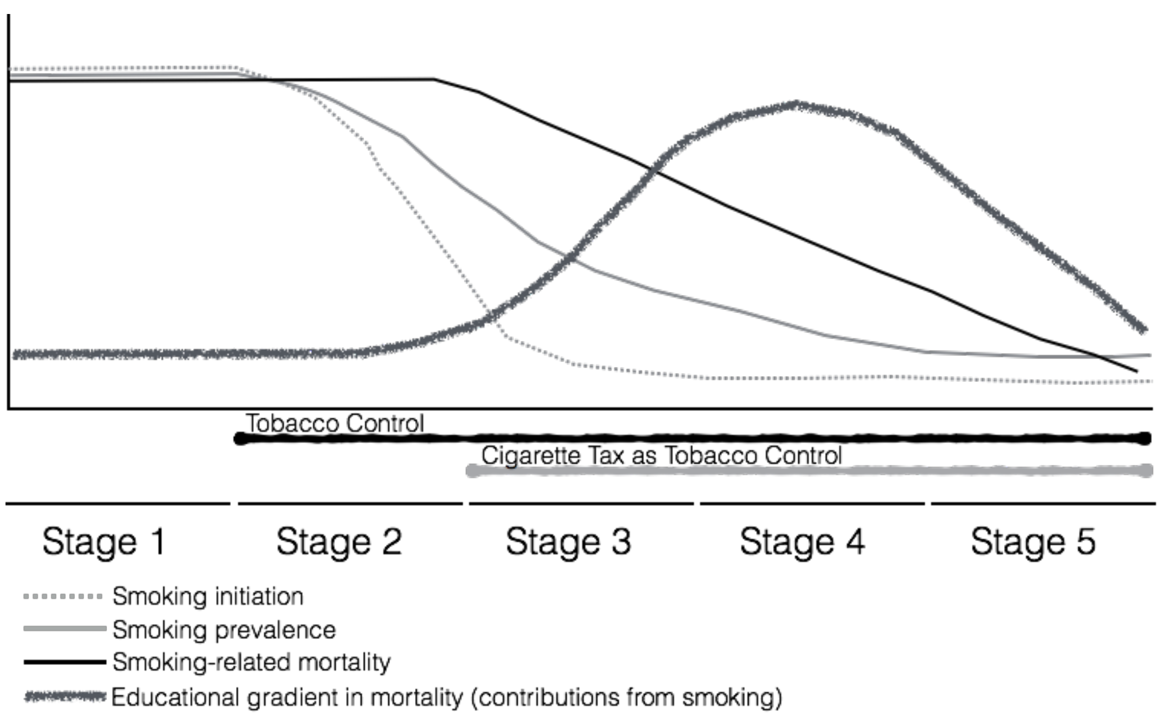
1. LOW Smoking Initiation
2. LOW Smoking Prevalence
3. DECLINING Smoking-related Mortality

4. HIGH Educational gradient in mortality (contribution from smoking)

Stage 5. Maintenance. As a population sustains the Tobacco Control Transition, the effects of clean indoor air regulations and cigarette taxes on smoking prevalence materialize as gains in life expectancy among former smokers. Smoking-related mortality continues to decline, with life expectancy gains strongest among those with less education since the burden of smoking-related mortality in this subsection of the population. As smoking-related mortality declines among those with low education catch up to those with high education, the educational gap in mortality stabilizes at a new low.

1. LOW Smoking Initiation
2. LOW Smoking Prevalence
3. DECLINING Smoking-related Mortality
4. DECLINING Educational gradient in mortality (contribution from smoking)

Figure 3. The Tobacco Control Transition Model



Situating cigarette taxes within the Tobacco Control Transition helps us predict how cigarette tax increases will impact smoking prevalence, smoking-related mortality, and, in turn, the contributions from smoking to the educational gradient in mortality. For states in Stages 2 and 3 of the Tobacco Control Transition, an increase cigarette taxes should result in a reduction in smoking prevalence through increased quitting and deceased initiation. But there is a lag between the effects of a cigarette tax increase on smoking-related mortality and, eventually, on the educational gradient in smoking. A recent study found that it takes ten years for the health consequences of cigarette tax increases to materialize as gains in life expectancy (Baum et al. 2019). Thus, cigarette tax increases enacted by states in the late 1990s and early 2000s may not have any noticeable effect on the educational gradient in mortality until 2010 or later.

Based on the tobacco policies enacted and population trends in smoking, I estimate that most U.S. states were in Stages 2 through 5 of the Tobacco Control Transition over my study period, 1999 to 2015. For most states, the educational gradient in mortality had already increased as a result of the educational inequalities in smoking cessation and initiation that emerged in response to scientific evidence of the health risks of smoking. During the late 1990s and early 2000s, large cigarette tax increases occurred contemporaneously with anti-smoking media campaigns, clean air regulations, and shifts in public consciousness and norms around smoking. Cigarette taxes complimented the efforts to raise awareness of the harms of smoking because they provide an additional incentive to not smoke. In this sense, any detectable impacts of cigarette tax level on an individual smoker's likelihood of quitting during my study period likely reflect more than just a response to a cost increase in smoking. Mindful of this, and mindful that cigarette taxes have been a central pillar of tobacco control policy since the late 1990s, I expect that the level of a state's cigarette taxes will act as an indicator of that state's progression along the TCT during my study period.

Disentangling State Policy Effects

Finally, it is important to acknowledge a major challenge with this kind of research is isolating the effect of state cigarette tax level from other state characteristics that vary with it. State policies tend to hang together. For example, Massachusetts and Alabama sit at opposite ends of the spectrum of state cigarette tax levels, but they also are at opposite ends of the spectrum of progressive social and economic policies (e.g., access to Medicaid, duration of unemployment benefits, and environmental regulations). This poses a challenge to estimating the effects of a single state policy with observational data. To account for this, I estimate models with and without state fixed effects. Others have also used state fixed effects to prevent bias from omitted state characteristics in studying the effect of cigarette taxes (For examples, see Bishop 2015 and DiCicca and McLeod 2008). I consider to what extent the effect of cigarette tax policy on educational disparities in mortality reflects a direct effect via changes in smoking behavior, or a confounded association driven by other unobserved state characteristics.

