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CROSS-NATIONAL SOURCES 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, raises concerns not only about the indisputable harm to global health but also about worsening health inequality. Arguments relating to economic cost and diffusion posit that rising educational disparities in tobacco use—and associated 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-income to upper-middle-income nations. Multilevel logistic regression models show that increases in national income and cigarette diffusion widen educational disparities in smoking 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.

SMOKING AND INEQUALITIES IN HEALTH AND MORTALITY

A huge literature demonstrates the harm done by tobacco use to health and longevity and describes the decline in use of cigarettes in the United States (see reports of the Surgeon General, Department of Health and Human Services [DHHS] 2000, 2004, for summaries of the literature). Even as much remains to be done to reduce smoking in the United States (Rock et al. 2007) and Western European nations (Huisman, Kunst, and Mackenbach 2005), new public health concerns about smoking have emerged: tobacco use and sales 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, the overwhelming majority of the world's 1.1 billion smokers, about 82%, reside in low- and middle-income countries (Sorensen, Gupta, and Pednekar 2005:1003). About 35% of men in developed countries and 50% in developing countries smoke (Mackay, Eriksen, and Shafey 2006:22). That differential is reversed for women: about 22% of women in developed countries and 9% in developing countries smoke (Mackay et al. 2006:23).

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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 global spread of cigarettes limits the longevity benefits that otherwise would result from development, medicine, and public health efforts (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% of the tobacco-related deaths in 2030 occurring in less developed nations (WHO 2008a:6) As in high-income nations, socioeconomically disadvantaged groups in less developed nations typically have higher smoking rates than more advantaged groups (Bobak et al. 2000; Pampel 2008). Smoking among poor and uneducated groups contributes substantially to the spread of tobacco use from the West to other parts of the world, and to widening disparities in smoking-related health and mortality (Blakely et al. 2005).

The adoption of cigarettes may contribute to a more general concern that economic development increases inequality in health, partly through differential use of new medical technologies (Glied and Lleras-Muney 2008). As Soares (2007:281) states, “Diffusion of 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 Delamonica 2004) and a central goal of the World Bank and WHO (Gwatkin 2000; Sastry 2004). Cigarette use already contributes 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, SES smoking disparities may worsen SES mortality disparities in developing countries over the next decades (Ezzati and Lopez 2003a).

Yet we know very little about the distribution of smoking outside high-income nations. How do SES-based 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 relationship between SES and smoking, or the size of socioeconomic disparities in smoking, likely varies substantially. Examining smoking patterns in low- and middle-income nations offers a special opportunity to help understand one crucial source of inequality in health and mortality.

A more complete understanding of SES-based patterns of smoking in the developing world requires high-quality individual-level data for a large number of nations that vary in economic development and in prevalence of cigarette use. Few if any previous studies meet these requirements. On one hand, the many studies of disparities within single nations (summarized by Bobak et al. 2000) differ enough in design and measurement to make comparisons suspect. On the other hand, comparisons across 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 smoking adoption by socioeconomic groups.

This study overcomes these limitations by examining the influence of both individual and aggregate determinants of smoking using World Health Survey (WHS) data on individuals in 50 low to upper-middle income nations (WHO 2008b). The WHS 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, the Americas, and Eastern Europe. This diverse sample includes regions where tobacco use has most recently spread and little is as yet known about social patterns of use. The WHS also contains comparable measures of education, typically the component of SES with the strongest relationship to smoking (Barbeau, Krieger, and Soobader 2004;

Pampel 2008). Education 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 EDUCATIONAL DISPARITIES IN SMOKING

Arguments about the prevalence of smoking across nations 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). Among low-income nations there is a price effect: cigarettes become more affordable as personal and family incomes rise. Among high-income nations, where greater longevity makes smoking's cost in potential years of life more salient, there is a health-cost effect: smoking declines as personal and family incomes rise (Lawlor et al. 2003). The balance of these two effects matches the inverted U-shaped relationship of national income and smoking.

The curvilinear pattern of smoking prevalence also fits a cigarette diffusion argument. The pattern of change in smoking prevalence resembles the rise and fall of a disease epidemic (Lopez 1995). As cigarettes begin to spread in a population, usage grows steadily to a peak and then declines (though it does not disappear). The mechanisms behind the change involve 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 later came to be rejected first by high SES groups (Ferrence 1989; Huisman et al. 2005). However, these patterns of smoking adoption vary by gender: women lag several decades behind men in both adoption and peak levels of smoking (Pampel 2007). If we assume that low- and middle-income nations—the focus here—are at the earlier stages of cigarette diffusion, their smoking prevalence should rise but likely not show the decline in tobacco use apparent in high-income nations. This truncated range of nations means that national income and cigarette diffusion should have positive or decreasing positive effects on smoking.

