CROSS-NATIONAL PATTERNS OF HEALTH INEQUALITY:

EDUCATION AND TOBACCO USE IN THE WORLD HEALTH SURVEY

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Abstract

The spread of tobacco use from the West to other parts of the world, especially among disadvantaged socioeconomic groups, not only raises concerns about the indisputable harm to global health but also raises questions about underlying patterns of inequality in mortality. Arguments relating to economic cost and diffusion posit that rising educational disparities in tobacco use – and worsening disparities in health and premature mortality – are associated with higher national income and more advanced stages of cigarette diffusion, particularly among younger persons and males. To test these arguments, we use World Health Survey data for 99,661 men and 123,953 women from 50 low to upper middle-income nations to examine educational disparities in smoking within and across nations. Multilevel logistic regression models show that national income and cigarette diffusion widen educational disparities among young persons and men, but have weaker influences among older persons and women. The results suggest that the social and economic patterns of cigarette adoption across low and middle-income nations foretell continuing, perhaps widening disparities in mortality.

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Smoking and Inequalities in Health and Mortality

A huge literature demonstrates the harm of tobacco use for health and longevity and describes the decline in use of cigarettes in the United States (see recent reports of the Surgeon General, Department of Health and Human Services [DHHS] 2000, 2004, for summaries of the literature). Although much remains to be done to reduce smoking from levels of 20.8 percent in the United States (Rock et al. 2007) and still higher in many Western European nations (Huisman, Kunst, and Mackenbach 2005), new public health concerns about smoking have emerged: Even while declining elsewhere, tobacco use and sales of tobacco companies have grown substantially in low- and middle-income nations (Jha and Chaloupka 2000; World Health Organization (WHO) 2008a; World Bank 1999; Yach and Bettcher 2000).

Today, about 82 percent of the world's 1.1 billion smokers reside in low- and middle-income countries (Sorensen, Gupta, and Pedneker 2005: 1003). As a result, smoking in developing nations often exceeds that in more developed nations. About 35 percent of men in developed countries and 50 percent in developing countries smoke (Mackay, Eriksen, and Shafey 2006:22). For women, the pattern is reversed: About 22 percent in developed countries and 9 percent in developing countries smoke (Mackay, Eriksen, and Shafey 2006:23). However, tobacco use by women in developing nations, after a period of low levels and little change, appears primed to move upward (Mackay 1998). The combination of current low levels of smoking among women in developing nations and the trend toward increasing prevalence of smoking for these women creates a serious and timely concern for public health intervention.

The global spread of cigarettes limits the longevity benefits that otherwise would result from forces of development, medicine, and public health (Ezzati and Lopez 2003a, 2003b). By some estimates, annual tobacco deaths worldwide will rise from 5.4 million today to 8 million by 2030, with 80 percent of the tobacco-related deaths in 2030 occurring in less developed nations (WHO 2008a). Such trends will widen the gap in mortality between the first and third worlds.

Worsening the problem, rising worldwide tobacco deaths tend to be concentrated among more vulnerable poor and uneducated groups. As in high-income nations, disadvantaged education, occupation, and income groups in less developed nations typically have higher smoking rates than more advantaged groups (Bobak et al. 2000; Pampel 2008) and have contributed substantially to the recent spread of tobacco use from the West to the other parts of the world. As a result, the smoking-related health and mortality advantages of high socioeconomic groups appear worldwide and worsen health disparities (Blakely et al. 2005).

The adoption of cigarettes may contribute to a more general concern that rising inequality in health accompanies economic development and mortality reduction. As Soares (2007:281) states, "The second and third waves of the health transition may be accompanied by a long-period of rising inequality in life expectancy, both within and between countries." Reducing health inequalities in developing countries thus has become a key concern of demographers (Minujin and Delmonica 2004) and a central goal of the World Bank and WHO (Gwatkin 2000; Sastry 2004). The literature highlights the role of technological diffusion as one source (Glied and Lleras-Muney, 2008) and public health programs as a counter-source (Koenig, Bioshai, and Khan 2001) of rising inequality in mortality. In addition, adoption of cigarettes by low SES groups, a less commonly cited cause of health inequality, may contribute. The harmful consequences of cigarette use for health and mortality already contribute to mortality inequalities

in lower- and middle-income nations of Eastern Europe (Mackenbach et al. 2008). Given the well-documented impact of smoking on premature death, the SES patterns of smoking cannot help but to seriously worsen mortality disparities in particular and public health more generally in developing countries over the next decades (Ezzati and Lopez 2003a).

However, other than broad understandings about the existence of disparities and their importance for mortality, we know very little about the distribution of smoking outside high-income nations. How precisely do smoking disparities differ across developing nations? Do they increase or decrease with economic development and the spread of cigarette sales across the world? Given global economic, regional, and social diversity, the strength of the inverse relationship and the size of socioeconomic disparities in smoking likely varies substantially. And if the relationship varies with national characteristics such as economic development and the spread of cigarette use, the variation may give insight into not only the patterns of tobacco use across the world but also into the socioeconomic sources of the patterns. Smoking in low- and middle-income nations offers a special opportunity to help understand one crucial source of inequality in health and mortality.

Toward this goal, studies need to examine patterns of smoking by education and other socioeconomic characteristics with comparable and high quality individual-level data for a large number of nations that vary in contexts of national income and the spread of cigarette use throughout the population. Few if any previous studies meet this requirement, however. On one hand, the many studies of disparities in single nations (summarized by Bobak et al. 2000) differ enough in design and measurement as to make comparisons suspect. On the other hand, comparisons across low and middle-income nations using comparable aggregate data on male and female smoking (Jha et al. 2002; Mackay, Eriksen, and Shafey 2006; Pampel 2007) can say

little about adoption by socioeconomic groups or the resulting disparities.

This study overcomes these limitations by using individual-level survey data on 50 low to upper middle-income nations from the World Health Survey or WHS (WHO 2008b) and examining the influence of both individual and aggregate determinants of smoking. The survey relies on representative samples and has comparable measures of tobacco use, social position, and economic resources for nations of Africa, Southeast Asia, the Western Pacific, the Eastern Mediterranean, and Eastern Europe. The diverse sample of nations offers the opportunity to study neglected regions of the world where tobacco use has most recently spread and knowledge of social patterns of use remains limited. The WHS also contains comparable measures of education, typically the component of socioeconomic status (SES) with the strongest relationship to smoking (Barbeau, Krieger, and Soobader 2004; Pampel 2008). Education or years of schooling relates closely to occupation and income but has advantages over other measures of SES: It has comparable meanings across the world, serves as an indicator of permanent rather than current income (Cowell 2006), and is determined early enough in life to cause rather than result from smoking and smoking-related poor health.