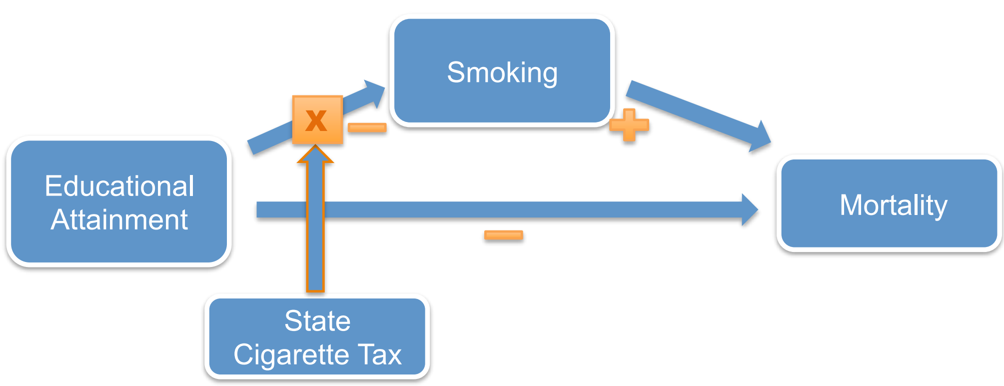
Summary

This study explores dynamics between state cigarette taxes, smoking, and the educational gradient in mortality. *Figure 4* depicts the hypothesized associations I test in this study. Educational attainment exhibits a negative gradient in mortality. This study investigates whether state cigarette taxes have an equalizing effect on the education-mortality association and whether it is plausible that this effect occurs by reducing smoking. First, I ask: does state cigarette tax moderate the effect of education on mortality? Second, I ask: does state cigarette tax reduce smoking? Finally, I consider to what extent the effect of cigarette tax policy on educational disparities in mortality is a direct effect via smoking, an indirect effect of the Tobacco Control Transition, or a confounded association driven by unobserved state characteristics. To answer these questions, I test the following hypotheses:

> H1: Higher cigarette taxes will have a stronger protective effect against mortality for the low educated.
>
> H2: Higher cigarette taxes will weaken the effect of years of schooling on time to death.
>
> H3: Higher cigarette taxes will be positively associated with smoking cessation.
>
> H4: A large increase ($0.50 or greater) in cigarette taxes will increase the likelihood of smoking cessation, above and beyond the effect of base tax level.

There are two reasons why higher cigarette taxes should have a stronger protective effect against mortality for the less educated (H1 and H2). First, cigarette taxes incentivize quitting more for individuals with limited financial resources. Second, cigarette taxes began to be used as a strategy for tobacco control at a time when educational disparities in smoking had already widened. As long as the burden of smoking is higher among the lower educated, I expect cigarette taxes will have a greater impact on mortality for the lower educated. This will result in a weakening of contributions from smoking to the educational gradient in mortality. As part of my efforts to test the potential for increases in state cigarette taxes to weaken the educational gradient in mortality, I first look for a positive association between higher cigarette taxes and smoking cessation (H3). But a key question is whether the positive association hypothesized in H3 results from a direct effect on smoking behavior, from an indirect effect of general progression through the Tobacco Control Transition, or from confounding due to unobserved state characteristics. To clarify causality, I test H4 with longitudinal panel data that links dynamics in cigarette tax exposure to changes in smoking behavior. I estimate the effect of a large increase in tax on smoking in the subsequent survey wave, allowing for an interaction with base tax level and adding state fixed effects to control for unobserved confounding at the state level.

Figure 4. Directed Acyclic Graph Depicting Hypothesized Associations



DATA & METHOD

Data

I drew on two survey data sets to carry out this study. The first is the National Social Life Health and Aging Project (NSHAP). The NSHAP is a nationally representative survey of community-dwelling older adults born in 1920 to 1947. I set up two analytic samples for cross-sectional analysis with 5-year mortality as the outcome. Because 58% of the sample smoked at one point in their lifetime and 17% of respondents died between waves, NSHAP is a useful data set despite its small sample size. My analytic samples consisted of the 3005 respondents from Wave 1 and 3377 respondents from Wave 2. 14.8% of them are smokers at Wave 1 and 13.3% are smokers at Wave 2. I used the NSHAP primarily for descriptive analyses which informed the regression models I ran with the PSID.

The majority of the analyses I present in this study drew on a second data set, the Panel Study of Income Dynamics (PSID). This is the longest running panel study in the U.S. Questions about smoking status were asked in 1986 and then every biennial wave from 1999 onward. I treated 1999 as the baseline year and defined my analytic sample as household heads and spouses, aged 25-97 in 1999 (n=10,949). I followed these respondents through 8 subsequent biennial waves to 2015. I set up the PSID data for longitudinal analysis with person-years nested within persons, nested within states. 2,372 respondents were smokers at baseline in 1999.

The data on cigarette taxes came from the Tax Burden on Tobacco **(**Orzechowski and Walker 2017). I merged this publically available data on state cigarette taxes with the NSHAP and PSID analytic samples.

Dependent Variables

I measured mortality cross-sectionally as 5-year mortality with the NSHAP (death between 2005 and 2010) and as 15-year mortality with the PSID (death between 1999 and 2015). I also measured time trends in death over the 9 PSID survey waves using survival analysis methods. My measures of smoking behavior were based on self-report. I distinguished between current smokers, former smokers, and never smokers. I defined smoking cessation as the transition from being a current smoker to a non-smoker. I also constructed a categorical measure of smoking intensity (non-smoker, light smoker, moderate smoker, or heavy smoker) based on number of cigarettes smoked per day. I used this to define an alternative outcome variable: reduction in smoking. I counted any transition from an increased level of smoking to a lower level of smoking as a reduction (i.e. Heavy→Light and Light→Non-smoker both count as a reduction in smoking).

Independent Variables

I measured state cigarette tax in multiple ways. First, I constructed a categorical measure of cigarette taxes with substantive cut points. I defined low cigarette taxes as less than $0.20 in 1999, medium taxes as $0.20-$0.59 in 1999, and high taxes as greater than $0.59

in 1999. But the distribution of state cigarette taxes in 1999 was such that many states fell in the low tax bin. Thus, I also constructed a 4-category variable based on quartiles of the distribution of person-year exposure to state cigarette taxes in 1999 experienced by the PSID sample. I constructed a similar 4-category variables of tax quartile for the 2001-2005 average and the 2006-2010 average, based on the tax distribution in the NSHAP sample. I also used a continuous measure of state tax (in dollars) by year, and averaged over 2001-2005 and 2006-2010. The measures I have described so far are measures of base state tax level.

I also measured changes in base cigarette tax level, or tax increases. Studies of the effects of cigarette taxes on smoking behavior tend to model tax increases dichotomously, defining a large tax increase as $0.50 or greater (See Baum et al. 2019). I follow this approach.

I measured educational attainment with a continuous measure of years of schooling completed and a 3-category measure of educational attainment: <High School, High School, or College or more.

Analytic Strategy

Unless otherwise noted, the models describe below drew on the analytic sample from the PSID. Thus, when I refer to the "study period," I am referring to the period from 1999 to 2015 during which my analytic sample from PSID was observed. The exploratory analyses I conducted using the two waves of the NSHAP are included as Appendix 2. Ultimately, the larger sample size and the longer time period covered by the PSID data made it more useful than the NSHAP data for testing my hypotheses.

Mortality

I explored the impact of cigarette taxes on the odds of 5-year mortality and 15-year mortality, as well as time to death.

> Testing H1: Higher cigarette taxes will have a stronger protective effect against mortality for the low educated.