Both the economic cost and diffusion arguments can be extended to explain educational disparities in smoking. Because education tends to be strongly correlated with income, the educational gap in smoking should widen with increasing national income in low- and middle-income nations. Here, the price effect increases smoking among low-education groups, while the health-cost effect decreases it among high-education groups. Low education groups cannot easily afford to purchase cigarettes, but higher national income increases that opportunity. High-education groups, through their greater access to high-quality health care, information on the health costs of unhealthy behaviors, better diet, and healthier living conditions, have incentives to avoid tobacco that the less educated do not. Tobacco use tends to rise with national income among all groups, but it rises less among high-education groups than low-education ones, and disparities in smoking consequently increase.[1]

Similar predictions follow from the diffusion argument. For nations at earlier stages, where cigarette 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

[1]The educational disparities in tobacco use may take a curvilinear form, much as overall prevalence does. Low-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 in smoking may begin to decline. However, such changes would likely show only in the most advanced stages of the epidemic in high-income nations, not in developing nations.

educational disparities should be 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 less educated groups. High-education groups, in contrast, do more to distinguish themselves from low-education groups by adopting more healthy behaviors and imitating the nonsmoking of high-education groups in the West. Thus, at later stages of cigarette diffusion, education disparities in smoking increase.

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 later stages of cigarette diffusion, as the growth in smoking is greater for low-education groups than high-education groups. Both hypotheses should apply more strongly to younger than older cohorts and to men than women (Denney et al. 2010).

Concerning age or cohort,[2] educational disparities have been influenced in recent decades by the scientific evidence of the harm of smoking and the worldwide strengthening of antitobacco norms (DHHS 2000; WHO 2008a). Since smoking is addictive and begins during adolescence and young adulthood, smoking among newer cohorts more than older cohorts reflects recent changes in antitobacco norms (Preston and Wang 2006). It follows that educational disparities in tobacco use should rise 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 opposition to smoking by health officials.

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 in tobacco use. More educated women with greater freedom and motivations to innovate may initially adopt smoking more than less educated women. If so, educational disparities in tobacco use 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 widen disparities in tobacco use among women than men.

In summary, the cost and diffusion arguments specify different mechanisms but offer similar predictions. They both posit that education has varied influences on smoking across nations, ages, and genders. In contrast, a null hypothesis is that national income and cigarette diffusion 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. In this scenario, all nations and age groups, and both genders, 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.

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

[2]While the arguments emphasize the importance of cohort differences to smoking (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 effects.

attract tobacco company investment and marketing and lead to government and public health anti-tobacco efforts. Both marketing and government response may affect more educated groups differently than less educated groups. These mediating influences are difficult to measure for previous decades when shifts in educational disparities began to occur. Moreover, marketing, prices, taxes, and tobacco restrictions are influenced by levels of smoking as well as determine smoking. This endogeneity creates estimation problems. While briefly examining some of these mediating influences, the approach here focuses largely on the exogenous forces of economic development, class-based 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 (Üstün et al. 2003). 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, the survey includes low-income to upper-middle-income nations along with the more commonly studied high-income nations. When combined with aggregate or contextual measures, this individual-level, cross-national health data improves greatly on designs that use only multi-nation aggregate data or individual-level data for one country.

The WHS uses a stratified multistage cluster sampling frame to select males and females age 18 and over belonging to households during the survey period. Household members in institutions are interviewed either in the institution or in their household upon return from the institution. The strata and cluster definitions vary across countries, but the WHS sets quality standards to obtain probability samples that, with proper weighting, accurately represent the population. Population weights for most countries further adjust for nonresponse 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-income to upper-middle-income nations with tobacco measures remain for analysis. Combining the individual-level data on the 50 countries and dropping the 5.6% of cases that are missing data on key variables yields a sample of 223,614 respondents—99,661 men and 123,953 women.

The WHS nations have high response rates (Appendix A lists the countries and response rates). In good part from the response rates but also from the WHS design standards, the national samples closely represent the populations. A Sample Population Deviation Index (SDI) compares the sample population by age and sex to the general population (Üstün et al. 2003) for each country. Using WHS reports, we examined the SDIs for selected nations within each region and found very good fit between samples and populations. Substantial deviations from equality showed only for the small groups of persons above age 80. For example, in African nations, older males are slightly overrepresented and older females are slightly underrepresented, and in Eastern Europe both groups are slightly overrepresented (WHO 2008b).

The WHS nations appear externally as well as internally representative. Because of the self-selected participation of countries in the WHS, it is worth comparing our sample to the larger population of low-income to upper-middle-income nations. Results indicate that the mean GDP for the 50 sample countries ($4446) does not differ significantly (t = 1.43) from the mean GDP ($5942) for 75 other low and middle-income countries not included in the sample. Additionally, the same tests within the six regions defined by WHO (see Appendix A) showed significant differences in GDP means only for Eastern Europe and Southeast Asia. In Southeast Asia, the WHS countries have a somewhat lower GDP, owing primarily to the exclusion of Thailand, a country that is richer than its neighbors and atypical of the region. There is no significant difference in GDP between 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.

As a cross-sectional data source, however, the WHS can test only indirectly for changes in the determinants of smoking. High-quality data do not exist that would allow within-nation comparisons for a large and regionally diverse sample of nations. We instead follow the less than ideal but still valuable strategy of comparing the determinants of smoking across nations at different levels of economic development and cigarette diffusion. Support for the predictions can offer preliminary and promising, though not conclusive, evidence for the hypotheses.

