The Population Education Transition Curve: A Hypothesis of the Education Gradient across Demographic Transitions and Pandemics [Draft March 2014]

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The salutary effect of formal education on health risks, disease, and mortality is extensively documented: *ceteris paribus*, greater educational attainment leads to healthier lives and longevity (cites). This relationship between education and health behaviors, known as the *education gradient*, is well established within the national development literature with education frequently referred to as a *social vaccine*—an intervention that can protect individuals and elevate the health of populations (SV cite). Education is known to be a key factor in avoiding health risks such as tobacco, alcohol, and illicit drug use, overconsumption of high fat and sugar diets, high-risk sexual practices, and sedentary life styles (1 cite for each). Modest amounts of formal schooling for mothers account for more effective use of medical resources for children's health in low-income nations, and higher education attainment leads to better adherence to complicated medical treatment regimes for chronic diseases and consistent use of preventative care in high-income nations (Case et al., 2005; Goldman and Lakdawalla, 2005).

Expanding access to education within populations is one likely cause of the historical decline in crude birth and death rates and the lower child mortality of the First Demographic Transition that since spread globally (Baker et al, Lutz). Education increases survival during some pandemics, and is likely responsible for the age compression of mortality in highly educated societies (Hayward…cites). Illustratively, a summative analysis of U.S. and U.K. data across an exhaustive list of health risks and

preventive measures finds that each year of education reduces mortality risk by 0.3 percentage points, or 24 percent (Cutler & Lleras-Muney, 2010). Education attainment is a central component of socio-economic factors that make up the social "fundamental cause" of disease, and there is evidence that disparities in education underlie racial and ethnic health disparities net of other demographic characteristics (Link, Hummer cites).

Even though the epidemiological evidence strongly indicates formal education as a leading social vaccine, there is intermittent reporting of counter education gradients for some health risks and diseases across populations and time periods. For example, in the HIV/AIDS pandemic in Sub-Saharan Africa, greater amounts of education was initially identified as a risk factor. Only during the later stages of the pandemic did education revert to its role as a social vaccine (Smith, Salinas & Baker, 2012; Coombe & Kelly, 2001; Fortson, 2008; Hargreaves et al., 2008). A similar pattern is apparent in De Walque's (2007) historical account of tobacco use over the second half of the 20th century in the U.S. (de Walque, 2004) where the prevelance of smoking is initially greater amongst the college educated crowd but by the turn of the 21st century those at greatest risk were individuals without a high school diploma. Additionally, evidence from the worldwide obesity epidemic and other diseases illustrates the same pattern over time (Authors, 2013; Cutler & Lleras-Muney, 2010; Pi-Sunyer et al., 1999). In addition to reverse education gradients are reports of non-linear, usually curvilinear, gradients with the linear increase of unhealthy risk taking through medium levels of education reversing to a social vaccine effect at higher levels of education; and, as education gradients are examined across longer historical periods, there is increased observation of these nonlinear effects (cites ours; Cutler & Lleras-Muney, 2010).

Assuming, and there is no evidence to the contrary, that these inconsistent findings are not a function of extensive measure error or spurious associations, they represent a gap in our knowledge about the education gradient. Namely, how can education have both salutary and harmful effects on health, and during which contexts do particular effects emerge? To address this gap, developed here is a hypothesis that the education effect is made up of multiple potent pathways by which health is influenced, and while under most conditions these pathways operate in a similar salutary direction, there can be circumstances under which pathways act in opposite directions or are differentially suppressed and enhanced. The most obvious circumstances to investigate are demographic transitions during which new health risks are introduced into populations with ensuing pandemics and health crises.

