Despite the growing burden of chronic disease globally, few studies have examined the socioeconomic patterning of risk across countries. The authors examined differences in the social patterning of body mass index (BMI) and current smoking by urbanicity among 70 countries from the 2002–2003 World Health Surveys. Age-adjusted, gender-stratified ordinary least squares and logistic regression analyses were conducted in each country to assess the relation between education and BMI or smoking. Meta-analytic techniques were used to assess heterogeneity between countries in the education-risk factor relations. Meta-regression was used to determine whether the heterogeneity could be explained by country-level urbanicity. In the least urban countries, persons with higher education had a higher BMI, while the opposite pattern was seen in the most urban countries, with this pattern being especially pronounced among women. In contrast, smoking was consistently concentrated among persons of lower education among all men and among women in the least urban countries. For women in the most urban countries, higher education was associated with higher odds of smoking, although there was substantial variability in this relation. These results highlight a global trend toward an increasing burden of chronic disease risk among persons of lower socioeconomic position as countries become more urban.

body mass index; smoking; socioeconomic factors; urbanization

Globally, chronic diseases are the primary cause of mortality, and the burden is projected to increase, especially in developing countries (1). Classic epidemiologic transition theory states that as countries achieve a certain level of development, the incidence of infectious diseases declines and chronic diseases emerge as major causes of morbidity and mortality (2). However, multiple forces are influencing this transition. The global population is quickly aging, and at a faster pace in poor countries (3). A nutrition transition toward increased consumption of processed foods and higher intake of salt, sugar, and fat (4) and a physical activity transition toward more sedentary work and leisure activities (5) are affecting even the poorest countries. Because of these changes, the increasing chronic disease burden in low- and middle-income countries is outpacing past transitions in high-income countries (3).

Despite the growing chronic disease burden in developing countries, relatively little is known about the social patterning of chronic disease in these countries. In many high-income countries, chronic disease was once associated with affluence, but it transitioned over time from a higher burden among persons of higher socioeconomic position (SEP) to a higher burden among persons of lower SEP (6, 7). It has been hypothesized that this social transition occurs because persons of high SEP, who are early adopters of new products like cigarettes or highly processed foods, recognize more rapidly that their lifestyles are not healthy and have the resources to change their behaviors and potentially their environments (8, 9). It is not clear whether a similar social transition is occurring in developing countries today.

A number of factors could affect the social patterning of chronic disease risk in developing countries over time. The globalization of food and tobacco processing and marketing has made these products more available, even in poor countries (10, 11). Likewise, as the world quickly urbanizes, with
most of the growth occurring in low- and middle-income
countries (12), people around the globe gain increased access
to processed foods and tobacco products (13, 14). The nutrition
and physical activity transitions, for instance, initially occur
in more urban areas and are filtered down to rural areas (13).

Despite a recent global focus on the social determinants of
health (15), few studies have examined socioeconomic
gradients in chronic disease risk within poor countries or
between countries at different levels of development. Using
meta-analytic techniques, we investigated heterogeneity in the
socioeconomic patterning of 2 major risk factors in the global
chronic disease epidemic—high body mass index (BMI) and
current smoking behavior—for 70 countries. We also exam-
in whether country-specific cross-sectional associations of
SEP with BMI and smoking were modified by country-level
urbanicity.

MATERIALS AND METHODS

Data source

This study used data from the World Health Organization
World Health Surveys (WHS), which were conducted in
70 countries from 2002 to 2003. The purpose of the WHS was
to provide reliable, comparable information across coun-
tries to policy-makers and to monitor health systems (16).
Countries participating in the WHS were required to use
a probability sample, with either a single-stage random sample
design or a multiple-stage cluster sample design; the sampling
frame was intended to cover 100% of all adults aged 18 years
or older in each country (17). These analyses were based
on the 70 countries with information on relevant ques-
tions. Sample sizes ranged from 585 to 38,610, for a total of
273,585 participants.

The WHS employed several versions of the questionnaire,
depending on the relative wealth of the countries, so not all
of the data were available for all countries. The questionnaires
were standardized and included household questionnaires for
both low-income and high-income countries, as well as in-
dividual questionnaires. Surveys were conducted via face-
to-face interviews in all countries except Australia, Israel,
Luxembourg, and Norway, where interviews were conducted
by telephone.