Measures

Smoking status is coded dichotomously, with nonsmokers as the referent and occasional and regular smokers as the alternative. The WHS asks about use of manufactured cigarettes, hand-rolled cigarettes, pipes, and other tobacco products. The results presented here for all tobacco use prove similar to those for use of manufactured cigarettes (the key component of worldwide tobacco increase), use of manufactured plus hand-rolled cigarettes (a common form of tobacco use in poorer nations), and regular tobacco use (excluding occasional use). However, the questions about smoking consider only current behavior, not former smoking, age of adoption, or age of cessation. Also, despite U.S. studies finding that self-reports of smoking are generally accurate (Patrick et al. 1994), the validity of such reports in lower-income nations is less clear, and reporting may differ by social position. Still, in the absence of physiological measures, survey responses remain the commonly accepted source of nearly all data on global patterns of tobacco use.

Among the control variables, a dummy variable for sex codes males as one. Age in decades ranges from 1.8 to 8.5 and older. Marital status indicates whether the individual is married or cohabiting; 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.[3]

Education equals years of schooling completed (from zero to a maximum of 20). An additional measure classifies education by highest level of complete schooling: (1) no formal schooling, (2) less than primary school, (3) primary school, (4) secondary school or high school, and (5) some college or higher. Both measures give nearly identical results, but we present the years of schooling measure, which has more easily interpretable units and

[3]All respondents from Slovenia lack data on this variable. Values are imputed for Slovenians using the relationships of age, gender, marital status, education, occupation, and household goods for other Eastern European nations and the values of Slovenian respondents on these individual variables.

avoids some problems of comparability in meanings of primary and secondary school across nations.[4]

Occupation consists of a series of dummy variables for no job, agricultural job, manual job, and nonmanual job. There are special challenges in collecting information on occupation in countries where subsistence living reigns: in some poor WHS countries as many as 70% of individuals 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.[5] An alternative to using dummy variables for a small number of job categories assigns scores to the original 10 WHS occupational categories according to the socioeconomic index of Ganzeboom, De Graaf, and Treiman (1992). It then uses the continuous occupational index measure with a dummy variable for no occupation. Since the WHS categories do not always match those of the socioeconomic index, the continuous measure includes some error and has slightly less explanatory power than the categories. Still, both produce much the same results.

Rather than measure income, the WHS asks 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 but in all cases include at least 11 items. Following Filmer and Pritchett (2001), we create a standardized scale based on the weights from the first dimension of a principal components factor analysis done within each country. The factor weights avoid summations that would attribute equal importance to each item (e.g., a bucket and a refrigerator) and instead reflect the contribution of each item to a linear index of household goods ownership. However, the divergent meanings of the goods across countries make comparisons of absolute levels potentially 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.[6]

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.[7] To reduce skewness and transform the measure into more meaningful percentage change units, the models use the natural log of GDP.

The second measure, per capita cigarette consumption (in thousands) for the year 2000, reflects the extent of cigarette diffusion. Among these low and middle-income nations, high

[4]Among the cases that have a score for the categorical measure of education, 11% lack an exact number of years of schooling. We use the categorical measure to impute the missing data, and checks show that the imputed values for years of schooling do little to change the results.

[5]Another potential problem, missing data on occupation and employment status, appears minor. About 3.5% of respondents report no occupation or employment status. However, a dummy variable for missing job or work fails to significantly influence findings concerning smoking. With the small numbers and minimal influence, we delete these cases from the analysis.

[6]About 10% of respondents fail to answer all the consumer goods items. Since a dummy variable for cases with missing values has no significant influence on findings concerning smoking, the missing cases are coded to the country-specific mean of zero and included in the analysis.

[7]Since older smokers became addicted to cigarettes decades ago, national 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 a nation.

consumption indicates a later stage of diffusion, while low consumption indicates an earlier stage. The measure assumes that it takes decades for tobacco use to spread through a population and that high cigarette consumption reflects an early start.[8] Obviously, high cigarette consumption relates to high smoking prevalence; it is more meaningful to ask whether high consumption strengthens the effect of education on smoking.

The figures on per capita cigarette consumption come primarily from the Tobacco Control Country Profiles web page (Shafey et al. 2003) and secondarily from the *Tobacco Atlas* (Mackay et al. 2006). These two sources together provide data on 39 of the 50 nations. Figures from *Tobacco or Health* (World Health Organization 1997) on consumption in 1990 for four more nations are projected to 2000 using the percentage rate of change for other nations in the same region. Values for the remaining seven countries are imputed using past values, region means, and 2000 GDP.[9] The values of the variable range from .072 thousand (or 72) cigarettes per adult in Ethiopia to 2.919 thousand (or 2919) in Russia.

