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Poverty

Assessing the distribution of health risks by socioeconomic position at national and local levels

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Preface

The Environmental Burden of Disease (EBD) series of guides aims to provide information on the amount of disease caused by specific environmental risk factors, and on how this burden is distributed across different subpopulations (e.g. infants, women). The data will allow policy-makers to prioritize and target actions to reduce environmental risks. The methods in the series use the general framework for global assessments described in the World Health Report (WHO, 2002), in which disease burdens and associations of risk factors with socioeconomic status were measured at the level of WHO epidemiological subregion (Annex 1 and 2). The introductory volume in the series outlines the general method (Prüss-Üstün et al., 2003), while subsequent volumes address specific environmental risk factors.

The present guide addresses the influence of socioeconomic status on the health burden of environmental and other risk factors. It is clear that socioeconomically disadvantaged communities and individuals are often exposed to higher levels of such risk factors than their less-disadvantaged counterparts, and they bear a disproportionate share of the health burden. This guide therefore describes how to calculate the exposure associated with low socioeconomic status. This will give policy-makers an indication of the potential gains that could be achieved by reducing poverty and by targeting health services, including preventive measures, to the most disadvantaged sections of society. Unlike for the other guides of this series, an advanced knowledge in epidemiology and data analysis is required, as the proposed methods involve analysis of epidemiological literature and/or survey data.

In the guide, conceptual issues that link socioeconomic status, exposure to risk factors and health are first explained. A practical, step-by-step approach is then used to assess the impact of socioeconomic status on risk factors and health, using numerical examples. The methods can be adapted both to local and national levels, and can be tailored to suit data availability.

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Abbreviations

CRA	Comparative risk assessment
DHS	Demographic and health survey
EBD	Environmental burden of disease
GDP	Gross domestic product
IF	Impact fraction
LSMS	Living standards measurement study
UK	United Kingdom
USA	United States of America
WHO	World Health Organization

Summary

Socioeconomic status is an important determinant of the likelihood that individuals and populations are exposed to environmental and other risk factors for health. In this guide, we describe a method for measuring the distribution of health risk factors as a function of socioeconomic position. An overview of the method and its requirements are first described, followed by a step-by-step numerical example that uses data for Pakistan. In the numerical example, we focus on income poverty as the measure of socioeconomic position, and we use child malnutrition as the health risk factor. The example uses World Bank estimates of income poverty, individual-level survey data on the distribution of risk factors by socioeconomic position, and external estimates of the prevalence of the risk factor. From this information, we estimate the risk factor prevalence by category of income poverty, as well as the impact fractions (or attributable risks). Problems in estimating the disease burden of socioeconomic position are also discussed.

We hope the method will be used and further developed by others, so that the contribution of socioeconomic position to the distribution of health risk factors and to the burden of disease will be better understood. A description of how health risk factors are distributed by socioeconomic position will illustrate how poverty contributes to poor health and, hopefully, encourage policy-makers to undertake intersectoral policies to improve population health, as well as public-health policies to reduce or prevent health inequalities.

1. Introduction

1.1 Overview

Social and economic resources shape the health of individuals and populations. This can be seen in the simple statistic that richer countries tend to have better average health than poorer ones (Wilkinson, 1996). Although no consistent association has been found between Gross Domestic Product (GDP) and life expectancy amongst richer countries, several studies have found that within richer countries lower socioeconomic status is associated with poorer health (Black et al., 1980; Feinstein, 1993; Sorlie, Backlund & Keller, 1995; Drever & Whitehead, 1997; Mackenbach et al., 1997; Kunst et al., 1998a; Marmot & Wilkinson, 1999; Berkman & Kawachi, 2000; Blakely, 2002).

The same tends to be true for individuals in poorer countries and regions of the world, although the evidence-base is not as broad (Evans, Wirth & Bhuiya, 2001; Leon & Walt 2001; Blakely et al., 2004) and is often derived from ecological studies that compare average levels of wealth and health in countries (Gwatkin, Guillot & Heuveline, 1999; Hales et al., 1999). Nevertheless, studies in poorer countries are starting to map the distribution of health by socioeconomic position at the level of the individual (Wagstaff, 2000; Gwatkin, 2001; Leon & Walt, 2001, Blakely et al., 2004). National burden of disease estimates can now use these research data and methods to estimate the proportion of the national disease burden that is attributable to socioeconomic position, even though little is known about the mechanisms by which low socioeconomic position is translated into poor health. If the health impacts of poverty are considered in both planning and advocacy, this will also contribute to the growing international movement to eradicate poverty.