First, to test H1, I used logistic regression with dummy variables for each year of schooling to inspect the functional form of the educational gradient in mortality. The specific outcome modeled here is odds of 15-year mortality – death between 2000 and 2015. I ran separate regressions for each quartile of the 1999 cigarette tax distribution to see whether the educational gradient is steeper when cigarette taxes are lower. Second, drawing on the NSHAP sample, I used multiple logistic regression to test the effect of 2001-2005 average cigarette taxes on the odds of 5-year mortality among smokers. I estimated this same model for never smokers as a robustness check.

> Testing H2: Higher cigarette taxes will weaken the effect of years of schooling on time to death.

To test H2, I first used unadjusted Kaplan-Meier survival curves to compare the magnitude of educational disparities in survival time across low, medium, and high cigarette taxes. I compared survival time between the three educational subgroups: less than high school; high school completed; and college or more. Kaplan-Meier survival curves are a common way of depicting differences in survival time (Rich et al. 2010). Kaplan-Meier curves provide more information about differences in time-to-death than a simple comparison of mean survival time. Nevertheless, they are univariate analyses so I proceeded to multivariate analyses.

Next, I modeled time to death in two ways. I used Cox proportional hazards regression with person random effects and state fixed effects to estimate the influence of cigarette tax on educational disparities in the relative hazard of death over the study period. I ran a series of these models, varying the subpopulation of observations by level of cigarette taxes. The first model estimates the hazard ratio for years of schooling from a Cox proportional zazards model not conditional on tax. The subsequent stratified models estimate the hazard ratio for years of schooling if cigarette tax is: less than $0.39; less than $0.50; less than $1.00; between $1.00 and $1.99; and more than $2.00. Hazard ratios can be interpreted as the risk of dying at time (t). In the case of Cox proportional hazards regression, a unit increase in the covariate of interest is multiplicative of the hazard rate. Thus, a covariate with a hazard ratio greater than 1 is interpreted as a good prognostic factor while a hazard ratio of less than 1 indicates a bad prognostic factor. Cox models make no assumption about the baseline hazard function. These models control for age, gender, and race.

I also analyzed educational disparities in time to death by cigarette tax level with parametric survival analysis models using the command `mestreg` in Stata 14. These survival models allow me to add a state-level random effect to account for the correlation of observations from the same state. I tested models that assume a hazard function with a Weibull distribution and models that assume a Gompertz distribution. The results shown come from models with a Weibull distribution. I stratified the models by gender and include person-level and state-level random effects. I use these mixed-effects Weibull regression models to estimate the hazard ratio of the interaction between years of schooling and state cigarette tax. The models control for age, gender, race, and total family income.

Smoking

> Testing H3: Higher cigarette taxes will be positively associated with smoking cessation.

To test H3, I first inspected trends in smoking prevalence by cigarette tax quartile in 1999. Second, I fit unadjusted Kaplan-Meier survival curves again to understand the effects of cigarette taxes on time to smoking reduction. Third, I used multiple logistic regression with the 1999 baseline sample to estimate the differential odds of smoking by education and cigarette tax quartile in 1999.

Testing H4: A large increase ($0.50 or greater) in cigarette taxes will increase the likelihood of smoking cessation, above and beyond the effect of base tax level.

Next, I turned to longitudinal analysis to test the hypothesized causal association between state cigarette tax increases and smoking cessation. I used random-effects logistic regression set up for panel data with person-years nested within persons from my 1999 baseline sample. With nine waves of biennial data, I was able to test both between- and within-state effects of cigarette taxes on smoking cessation. I began by testing the effects of base state cigarette tax (continuous) on smoking cessation among smokers during the study period from 1999 to 2015. Exposure to cigarette tax is lagged (*t-1*) and used to predict odds of staying a smoker in the subsequent survey wave. I also tested the effect of a large increase of cigarette taxes ($0.50 or greater =1, <$0.50 =0) on smoking cessation and I allowed for an interaction between a large tax increase (0 or 1) and state tax at the previous wave (continuous). My preferred model, Model 4, includes a random intercept for subject and state fixed effects (as dummies). Finally, using mixed-effects logistic regression with random intercepts for persons and states, I tested whether education level (categorical) moderates the effect of cigarette tax on smoking cessation. These models included age, gender, and years of education as controls.

Robustness Check

The primary way I evaluated the robustness of my results was by treating never smokers as a negative control. Where possible, I re-ran all of the models estimating an effect of cigarette taxes on smoking for never smokers to check that the effects of cigarette tax increases were minimal for never smokers.

RESULTS

Descriptive Statistics

Table 1 displays descriptive statistics for the PSID analytic sample, the primary sample used for the analyses presented here. While the majority of respondents had completed high school, 16.5 percent had not completed high school and 22 percent had some college or more. 21.8 percent PSID sample smoked at baseline and 28.8 percent of the person-years over the study period were contributed by smokers. The average state cigarette tax level experienced by the PSID sample in 1999 was $0.40 and the average cigarette tax increase experienced over the study period was $0.84. The average age for the PSID sample was 44 years at baseline in 1999. The NSHAP is a much older sample with an average age of 73 years in 2005. Descriptive statistics for the NSHAP samples can be found in the Appendix (See Tables A1 and A2).

Table 1. PSID Sample Statistics (baseline = 1999)

	Possible Range	Mean (SD) Number (%)

15-year mortality 1999-2015	0 or 1	614 (5.6)
Current Smoker (longitudinal)	0 or 1	3,145 (28.8)
Baseline Smoker	0 or 1	2,372 (21.8)
State cigarette tax in $ (longitudinal)	0.025 to 4.35	0.84 (0.44)
Baseline state cigarette tax in $	0.025 to 1.00	0.40 (0.25)
Increase in experienced cigarette tax from baseline in $ (longitudinal)	-0.80 to 4.18	0.44 (0.35)
Large (>$0.50) increase in cigarette tax (longitudinal)	0 or 1	5,860 (55.3)
Cigarette tax in 1999:		
Low < $0.20	0 or 1	2,448 (22.5)
Medium $0.20-$0.59	0 or 1	6,124 (56.2)
High > $0.59	0 or 1	2,318 (21.3)
Years of schooling	1 to 17	12.9 (2.6)
Educational attainment:		
Less than High School	0 or 1	1,693 (16.5)
High School	0 or 1	6,329 (61.6)
College or more	0 or 1	2,248 (21.9)
Age	15 to 97	43.8 (15.1)
Female	0 or 1	6,039 (55.2)
White	0 or 1	6,980 (64.5)

Educational Gradients in Mortality

An observable educational gradient in mortality was present in the sample data from both the NSHAP and the PSID. *Figure 5* shows the functional form of the educational gradient in mortality by 1999 cigarette tax quartile in the PSID sample. Comparing these plots, I see there was already evidence of differentiation of the gradient by cigarette tax level in 1999. There is a steep negative linear association between years of schooling and odds of death when cigarette taxes are low (See *Figure 5, Quartile 1*) and that transforms to a nearly flat association in the higher quartiles of cigarette taxes. A discontinuity in odds of death remains visible around the completion of high school when cigarette taxes are at medium levels. The highest quartile of taxes shows a flat gradient with the exception of a mortality disadvantage for individuals with nine years of education.