This hypothesis is developed in three sections. First it shown that education has multiple causal pathways to health and that these can act in concert or in disunity. Based on this the Population Education Transition (hereafter PET) Curve is developed as a unifying way to predict the education gradient across the onset and course of demographic transitions and pandemics. Lastly, the viability of the PET curve is illustrated though four empirical cases of population transitions, each chosen to demonstrate a different dynamic of the PET curve; the education gradient on: 1) women's overweight during the nutritional transition in Latin American and Caribbean; 2) smoking in the U.S. and over China's tobacco-disease epidemic; 3) HIV/AIDS infections from the mid-1970s to 2000 in Sub-Saharan African; and 4) chronic disease over late stages of the epidemiological transitions in high-income nations.

Education's Multiple Pathways

The multiple mediating pathways of the education-health gradient are influenced by the emergence of new health risks and culturally innovative behavior within the context of demographic change. Culturally innovative behavior refers to individuals' access to new health threats that increase their disease risk. Because individuals with higher levels of education have increased material wealth and access to resources and experiences that increase their risk for disease, they are the first group within a population to experience negative health effects when a new disease threat is introduced (Baker, et. al, 2011; Jeon, Salinas & Baker, 2013). This finding runs counter to prior assessments of the effect of education on health where those with higher levels of educational attainment experience better health outcomes.

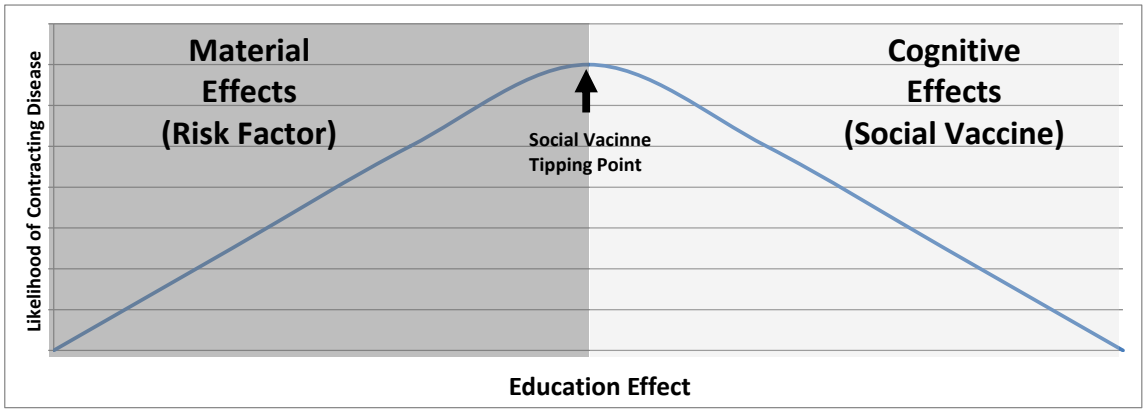
The education-health gradient pathway has been explained in either status-material or cognitive-psychological terms (Link and Phelan, 1995; Phelan, Link and Tehranifar, 2010; Link, et. al, in press). The underlying assumption between each of these pathways is that more educated individuals have access to improved health care and are better able to enact preventative health behaviors. While educated individuals are more likely to have higher material wealth compared with those with lower levels of education, the status-material pathway does not fully capture how and why individuals with higher levels of education are often the first to experience negative health outcomes when a new health risk emerges. The spread of HIV/AIDS in Sub-Saharan Africa in the early stages of the pandemic is illustrative of the negative effects of culturally innovative health behavior in the context of an emergent health threat. As this case highlights, the cognitive-psychological effects of education on disease prevention were suppressed by

the status-material advantage among individuals with higher levels of education. The cognitive-psychological pathway, however, becomes more salient over time throughout the course of a demographic transition. Individuals with higher levels of education are able to enact cognitive and psychological resources to reduce their risk of infectious and chronic disease, shifting the burden of disease and risk to individuals with lower levels of education within a population.