The aim of this guide is to describe a method to “map” health risk factors by socioeconomic position. The numerical example in this chapter uses income poverty as the measure of socioeconomic position, and child malnutrition as the health risk factor. The health impact of eradicating poverty is quantified by population impact fractions (IFs) (or equivalently, population attributable risks). These epidemiological measurements assess the impact of interventions that change exposure distributions. In the case of income poverty, the IF is an estimate of the change in a risk factor (prevalence) for a given change in the prevalence of income poverty. The IFs we report relate to the impact of poverty on risk factors, in contrast to the IFs in the WHO Comparative Risk Assessment (CRA) project, which related to the impact of risk factors on the burden of disease (Ezzati et al., 2004). Because it is difficult to assign a causal amount to poverty (see below), the uncertainties associated with our IFs are greater than those in the WHO project.

A major challenge in mapping health risks by socioeconomic position is that relative risk estimates for the association of socioeconomic position and disease will be required for each country. Often, it is assumed that the relationship between risk factors and disease risk can be generalized across populations (e.g. exposure to indoor smoke is assumed to have much the same association with respiratory disease throughout the world). This is unlikely to be true for risks associated with adverse socioeconomic conditions, where the relationship with disease will probably vary by country. For example, excellent access to primary health-care services among the poor may mitigate inequalities in health derived from socioeconomic position. A country could also be at the stage of a tobacco-related disease epidemic where consumption is more common among higher socioeconomic groups. If risk estimates and data are not available for a country, and proxy information from other countries is used, the countries should ideally have very similar characteristics to the country under study.

Other challenges in attributing health to socioeconomic position at the country-level are covered in this guide, including:

- should the link between socioeconomic status and health be examined, or the link between socioeconomic status and risk factors?
- which are the important pathways and intermediary variables between socioeconomic status and health?
- which socioeconomic factor should be used?
- can we control for confounding appropriately?
- which time lags are involved (assuming causality between socioeconomic status and risk factors)?

Finding answers to these questions will not be straightforward, but ignoring them will mean that the search for the causes of ill-health will tend to focus on proximal causes, rather than on more distal ones. Yet distal causes of ill-health will also need to be addressed, at least in part, if the proximal causes of ill-health are to be mitigated. Estimating the impact of social adversity on the distribution of health risk factors is an important step towards reducing inequalities in health associated with variables such as income and education. Reducing the disease burden, as well as the social inequalities that increase the burden of disease for the poor, are both overriding health goals in many countries.