Figure 5. Educational Gradient in Mortality by 1999 Cigarette Tax Quartile

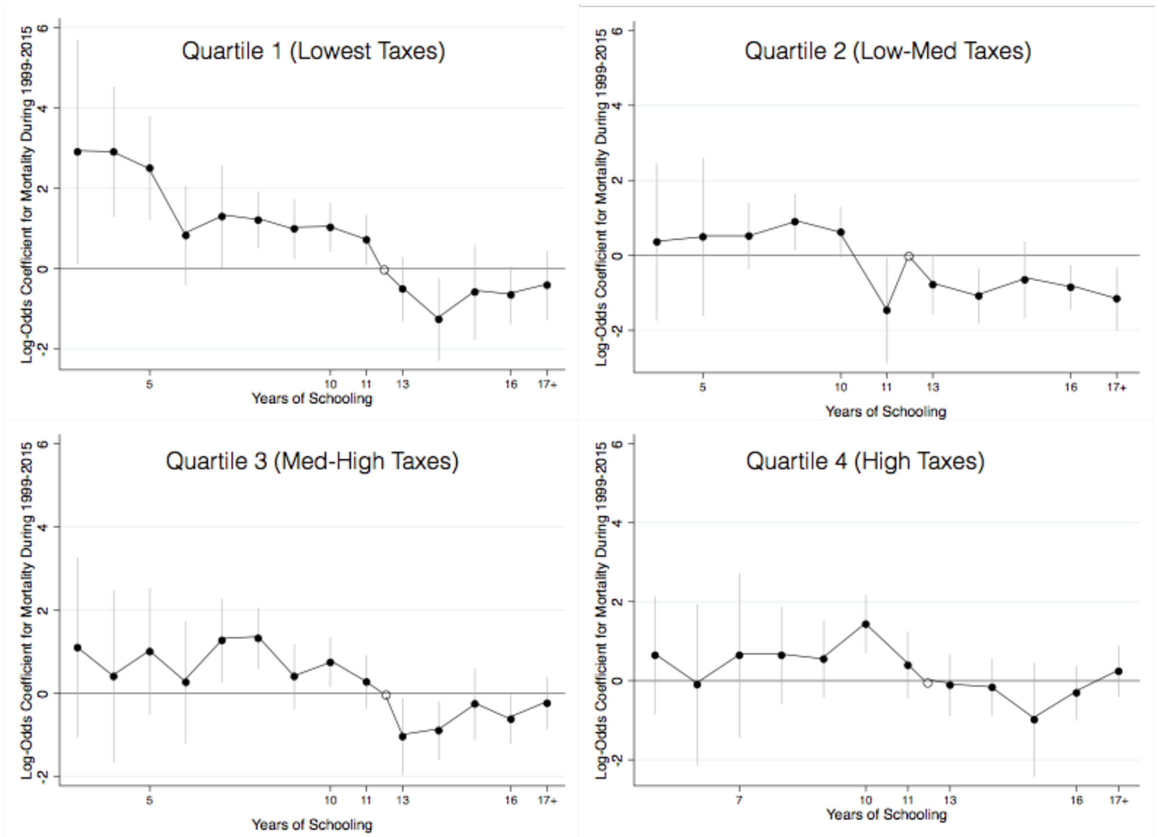
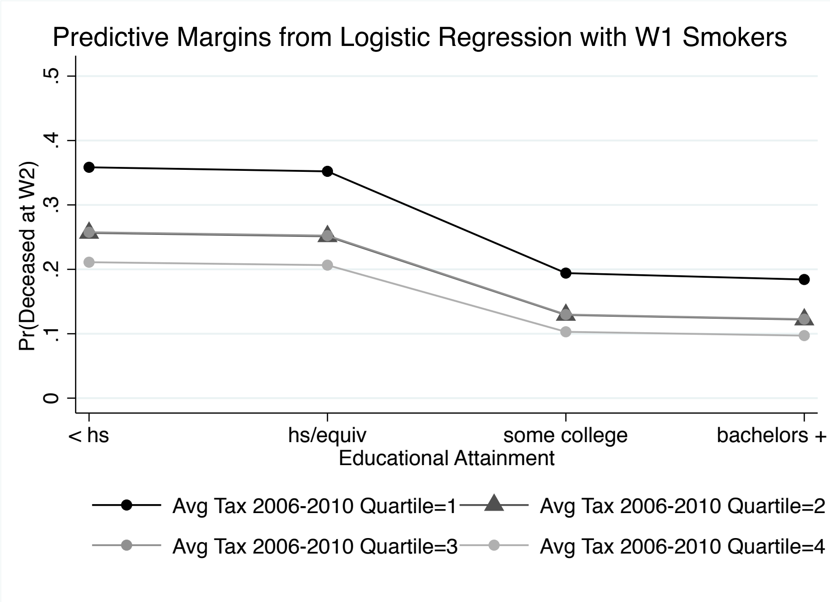
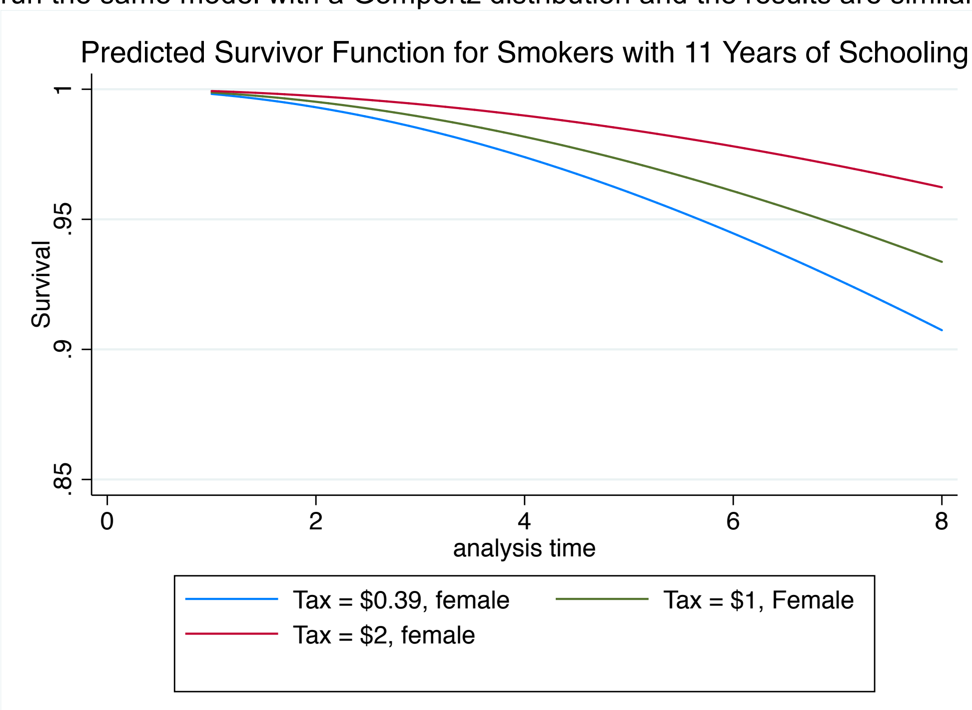