We investigated 2 markers of chronic disease risk. BMI
(weight (kg)/height (m)²) was calculated from self-reported
height and weight. BMI was used rather than obesity
(BMI ≥30) because of the low prevalence of obesity in many
of the poorer, less urban countries. However, in sensitivity ana-
lyses using obesity, results from the meta-analysis and
meta-regression were qualitatively similar to those for BMI.
Participants were classified as current smokers if they an-
swered “yes” to the question, “Do you currently smoke any
tobacco products such as cigarettes, cigars, or pipes?” While
information on BMI was available for all 70 countries, informa-
tion on smoking status was available for only 53 countries.
The 17 countries that did not have information on smoking
status were all high-income countries with urbanicity levels
ranging from 56% to 90%. BMI, although available for all
70 countries, had a high degree (>25%) of missingness in
18 countries. These countries were mostly low- and lower
middle-income countries, with urbanicity ranging from 15%
to 75%. Participants who did not have information on BMI
were dropped from the BMI analyses; therefore, we conducted
a complete-case analysis, and multiple imputation was not
conducted. Since there were no additional variables outside
the model that would be used to impute BMI, the same
missing-at-random assumption held in both the multiple-
imputation case and the complete-case analysis case. Sen-
sitivity analyses were conducted by excluding countries with
statistically different mean SEP levels for missingness.

Education was defined as the total number of years of
formal education completed. When data were available for
level of education completed (i.e., no formal schooling, less
than primary school, completion of primary school, completion
of secondary school, completion of high school (or the equi-
valent), completion of college/preuniversity/university, or
attainment of a postgraduate degree) but not the number of
years of education, years of formal education completed
were imputed using the mode of the years per category of
educational level by country. More than half of the countries
had less than 3% of their data recoded, and only 3 countries
had more than 50% of their data recoded. In addition, these
3 countries had more than 65% (67%–99%) of their data
recoded as “0 years” to correspond with the category of
“no education.” Education was modeled in standard deviation
(SD) units to standardize the measure across countries.

Country-level urbanicity was defined as the percentage of
the 2003 midyear population that lived in urban areas in each
country as reported to the United Nations (18). Countries
were then categorized as <25%, 25%–<50%, 50%–<75%,
or ≥75% urban for analyses.

Statistical methods

All analyses were conducted using Stata, version 11
(StataCorp LP, College Station, Texas). Mean values and
SDs for age and years of education and mean values and
standard errors for BMI and prevalence of smoking were
calculated by gender, taking into account the complex survey
design (including weights, sampling units, and strata) in each
country that utilized that method.

We fitted ordinary least squares and logistic regression
models by country to determine the relation between BMI or
current smoking and education. In each model, results were
adjusted for age and stratified by gender. Since the overall
data are better described as a combination of separate studies
by country (because of differences in the sampling designs
between countries (either a single-stage random sample
or a multiple-stage cluster sample design)), we used meta-
analytic techniques to assess the heterogeneity between
countries in the relations between BMI or smoking and education.
We used standard meta-analytic techniques to determine
whether there was effect modification of the association of
BMI or smoking with education by the country’s level of
urbanicity. To investigate the heterogeneity in the relations
between countries, forest plots were created. To create sum-
mary measures of the association of within-country factors
(individual level) and to quantify the variability in these asso-
ciations, we used a standard random-effects method (19). The
Q statistic for heterogeneity and the Der Simonian and Laird

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estimate of between-study (i.e., between-country) variance were calculated for each meta-analysis. To investigate the possible associations of country-level factors with the between-country differences, we conducted meta-regression analysis by gender, using categories of urbanicity as the covariate, in order to determine whether the observed heterogeneity in each of the estimates could be explained by this country-level factor. P-trend values were calculated to determine the linear trend of the relation. For maximum statistical power, we used the continuous measure “percent urban” rather than the categories when calculating the P-trend values. We calculated percent decrease in the between-country variance when urbanicity was added to the models in order to determine how much of the between-country variance was explained by urbanicity in the meta-regression.

RESULTS

Web Table 1 (available on the Journal’s Web site [http://aje.oxfordjournals.org/]) shows selected characteristics of all countries that participated in the WHS, in order of ascending urbanicity. Mean age ranged from 33 years (Kenya) to 51 years (Denmark, Greece, Russian Federation). Educational levels were generally higher for men than for women, except in a few, mostly higher-income countries. Mean education was lowest in Burkina Faso for men and women (1.7 years and 0.8 years, respectively) and highest in Belgium for both genders (14.1 years for men and 13.5 years for women). One SD of education ranged from 2.5 years (Kazakhstan) to 5.8 years (Morocco) for men and from 2.7 years (Czech Republic) to 7.6 years (United Arab Emirates) for women. In general, countries that were less urban and had a lower country-income classification had a younger population structure and lower educational levels than those that were more urban and had a higher country-income classification.