1.2 Concepts

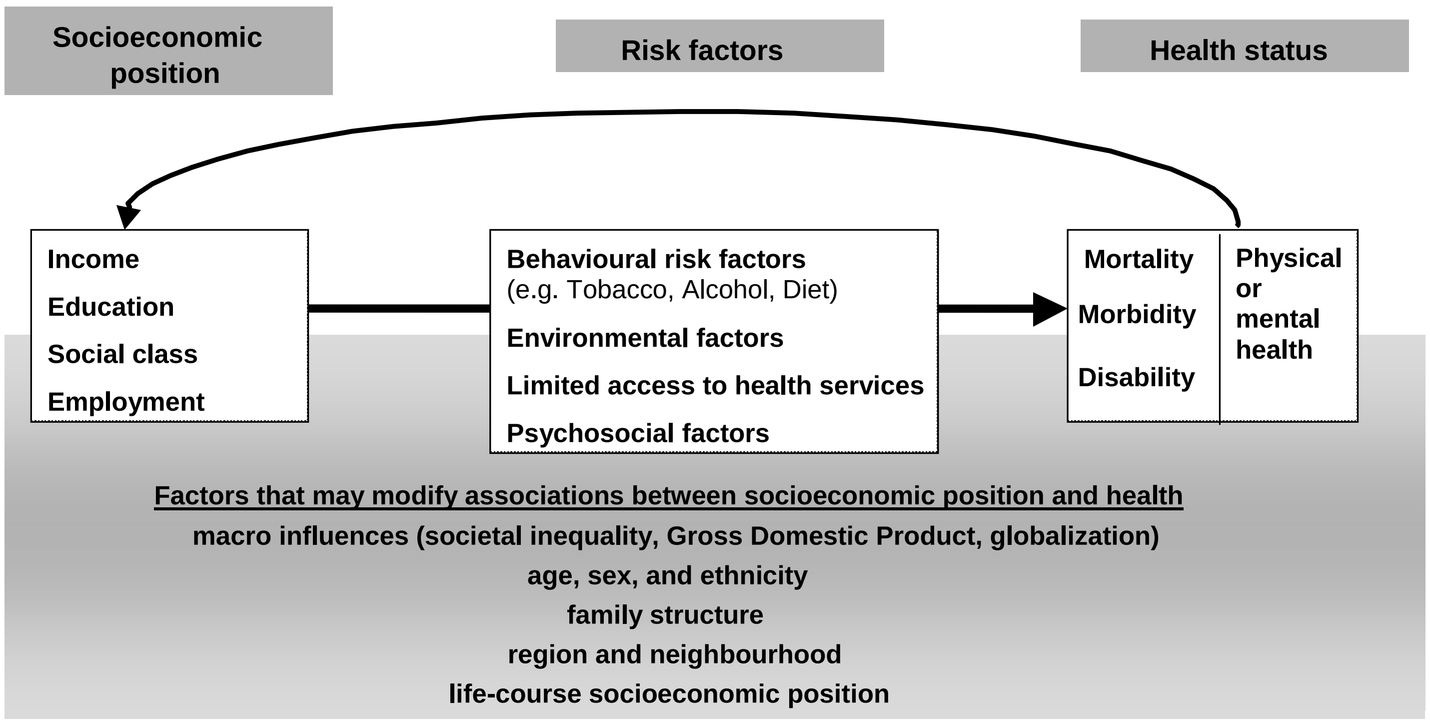
1.2.1. Pathways from socioeconomic position to health

Many pathways can lead from socioeconomic position to health outcome, some of which are shown in Figure 1. The pathway variables (or risk factors) can also vary by time and by country. For example, tobacco consumption (a health risk factor) may be taken up earlier by the higher socioeconomic groups in a country, but tobacco consumption typically becomes concentrated among lower socioeconomic groups.

Socioeconomic position is necessarily associated with health via more proximal exposures or risk factors. It may therefore be helpful to estimate the association of socioeconomic position with intermediate variables, as well as with health status. A further argument for examining the patterning of risk factors (pathway variables, Figure 1) by socioeconomic position, rather than examining health state by socioeconomic position, is that such an analysis illuminates how causal pathways are distributed by socioeconomic position. Although many countries may not have data on mortality or morbidity by socioeconomic position, they may have survey data that allow associations between socioeconomic position and health risk factors to be studied. A first step may therefore be to map the associations of health risk factors by socioeconomic position.

Later work, outside the scope of this guide, could either directly examine the distribution of health states by socioeconomic position; or directly examine the distribution of health states by risk factors, and then combine estimates from two models (e.g. a socioeconomic position to risk factor model and a risk factor to health state model) to make a two-step link from socioeconomic position to health status.
The remainder of this guide will focus on determining the distribution of risk factors by socioeconomic position.

Figure 1 Socioeconomic position and risk factor pathways to health



1.2.2. Socioeconomic position is a complex parameter

Socioeconomic position depends on several socioeconomic factors. Within categories of income there can be variation by other "classic" socioeconomic factors, such as education and occupational class, and also by measures of socioeconomic deprivation and rurality (a common proxy for low socioeconomic position in poorer countries). It is possible to combine multiple socioeconomic factors into one index, but the policy implications of this approach are often not clear. Also, composite indices of socioeconomic (dis)advantage are often not comparable between countries or over time.

1.2.3. Which socioeconomic factor?

Which socioeconomic factor should be used? There is no right answer to this question. The choice will depend on issues such as data availability, policy applicability, and the desire for comparability with estimates from other countries. If income redistribution or subsidies are likely policy options, then income would be an appropriate socioeconomic factor to measure. If the assessment will be used to target health (and other) resources to needy individuals or subpopulations, then measures such as area deprivation, regional socioeconomic characteristics or rurality might be preferable. An important point when choosing a socioeconomic factor is that the interpretation may not be generalizable across socioeconomic factors. For example, the distribution of disease by income may differ from that by education. Also, policies targeted by regional socioeconomic characteristics will not help people of low socioeconomic position who live in non-targeted areas (not all poor people live in poor areas). Ideally, a variety of measures of socioeconomic position should be used, but data and other limitations will often constrain the choices.