The Population Education Transition Curve

The Population Education Transition (PET) curve (Figure 1) explains the seemingly contradictory research on education's effect on health as one continuous pattern in which different mediating paths, previously outlined, are paramount at a given time specific, population context. The PET curve suggests that generally during the onset of a disease education acts as a risk factor, a relationship more pronounced if is there is a status or wealth relationship with the associated risk factors of the disease. Over historical time and due to various factors laid out in the following empirical examples, the effect of education on disease shifts from risk factor to social vaccine. This transition point is identified as the social vaccine tipping point. The socio-political environment can also shape the appearance of the PET curve with the social vaccine tipping point happening sooner or later and the relative risk factor or social vaccine slopes largely dependent on disease specific and societal factors.

Figure 1: The Population Education Transition Curve



PET Curves across Four Population Transitions

The basic features of the PET curve are illustrative through four empirical examples (see Table 1). First, changes in the education gradient for overweight among childbearing-aged women across various stages of the nutritional transition in Latin American and Caribbean nations shows the historical dynamics of the PET curve as populations are exposed to a new health risk. Second, tobacco use in the U.S. is contrasted with cigarette smoking across age cohorts during China's growing tobacco-disease epidemic demonstrating the suppression of the education SES-wealth pathway in the later. Third infections over the course of the Sub-Saharan African HIV/AIDS pandemic illustrate the importance of the information environment and the suppression of the cognitive pathway. Lastly the increase in chronic disease in later stages of the epidemiological transitions suggests that simultaneous PET curves are in play with the effect of education not necessarily acting in unison across diseases.

Table 1: Included Empirical Examples

Case	Authors	Method	Data	Dependent variable	Education
Obesity in Latin America	Jeon, Salinas & Baker	Multilevel logistic regression	22 cross-sectional national	Mother's Overweight	Years of schooling

	(2013)		Demographic Health Surveys in 9 countries		
Smoking: U.S. Story	De Walque (2007)	Panel logistic regression	National Health Interview Survey	Current smoker	Bivariate variable: College attainment versus less than college
Smoking: China Story	Fu et al. (2014)	Multivariate logistic regression Ordered logistic regression Structural Equation Modeling	Global Adult Tobacco Survey in China	Current smoking self-reported status Tobacco-related behavioral change	4 categories: 1) primary school and below, 2) middle school and lower, 3) high school and lower, 4) college and above.
HIV/AIDS	Leon et al. (2013); Smith, Salinas & Baker (2012)	Multilevel logit regression across 3 age cohorts	11 cross-sectional national Demographic Health Surveys	HIV infection	Years of schooling
Chronic Disease	Smith et al. (Forthcoming)	Random effect Meta-analysis	JSTOR and ScienceDirect studies published between 1990 and 2010	7 chronic disease categories	Bivariate variable: more education vs. less education

Obesity Story in Latin America

In contrast to the well-established effect of education as a social vaccine to reduce the likelihood of obesity in developed countries like the United States, previous studies found that low- and middle-income countries present the inverse effect of education (McLaren, 2007): more years of a person's formal schooling led to higher likelihood of

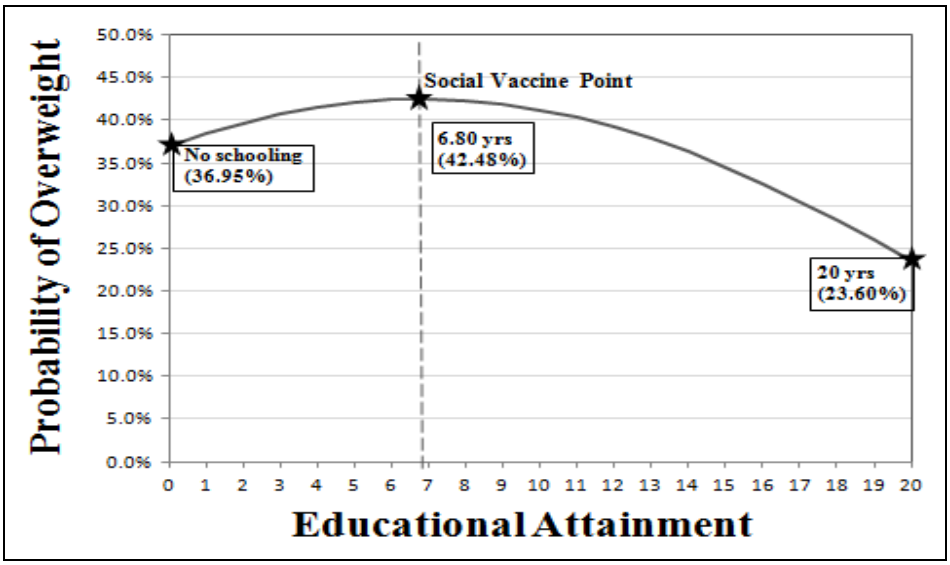
obesity. In order to explain the opposite direction of the education gradient between developed and less developed countries, Jeon, Salinas and Baker (2013) developed an analysis model to consider the moderating impact of population context on the role of education in reducing obesity.