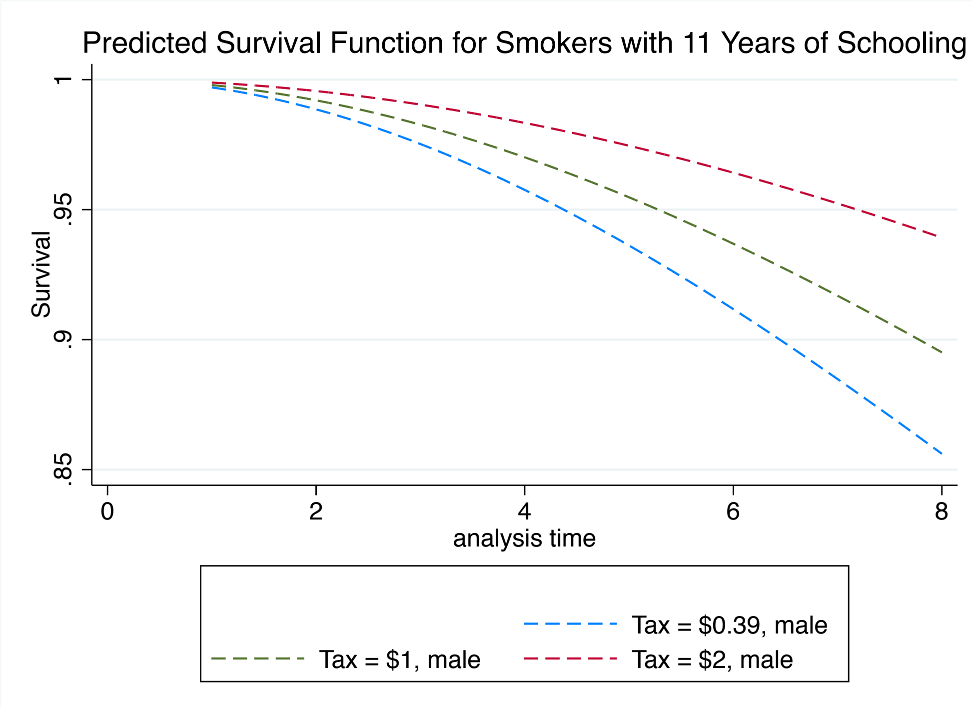
Figure 6 shows results from logistic regression predicting 5-year mortality with the interaction of cigarette taxes and education category, adjusting for age. Older adult smokers exposed to higher state cigarette taxes are less likely to have died between 2006 and 2010. Further, the relative mortality disadvantages associated with lower education are largest in the lowest quartile of cigarette taxes, smaller in quartiles 2 and 3, and again smaller in the higher quartile of taxes. It appears that the educational gap in mortality is reduced in the shift from tax quartile 1 to tax quartile 2 (See Figure A1). This same regression model with never smokers does not show any moderation of education by cigarette taxes. Thus, there is support for Hypothesis 1: higher cigarette taxes have a stronger protective effect against mortality for the low educated.

Figure 6.



Finally, *Figures 7 and 8* display predicted survival curves for a 65 year old with 11 years of schooling, by tax level ($0.39, $1, $2), stratified by gender. Tax has a graded, inverse effect on time to death. Results from this model did not show differences by gender, but there was an opposite effect of tax level at the highest levels of education. I have also run the same model with a Gompertz distribution and the results are similar.

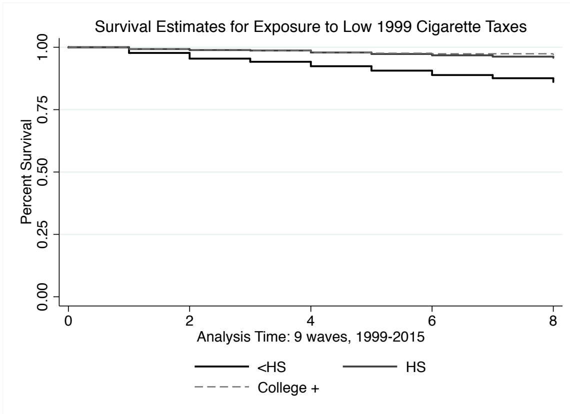


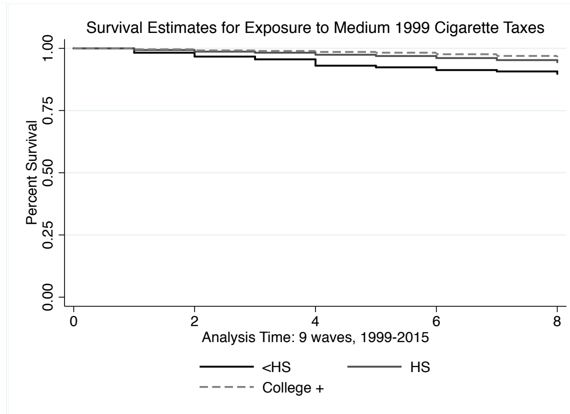


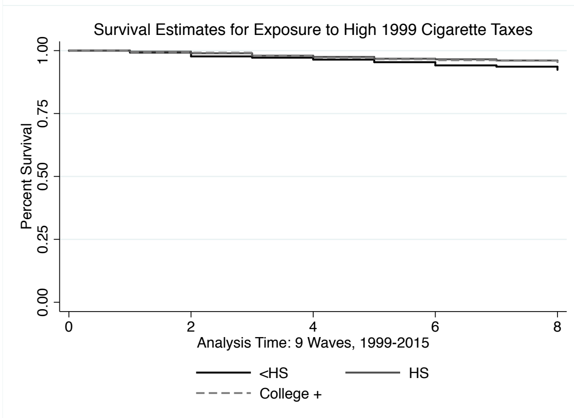
Effects of State Cigarette Taxes on Time to Death

Moving next to the effects of cigarette taxes on time to death, *Figures 9-11* show educational differences in survival curves, by substantive tax level in 1999 (low <$0.20; medium $0.20-$0.59; and high >$0.59). These plots reveal that, particularly for the lowest educated individuals, cigarette tax level differentiates their survival time. State cigarette taxes greater than $0.59 close the gap in survival between respondents with less than high school and those with a high school or college education.