Estimation

Multilevel models treat level-1 individuals as nested within level-2 nations and allow level-1 effects to vary across nations. The 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}):

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

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:

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

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

$$\beta_{kj} = \gamma_{k0}. \tag{2c}$$

The γ_{0m} and γ_{1m} coefficients represent the effects of the aggregate variables on the nation-specific level of smoking and the effect of education on smoking. 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

[8] An alternative measure examines the *change* in consumption; increases indicate an early stage of diffusion and declines indicate a late stage. However, incomplete figures on cigarette consumption before 2000 make this measure less reliable than the 2000 measure.

[9] These nations are United Arab Emirates, Comoros, Mali, Mauritania, Namibia, Swaziland, and Chad. A multiple imputation procedure that imputes five sets of cigarette consumption values for these nations, estimates five models, and computes average coefficients and weighted standard errors (Allison 2002) gives much the same results.

distributed, each with a mean of zero and nonzero variances and covariances. The full maximum likelihood parameter estimates come from HLM 6.08 (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% of men smoke, while fewer than 12% of women smoke. These patterns vary across regions. For example, over 58% of men in the Western Pacific smoke, compared to just over 25% of men in Africa. Less pronounced differences exist for women as well; nearly 20% of women in Southeast Asian nations smoke, but fewer than 4% of women in Eastern Mediterranean nations do so.

SES indicators for males and females also differ across the regions. In the total sample, males average 7.3 years of completed schooling, but this mean falls to 5.7 in Africa and reaches 12.2 in Eastern Europe. The percent nonmanual workers is lowest in Africa, highest in Eastern Europe, and equal to 21.3 overall. Females average less education than males across all regions.

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 the Americas have the lowest cigarette consumption, and Eastern Europe and the Eastern Mediterranean have the highest. The aggregate measures, logged GDP and cigarette consumption, are correlated at . 80—higher income nations are more advanced in cigarette diffusion—and are used separately rather than in combination to test the hypotheses.

Multilevel Models for Males

The multilevel models in Table 3 show first that individual determinants of male smoking, when averaged across all nations, have the influences we expected. The first equation presents odds ratios for a model including only individual-level variables. Education has a strong negative influence—the odds of smoking drop by 5% for a one-year increase in education and by 40% for a ten-year increase in education. Nonmanual workers and nonworkers are less likely to smoke than agricultural and manual workers. The measure of goods owned (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 age 43 and then begins to decline. Urban residence has an insignificant association with smoking, and marriage has a modest negative association.

The model in equation 1 allows the intercept and the education coefficient to vary across nations. The variance components for both prove significant.[10] Adding logged GDP (equation 2) and the cigarette diffusion measure (equation 3) to the model partially supports hypotheses 1a and 1b concerning levels of smoking and education disparities in smoking. Logged GDP increases the intercept or level of smoking (OR = 1.34) but does not significantly affect the education coefficient or educational disparities (OR = 0.99). The cigarette diffusion measure shows more consistent influence: it increases the prevalence of male smoking (OR = 1.68) and strengthens the negative effect of education (OR = 0.98). Both higher national income and cigarette diffusion are associated with greater smoking

[10]Larsen and Merlo (2005) offer a formula to translate the variance between level-2 units into odds ratios. For the WHS data, the median odds ratio of 2.06 shows that, on average, two persons with the same characteristics but in different nations have widely varying smoking outcomes.

prevalence, supporting hypothesis 1a. A later stage of cigarette diffusion is also associated with greater educational disparities, supporting hypothesis 1b.[11] At least among males, the spread of cigarettes through a population widens the smoking gap between the least and most educated.

As we predicted, the effects of education and the aggregate variables generally prove stronger for younger men than for older ones. Equations 4 and 5 replicate the random-effects models for men ages 18 to 39, and equations 6 and 7 do the same for men ages 40 and over. First consider differences by age in the effect of education. The education odds ratio for young men is significantly lower than that for older men (0.92 versus 0.96, $t = -4.36$, $p < .001$), indicating greater educational disparities in smoking among more recent cohorts or age groups. Greater educational attainment generally reduces the likelihood of smoking, but it does so more for younger men than older men.

Next consider age differences in the interaction terms. Both logged GDP and cigarette diffusion significantly strengthen the negative effect of education (i.e., they widen the gap in smoking between the least and most educated) 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 65%, but also multiplies the average education odds ratio of 0.92 by 0.98. Thus, as nations develop economically, the educational gap in smoking widens among younger men. In contrast, in model 6 (for older men) logged GDP has little influence on either the prevalence of smoking or the effect of education on smoking. The odds ratios for logged GDP and for the logged-GDP-and-education interaction term in model 6 differ little from one. Despite the contrasting individual odds ratios, there is a qualification: a more precise comparison reveals that the logged-GDP-by-education interaction does not differ significantly between the young and the old (0.98 versus 1.00, $t = -1.62$, $p < .107$).

The cigarette-diffusion-by-education interaction likewise shows stronger age differences among men. The interaction with education is significant among younger men in model 5 but insignificant among older men in model 7. Further, the interactions differ significantly across age (0.95 versus 0.99, $t = -2.96$, $p < .006$). That is, a later stage of cigarette diffusion widens the education gap in smoking among younger men but does little to affect smoking among older men, who likely adopted the habit many decades ago.