Changes in Education Disparities

Arguments about the cross-national prevalence of smoking can serve as a starting point to explain cross-national variation in educational disparities in smoking. At least among men, smoking proves highest in middle-income nations and lowest in low- and high-income nations (Pampel 2007). From an economic cost perspective, this curvilinear pattern reflects the possible influence of two mechanisms (Cutler and Glaeser 2006). A price effect shows in the initial rise in smoking with national income in low-income nations and reflects the increased affordability

of cigarettes with higher personal and family income. A health-cost effect shows in declines in smoking with greater personal and family income in higher income nations. Because income brings longevity benefits in middle- and high-income nations, the costs of smoking to health and potential years of life lead to lower usage (Lawlor et al. 2003). The balance of the price and health-cost effects matches the inverse U-shaped relationship of national income and smoking.

The curvilinear pattern of smoking prevalence also fits a cigarette diffusion argument. A pattern of change occurs in smoking prevalence that resembles a disease epidemic in its rise and fall (Lopez 1995). As cigarettes begin to spread in a population, usage grows steadily to a peak and then declines (though does not disappear). The mechanisms behind the change involve processes of social innovation and communication (Rogers 2003). Historically, smoking began in high-income nations with the adoption of the innovative behavior by high SES groups, then diffused through the population to lower SES groups, and came to be rejected first by high SES groups (Ferrence 1989; Huisman, Kunst, and Mackenbach 2005). Women also go through the rise and fall of the cigarette epidemic but lag several decades behind males in the start of the adoption process and in the peak levels of smoking (Pampel 2007).

For low- and middle-income nations at the earlier stages of diffusion – the focus here – smoking prevalence should rise but likely not show the decline apparent in high-income nations. This truncated range of nations means that national income and cigarette diffusion should have positive or decreasing positive effects. With this point in mind, the economic cost and diffusion arguments can be extended to explain educational patterns of smoking.

First, based on the cost argument, the educational gap in smoking in low- and middle-income nations should widen with national income. The price effect should have dominant influence among low education groups, while the health-cost effect should have dominant

influence among high education groups. Low education groups cannot easily afford to purchase cigarettes, but higher national income increases that opportunity. At the same time, national income increases the health costs of smoking, especially for high education groups. Given their greater access to high-quality health care, information on the health costs of unhealthy behaviors, better diet, and healthier living conditions, the more educated have incentives to avoid tobacco that low education groups do not. Smoking tends to rise with national income among all groups but does so less among high than low education groups and consequently increases disparities.[1]

Second, predictions of widening disparities similarly follow from the diffusion argument. Although educated persons in the past often took up smoking as a form of social innovation, the majority of less educated groups have adopted the habit more recently and now on average have greater smoking rates than the highly educated. Yet, the degree of the disparity varies by the stage of the diffusion process. For nations at earlier stages, where diffusion to the majority of the population has proceeded less far and low education groups have had less time to imitate the smoking of high education groups, the educational disparities should be reversed in direction or small in magnitude. At later stages of diffusion, low education groups imitate the smoking of more prestigious groups in larger numbers and respond more fully to tobacco advertising campaigns that link smoking to sophistication, affluence, and Western lifestyles – statuses otherwise largely unattainable for low educated groups. High education groups, in contrast, do more to distinguish themselves from low education groups by adopting more healthy behaviors and imitating the non-smoking of high education groups in the West. Thus, at later stages of diffusion, education disparities in smoking increase as they do with increasing national income.

These arguments lead to the following hypotheses: 1a) Smoking rises with increasing national income and cigarette diffusion among all groups, and 1b) educational disparities in

smoking widen with increasing national income and cigarette diffusion as the growth in smoking occurs more strongly for low education groups than high education groups. In addition, these hypotheses should apply more strongly to younger than older cohorts and to men than women.

Concerning age or cohort,[2] the scientific evidence of the harm of smoking has become widely accepted and anti-tobacco norms have strengthened, not just in high-income nations (DHHS 2000). The World Health Organization and national public health agencies have publicized the harm of tobacco use throughout other parts of the world (WHO 2008a). With this scientific and normative change in knowledge of the harm of tobacco, the health-cost effects of smoking should become stronger, particularly among high education groups. More than among older cohorts, smoking among newer cohorts reflects the anti-tobacco norms of more recent decades (Preston and Wang 2006). It follows that educational disparities should grow with national income and stage of diffusion most clearly for today's younger cohorts who grew up in an environment of a better publicized health-cost effect and normative rejection of smoking by health officials and elites.[3]

Concerning gender, normative restrictions and sanctions on smoking by women in some developing nations remain in place or have weakened only recently (Waldron et al. 1988). The later adoption of cigarettes by women keeps their usage lower, since the adoption occurs during periods of widespread knowledge of the harm of smoking. The late start and current restrictions on smoking among women may affect educational disparities. More educated women with greater freedom and motivations to innovate may initially adopt smoking more than less educated women. If so, educational disparities for women should be smaller than for men or perhaps reversed in direction (Pampel 2008). The lag in adoption by women further implies that the effects of national income and cigarette diffusion on smoking may be delayed for women.

As highly educated women play a greater role in early adoption, these national characteristics will do less to narrow disparities among women than men.

In summary, the two theories specify different mechanisms but offer similar predictions. They both recognize that education has changing meanings for smoking and can account for variation in education effects across nations, ages, and genders. Rather than competing, the economic and social forces specified by the two theories can be seen as jointly contributing to patterns of educational disparities in smoking. Alternatively, increasing national income and cigarette diffusion may raise the number of smokers but do so similarly for all education groups. A rise or decline in smoking that occurs proportionally among all education groups maintains disparities, as all groups respond to the price effect at low income levels and to the health cost effect at higher income levels and all groups contribute similarly to the cigarette epidemic. Thus, a null hypothesis recognizes that educational disparities may differ little across nations.

Still other factors such as tobacco company market penetration, cigarette advertising, and government bans, restrictions, and regulations may mediate the influence of structural changes in the economy on smoking disparities. Income growth and increased smoking attract tobacco company investment and marketing, which in turn lead government and non-government anti-tobacco organizations to respond. Both the marketing and government response may affect educational groups differently. Yet, these mediating influences unfortunately are near impossible to measure for previous decades when shifts in educational disparities began to occur and difficult to measure reliably even today. While not denying the importance of the mediators, the approach here focuses on the exogenous forces of economic development, class-based of adoption, and the total (both direct and indirect) effects of development and diffusion on smoking disparities.

Methods

Data

The data come from the World Health Survey (WHS), a World Health Organization initiative aimed at collecting high-quality individual-level health data worldwide. With supervision from the WHO, 70 countries chose to implement the WHS during the 2003 and 2004 survey period (WHO 2008b). In addition to data collected from individuals on demographic and SES variables, the WHS includes risk factor modules that collect data on topics such as tobacco consumption. The consistent question format and use of face-to-face or telephone interviews creates a set of comparable health indicators at the national and regional level and, importantly, includes low to upper middle-income nations along with the more commonly studied high-income nations. When combined with aggregate or contextual measures, cross-national health data at the individual-level from the WHS improves greatly on designs that use only aggregate or individual-level data for one country.