Figures 9-11



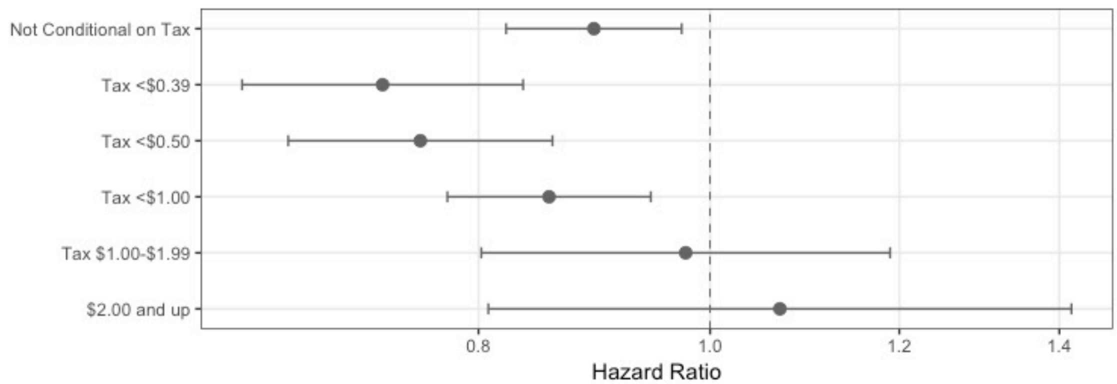




I find that there is a protective effect of higher taxes on the relative hazard of death for individuals with less than a high school diploma (See Figure A2). The educational gap in the predicted hazard of death is large among individuals exposed to state taxes <$0.20 in 1999, but disappears among individuals exposed to tax states of $0.20 to $0.59. Taken together, the results from logistic regression and survival analysis suggest that variation in state cigarette taxes in 1999 was sufficient to moderate educational disparities in risk of death and time to death. This evidence supports Hypothesis 2, which supposes that higher cigarette taxes weaken the effect the effect of years of schooling on time to death.

I explored this education-tax interaction further as displayed in *Figure 12*. The first line reports the hazard ratio for years of schooling from a Cox proportional hazards model not conditional on tax. Then I ran a series of stratified models that varied the subpopulation of observations. The resulting trend shows that the years of schooling effect on time to death is strongest when taxes are low and then gets weaker when taxes are higher. This suggests that cigarette taxes reduce educational disparities in mortality, providing further support for H2.

Figure 12. Hazard Ratios for Years of Schooling from Models Stratified by Tax Level



Additional models revealed that the educational gradient in time to death is weakened with each $1 increase in state cigarette taxes (See Table A3). This interaction effect is strong among men, but not statistically significant among women.

Effects of State Cigarette Taxes on Smoking

Figures 13-15 display time trends in smoking prevalence by education under exposure to relatively low, medium, or high state cigarette taxes. The quartiles correspond to the distribution of person-year exposure to cigarette taxes at each survey wave. There were declines in smoking among the less educated (<HS and HS only) under exposure to low to medium taxes over the study period. The results also reveal a puzzling increase in smoking prevalence among individuals with less than a high school diploma under exposure to the highest taxes. There is minimal reduction in smoking prevalence among the college-educated over the study period. This is likely because smoking prevalence is already quite low in this group at the start of the study period in 1999, regardless of exposure to cigarette taxes.

Figure 13. Time Trend in Smoking Prevalence in Tax Quartile 1
(Low Tax), by Survey Wave

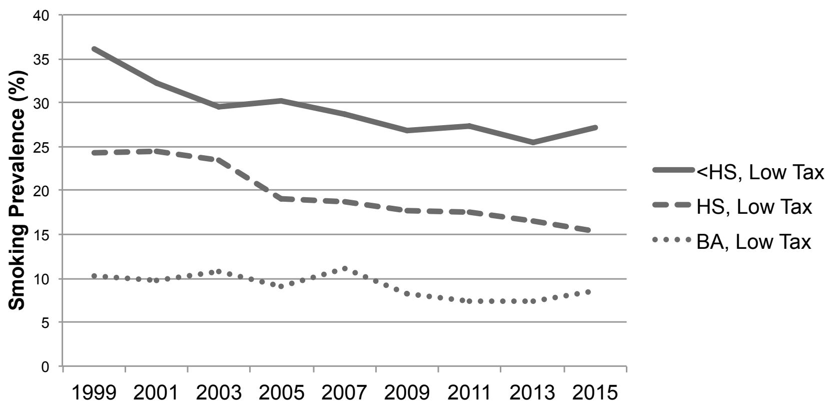


Figure 14. Time Trend in Smoking Prevalence in Tax Quartiles 2 and 3, by Survey Wave

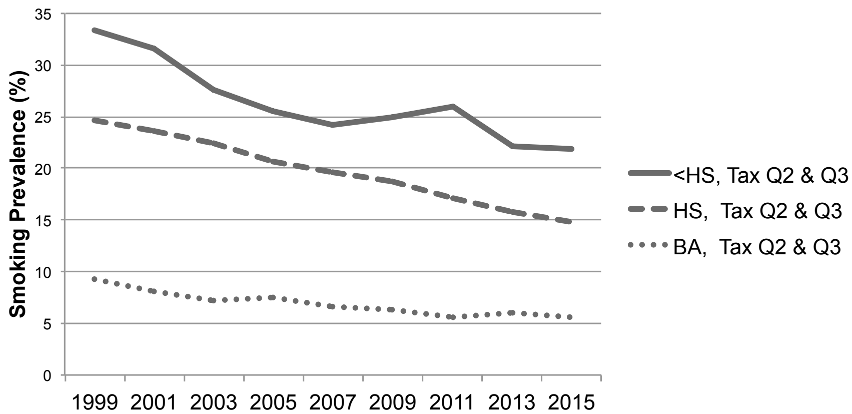
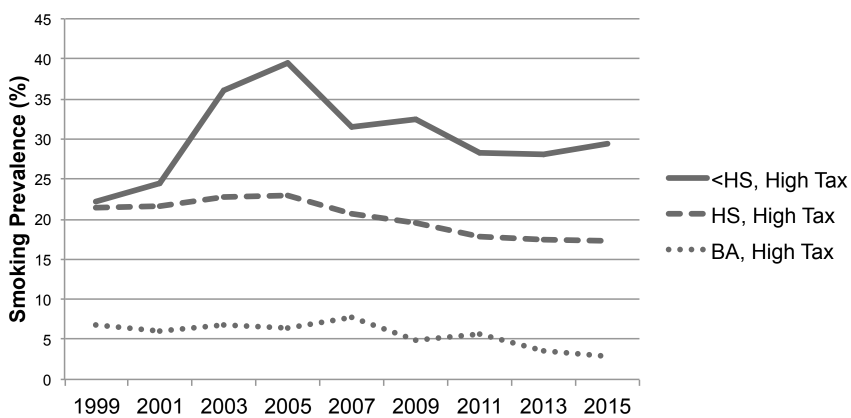


Figure 15. Time Trend in Smoking Prevalence in Tax Quartile 4 (High Tax), by Survey Wave



Studies have shown that many smokers who attempt to quit are unsuccessful. In light of this, I also looked at the effects of cigarette tax increases on any reduction in smoking intensity. I found that there were reductions in smoking intensity over the study period, regardless of exposure to cigarette taxes (See Figure A3). In fact, the trend in smoking reduction for exposure to a decrease or no change in cigarette tax was similar to the trends for exposure to large proportional increases in cigarette taxes. Only exposure to a 10-fold increase or greater led to a distinguishably stronger trend in smoking reduction.