Mean BMI was lowest in Vietnam for both men and women (20.3 and 19.8, respectively). Mali had the highest mean BMI among men (32.7), whereas South Africa had the highest mean BMI among women (30.9). The lowest prevalence of current smoking was in Ethiopia for men (7.3%) and in Morocco for women (0.3%). Current smoking prevalence was highest in Laos for men (66.2%) and in Bosnia and Herzegovina for women (34.2%). Several countries, mostly in Eastern Europe and the eastern Mediterranean region, had a large difference in prevalence between men and women; Georgia had the largest difference (60.3% for men and 6.2% for women).

Figures 1 and 2 display forest plots from the meta-analysis of differences in mean BMI per 1-SD increase in education for men and women, respectively. Point estimates and confidence intervals represented in the figures can be found online in Web Table 2. Countries were sorted in ascending order of percentage urban. Men generally showed a positive association between education and BMI, such that men with higher education had a higher BMI in the least urban countries; in contrast, in countries with the highest levels of urbanicity, there was an inverse association between education and BMI. Major exceptions to this trend were Mexico and Brazil, two countries with high urbanicity in which men with higher education had a higher mean BMI. Similarly to men, women in the least urban countries showed a positive relation between education and BMI, but this relation transitioned to an inverse relation with increasing urbanicity, such that at the highest levels of urbanicity women with higher education had a lower mean BMI. This change in the social patterning of BMI associated with country-level urbanicity was more pronounced in women than in men.

Figures 3 and 4 show the forest plots of odds ratios for current smoking (versus not currently smoking) associated with a 1-SD increase in education for men and women, respectively. Point estimates and confidence intervals represented in the figures can be found online in Web Table 3. Regardless of urbanicity, men generally had an inverse association between education and smoking, such that those with higher education had lower odds of current smoking. For women, the results were more mixed. In the least urban countries, with the exception of Chad, women with higher education had lower odds of current smoking. However, in more urban countries (starting just below 50% urban), women with higher education tended to have higher odds of smoking, with mixed results at the highest level of urbanicity: In Turkey, Ukraine, Mexico, and the United Arab Emirates, higher education was associated with more smoking, whereas the opposite relation was observed in other Eastern European (e.g., Latvia) and Latin American (e.g., Brazil) countries.

For all meta-analyses (Table 1), tests for homogeneity led to the rejection of the null hypothesis that there was no heterogeneity in the associations between the countries (all P’s < 0.20, the traditional cutoff). The between-country variance was greater for women than for men in each analysis. Since heterogeneity was present in all of the meta-analyses, we conducted meta-regressions for each relation to determine whether the heterogeneity could be explained by the country-level factor of urbanicity. The regression coefficients shown in Table 2 represent the estimated change in the mean difference (BMI) or log odds ratio (smoking) associated with a 1-SD increase in education for different categories of urbanicity, with the least urban category (<25%) used as the reference category. For both men and women, the mean difference in BMI associated with a 1-SD increase in education became less positive or more strongly negative with increasing urbanicity. The trends were stronger for women than for men; urbanicity explained a substantial proportion (48%) of the between-country variance in women but did not explain any of the variance in men. In men, there was no association between country-level urbanicity and differences in the relation between education and smoking. In contrast, women showed a trend by which the association of education with the log odds of smoking became less negative or more positive as urbanicity increased. Urbanicity explained a substantial proportion of the variance of the country-specific regression estimates in women (44%) but none of the variance in men.

DISCUSSION

Analyses of this large, multicountry sample showed that the socioeconomic patterning of BMI and smoking varied greatly by country-level urbanicity. Overall, countries seem to be transitioning to a concentration of worse BMI among

persons of lower education as urbanicity increases, especially for women. In contrast, smoking was consistently concentrated among persons of lower education regardless of urbanicity in men. In women, however, greater urbanicity was associated with greater concentration of smoking in the higher education groups.

Our results are consistent with recent reviews of socioeconomic status and obesity, which showed that women and men have more positive SEP-BMI relations in less developed countries but more negative (women) or null (men) associations as countries become more developed (20, 21). The poorest, least urban countries are also those where calories

**Figure 1.** Mean difference in body mass index (weight (kg)/height (m)^2) per standard-deviation increase in education for men, World Health Surveys, 2002–2003. Bars, 95% confidence interval.
are more scarce, making it difficult to meet the minimum dietary energy requirement (22). The more affluent people in these countries may have better access to sufficient calories, which could explain the positive socioeconomic gradients for BMI in the least urban countries. With increasing economic growth and urbanization, calories become more plentiful and cheaper but are increasingly delivered in the form of fats and sugars (4, 13). Diets rich in energy-dense foods also tend to be less expensive and consumed by people of lower SEP (23). Urban living also involves more sedentary behavior, but persons of higher SEP may be the first to engage in more physically active leisure-time activity or may have the

Figure 2. Mean difference in body mass index (weight (kg)/height (m)²) per standard-deviation in education for women, World Health Surveys, 2002–2003. Bars, 95% confidence interval.
wherewithal to change their environments (8, 9), supporting inverse socioeconomic patterning.