The WHS uses a stratified multi-stage cluster sampling frame to select males and females age 18 and over living in households (including household members who have been institutionalized). The strata and cluster definitions vary across countries, but the WHS sets clear quality standards needed to obtain probability samples that, with proper weighting, accurately represent the population. Population weights for most countries further adjust for non-response as well as for oversampling (WHO 2008b).

Individual countries decide which of the recommended question modules to include in their surveys, and most of the high-income nations plus a few other nations opted to exclude the module with smoking questions (presumably because they have other national surveys with such

data). Fifty low to upper middle-income nations with tobacco measures remain for analysis (see Appendix A for a full list of the countries). Combining the individual-level data on the 50 countries and dropping the 5.6 percent of cases that are missing data on key variables yields a sample of 223,614 respondents – 99,661 men and 123,953 women.

Because of the self-selected participation of countries in the WHS, it is worth comparing our sample to the larger population of low to upper middle-income nations. Results indicate that the mean GDP for the 50 sample countries ($4667) does not differ significantly (t = 1.43) from the mean GDP ($5942) for 75 other countries not included in the sample. Additionally, the same tests within the five WHO regions (defined in the appendix) showed significant differences in the GDP means only for Eastern Europe and Southeast Asia. In Southeast Asia, the WHS countries have a somewhat lower GDP, due primarily to the exclusion of Thailand, a country that is richer than its neighbors and atypical of the region. No significant difference exists in GDP for the WHS nations in Southeast Asia and the other nations without Thailand. In the Eastern European region, the exclusion from the WHS of some poor former Soviet Republic nations such as Uzbekistan and Kyrgyzstan makes the WHS sample somewhat richer. However, the inclusion of more developed Eastern European nations such as the Czech Republic, Georgia, and Slovenia extends the income range of the sample and allows for more valid worldwide comparisons.

Measures

Smoking status is coded dichotomously with non-smokers as the referent and occasional and regular smokers as the alternative. The WHS distinguishes between use of manufactured cigarette smoking, hand-rolled cigarettes, pipe smoking, cigars or any other tobacco products, but the results presented here for all tobacco prove similar to the results for cigarette use, the key

component of worldwide tobacco increase. The tobacco smoking questions consider only current behavior, not age of adoption, former smoking, or age of cessation. Although U.S. studies find that self-reported smoking is generally accurate (Patrick et al. 1994), the validity of such items in lower- income nations is less clear, and the items may reflect differential reporting by social position. Lacking physiological measures, survey responses remain the commonly accepted source of nearly all data on global patterns of tobacco prevalence.

Among the control variables, a dummy variable for sex codes males as one. Age in years ranges from 18 to 85 and older. Marital status indicates whether the individual is married or cohabiting, and the referent includes never married, divorced, separated, and widowed. Residence measures whether the geographic location of the individual is considered by the WHS nations as rural (the referent) or urban.[4]

Education equals the highest level of schooling completed and includes the following categories: (1) no formal schooling, (2) less than primary school, (3) primary school, (4) secondary school, (5) high school completed, and (6) some college or higher.[5] Occupation consists of a series of dummy variables for no job, agricultural job, manual job, and non-manual job. Collecting information on occupation in countries where subsistence living reigns presents special challenges. Consequently, as much as 70 percent of individuals in some poor WHS countries report having no occupation. In addition, reports on occupations may differ so greatly across poor and more industrial nations as to reduce the reliability of the classification. The measure has value but likely not as much as education.

Finally, the WHS captures differences in economic standing across the diverse nations by asking about the ownership of a list of goods. The goods mentioned in the survey, such as a bucket, bicycle, refrigerator, or computer, are selected to fit the standard of living of the

countries. A standardized scale based on a count of the number of goods owned distinguishes the economic standing of individuals within countries. Across countries, however, the divergent meanings of the goods make comparisons misleading. The scales therefore are centered to have a mean of zero and a standard deviation of one within each country and do not vary cross-nationally.

Two aggregate measures corresponding to the cost and diffusion arguments reflect long-term changes in the national context of smoking. The first, real gross domestic product per capita (GDP), measures the value of goods and services and is associated with economic and social development, greater disposable income, and changes in the affordability and health cost of cigarettes. The measure, available from the Tobacco Control Country Profiles web page (Shafey, Dolwick, and Guindon 2003), uses purchasing power parities to make national currencies comparable and adjust for inflation. Figures available for the 50 nations in 1975, 1980, 1985, 1990, 1995, and 2000 make it possible to average the available years, thus reflecting lags of various length and past influences.[6] To reduce skewness and transform the measure into more meaningful percentage change units, the models use the natural log of GDP.

The second measure, the proportional decline in per capita cigarette consumption from 1970 to 2000, reflects the extent of cigarette diffusion. So that a high score indicates a late stage of diffusion, the rate of decline rather than the rate of growth is measured. Nations at the early stage with a positive rate of growth receive a low score, nations at middle stages with a leveling off of the growth rate receive a medium score, and nations at the late stage with a negative rate of growth receive a high score. Although nations at the late stage show a decline in cigarette use, they also show relatively high prevalence levels because cigarette use has already spread throughout the population. However, a measure of cigarette level rather than change would fail

to distinguish two nations with the same prevalence but with one on the upslope and the other on the downslope of diffusion.[7] The figures on per capita cigarette consumption come from the Tobacco Control Country Profiles web page (Shafey, Dolwick, and Guindon 2003).

Estimation

Multilevel models treat level-1 individuals as nested within level-2 nations and allow for level-1 random effects. The restricted maximum likelihood estimates of the model coefficients adjust for clustering by nation, different sample sizes for level-1 and level-2 units, heteroscedastic error terms, and varying numbers of cases within level-2 units – all problems that otherwise downwardly bias estimated standard errors (Raudenbush and Bryk 2002). In a logistic regression model at level 1, the logged odds of smoking for individual i in nation j (Y_{ij}) is a function of education (E_{ij}) and k control variables (X_{kij}):

$$\ln [\text{Prob}(Y = 1)/\text{Prob}(Y = 0)] = \beta_{0j} + \beta_{1j}*E_{ij} + \Sigma\, \beta_{kj}*X_{kij}. \quad (1)$$

With all determinants centered at their means, β_{0j} shows the mean adjusted logged odds of smoking, and β_{1j} and β_{kj} show the effects of education (E_{ij}) and the control variables (X_{kij}) on the logged odds of smoking for each nation j.