These relationships are revealed graphically in Figure 1a, which presents the predicted probabilities of smoking by logged GDP for a low-education group (no schooling) and a high-education group (12 years of schooling) and for young and old ages. For young low educated men, smoking rises faster with logged GDP than for young highly educated men. As a result, moving from left to right, the gap in the probability of smoking for low educated versus high educated young men becomes larger as GDP increases: .06 at the lowest logged GDP and .28 at the highest. For older men, the gap changes little, from .09 at the lowest GDP to .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 the effects of education on smoking.

Could mortality selection account for differences across ages in the effects of education? If less educated persons smoke more but also die younger, it would leave fewer smokers among the less educated survivors and mask educational differences in smoking among older age groups. To check on this possibility, we examined results for ages 18-30 and ages

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

31-45—those young enough to largely avoid differential mortality from smoking. Comparisons across these two groups show weaker education effects on smoking among those aged 31 to 45. These age differences in effects are not as large as between the young and old age groups in Table 3. Even so, education effects on smoking do vary across age groups that are not greatly affected by smoking mortality.

A few other checks on the results confirm the findings. Including dummy variable controls for region of the world shows that aggregate variables are influential within, as well as between, these regions. For younger men, logged GDP and cigarette diffusion still have significant effects on smoking and nearly significant effects ($p < .10$) on the relationship between education and smoking. (Because of the small number of nations and level-2 degrees of freedom, however, we avoid routine use of the region variables in all the models.) Measures of the prices of a pack of Marlboro and local cigarettes (Mackay, Eriksen, and Shafey 2006) and a scale measuring requirements of warnings on packages and restrictions on advertising, sales, and allowable places to smoke (Goel and Nelson 2004, 2008) fail to significantly influence either the intercept or the education slope. Further, graphs of the level-2 empirical Bayes residuals for the key education interactions with logged GDP and cigarette diffusion among young men show a normal distribution without evidence of major outliers, influential cases, heteroscedasticity, or nonlinearity.

Multilevel Models for Females

Table 4 replicates the multilevel models for females but with contrasting results: as we predicted, high education does less to discourage smoking among women than among 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 nonmanual work. The education odds ratio for men of .95 falls significantly below the odds ratio for women of 0.97 ($t = -2.54$, $p < .018$). To illustrate, the odds of smoking for a male with 16 years of education are 40% lower than the odds of smoking for a male with six years of education, while for females in the same scenario the odds of smoking for the more educated female are only 26% lower. In addition, the insignificant odds ratio of 1.06 for male nonmanual workers (relative to nonworkers) becomes a significant odds ratio of 1.25 for female nonmanual workers (the two coefficients differ significantly, $t = -3.11$, $p < .004$). Among females but not males, nonmanual workers smoke more than nonworkers.

Taking into account logged GDP also identifies some differences between men and women. In model 2 of Table 4, an increase in logged GDP increases smoking among women (OR = 1.55) as it does among men (OR = 1.34), but it also weakens the negative effect of education—just the opposite of the influence found for men. For women, a unit increase in logged GDP multiplies the odds ratio for education of 0.95 by 1.06. This indicates that, for women, education effects on smoking in high-income nations are weaker than in low-income nations.[12] The cigarette diffusion measure in model 3 likewise shows a positive and significant interaction. A later stage of cigarette diffusion with higher consumption of cigarettes is associated with a weaker education gradient for female smoking. The effect contrasts with the significant and negative effect—or the stronger education gradient—at later stages of cigarette diffusion among men. In other words, as nations grow economically and as cigarettes become more prevalent in the population, the gap in smoking between the least and most educated women does not widen.

[12]Additional tests for the interaction of logged GDP with occupation and goods among females reaffirm this finding. High GDP nations have weaker disparities by nonmanual occupation and goods as well as by education.

An alternative explanation suggests that gender equality relates better to cross-national differences in female smoking than do measures that gloss over gender differences. In fact, measures of gender equality correlate highly with logged GDP. Accordingly, we examined the effects on smoking among females of two measures of gender equality, the total fertility rate and the ratio of females in school to males in school. When included with logged GDP, neither gender equality measure has a strong influence on tobacco use or on the education gap in smoking.

Controls for region of the world, however, 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. Returning to Table 4, models 4 and 5 list the coefficients for women ages 18-39 and models 6 and 7 list the coefficients for women ages 40 and older. The key result is that neither logged GDP nor cigarette diffusion significantly affects the education slope for smoking among 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 on tobacco use—an effect that is already weaker among older than among younger women (0.93 versus 0.96, $t = -2.86$, $p < .008$).

Figure 1b depicts the results of the logged-GDP-by-education interaction for women. For younger women, smoking rises similarly for those with no schooling and those with 12 years of schooling. 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. In nations such as Czechoslovakia, Slovenia, and Hungary, educated women smoke more than less educated women.

As we predicted, educational disparities in tobacco use are weaker for women than for men and rise less with national income and cigarette diffusion for women than for men. Moreover, these disparities are smaller for older than for younger women (or even reversed).