For their empirical analysis, they focused on Latin American countries where obesity epidemic becomes rapidly widespread during recent decades. At the same time, those countries experienced shift of nutrition transition from high dependence on cereals to westernized diet style consisting of high animal fat and sugar consumption. Since the nutrition transition is reported to be a significant factor increasing obesity rate in a certain population (Popkin, 2004), authors hypothesized that as the nutrition transition unfolds within nations the shape of education-obesity gradient may change. In the low level of nutrition transition, obesity is not prevalent among the whole population due to the lack of food supply. In this population context, most people do not worry about the risk of obesity and the information on obesity is lacking. Rather, fat body size serves as the symbol of wealth/health because food accessibility is disproportionally distributed mostly to the people of higher socioeconomic status, which makes the status/material effect of education on increasing obesity. On the contrary, in the intermediate and high level of nutrition transition, energy-dense food with high fat and sugars is accessible for the whole population regardless of social status, obesity rate increases, and obesity acts as a risky behavior causing chronic diseases such as diabetes. In this population context of widespread obesity epidemic, it is necessary to control themselves from over-nutrition of westernized diet style. Thus, those with higher levels of education are better equipped to decipher the information related to controlling of their body size from the risk of over-

nutrition. In other words, better cognitive skills accumulated by more education plays a key role in reducing the likelihood of obesity in higher level of nutrition transition.

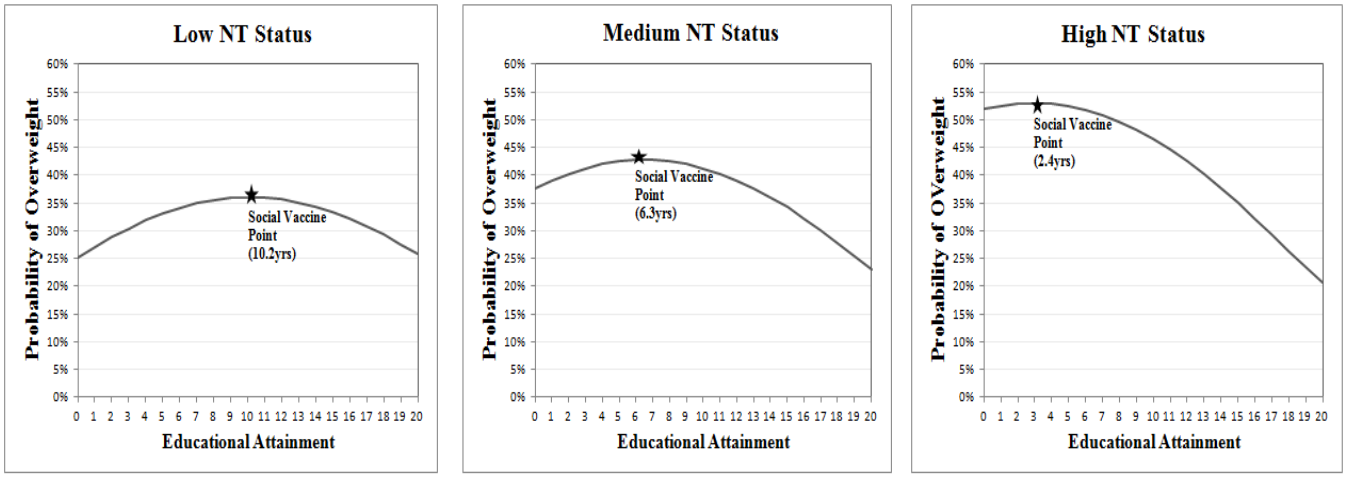
Under the theoretical framework, we examined two hypotheses using the Demographic and Health Survey (DHS), focusing on mothers of reproductive age in 22 DHS administrations collected at different time point from 9 Latin American countries. Jeon, Salinas, and Baker (2013) first hypothesized a U-inverted curve to best describe the education-obesity association, because highly educated people are likely to access the most up-to-date information on the risk of obesity even in the population context with the low level of nutrition transition. The curvilinear relationship was assumed to explain the hook effect of higher education with the relationship between education and increasing obesity. Figure 2 shows that education acts as a risk factor in for each additional year of primary school (0-6 years), indentified by a positive slope. The social vaccine tipping point occurs at 6.8 years of schooling with education then acting a social vaccine through through higher education. In other words, the pooled sample from Latin America suggests that for mothers who have completed education beyond the social vaccine tipping point, the probability of being overweight decreases with each additional year of schooling.