A set of level-2 equations treat the level-1 β coefficients as outcomes and treat nations rather than individuals as the units of analysis. With national measures (C_{mj}) for logged GDP and cigarette diffusion as determinants of the β coefficients, the level-2 equations take the following form:

$$\beta_{0j} = \gamma_{00} + \Sigma\, \gamma_{0m}*C_{mj} + u_{0j}\,, \quad (2a)$$

$$\beta_{1j} = \gamma_{10} + \Sigma\, \gamma_{1m}*C_{mj} + u_{1j}\,, \quad (2b)$$

$$\beta_{kj} = \gamma_{k0}\,. \quad (2c)$$

The γ_{0m} and γ_{1m} coefficients represent the effects of the aggregate variables on the nation-specific level of smoking and effect of education. The model treats the intercept (β_{0j}) and education effect (β_{1j}) as random and the effects of the control variables as fixed. The error terms for equations 2a and 2b are assumed to be multivariate normally distributed, each with a mean of zero and non-zero variances and covariances. The restricted maximum likelihood parameter estimates come from HLM 6.05 (Raudenbush et al. 2004).

Results

Descriptive Statistics

There are stark differences in smoking prevalence between males and females (Tables 1 and 2). Across all regions, nearly 40 percent of men smoke, while less than 12 percent of women smoke. The patterns further vary across regions. For example, over 58 percent of men in the Western Pacific smoke compared to just over 25 percent of men in Africa. Differences exist, though less pronounced, for women as well. Nearly 20 percent of women in Southeast Asian nations smoke, but less than 4 percent of women in the Eastern Mediterranean nations do.

Tables 1 and 2 About Here

Differences in SES indicators for males and females also appear across the regions. In the total sample of males, roughly 18 percent have had no formal schooling at all. For men in African countries that figure climbs to nearly 35 percent of men but in Eastern Europe the percentage falls to near zero. By contrast, nearly 26 percent of women have no formal schooling. Over 56 percent of women in Eastern Mediterranean countries and 2 percent of women in Eastern Europe fall into this category.

The aggregate measures likewise vary greatly across regions and nations. The African

nations of Ethiopia, Mali, and Malawi have the lowest GDP, while Eastern European nations and the United Arab Emirates have the highest GDP. Africa and Eastern Europe, respectively, are also at the earliest and latest stage of diffusion. The correlation of .42 between percent cigarette change and logged GDP for the 50 nations indicates that higher income nations are, as would be expected, more advanced in the stage of diffusion, but the two measures differ to some degree.

Male Multilevel Models

The multilevel models in Table 3 show first that individual determinants of male smoking, when averaged across all nations, have expected influences. The first equation presents odds ratios when including only individual-level variables in the model. Education has a strong negative influence on smoking, while non-manual and non-workers have lower smoking than agricultural and manual workers. The income and wealth proxy based on goods owned (and centered within each nation) fails to have much influence. For the demographic variables, the positive effect of age and the negative effect of age squared indicate that smoking increases with age until a peak at 38 and then begins to decline. Urban residence has a weak positive association and marriage has a modest negative association with smoking.

Table 3 About Here

The model in equation 1 allows the intercept and the education coefficient to vary across nations. The variance components for both prove significant. The level-1 pseudo-variation in smoking across individuals remains large, however, and falls by only 2.3 percent with inclusion of the individual determinants in the model. Some of the individual differences in the logged odds of smoking stem from national influences that the individual variables do not capture. The intraclass correlation coefficient indicates that about 9.6 percent of the variance in smoking

occurs between nations. The level-2 variables may account for some of this variation.[8]

Adding logged GDP (equation 2) and the cigarette diffusion measure (equation 3) to the model partially supports hypothesis 1a and 1b concerning levels and education disparities in smoking. Logged GDP increases the intercept or level of smoking (OR = 1.32) but does not significantly affect the education coefficient or educational disparities (OR = .98). The cigarette diffusion measure shows more consistent influence. It increases the prevalence of male smoking (OR= 1.06) and strengthens the negative education effect (OR = .97). Both higher national income and cigarette diffusion are associated with greater smoking prevalence and support hypothesis 1a, while cigarette diffusion is associated with greater educational disparities and supports hypothesis 1b.[9]

The effects of education and the aggregate variables generally prove stronger for younger than older men and partially support the aged-based variation on the hypotheses. Equations 4 and 5 replicate the random effect models for men ages 18 to 39, and equations 5 and 6 do the same for men ages 40 and over. The education odds ratio for young men is significantly lower than for older men (.79 versus .87, $t = -3.34$, $p < .002$), indicating greater educational disparities among more recent cohorts or age groups. Education inhibits smoking among older men but not as much as among younger men.

Furthermore, both logged GDP and cigarette diffusion significantly strengthen the negative effect of education among younger men but not among older men. In model 4, a one unit increase in logged GDP not only increases the odds of smoking by 59 percent, it also multiplies the average education odds ratio of .78 by .94. Among younger men, then, high GDP nations have greater educational disparities. In contrast, logged GDP has little influence on either the prevalence or the education effect for older men. The odds ratios for logged GDP and

for logged GDP by education in model 6 differ little from one. However, other evidence qualifies the claim that national differences widen educational differences less among older men than younger men. The logged GDP by education interaction does not differ significantly between the young and old (.94 versus .99, $t = -1.45$, $p < .139$). The cigarette diffusion by education interaction is significant but has an effect among older men that is identical among younger men (.97 for both age groups). Perhaps the most important conclusion to come from the age comparisons among males is that educational differences in smoking are smaller among older men who typically adopted smoking many decades ago.

The implications of the age-specific coefficients are shown in Figure 1a, which graphs the predicted probabilities of smoking by logged (and centered) GDP for a low education group (education equal to less than primary school completed) and a high education group (high school completed) and for young and old ages. For young men, smoking among the low education groups rises faster with logged GDP than the high education group, and a small gap at low GDP becomes a larger gap at high GDP. The difference in the probability of smoking equals .05 at the lowest logged GDP and .26 at the highest. For older men, the gap changes little. The educational difference in the probability of smoking equals .08 at the lowest GDP and .13 at the highest. With only 50 cases and an insignificant difference in the slopes across age, the graph is more suggestive than definitive, but it is consistent with arguments about age differences in education disparities.

Figure 1a and 1b About Here

When including the logged GDP and cigarette diffusion measures together, the high correlation between the two reduces the strength of both variables (results not presented). Logged GDP has the stronger effect on smoking prevalence, while cigarette diffusion has the

stronger effect on the education relationship. Another check includes dummy variable controls for region to see if the influences of the aggregate variables occur within as well as between nations.[10] With region controls, logged GDP again has the stronger effect on smoking level, while cigarette diffusion again has the stronger effect on the education relationship. Still further, graphs of the level-2 residuals for the intercept and education effect show a normal distribution without evidence of outliers, heteroscedasticity, or non-linearity. Despite measurement error and relatively few level-2 units, consistency in effects indicates the robustness of the results.