CONCLUSIONS

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, rising national income 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 how greater national income changes the balance between the effects of cigarette prices and health costs (Cutler and Glaeser 2006), and a diffusion argument highlights how innovative behavior changes among highly educated groups during the spread of tobacco (Ferrence 1989; Pampel 2005). Tests of the theories using data on smoking levels and smoking differences by education across 50 low-income to upper-middle-income nations support both arguments.

To review the findings, national income and cigarette diffusion are generally and plausibly associated with increased smoking for persons living in this sample of nations. On average, growth of national income allows more persons to purchase cigarettes, and a later stage of diffusion obviously 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 particularly cigarette diffusion tend to strengthen the negative effects and widen educational disparities in tobacco use. Higher

national income may increase access to cigarettes among low education groups, but associated health problems may present greater costs for the more educated groups that enjoy growing longevity. Hence, smoking among the less educated rises most with national income and thereby increases educational disparities in tobacco use. 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.

In addition, the results differ by gender and age. Younger males most clearly show that education decreases smoking, and does so increasingly as national income rises and cigarettes become more common. Older females diverge most from this pattern. They show relatively weak educational disparities in tobacco use, disparities that become even weaker as national income rises and cigarettes become more common. As the hypotheses predicted, educational disparities in tobacco use 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. The results for younger persons suggest that global tobacco growth will occur most among the least educated, or the most disadvantaged. This pattern already holds for young men, and given the lag in diffusion, 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 will exacerbate inequalities in mortality between the first and third worlds and between advantaged and disadvantaged groups within nations. High-income nations have succeeded in reducing cigarette smoking and related causes of mortality, in part because of smoking's high health costs among groups with low mortality from other causes and the advocacy of antismoking norms. But in the developing world, with a substantial majority of the world's population, higher income and diffusion of cigarettes contribute (at least among males) to higher smoking and greater educational inequalities in smoking, which may counter other mortality benefits from continued economic growth.

Because of the strengths of the World Health Survey, these theoretical and applied conclusions rest on a stronger methodological foundation than do those of previous studies. Despite the public health disaster of the global spread of cigarettes, no study has yet examined educational (or other SES) disparities in tobacco use 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 the ability to examine changes within nations and compare different cohorts at the same ages. The relationships reported here represent associations more 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. Also, antismoking policies may help counter rising smoking, but we have been unable to effectively measure their influence across these 50 nations. Studies using different designs, perhaps with fewer nations over a longer time span, can do better to test for policy effects. Even so, the 50 nations and hundreds of thousands of individual survey responses available from the WHS go well beyond the aggregate comparisons of smoking prevalence that typify existing studies of global patterns. In addition, the persistence of cigarette use over the life course makes cross-sectional comparisons of young and old people informative. In all, then, the

World Health Survey offers a valuable resource for studying contextual influences on health-related behaviors such as tobacco use.

Appendix

Appendix A

Countries and Response Rates by Region

World Region											
Southeast Asia	Response Rate	Africa	Response Rate	Western Pacific	Response Rate	Eastern Mediter-ranean	Response Rate	Americas	Response Rate	Eastern Europe	Response Rat
Bangla-desh	85.4	Burkina Faso	95.6	China	99.8	Morocco	79.4	Brazil	100.0	Bosnia and Herzegovina	93.
India	93.0	Chad	91.9	Lao	97.8	Pakistan	93.4	Dominican Republic	73.8	Croatia	99.
Myanmar	97.3	Comoros	94.6	Malaysia	80.2	Tunisia	95.6	Ecuador	77.4	Czech Republic	48.
Nepal	98.3	Congo	79.1	Philippines	99.9	United Arab Emirates	99.7	Guatemala	97.6	Estonia	99.
	98.7	Cote d'Ivoire	96.5	Viet Nam	83.7			Mexico	96.9	Georgia	92.
		Ethiopia	96.2					Paraguay	97.1	Hungary	100
		Ghana	69.6					Uruguay	99.7	Kazakhstan	99.
		Kenya	82.3							Latvia	92.
		Malawi	92.7							Russia	99.
		Mali	78.7							Slovakia	99.
		Mauritania	97.8							Slovenia	44.
		Mauritius	88.4							Ukraine	99.
		Namibia	91.3								
		Senegal	88.4								
		South Africa	89.2								
		Swaziland	99.9								
		Zimbabwe	94.4								

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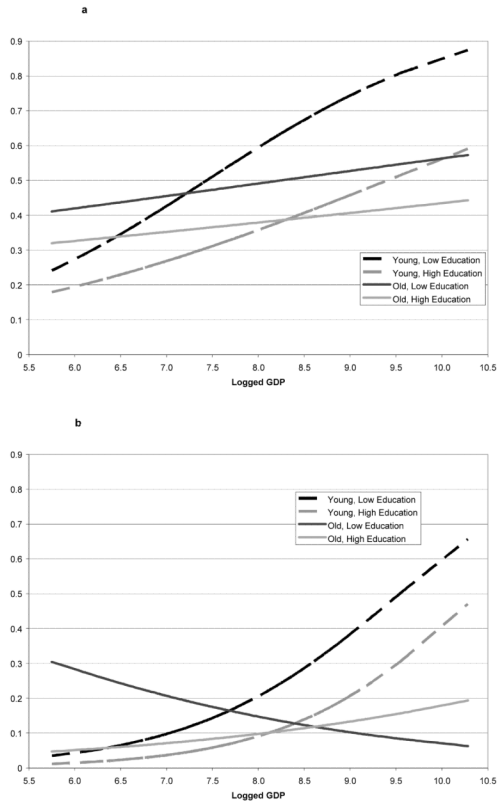