Figure 2: Predicted Probability of Overweight in a Pooled Sample of Latin American Mothers.



In the second hypothesis, the authors examined the moderating effect of the Nutrition Transition (hereafter NT) as a decisive population context on the education-obesity association. Using the hierarchical linear modeling analysis, Jeon, Salinas and Baker (2013) found that the effect of education on overweight transitions as countries advance through NT statuses. As a country moves from low to medium to high NT status the education effect on increasing mothers' overweight declines and eventually shifts to a negative effect. Figure 3 illustrates this changing trend. These results suggest that advanced NT status changes the role of education on overweight from a risk factor to a social vaccine. Additionally, across the NT statuses, the prevalence of overweight increases and the social vaccine tipping point occurs earlier, shifting from 10 to 7 to just under 3 years of schooling. As the tipping point moves to the left of the graph the risk factor (positive gradient) section of the PET curve is nearly eliminated.

Figure 3: Predicted Probability of Overweight across Nutrition Transition Statuses

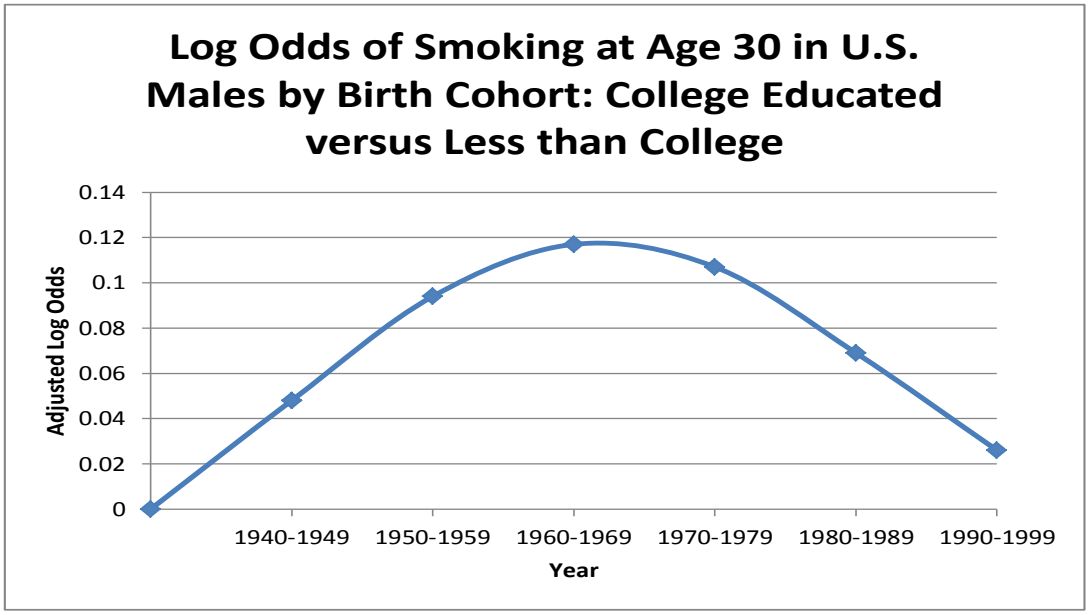


Smoking Story in U.S. and China

Figure 4 uses De Walque's (2007) data from the U.S. National Health Interview Survey to construct a PET curve displaying the log odds of smoking for 30 year olds in the U.S. over time. In 1940, individuals with a college degree were more likely to smoke (probability = 40.4%) relative to those without a high school diploma (35.8%). Increased education, during this time, acts as a risk factor for smoking as indicated by the positive slope in Figure 4. The differences in slope over time illustrates the changing log odds of smoking for 30 year olds in the U.S. with the social vaccine tipping point for smoking occurring during the 1960s. As the 20th century progressed the social vaccine effect of education was amplified, indicated by the increasing negative slope in the 1970s, 1980s, and 1990s. By the year 2000, the probability of a college graduate smoking (14.2%) was less than half of that of an individual without their high school diploma (29.2%). The transition from education acting as a risk factor to a social vaccine, for the case of smoking in the

U.S., can be partially explained by a change in the information quality and the relative cost of smoking throughout this time period.

Figure 4: Effects of Education on Smoking in the U.S.: 1940 – 2000.



Smoking in the U.S. was not universally identified as a health concern until the first Surgeon General Report was published in 1964 (Smith, Salinas & Baker, 2012). During this time of information transition, those with higher levels of education were better equipped to decipher the information accuracy and applicable risk. The cognitive effects of education, therefore, led the most educated to identify smoking as harmful and avoid the behavior. This shift in information acted in unison with changes in the relative costs of cigarettes. Figure 5 indicates that the price of one pack of cigarettes relative to the GDP per capita per week in the U.S. declined steadily from the 1950s to 1980 with an overall decrease in relative price of approximately 20% between 1954 and 2000.

Figure 5: Relative Costs of One Pack of Cigarettes in the U.S.