Female Multilevel Models

Table 4 replicates the multilevel models for females but with contrasting results: High education does less to discourage smoking among women than men. The individual determinants of female smoking listed in model 1 of Table 4 show a weaker effect of education and a stronger effect of non-manual work. For men, the education odds ratio of .83 falls significantly below the odds ratio for women of .90 ($t = 3.49$, $p < .011$). To illustrate, the odds of a male college graduate smoking are 60 percent lower than the odds of someone with no formal schooling, while the odds of a female college graduate are 40 percent lower. As predicted, then, education has a weaker effect for females than males. In addition, the insignificant odds ratio of 1.06 for male non-manual workers (relative to non-workers) becomes a significant odds ratio of 1.30 for female non-manual workers (the two coefficients differ significantly, $t = 3.49$, $p <.001$). Among females, non-manual workers smoke more than non-workers.

Table 4 About Here

Including the aggregate determinant of logged GDP in the model also identifies some differences between men and women. In model 2, logged GDP increases smoking among

women as it does among men, but it also weakens the negative effect of education – just the opposite as found for men.[11] High income nations show a weaker education gradient for female smoking than lower income nations. The cigarette diffusion measure in model 3 reproduces the results for logged GDP less clearly, as it has a positive but insignificant influence on the effect of education. However, the effect contrasts with the significant and considerably stronger negative effect of cigarette diffusion among men.[12]

Perhaps gender equality relates better to cross-national differences in female smoking than measures that gloss over gender differences. In fact, measures of gender equality correlate highly with logged GDP. For this sample of nations, the total fertility rate, which relates inversely to the freedom of women to take on roles and activities outside the family, has a correlation of -.74 with logged GDP. A measure of percent female school enrollment as a ratio to percent male school enrollment has a correlation of .79 with logged GDP. When included with logged GDP, neither gender equality measure has a strong influence (available on request). Used separately, the gender equality measures have effects much like those of logged GDP. Equality increases smoking overall and narrows educational differences in smoking.

Controls for region reduce the effects of logged GDP substantially. Logged GDP's effect on the intercept falls to just below significance, while its effect on the education slope remains significant but is smaller. These results indicate larger between-region than within region-effects of logged GDP on female smoking and less reliable evidence of the effects of logged GDP.

Comparisons by age offer additional insights. Equations 4 and 5 list the coefficients for women ages 18-39 and equations 6 and 7 list the coefficients for women ages 40 and older. The key result is that neither logged GDP nor cigarette diffusion affect the education slope for young women. At ages 18-39, education clearly reduces smoking in all nations regardless of national

income or stage of diffusion. At the older ages, however, both logged GDP and cigarette diffusion weaken the negative effect of education – results consistent with those for all ages combined. Moreover, older women have a weaker average effect of education than younger women (.75 versus .84, $t = -2.30$, $p < .031$).

Figure 1b depicts the implications of the logged GDP by education interaction for women. For younger women, smoking rises similarly for those with less than primary completed schooling and those with secondary degrees. For older women, however, the change in smoking with logged GDP diverges by education. Smoking rises with GDP among more educated older women but declines with GDP among less educated older women. As a result, higher educated women smoke more than less educated women in nations with high national income such as Czechoslovakia, Slovenia, and Hungary. In general terms, the education gradient reverses from negative to positive with national income.

The results support the gender-based variant on the hypotheses that educational disparities are weaker for women than men and rise less with national income and cigarette diffusion for women than men. Perhaps surprisingly, educational disparities among older women (though not younger women) decrease at higher levels of national income and cigarette diffusion. Consistent with the hypotheses, educational disparities in smoking are not only smaller for women than men, they are smaller (or even reversed) for older than younger women.

Conclusions

Problems of widening inequalities in mortality in nations of the developing world (Soares 2007) and Eastern Europe (Mackenbach et al. 2008) may be worsened by patterns of smoking in these nations. According to two arguments, increases in national income increases and diffusion

of cigarette use widen educational disparities in smoking – and mortality disparities in decades to follow – among low and middle-income nations. An economic argument highlights the changing balance of price and health costs effects with greater national income (Culter and Glaeser 2006), and a diffusion argument highlights the changing nature of innovative behavior among highly educated groups during the processes of change (Ferrence 1989; Pampel 2005). Tests of the theories using data on smoking levels and smoking differences by education across 50 low to upper middle-income nations support both theories. Despite the different mechanisms they specify and some differences in effects, they complement one another and both receive support.

To review the findings, national income and cigarette diffusion are generally and plausibly associated with increased smoking for this sample of nations. On average, growth of national income allows more persons to purchase cigarettes, and a later stage of diffusion reflects the spread of cigarette use throughout the population. More intriguing are the varied effects of education across contexts. Education generally lowers smoking, but as the theories predict, logged GDP and cigarette diffusion strengthen the negative effects and widen educational disparities. Higher national income appears to increase access to cigarettes among low education groups but associated health problems seem to present greater costs for the more educated groups that enjoy growing longevity. Hence, smoking among the less educated rises most with national income and increases educational disparities. Similarly, a later stage of diffusion appears to involve the rejection of smoking and the pursuit of healthy lifestyles by innovative high education groups at the same time smoking grows among less educated groups. This diffusion process also leads to divergence in smoking by education.

In addition, the results differ by gender and age. Younger males most clearly show the negative effects of education and the strengthening negative effects of education with logged

GDP and diffusion. Older females diverge most from this pattern. They show relatively weak educational disparities and effects of higher national income and greater diffusion that weaken rather than widen educational differences. As the hypotheses predicted, educational disparities are greater among men than women and among younger than older cohorts, and the rise in educational disparities with increasing national income and cigarette diffusion occurs more strongly among men than women and among younger than older cohorts.

The findings on social patterns of smoking in the developing world indicate worrisome trends for future population health. Based on the results for younger persons, it appears that global tobacco growth will occur most among the least educated, or the most disadvantaged. This pattern already holds for young men, and young women will likely follow in decades to come. Given that tobacco kills one-third to half of those who use it (WHO 2008a), such trends obstruct progress in reducing mortality rates and highlight the need for tobacco control. They also exacerbate inequalities in mortality between the first and third worlds and between advantaged and disadvantaged groups within nations.

While these results help clarify the significance of educational advantage for harmful health behaviors, they pose a significant challenge for public health policy aimed at addressing the increasing number of deaths attributable to smoking throughout the world. High income nations successfully reduced cigarette smoking and related causes of mortality, in part because of the high health costs among groups with low mortality and the diffusion of anti-smoking norms. Yet the developing world, a substantial majority of the world's population, presents a unique and alarming problem: Higher income and diffusion contribute to higher smoking and greater inequalities, which may counter other mortality benefits from continued economic advancements.