The gender differences we found in the socioeconomic gradients were also consistent with the recent reviews: While women in the most urban countries had an inverse socioeconomic gradient, men had more null and some inverse associations between BMI and education (20, 21). These differences could be related to gender differences in desirable body image. In high-income countries, repeated studies have found that women consider smaller body sizes more desirable (24) and that women of higher socioeconomic status may be particularly sensitive to body image (25). This could lead toward increased attention to diet and physical activity for women of higher SEP, contributing to the inverse socioeconomic gradients. Weight is also linked to educational achievement and employment (26), and the consequences of weight for social mobility appear to be particularly prominent for women (27). These cultural norms may be transferred to other countries as they urbanize, resulting in increasingly stronger inverse associations of education with weight in women.

Our analyses on tobacco use also showed evidence for a social transition and gender differences therein. For men, there was a predominance of smoking among persons of lower education globally, regardless of country-level factors. Exceptions to this pattern were observed in several countries in sub-Saharan Africa, which had null or positive associations, possibly representing a lag in their social transition. Women had a wider range of relations between education and tobacco use. In countries with populations that were approximately
50% urban, women had mostly no socioeconomic gradient for smoking. At higher levels of urbanicity, there was more heterogeneity. Women’s smoking prevalence increased with country-level urbanicity (data not shown), possibly because of increased liberalization of women’s behavior in general. In many middle-income countries, women’s tobacco use may represent a signal of autonomy and equality with men (28). Women are also the target of marketing by the tobacco industry and of advertising that suggests smoking as a method of weight control (29). As the prevalence of smoking grows, women from all social classes are likely to smoke (resulting in no gradient). Subsequently, as health messages and tobacco control policies emerge, smoking may become more concentrated among the lower social classes (30). An interesting finding is the presence of an inverse socioeconomic gradient among women in the least urban countries, such that those of lower education had higher odds of smoking. Women in the least urban countries may be smoking more traditional forms of tobacco, which may be more common among persons of lower SEP (31). The WHS asks questions about the amount of manufactured cigarettes, hand-rolled cigarettes, pipefuls of tobacco, and “other” products smoked each day. Several low-urbanicity countries (e.g., Nepal, Malawi, Burkina Faso, Laos, Bangladesh, Vietnam, and India) did show inverse gradients (i.e., lower education associated with higher consumption) in daily consumption of hand-rolled cigarettes, pipefuls of tobacco, and “other” products among women (results not shown). Additionally, smuggling may lead to the availability of cheaper tobacco products in these countries, making them more accessible to persons of

**Figure 4.** Odds ratios for current smoking (versus not currently smoking) associated with a 1-standard-deviation in education (years) for women, World Health Surveys, 2002–2003. Bars, 95% confidence interval.

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lower SEP (32). This, together with less regulated advertising and distribution, could enhance the use of smoking as a coping mechanism in low-SEP women.

Our analyses were limited to the countries that participated in the WHS. Although these countries represented all regions of the world and covered a large spectrum in terms of urbanicity and development, the analyses may not have completely captured the full range of patterns seen globally. This may be particularly true of our tobacco results, since few of the high-income countries included the tobacco questions in their surveys. For instance, many of the higher-urbanicity countries were middle-income countries, which might explain why we did not see overall inverse socioeconomic gradients for women by smoking. The cross-sectional analyses also had limitations for drawing inferences regarding changes in the social gradient over time as a given country urbanizes. Countries are unlikely to be homogenous in terms of urbanicity, and there is some evidence that regional urbanicity within a country affects social gradients in chronic disease risk factors (33). However, detailed within-country data were not available for all countries we studied.