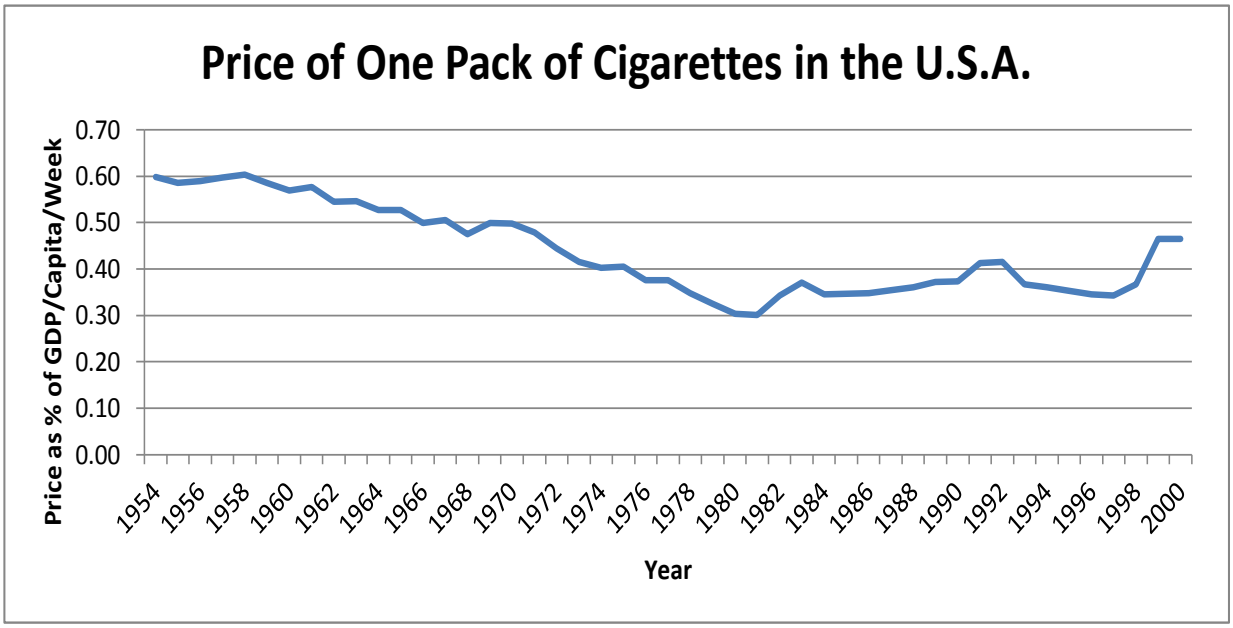
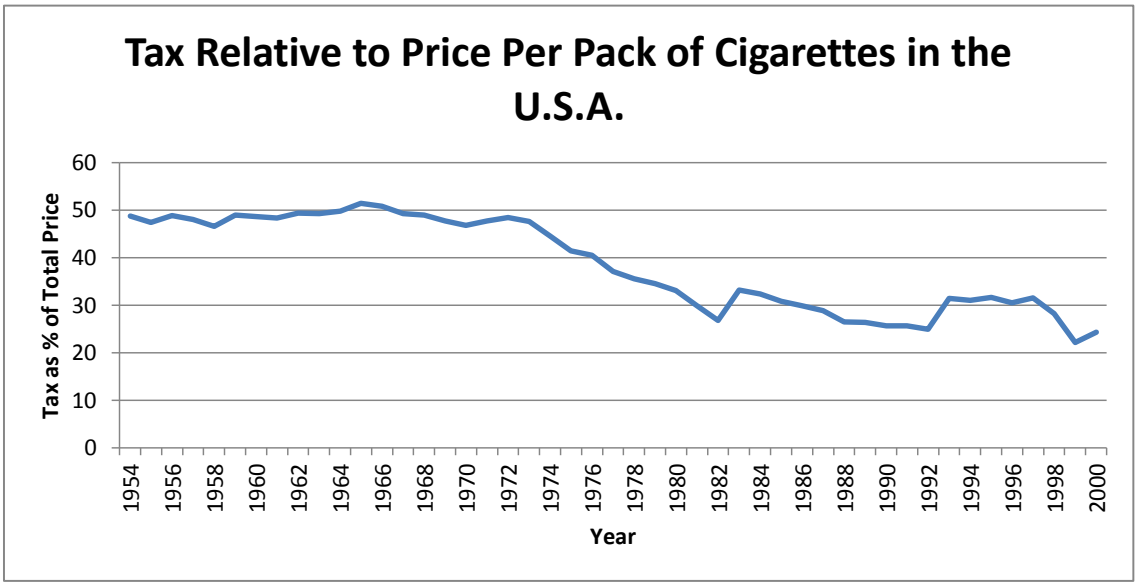


Figure 6 suggests that part of the high price of cigarettes during the middle of the twentieth century may be accounted for by high tax rates. From 1954 until about 1970 taxes accounted for roughly half of the price of one pack of cigarettes in the U.S. Since 1980, taxes have accounted for approximately 25 to 30% of the per pack price. The relatively high cost of cigarettes at the beginning of this time period increased access to cigarettes for those with higher income, illuminating the resource/wealth effect of education, often associated with education as a risk factor, and synonymous with trends in obesity in Latin America and HIV/AIDS in Sub-Saharan Africa.

Figure 6: Tax as a Percent of the Overall Price of One Pack of Cigarettes in the U.S.