These theoretical and applied conclusions rest on a stronger methodological foundation than previous studies. Despite the public health disaster of the global spread of cigarettes, no study has yet examined educational (or other SES) disparities across numerous low- and middle-income nations with high quality and comparable data. The World Health Survey provides a unique resource in this regard – the findings about educational disparities can come only from data on individuals across a large and diverse set of nations. On the negative side, the cross-sectional design of the WHS limits its ability to examine changes within nations and to compare different cohorts at the same ages. The reported relationships represent more in the way of associations than causes. Inferences drawn about nations with different national income and at different stages of the cigarette diffusion process may not hold when comparisons are made over time within the same nations. Even so, the 50 nations and hundreds of thousands of individual survey responses available from the WHS go well beyond aggregate comparisons of smoking prevalence that typify existing studies, and the persistence of cigarette use over the life course makes cross-sectional comparisons of young and old informative. In all, then, the World Health Survey offers a remarkable resource for studying contextual influences on health-related behaviors such as tobacco use.

Endnotes

[1] The educational disparities may take a curvilinear form, much as overall prevalence does. Lower education groups may eventually follow in rejecting smoking as they come to live longer and recognize the health costs of the habit. At the highest levels of national income, then, educational disparities may begin to decline. However, such changes would likely show only in the most advanced stages of the epidemic in high-income, not in developing nations.

[2] While the arguments emphasize the importance of cohort differences and smoking has a strong cohort basis (Preston and Wang 2006), life course or aging also has an influence. The cross-sectional data to be examined make it impossible to distinguish between age and cohort.

[3] Higher mortality among smokers could also contribute to smaller disparities, but separate tests at younger ages can control for this influence.

[4] All respondents from Slovenia lack data on this variable and instead are assigned the mean proportion urban of its neighbor Croatia.

[5] Centering education so that respondents in each nation have a score relative to their nation's mean and all nations have the same mean of zero makes sense when only the within-nation relative standing, not the absolute level of education, influences smoking. Given that the health-cost and diffusion arguments recognize the importance of both within- and between-nation differences in education, the variable is measured on the same scale for all nations.

[6] Since older smokers became addicted to cigarettes decades ago, income in previous decades may influence later smoking. At the same time, younger smokers may respond more to current than past income in starting to smoke. Averaging the values for all the years avoids having to select one available year (such as a lag of 30, 20, or 10 years) and should better reflect

the economic history of the nations.

[7] Also, because aggregate consumption measures the percentage decrease in the number of cigarettes smoked by all persons while the individual measures focus on educational and gender differences in smoking, it reduces the potential overlap of the diffusion measure and the outcome smoking variable. The aggregate measures should have a relationship with educational differences in smoking among men and women because of the varied stages of cigarette diffusion rather than because of commonality in definition.

[8] Larsen and Merlo (2005) criticize the partitioning of variance in multilevel logit models and offer odds ratios measures of variation between level-2 units. For the WHS data, the median odds ratio of 2.13 shows that, on average, two persons with the same characteristics but in different clusters have widely varying smoking outcomes.

[9] Additional tests show that logged GDP fails to influence the effects of occupation and goods for young men the way it influences the effect of education. Education not only influences smoking more strongly but also has more clearly patterned variation in influence across the nations than other measures of socioeconomic position.

[10] The small number of cases within several of the regions warrants against use of these effects in all the models.

[11] Additional tests for the interaction of logged GDP with occupation and goods reaffirm this finding. High GDP nations have weaker disparities by non-manual occupation and goods as well as by education.

[12] When included together (results not presented), logged GDP has the stronger results on both the intercept and education effect.

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Table 1. Descriptive Statistics for Males by Region.[a]

	World Region						
	Southeast Asia	Africa	Western Pacific	Eastern Mediterranean	Americas	Eastern Europe	**Total**
Smoking Status							
Does not Smoke	46.15%	74.81	41.78	60.22	65.94	49.12	60.15
Smokes	53.85	25.19	58.22	39.78	34.06	50.88	39.85
Age							
Mean	40.41	38.13	39.88	38.57	39.16	45.50	39.75
Std Dev	15.50	15.93	14.95	15.64	16.12	17.00	16.09
Marital Status							
Married	76.37%	63.95	74.45	65.73	66.30	66.56	68.43
Not Married	23.63	36.05	24.55	34.27	33.70	33.44	31.57
Residence							
Rural	82.17%	62.68	54.23	46.66	29.83	34.01	51.41
Urban	17.83	37.32	45.77	53.34	70.17	65.99	48.58
Education							
No Formal Schooling	24.45%	34.68	7.11	31.65	4.15	0.35	17.58
Less than Primary School	13.10	17.89	14.89	4.83	10.15	2.44	12.13
Primary School	23.11	21.81	25.83	22.69	18.42	6.95	20.40
Secondary School	19.59	14.42	27.54	13.52	43.68	20.91	25.91
High School	11.63	6.39	14.32	14.19	19.85	38.57	15.44
College Degree	8.12	4.82	10.31	13.12	3.75	30.78	8.54
Occupation							
No job	18.03%	31.59	21.11	25.00	18.83	40.79	24.58
Agricultural	38.71	32.27	33.54	19.40	22.76	3.58	27.25
Manual	25.24	19.46	26.84	31.46	34.03	23.89	26.94
Non-manual	18.03	16.68	18.51	24.14	24.37	31.74	21.23
Zgoods							
Mean	0.16	0.11	0.09	0.06	0.09	0.06	0.10
Std Dev	1.01	1.03	0.98	0.96	1.03	1.01	1.01
GDP							
Mean	1131.34	1775.97	3229.26	4708.06	6299.96	7339.49	3879.98
Std Dev	439.27	1755.14	1758.32	7092.23	1587.38	2675.98	3448.81
Cigarette Consumption							
Mean	267.20	351.14	1437.19	1005.67	709.08	2018.91	813.22
Std Dev	157.61	377.62	188.26	545.22	174.00	619.11	632.87
Number of Nations	5	17	5	4	7	12	50

[a]All information weighted and represents percentage of the population unless otherwise noted.