Multiple logistic regression with the baseline sample (See *Figure A4*) confirmed the existence of an educational gap in smoking prevalence between individuals with high school or more, and individuals with less than a high school diploma at all levels of cigarette taxes. But there is evidence that, already in 1999, cigarette taxes moderated the educational gap in smoking such that the <HS vs. HS+ gap was largest in the lowest quartile of taxes and smallest in the highest quartile of taxes. Interestingly, this moderation by cigarette taxes of the educational gap in smoking was not detectable in the <College vs. College+ comparison.

So far I have described results that support Hypothesis 3: higher cigarette taxes are positively associated with smoking cessation. But the question remains as to whether this positive association results from a direct effect on smoking behavior, an indirect effect of general tobacco control, or confounding due to unobserved state characteristics. *Table 2* displays the results from random effects logistic regression models testing for a causal relationship between cigarette tax increases and smoking cessation. Models 1 estimates the effect of base state cigarette tax at time *t-1* on the odds of staying a smoker at time *t*. Exposure to $1 higher state cigarette tax is associated with 27% lower odds of staying a smoker (OR: 0.724). The addition of state fixed effects only strengthens the effect of base cigarette tax (OR: 0.593). Models 3-5 tested the effect of a large increase in tax (>$.50) on smoking in the subsequent survey wave, allowing for an interaction with base tax level. While the negative effect of base cigarette tax on likelihood of staying a smoker remains unchanged (OR: 0.710), there is a non-significant negative effect of a large tax increase on staying a smoker which interacts with base tax such that the effect of a large tax increase is negative (OR: 0.767) when base tax is 0 and becomes positive as base tax increases. This significant interaction likely reflects the ceiling in smoking cessation that is reached once all of the smokers sensitive to price changes have already quit smoking. Some smokers are simply resistant to tobacco control. It is likely that the smokers who remain in states with high cigarette taxes are more likely to be these resistant smokers. Thus, it makes sense that the interaction term for large increase X base tax level is positive. Model 4, the preferred model, adds state fixed effects to control for any unobserved confounded at the state level. The addition of state fixed effect strengthens the negative effect of base tax on continued smoking, bumps the negative effect of a large tax increase into marginal statistical significance, and weakens the interaction term. Finally, Model 5 adds a random intercept for state instead of fixed effects. This increases the statistical significance of the interaction term, but the overall story told by the coefficients remains unchanged. The results of Model 4 are presented visually in *Figures 16 and 17*. *Figure 16* provides a graphical representation of the interaction of base state cigarette tax and large increase in tax, estimated as the marginal odds of continued smoking for 10, 12, and 16 years of schooling. *Figure 17* displays the marginal odds ratio for a large increase in cigarette tax at various levels of base state tax, estimated for 10, 12, and 16 years of schooling. We see that a large increase in cigarette tax makes quitting more likely in the subsequent two years when then base tax is less than $1.00. When the base tax is greater than $1.00, the odds of quitting without a large tax increase are already quite high so a large increase does not further enhance the likelihood of quitting.

Table 2. Random-Effects Logistic Regression Predicting Stayed Smoker

Person-years	11,747	11,746	11,734	11,733	11,734
Persons	2,692	2,692	2,689	2,689	2,933
States		51		51	50
MODELS:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Coefficients reported as Odds Ratios.					
State Tax (Lagged t-1)	.724***	.593***	.710***	.574***	.672***
	(.041)	(.042)	(..041)	(.043)	(.044)
Large Tax Increase ($0.50 or greater)	--	--	.767	.735°	.757°
			(.127)	(.123)	(.127)
Large Increase X **State Tax**	--	--	1.572*	1.341	1.486***
			(.324)	(.279)	(.309)
Age	.993*	.993*	.993*	.992*	.992*
	(.003)	(.003)	(.003)	(.003)	(.003)
Female	.996	.986	.997	.987	.987
	(.071)	(.071)	(.072)	(.072)	(.070)
Years of Education	.935***	.936***	.931***	.931***	.932***
	(.016)	(.016)	(.016)	(.016)	(.016)
Constant	18.708***	16.317***	20.173***	20.185***	21.859***
	(4.703)	(6.452)	(5.108)	(8.172)	(5.467)
Person Random Intercept	YES	YES	YES	YES	YES
State Random Intercept					YES
State Fixed Effects		YES		YES	

°p<0.10 * p<0.05; **p<0.01; *** p<0.001

Data Source: Panel Study of Income Dynamics, Waves 1999-2015

Figure 16. Odds of continued smoking during any 2 year period from the preferred model. Dashed lines are for a recent tax increase of $0.50 or more. Solid lines are for a recent increase of $0.49 or less (including no change or a decrease).

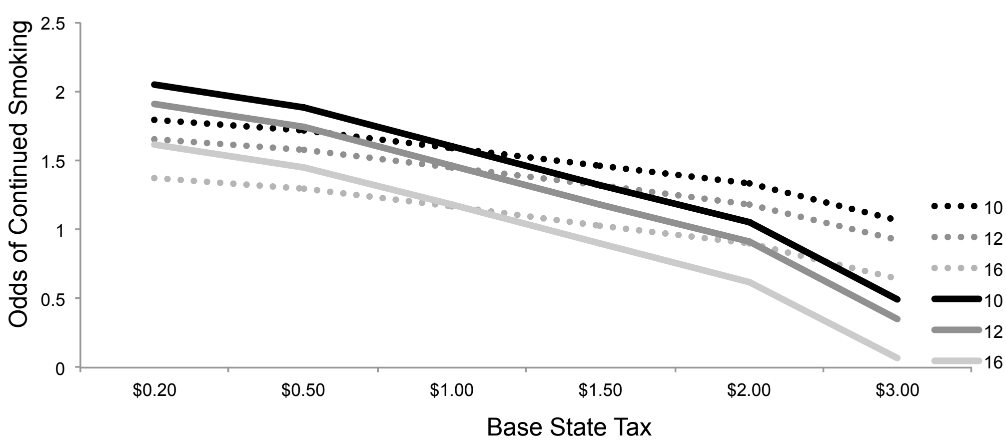
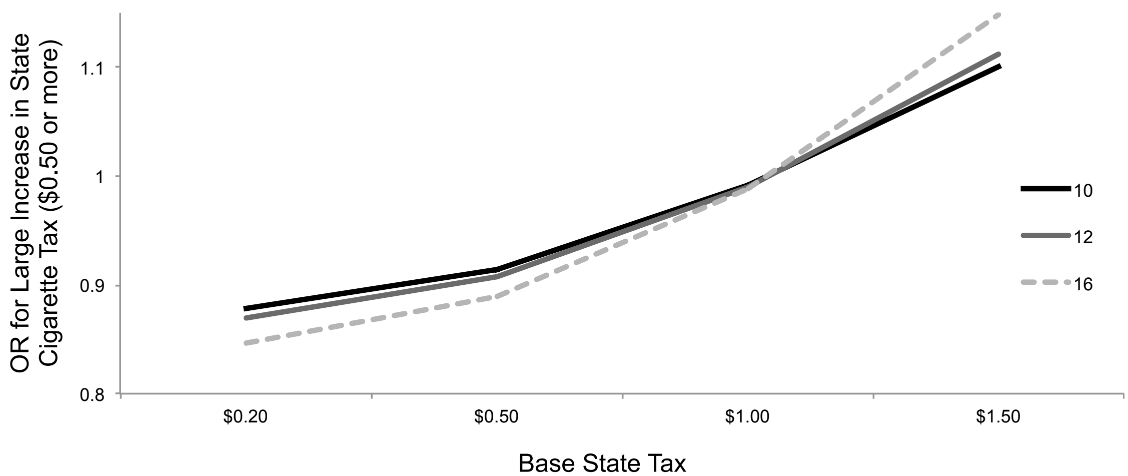