Figure 1.

a. Logged GDP and Predicted Proportion Smoking: Males by Age and Education

b. Logged GDP and Predicted Proportion Smoking: Females by Age and Education

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Table 1

Descriptive Statistics for Males by Region

Variables	Southeast Asia	Sub-Sah. Africa	Western Pacific	Eastern Mediter.	Americas	Eastern Europe	Total
Smoking Status							
Does Not Smoke	46.5	74.9	41.6	60.2	66.0	49.3	60.3
Smokes	53.5	25.1	58.4	39.8	34.1	50.7	39.7
Age (Decades)							
Mean	4.0	3.8	4.0	3.9	3.9	4.5	4.0
Std Dev	1.6	1.6	1.5	1.6	1.6	1.7	1.6
Marital Status							
Married	76.3	64.2	75.4	65.7	66.3	65.5	68.4
Not Married	23.7	35.9	24.6	34.3	33.7	34.5	31.7
Residence							
Rural	77.2	63.4	53.2	46.6	29.8	34.0	50.6
Urban	22.8	36.6	46.8	53.4	70.2	66.0	49.4
Years Education							
Mean	6.2	5.7	8.0	6.9	7.7	12.2	7.3
Std Dev	4.9	5.2	4.2	5.8	5.0	3.3	5.2
Occupation							
No Job	18.0	31.6	21.1	25.0	18.8	40.8	24.6
Agricultural	38.4	32.2	33.5	19.4	22.7	3.6	27.2
Manual	25.2	19.6	26.5	31.5	34.0	23.8	26.9
Nonmanual	18.3	16.8	18.6	24.1	24.4	31.7	21.3
Goods Owned							
Mean	0.12	0.04	0.06	0.02	0.08	0.05	0.07
Std Dev	1.03	0.91	1.00	0.96	1.03	0.98	0.99
GDP ($)							
Mean	1174	1964	2752	9533	5042	7987	4446
Std Dev	514	1861	2009	13193	1807	3370	4883
Cigarette Consumption (#)							
Mean	268	414	1218	1430	765	1922	972

Variables	Southeast Asia	Sub-Sah. Africa	Western Pacific	Eastern Mediter.	Americas	Eastern Europe	Total
Std Dev	167	329	505	962	315	632	791
N Nations	5	17	5	4	7	12	50
N Individuals	16107	26299	13031	8408	27604	8212	99661

Table 2

Descriptive Statistics for Females by Region

Variables	Southeast Asia	Sub-Sah. Africa	Western Pacific	Eastern Mediter.	Americas	Eastern Europe	Total
Smoking Status							
Does Not Smoke	80.4	94.6	91.3	96.6	85.5	83.6	88.3
Smokes	19.6	5.4	8.7	3.4	14.5	16.5	11.7
Age (Decades)							
Mean	3.9	3.9	4.0	3.9	3.9	4.8	4.0
Std Dev	1.5	1.6	1.5	1.5	1.6	1.8	1.6
Marital Status							
Married	73.2	61.5	74.4	69.7	63.4	51.2	64.9
Not Married	26.8	38.5	25.6	30.3	36.6	48.8	35.1
Residence							
Rural	76.9	65.6	51.7	45.6	28.9	32.9	50.4
Urban	23.1	34.5	48.4	54.4	71.1	67.1	49.6
Years Education							
Mean	4.3	4.6	7.2	4.2	7.3	11.9	6.5
Std Dev	4.7	4.8	4.5	5.5	5.0	3.6	5.3
Occupation							
No Job	61.4	62.4	46.6	84.8	70.1	51.7	62.8
Agricultural	22.6	16.1	23.4	2.6	2.0	1.5	11.5
Manual	10.0	9.8	13.6	5.8	11.5	6.7	10.1
Nonmanual	6.0	11.5	15.5	6.8	16.4	40.4	15.4
Goods Owned							
Mean	0.12	0.02	0.09	0.03	0.10	0.03	0.07
Std Dev	1.04	0.89	1.00	0.97	1.01	1.00	0.98
GDP ($)							
Mean	1174	1964	2752	9533	5042	7987	4446
Std Dev	514	1861	2009	13193	1807	3370	4883
Cigarette Consumption (#)							
Mean	268	414	1218	1430	765	1922	972

Demography. Author manuscript; available in PMC 2012 May 1.