Table 2. Descriptive Statistics for Females by Region.[a]

	World Region						
	Southeast Asia	Africa	Western Pacific	Eastern Mediterranean	Americas	Eastern Europe	**Total**
Smoking Status							
Does not Smoke	80.29%	94.62	91.42	96.64	85.50	83.85	88.36
Smokes	19.71	5.38	8.58	3.36	14.50	16.15	11.64
Age							
Mean	39.05	37.41	40.10	38.72	39.44	47.90	39.84
Std Dev	15.23	15.72	14.94	15.32	16.27	17.63	16.18
Marital Status							
Married	72.98%	61.34	74.25	69.69	63.40	50.88	64.77
Not Married	27.02	38.66	25.75	30.31	36.60	49.12	35.23
Residence							
Rural	81.25%	64.93	53.10	45.60	28.96	33.00	51.13
Urban	18.75	35.07	46.90	54.40	71.04	67.00	48.87
Education							
No Formal Schooling	43.66%	43.70	14.85	56.05	5.79	1.21	25.66
Less than Primary School	12.75	17.32	14.51	3.31	10.77	3.20	11.88
Primary School	18.15	20.92	24.30	16.55	19.66	8.40	18.85
Secondary School	14.44	11.41	24.37	7.34	42.35	18.59	22.62
High School	6.99	4.14	12.21	9.23	17.55	37.34	13.39
College Degree	4.00	2.50	9.75	7.52	3.88	31.25	7.60
Occupation							
No job	61.38%	62.41	46.64	84.75	70.10	51.73	62.76
Agricultural	22.54	16.34	23.54	2.64	2.01	1.66	11.65
Manual	9.91	9.67	14.14	5.79	11.50	6.76	10.18
Non-manual	6.17	11.59	15.68	6.82	16.39	39.85	15.41
Zgoods							
Mean	0.17	0.09	0.12	0.06	0.10	0.06	0.10
Std Dev	1.02	1.02	0.98	0.97	1.01	1.03	1.01
GDP							
Mean	1121.72	1820.69	3250.54	4570.14	6159.57	7277.60	3894.78
Std Dev	427.60	1734.22	1773.96	6428.64	1660.34	2434.83	3256.31
Cigarette Consumption							
Mean	283.39	342.86	1428.28	1076.88	696.66	2011.67	856.87
Std Dev	159.87	361.88	187.57	565.99	180.81	607.85	674.93
Number of Nations	5	17	5	4	7	12	50

[a]All information weighted and represents percentage of the population unless otherwise noted.

Table 3. Multilevel Logistic Regression Odds Ratios and Z-Values for Male Models of Smoking (N = 99,661)

	All Ages			Ages 18-39		Ages 40+	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intercept	.68**	.67*	.68**	.71**	.73*	.69**	.69**
	-3.90	-4.21	-3.97	-3.01	-2.63	-4.02	-4.06
x Logged GDP		1.32**		1.59**		1.12	
		3.02		4.64		1.23	
x Cig. Decline			1.06*		1.06*		1.07**
			2.66		2.74		3.11
Education	.83**	.83**	.83**	.78**	.79**	.87**	.87**
	-9.29	-10.10	-10.29	-9.64	-9.54	-7.58	-7.72
x Logged GDP		.98		.94**		.99	
		-.77		-2.27		-.59	
x Cig. Decline			.97**		.97**		.97**
			-5.15		-4.67		-4.37
Urban	1.10	1.10	1.10	1.11	1.11	1.08	1.08
	1.84	1.86	1.86	1.88	1.85	1.63	1.66
Age	1.08**	1.08**	1.08**	1.24**	1.24**	1.03	1.03
	7.41	7.26	7.38	5.70	6.05	1.93	1.92
Age 2	.99**	.99**	.99**	.99**	.99**	.99**	.99**
	-7.42	-7.22	-7.37	-5.43	-5.72	-3.25	-3.23
Agric. Job	1.24**	1.24**	1.24**	1.24**	1.22**	1.15*	1.15*
	4.11	4.07	4.11	4.25	4.21	2.08	2.07
Manual Job	1.29**	1.29**	1.29**	1.30**	1.28**	1.17*	1.17*
	6.71	6.62	6.67	5.06	4.95	2.32	2.32
Non-Manual Job	1.06	1.06	1.06	1.13*	1.12	.89**	.89**
	1.38	1.41	1.34	1.97	1.84	-2.65	-2.66
Married	.92*	.92**	.91	.95	.95	.81**	.81**
	-2.79	-2.78	-2.81	-1.57	-1.61	-4.84	-4.85
Goods Scale	1.01	1.01	1.01	1.02	1.02	1.00	1.00
	.47	.48	.48	1.12	1.10	-.14	-.14
Var. Comp. Inter.	.63**	.54**	.63**	.78**	1.04**	.48**	.48**
Var. Comp. Educ	.03**	.03**	.02**	.04**	.04**	.03**	.02**

* p < .05, ** p < .01

Table 4. Multilevel Logistic Regression Odds Ratios and Z-Values for Female Models of Smoking (N = 123,953)

	All Ages			Ages 18-39		Ages 40+	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intercept	.11**	.10**	.11**	.12**	.16**	.11**	.12**
	-22.07	-26.03	-23.50	-16.84	-11.42	-20.92	-23.57
x Logged GDP		1.61**		2.50**		1.20	
		4.58		6.54		1.68	
x Cig. Decline			1.12**		1.18**		1.11**
			4.68		5.27		5.06
Education	.90**	.83**	.89**	.75**	.79**	.84**	.87**
	-4.86	-7.36	-5.07	-8.82	-6.95	-5.94	-4.25
x Logged GDP		1.25**		1.03		1.28**	
		7.21		.88		6.86	
x Cig. Decline			1.03		1.00		1.06*
			1.70		-.16		2.29
Urban	1.14*	1.15*	1.14*	1.28**	1.24**	1.03	1.03
	2.01	2.07	2.04	4.92	4.52	.35	.33
Age	1.06**	1.06**	1.06**	1.11**	1.09**	1.02	1.03
	7.10	6.86	7.09	6.50	6.02	1.48	1.47
Age 2	.99**	.99**	.99*	.99**	.99*	1.00	1.00
	-6.64	-6.73	-6.67	-4.91	-4.45	-1.85	-1.80
Agric. Job	1.31**	1.34**	1.31**	1.41**	1.31**	1.27**	1.27**
	7.18	6.65	7.20	6.49	6.39	4.42	4.38
Manual Job	1.21**	1.22**	1.21**	1.20**	1.17**	1.21**	1.21**
	4.85	5.11	4.91	3.79	3.61	3.34	3.24
Non-Manual Job	1.30**	1.29**	1.30**	1.12**	1.12**	1.34**	1.37**
	6.99	7.08	7.18	3.05	2.96	5.32	5.51
Married	.77**	.77**	.77**	.82**	.84**	.80**	.80**
	-7.76	-7.56	-7.77	-5.76	-6.24	-6.24	-6.70
Goods Scale	1.04	1.04	1.04	1.06	1.05	1.03	1.03
	1.13	1.13	1.14	1.55	1.53	.80	.77
Var. Comp. Inter.	1.33**	1.03**	1.30**	1.73**	2.75**	1.06**	1.04**
Var. Comp. Educ	.21**	.15**	.21**	.13**	.14**	.12**	.19**