1.2.4. Causal or confounded associations?

An underlying assumption in all calculations of the disease burden is that the associations between risk factors and disease are causal. By extension, it is assumed that estimates of the avoidable disease burden are the actual changes that would occur if exposure to the risk factor were altered. Can the same be said for the association of socioeconomic position with risk factors? Theoretically, one could say "yes", but pragmatically the answer is often "no". Theoretically, socioeconomic position *causes* different exposures to risk factors and other pathway variables that in turn cause disease. In practice, the association of any specified socioeconomic factor (e.g. income) with risk factors or disease is likely to be confounded by socioeconomic variables (e.g. education), demographic variables (e.g. age and ethnicity) and others.

In practice, we generally lack information on many potentially confounding factors and even when the information is available it is often unclear how best to control for the confounding factors. As a first step, we have mapped risk factors by a single socioeconomic factor. Future analyses should consider controlling for clear-cut confounders (e.g. rurality and ethnicity in the association of income poverty with child malnutrition). The final stage would be to control for the confounding component of other variables (but not the mediating, or "effect modifying" component). However, such analyses are empirically challenging and risk decontextualizing the analyses.

1.2.5. Time lags

An extension of the above concerns about measuring causal associations versus crude associations is the issue of time lags. One goal of burden of disease studies is to estimate *avoidable* fractions of disease in future years, based on time lags between exposure to the risk factor and disease onset. But there is no clear understanding of the time lag between socioeconomic position and exposure to risk factors, nor between socioeconomic position and disease outcomes. Evidence from Eastern European countries suggests that the rapidly declining socioeconomic conditions that followed the collapse of the Soviet Union were associated with rapidly increasing mortality (McKee, 2001). But not all effects of socioeconomic position occur with a short time lag, and a number of life-course studies suggest that socioeconomic conditions in childhood affect disease risk into adulthood (Kuh & Ben-Shlomo, 1997). Without a clear understanding of the time lags between socioeconomic position and health risk factors (rather than disease, in the context of this chapter), it is not possible to estimate the avoidable burden of risk factors, only estimates of the attributable burden of risk factors are feasible.

2. Summary of the method

The assessment of the distribution of risks by socioeconomic position is based on the following steps:

Select an appropriate measure of socioeconomic position. Ideally, select one that is unconfounded with other variables, has good data coverage, and is directly related to feasible policy interventions. In this guide we use income poverty as our measure of socioeconomic position.

Determine the population distribution of the socioeconomic measure (see section 3). For example through national censuses.

Determine the relative risk for the association between socioeconomic position and risk factors (see section 4). For example, through analyses of epidemiological studies, or through surveys such as the demographic health surveys or world health surveys.

Determine the current overall distribution of risk factor levels within the population (see section 5). For example, through national censuses or representative surveys.

Calculate the population attributable risks (see section 6). Define an appropriate counterfactual or "target" scenario (such as ensuring that all individuals have an income of at least US$ 2 per day), and apply the formula for calculating attributable fractions.

Estimate uncertainties (see section 7). There are likely to be many uncertainties in any analysis of risk factors and socioeconomic position. In this guide, we present a sensitivity analysis of the assumption that ranking by income poverty approximates ranking by asset score.

These processes are described in more detail in the following sections. A step-by-step numerical example is given for Pakistan in Section 8.

3. Determine the population distribution of the socioeconomic factor

Having chosen the socioeconomic factor to use, data must be obtained on the distribution of the population by socioeconomic status. The most obvious source of data is a census. However, even in countries that do have national census data, some key socioeconomic factors such as income may not be collected. Further, many countries do not have population-wide censuses. In such instances, survey data will need to be used.

Household survey data (e.g. economic and employment surveys) that are representative of the general population are available in many countries. The Living Standards Measurement Study (LSMS, available at web site http://www.worldbank.org/lsms) usually includes variables for income, education and rurality. The Demographic and Health Survey (DHS, http://www.measuredhs.com) includes information on maternal education and some proxies for socioeconomic position (e.g. housing construction materials) that can be used to construct a household asset index. Care should be taken to ensure that the survey data are representative of the population of the country, and that sampling weights are used if necessary.