Variables	Southeast Asia	Sub-Sah. Africa	Western Pacific	Eastern Mediter.	Americas	Eastern Europe	Total
Std Dev	167	329	505	962	315	632	791
N Nations	5	17	5	4	7	12	50
N Individuals	19278	31247	15193	8600	35919	13716	123953

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Table 3

Multilevel Logistic Regression Odds Ratios and t Statistics for Male Models of Smoking (N = 99,661)

Predictors	All Ages			Ages 18-39		Ages 40+	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intercept	.70**	.69**	.69**	.73**	74**	.70**	.70**
	−3.56	−3.97	−4.43	−2.80	−3.20	−3.89	−4.12
x Logged GDP		1.34**		1.65**		1.13	
		3.16		4.76		1.33	
x Cig. Consump.			1.68**		2.34**		1.37*
			4.64		6.86		2.72
Education	.95**	.95**	.95**	.92**	.92**	.96**	.96**
	−8.51	−9.05	−9.56	−8.84	−9.66	−6.88	−7.14
x Logged GDP		.99		.98*		1.00	
		−.74		−2.15		−.39	
x Cig. Consump.			.98*		.95**		.99
			−2.32		−4.21		−1.49
Urban	1.08	1.08	1.08	1.09	1.09	1.06	1.06
	1.58	1.59	1.57	1.47	1.47	1.16	1.14
Age	2.06**	2.06**	2.11**	9.59**	11.11**	1.35*	1.37*
	7.09	6.61	7.00	5.77	6.38	2.20	2.24
Age 2	.92**	.92**	.92**	71**	.69**	.96**	.96**
	−6.96	−6.46	−6.83	−5.65	−6.19	−3.46	−3.50
Agric. Job	1.22**	1.22**	1.23**	1.22**	1.22**	1.14*	1.14*
	3.87	3.78	3.85	3.72	3.70	1.98	2.01
Manual Job	1.28**	1.28**	1.29**	1.29**	1.30**	1.14*	1.14*
	7.01	6.88	6.94	4.55	4.59	2.28	2.30
Nonmanual Job	1.06	1.06	1.06	1.13	1.13	.88**	.88**
	1.23	1.26	1.27	1.85	1.89	−2.76	−2.70
Married	.93*	.93*	.93*	.97	.96	.82**	.82**

Predictors		All Ages		Ages 18-39		Ages 40+	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	−2.20	−2.16	−2.21	−1.04	−1.19	−4.60	−4.62
Goods Scale	1.01	1.01	1.01	1.02	1.03	1.01	1.01
	.69	.69	.69	1.26	1.26	.35	.35
Variance Components							
Intercept	.58**	.47**	.37**	.70**	.49**	.45**	.40**
Education	.002**	.002**	.002**	.005**	.004**	.002**	.002**

*p < .05

**p < .01

Table 4

Multilevel Logistic Regression Odds Ratios and t Statistics for Female Models of Smoking (N = 123,953)

Predictors	All Ages			Ages 18-39		Ages 40+	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intercept	12**	.10**	11**	.13**	.13**	12**	.13**
x Logged GDP	−21.94	−26.13 1.55**	−25.36	−17.29 2.54**	−17.80	−20.64 1.10	−21.66
		4.35		7.10		.95	
x Cig. Decline			1.54**		3.16**		1.02
			3.56		6.98		0.17
Education	.97**	.95**	.96**	.92**	.93**	.96**	.96**
	−4.42	−6.58	−6.05	−8.91	−8.30	−5.00	−4.87
x Logged GDP		1.06**		1.01		1.07**	
		6.84		.75		5.88	
x Cig. Consump.			1.06**		.98		1.08**
			6.60		−1.55		7.56
Urban	1.11	1.12	1.11	1.23**	1.25**	1.00	1.00
	1.84	1.83	1.80	4.59	4.05	.02	.03
Age	1.80**	1.83**	1.82**	2.76**	2.87**	1.32	1.32
	7.73	7.44	7.24	6.05	5.71	1.79	1.80
Age 2	.95**	.95**	.95**	.88**	.87**	.97*	.97*
	−7.16	−7.26	−7.13	−4.19	−3.97	−2.12	−2.12
Agric. Job	1.33**	1.35**	1.34**	1.47**	1.45**	1.29**	1.29**
	7.62	7.06	7.21	7.30	7.23	4.89	4.92
Manual Job	1.21**	1.22**	1.22**	1.22**	1.23**	1.22**	1.22**
	4.52	4.64	4.44	4.10	3.66	3.16	3.11
Non-Manual Job	1.25**	1.24**	1.25**	1.12**	1.13**	1.28**	1.29**
	7.10	6.96	6.70	3.13	2.84	4.97	4.93
Married	.77**	.77**	.77**	.81**	.80**	.79**	.79**
	−7.18	−6.87	−6.91	−4.75	−5.10	−6.75	−6.64

Predictors	All Ages			Ages 18-39		Ages 40+	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Goods Scale	1.03	1.03	1.03	1.05	1.05	1.01	1.01
	.97	.93	.92	1.47	1.35	.31	.28
Variance Components							
Intercept	1.19**	.91**	1.01**	1.55**	1.61**	.98**	.99**
Education	.016**	.012**	.013**	.010**	.010**	.010**	.011**

* $p < .05$

** $p < .01$