Figure 17. Odds Ratios showing the effect of a $0.50 or more tax increase (dichotomous variable) on the odds of continued smoking by base state tax.



To summarize, I find that smokers are more likely to have quit smoking within two years when they are exposed to a large increase in state cigarette tax compared to a smaller increase or no increase. These results support H4 and suggest that the effect of cigarette taxes on smoking behavior reflects both direct effects through tax increases, but also indirect effects. The effects of cigarette taxes on smoking do not appear to be driven by unobserved variation between states. Instead, it is likely that the strong negative effect of base cigarette taxes on smoking reflects the tendency for cigarette taxes to act as an indicator or signal of general progress in tobacco control.

DISCUSSION

This study set out to explore the potential for a state policy, cigarette taxes, to moderate the educational gradient in mortality. I found evidence that higher state cigarette taxes weaken the educational gradient in mortality. It appears that higher taxes have a stronger protective effect against mortality for the low educated, particularly for men. While it is difficult to determine causality, I find a positive association between state cigarette tax and the odds of quitting smoking, even after controlling for unobserved differences between states. And I find evidence that when cigarette taxes in a state are still approximately $1.00 or less, an increase in taxes of $0.50 or more will increase the likelihood of quitting within the next two years. I interpret these results as evidence that state cigarette taxes can and do influence the educational gradient in mortality in an equalizing way.

It is helpful to situate these findings within the Tobacco Control Transition model I described earlier in this study. My study period, 1999 to 2015, includes the largest increases in state cigarette taxes to date. My study period also begins 30 years after the first major public report on the health risks of smoking. Thus, the widening of educational disparities in smoking and in smoking-related mortality had already occurred across the U.S. prior to my study period. This is important to note because it is only once educational disparities in the prevalence of smoking exist that state cigarette taxes should have an equalizing effect on the educational gradient in mortality. Further, any causal effect of cigarette taxes on mortality takes time to materialize. A recent study estimated that it takes ten years for cigarette taxes to show up at the population level as detectable gains in life expectancy. If this is an accurate estimate, tax rates in 1999 should influence mortality rates beginning in 2009.

While it is plausible that my mortality models detect causal effects of cigarette tax increases that occurred since 1999, it is also likely that a state's cigarette tax level at baseline in 1999 accounts for additional unobserved variation between states. For example, Alabama has very low cigarette taxes and Massachusetts has high cigarette taxes placing them at opposite ends of the distribution of state cigarette taxes. But they also sit at opposite ends of the distributions of Medicaid inclusivity, unemployment insurance benefits, public health regulations, and many other political and economic policy variables. Thus, it should be quite easy to show that state cigarette taxes are merely associated with a weakening of the educational gradient in mortality. It is much more difficult to provide causal evidence that specific increases in state cigarette taxes reduce smoking and, in turn, reduce mortality rates among those with lower education disproportionately such that the educational gradient in mortality lessens.

I have presented evidence in parts: first demonstrating that higher state cigarette taxes are associated with a weaker educational gradient in mortality; then showing a positive association between state cigarette tax and the odds of quitting smoking; and finally showing mixed evidence from longitudinal data that exposure to a large tax increase increases the likelihood of quitting smoking within two years when base taxes are low. We are left to interpret to what extent these findings convince us that cigarette taxes are indeed an example of a single state policy moderating the educational gradient in mortality.

Taken broadly, my results provide compelling evidence that states do indeed vary in the extent to which educational attainment maps onto health and, in turn, onto mortality. How exactly states disrupt the effects of educational inequality on mortality is less clear. I have considered three possible mechanisms: 1) the direct effect of cigarette taxes on smoking; 2) the indirect of effect state's progress in tobacco control for which cigarette taxes may act as a proxy or indicator; and 3) the effect of a suite or clustering of state policies that distinguish states and of which cigarette tax is representative. While I find some evidence for the direct effect of cigarette tax increases on smoking cessation, this may not be the whole story. The next obvious explanation for my results is that the effect of cigarette taxes is confounded by a myriad of other state policies and state characteristics, but the effects of cigarette taxes persisted even in the models that explored variation within states. This leaves the possibility of an indirect effect due to cigarette taxes acting as an indicator of general progress in tobacco control. I suspect that

My ability to further tease apart the relative contribution of each of these three mechanisms is limited in several ways by my study design. First, many of the sample respondents quit smoking prior to the study period. This is particularly true of the respondents from states with highest taxes so I only retrospectively guess, based on the mortality trends, that they quit in response to increasing cigarette taxes. But it may be that they quit for other reasons. Second, my current analysis does not take into account local taxes, which may be higher than state taxes. Still, local taxes are a much more recent trend, they are blocked in many states by preemption laws, and where they are legal, they are generally very small (<$0.20). Third, I draw on the publically available PSID data so my outcome of death is not verified as in the restricted National Death Index data files. In future work, I intend to use the restricted data to compare trends in cause-specific mortality. Finally, although controlling for state fixed effects helps reduce some of the concern around confounding by other unobserved state characteristics, I was unable to control for state-level confounding in my cross-sectional mortality models.

CONCLUSION

This study uses state cigarette taxes as a case to demonstrate how a specific state policy can shift educational disparities in smoking and mortality. My research begins to reframe fundamental causes, such as educational inequality, as contingent on state policy. While there has been progress in theorizing the processes by which social structures produce health inequalities (Geronimus 2000; House 2016; Mechanic 2002), much more research into specific policy mechanisms is needed to generate an evidence base that can inform intervention.