It is also possible to use estimates of income poverty that are based on survey data and on econometric methods. The World Bank has led a programme of work estimating the percentage of people in countries, and by aggregated regions, living on less than US$ 1 per day, US$ 1–2 per day, and more than US$ 2 per day (World Development Indicators, 2.6 Poverty; Ravallion, Datt & van de Walle, 1991; Chen & Ravallion, 2000).

4. Determine the relative risks for the association between socioeconomic position and risk factors

This will usually be the most demanding stage. Ideally, country-specific estimates should be used for the association of the chosen socioeconomic factor with the relevant risk factors. As pointed out, there may be substantive variations between countries in the associations of socioeconomic status with risk factors.

In this context, risk factors include behaviours and conditions or states of individuals that are causally associated with the incidence of disease. Examples include malnutrition, indoor air pollution, unsafe water and sanitation, unsafe sex, tobacco and alcohol consumption, exercise, diet, blood pressure, weight, and cholesterol. Information on the relative risk for the association of the socioeconomic factor with each risk factor may come from one of two sources within a country: epidemiological studies or survey data. In poor countries, the DHS and LSMS are common data sets that may include variables for risk factors and socioeconomic factors. However, differences in study design and missing information may limit cross-national comparisons.

The DHS (http://www.measuredhs.com) includes data on child malnutrition, unsafe water and sanitation, solid fuel use (since 1999), unsafe sex, lack of breastfeeding and maternal obesity. Asset scores, as a measure of socioeconomic position, can be calculated from a range of questions in the DHS. The LSMS (http://www.worldbank.org/lsms) includes data on income, alcohol, tobacco, and indoor air pollution (the use of smoke-producing fuels in cooking, such as wood, coal and charcoal). The 1993 China Health and Nutrition Survey (http://www.cpc.unc.edu/china) includes data for income and the following risk factors: child malnutrition, unimproved water and sanitation, indoor air pollution, tobacco, alcohol and body weight. Finally, the World Health Survey should improve the availability of country-level data on the distribution of socioeconomic factors with a range of risk factors, such as water and sanitation, indoor air pollution, fruit and vegetable intake, and alcohol consumption (http://www3.who.int/whs/).

This guide focuses on the association of socio-economic position with *risk factors*. Box 1 contains a brief review of possible data sources if the focus in on the association of socio-economic position with *disease* or *health status*.

5. Determine the current distribution of risk factor levels within the population

It is likely that the same sources that provide data on distribution of the socioeconomic factor (section 3), and it's association with the health risk factor (section 4) will also provide information on the population distribution of the health risk factor. An exception would be when epidemiological studies are used to determine relative risk associations, in which case analysts will need to estimate the current disease or risk-factor prevalence from administrative and survey data. For example, the best overall prevalence of hypertension in a given nation may be best taken from a large health survey that does not include socio-economic measures.

Box 1: Data sources for an analysis of disease by socioeconomic position

This guide focuses on the association of socioeconomic position with risk factors. However, it is also useful to consider the association of socioeconomic position and disease, even though data for such analyses are often missing. This text box provides some brief notes for people considering such an analysis.

Information on relative risks for the association of a socioeconomic factor and disease may come from one of three sources within a country:

- epidemiological studies
- survey data
- administrative/surveillance data.

For a given country, epidemiological studies may provide relative risk estimates of either disease incidence or prevalence by socioeconomic factors. However, it is likely that this information will be available for a limited range of diseases, such as when the epidemiological data come from case–control studies of a single disease. Different studies are also likely to have measured disease outcome differently (e.g. prevalence, incidence, self-report, etc.). Similarly, for survey data of disease prevalence that also include socioeconomic variables, it is likely that only a limited range of diseases will have been studied.

Administrative data typically include hospitalization and other measures of health services utilization, as well as mortality data. It may be possible to estimate disease prevalence and incidence from health services data, using census or other estimates of the total population. However, socioeconomic variables in health services data are likely to be of poor quality or nonexistent. If socioeconomic variables are available, they would most likely be derived from area of residence (e.g. poor versus rich areas, and rural versus urban areas) which is likely to be too crude for burden of disease estimates. Moreover, the estimates may be biased by differences in the availability and utilization of health-care services by place.