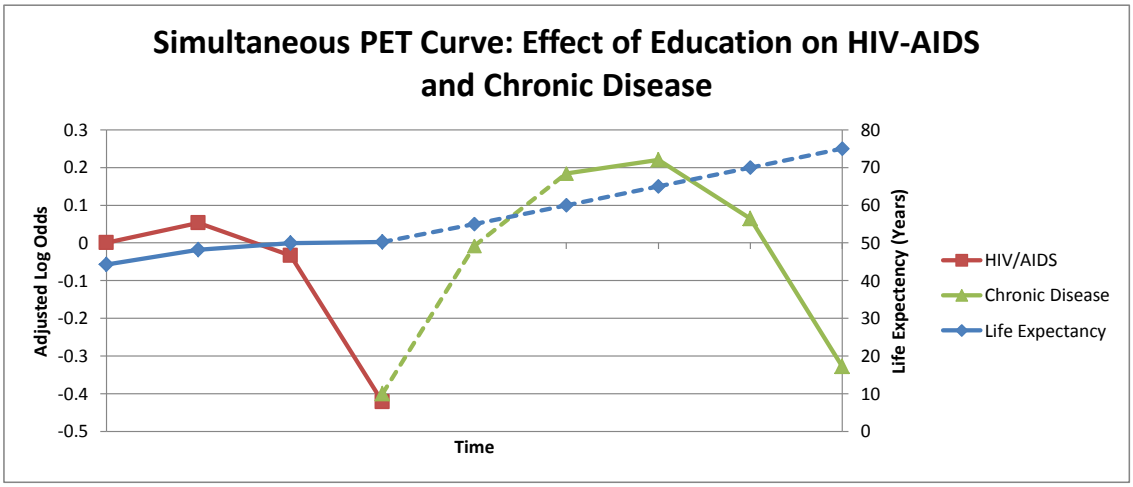
This patterned differed from that observed in China which has low to non-existent tobacco tax resulting in per pack prices that suppress the status-wealth effect of education (Fu et al., 2014). The PET curve in China, prominently shaped by the vast accessibility of tobacco products across all economic groups, lacks the positive gradient where greater education acts as a risk factor. The similar probability of higher educated and lower educated individuals produces a flat or null education effect in the mid-1900s. Across time an increasingly negative slope captures the education effect of smoking in China.

Simultaneous PET Curves: Education Effect on HIV/AIDS and Chronic Disease

PET curves do not occur in isolation but simultaneously across diseases and risk factors with the potential effects of education acting as a social vaccine for one disease while acting as a risk factor for a second disease. The variant effect of education on multiple diseases given a specific population context adds complexity

to the interpretation of the overall education-health relationship. Figure 7 plots simultaneous PET curves illustrating the education effect on HIV-AIDS (Smith, Salinas, & Baker, 2012) and the education effect on chronic disease (Smith et al. Forthcoming). Estimating the average log odds of an individual with the highest level of education (16 years) having HIV-AIDS relative to an individual with the lowest level of education (less than 4 years) from the four Sub-Saharan African countries on Figure 2 of Smith, Salinas, and Baker (2012), it becomes clear that over time – both as the quality of information improve and life expectancy increases – education shifts from a risk factor to a social vaccine. When the HIV-AIDS PET curve is plotted next to the chronic disease PET curve, extrapolated by extending the inverted U graph from Figure 3 of Smith et al (Forthcoming), the complex, overlapping relationship in which education is simultaneously a social vaccine (HIV-AIDS) and a risk factor (chronic disease) is apparent. This is confirmed by demographic research that indicates increases in mean education increase national life expectancy and contributes to the first demographic transition (Baker et al., 2011). Education, then, acts concurrently to extend the life expectancy while increasing the likelihood that an individual will age into a life stage where chronic disease is more likely.

Figure 7: Simultaneous PET Curves: The Inverse Effects of Education on HIV/AIDS and Chronic Disease.


Simultaneous PET Curve: Effect of Education on HIV-AIDS and Chronic Disease
Adjusted Log Odds
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
Life Expectency (Years)
80
70
60
50
40
30
20
10
0
Time
HIV/AIDS
Chronic Disease
Life Expectancy