* p < .05, ** p < .01

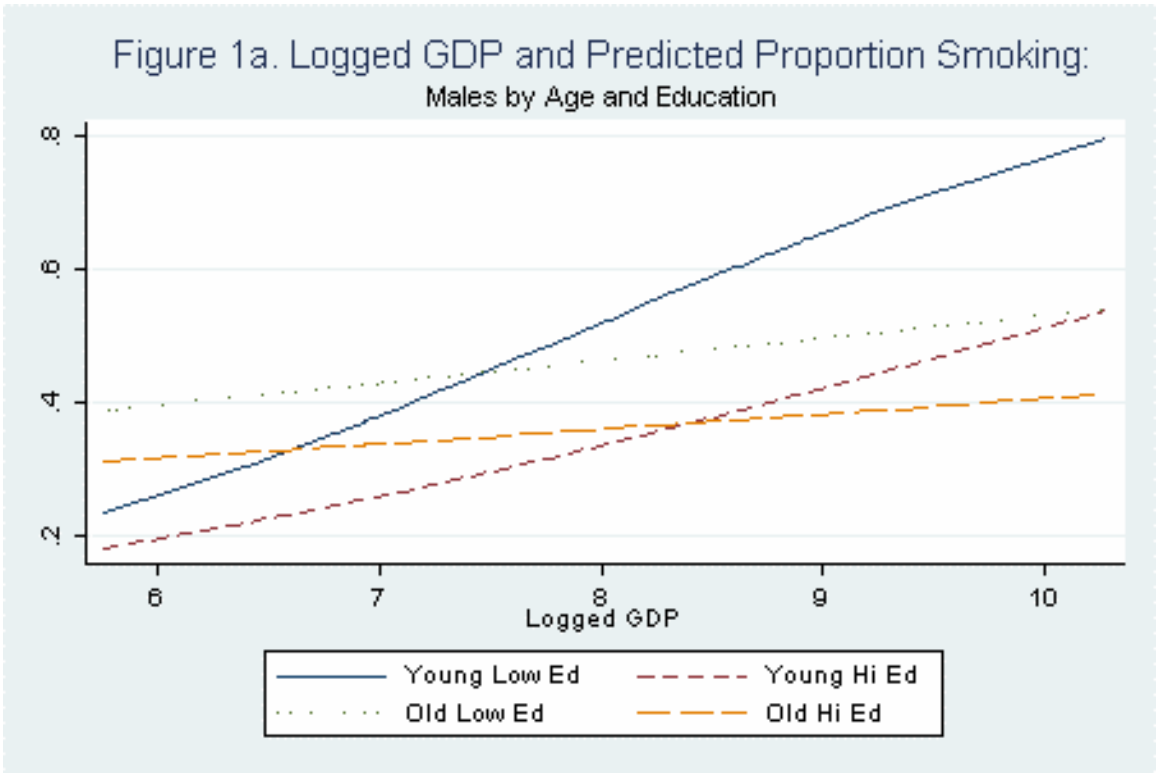
Figure 1a. Logged GDP and Predicted Proportion Smoking:
Males by Age and Education
.2
.4
.6
.8
6
7
8
9
10
Logged GDP
Young Low Ed
Young Hi Ed
Old Low Ed
Old Hi Ed

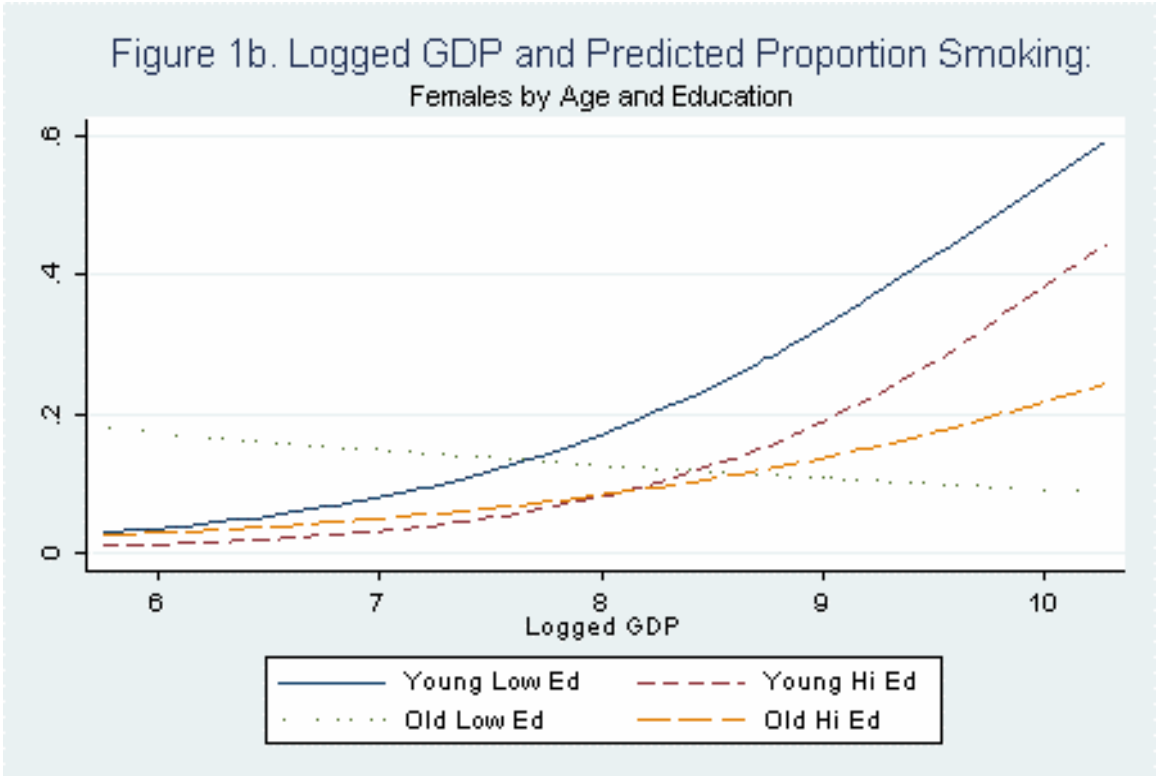
Figure 1b. Logged GDP and Predicted Proportion Smoking:
Females by Age and Education
0
.2
.4
.6
6
7
8
9
10
Logged GDP
Young Low Ed
Young Hi Ed
Old Low Ed
Old Hi Ed

Appendix A. Countries by Region.

World Region					
Southeast Asia	**Africa**	**Western Pacific**	**Eastern Mediterranean**	**Americas**	**Eastern Europe**
Bangladesh	Burkina Faso	China	Morocco	Brazil	Bosnia and Herzegovina
India	Chad	Lao	Pakistan	Dominican Republic	Croatia
Myanmar	Comoros	Malaysia	Tunisia	Ecuador	Czech Republic
Nepal	Congo	Philippines	United Arab Emirates	Guatemala	Estonia
Sri Lanka	Cote d'Ivoire	Vietnam		Mexico	Georgia
	Ethiopia			Paraguay	Hungary
	Ghana			Uruguay	Kazakhstan
	Kenya				Latvia
	Malawi				Russia
	Mali				Slovakia
	Mauritania				Slovenia
	Mauritius				Ukraine
	Namibia				
	Senegal				
	SouthAfrica				
	Swaziland				
	Zimbabwe				