While urbanicity has been shown to be associated with the nutrition and physical activity transitions, other country-level factors, including cultural norms or economic development, may also play a role. Percent urban and gross national index

### Table 1. Homogeneity Test Results and Der Simonian and Laird Estimates of Between-Country Variance From Meta-Analyses of Chronic Disease Risk Factors, World Health Surveys, 2002–2003

<table>
<thead>
<tr>
<th>Gender</th>
<th>Body Mass Indexa and Education</th>
<th>Smoking and Education</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heterogeneity (Q)</td>
<td>Variance (τ²)</td>
</tr>
<tr>
<td>Men</td>
<td>348.23 (69)</td>
<td>0.081</td>
</tr>
<tr>
<td>Women</td>
<td>652.84 (52)</td>
<td>0.246</td>
</tr>
</tbody>
</table>

- The P value for heterogeneity was less than 0.001 for each meta-analysis. P for heterogeneity tests the null hypothesis that there is no difference in the associations between countries (traditional cutoff is P < 0.20).
- Weight (kg)/height (m)².
- Q statistic for heterogeneity.
- Der Simonian and Laird estimate of between-country variance.
- Numbers in parentheses, degrees of freedom.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Body Mass Indexa and Education</th>
<th>Smoking and Education</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Change in Mean Difference 95% CI</td>
<td>Change in Log Odds Ratio 95% CI</td>
</tr>
<tr>
<td>Men</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constantb</td>
<td>0.27</td>
<td>−0.24</td>
</tr>
<tr>
<td>% urban</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>25–&lt;50</td>
<td>−0.07</td>
<td>−0.33, 0.19</td>
</tr>
<tr>
<td>50–&lt;75</td>
<td>−0.15</td>
<td>−0.39, 0.09</td>
</tr>
<tr>
<td>≥75</td>
<td>−0.45</td>
<td>−0.71, −0.18</td>
</tr>
<tr>
<td>P trendc</td>
<td>0.001</td>
<td>0.4444</td>
</tr>
<tr>
<td>% decrease in between-country variance</td>
<td>(0.081 − 0.0818)/0.081 = −1.0</td>
<td>(0.043 − 0.0476)/0.043 = −10.7</td>
</tr>
</tbody>
</table>

| Women |                             |                        |
| Constantb | 0.53 | −0.84 |
| % urban |                             |                        |
| <25 | 0 | 0 |
| 25–<50 | −0.36 | −0.70, −0.03 | 0.49 | 0.20, 0.78 |
| 50–<75 | −0.91 | −1.22, −0.60 | 0.66 | 0.38, 0.94 |
| ≥75 | −1.11 | −1.44, −0.77 | 0.82 | 0.43, 1.21 |
| P trendc | <0.001 | <0.001 |
| % decrease in between-country variance | (0.246 − 0.1289)/0.246 = 47.6 | (0.20 − 0.1128)/0.20 = 43.6 |

Abbreviation: CI, confidence interval.
- Weight (kg)/height (m)².
- Mean difference in body mass index associated with a 1-standard-deviation increase in education in the reference category and log odds ratio for smoking associated with a 1-standard-deviation increase in education in the reference category, respectively.
- P trend refers to the test of the null hypothesis that the slope of a line fitted for the relation between percent urban and the outcome-education association equals zero.

per capita, at least, were highly correlated in this sample (Spearman correlation = 0.83), and it may be difficult to separate the impacts of urbanization and development in this context. In addition, geographic regions and urbanicity are highly correlated. For instance, many of the least urban countries (which have similar education/risk factor patterns) can be found in Africa and Southeast Asia, while the most urban countries (which, again, have similar patterns) are generally in Europe and some parts of Latin America. We cannot determine from these analyses whether urbanicity or some other factor correlated with urbanicity is driving the patterns in social gradients that we observed. However, in other sensitivity analyses, we tested whether mean country education explained the heterogeneity in any of the education-risk factor cases, and it did not. When added to the meta-regression models with urbanicity, the variance changed very little, and none of the country-level education coefficients were significant.

Measures other than education may be more appropriate markers of SEP in specific countries, and education measured per SD may not fully capture the range of social circumstances across countries. The use of SD units also has limitations because the magnitudes of 1 SD of education are clearly different across countries. This would be highly problematic in these analyses if the absolute value of 1 SD were correlated with urbanicity, but it was not. In addition, sensitivity analyses carried out using a different measure of SEP, wealth (34), revealed similar overall patterns.

Self-reported height and weight could be subject to measurement error, which may be differential according to SEP and country-level urbanicity. For instance, in the least urban countries, persons of lowest SEP may not know their height and weight. Eighteen of the 70 countries had less than 75% reporting for BMI. In sensitivity analyses excluding countries that had statistically different mean SEP levels for missingness, the meta-analysis and meta-regression results were qualitatively the same.

Our results suggest a social transition from a concentration of higher BMI among the more affluent to higher BMI among the poorest members of society with increasing country-level urbanicity, especially among women. We also found a clear concentration of smoking among the poorest members of society, regardless of country-level urbanicity for men and among the least urban countries for women. These results highlight the need to consider health disparities in addition to the increasing population-level burden of chronic diseases, particularly in developing countries. Public health policy would benefit from additional attention to the social transition of chronic disease risk.

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