Mortality data sets may include a socioeconomic measure of the deceased, such as educational qualification or occupational class. If similar data are also available for the total population (e.g. census data, population estimates from household economic survey data), then it may be possible to calculate mortality rates according to socioeconomic status (Marmot & McDowall, 1986; Drever & Whitehead, 1997; Pearce et al., 2002). The mortality data may be linked with census data, which would allow a straightforward calculation of mortality rates by socioeconomic position (Martikainen & Valkonen, 1996; Kunst et al., 1998b; Harding et al., 1999; Blakely et al., 2000). To our knowledge, such linked data only exist in a limited number of developed countries: Denmark, Finland, France, Italy, New Zealand, Norway, Sweden, UK, USA (Kunst, 1997; Blakely, 2002).

If linked data are not available, or if a socioeconomic factor is not assigned to mortality cases, it may still be possible to assign each death record to a socioeconomic position. A common method is to use place of residence as a proxy for personal socioeconomic position, but this is likely to be too crude for analysis (as with health services data).

6. Calculate the population attributable risks

A key decision is the choice of counterfactual. The counterfactual is a hypothetical "target" distribution in which the risk factor is removed or reduced. The counterfactual can be used as a comparison to estimate attributable or avoidable burdens. The choice of counterfactual will vary from assessment to assessment, but should be based on plausible scenarios.

In a comparative risk assessment within the global burden of disease project (see Annex 1 and 2), we calculated the distribution of risk factors by absolute income poverty (Blakely et al., 2004). Poverty was categorized as a trichotomous variable: living on less than US$ 1 per day; living on US$ 1–2 per day; and living on more than US$ 2 per day. We chose as the counterfactual scenario: that people living on *less than* US$ 2 per day adopt the risk factor profile of those living on *greater than* US$ 2 per day.

It is possible to choose other counterfactuals. We could have used the Millennium Development Goal of halving the number of people living on less than US$ 1 per day by 2015. Both counterfactual scenarios assume that changing the poverty level will change the levels of risk factors in the population. Both of these examples are also aligned with growing international efforts to reduce and, if possible, eradicate absolute poverty.

Having specified the counterfactual, it is a straightforward task to estimate the population attributable risk (PAR) using the information assembled in Steps 1–3 and the following standard formula:

$$PAR = \frac{\sum_i (P_i \times RR_i) - \sum_i (P_i' \times RR_i)}{\sum_i (P_i \times RR_i)} \qquad \textit{Equation 1}$$

where:

RR_i = relative risk by exposure strata "i".
P_i = proportion of population in exposure strata "i" before counterfactual change.
P_i = proportion of population in exposure strata "i" after counterfactual change.

NB: the calculation should include the unexposed populations (i.e. with RR = 1), both before and after the counterfactual change.

It is critical to realize that any such estimated population attributable risks are not necessarily accurate predictors of the avoidable burden of the risk factors. Changing only poverty within a population, for example, would not necessarily immediately reduce the risk-factor burden by a commensurate amount. This is because it is likely that the population distribution of relative risks by socioeconomic factor are confounded by other factors, and because time lags are uncertain. Nevertheless, it is possible to state that: “If people with socioeconomic level X had the same risk-factor prevalence as people with socioeconomic level Y, then the overall risk-factor prevalence would be decreased/increased by Z”.

7. Estimate uncertainties

The main drivers of uncertainty in the calculations are likely to include:

- *Limited data*. Joint data on the distributions of socioeconomic position and risk factors may be sparse.
- *Confounders*. Estimates of the associations between socioeconomic position and risk factors are likely to be confounded by other factors that cannot be assessed independently.
- *Time lags*. How should time lags be incorporated into the calculations? For example, how long does it take for an improvement in income to manifest as a change in risk-factor exposure?
- *Contextual factors*. Contextual factors influence the relationship between socioeconomic position and risk factors. For example, in a poor rural community with no infrastructure for safe water and sanitation, an improvement in income will not inevitably result in safe water and sanitation. Political commitment as well as collective wealth are needed in order to implement infrastructure changes.

We have not explored the effects of these uncertainties quantitatively. Our recommendation is that people carrying out national burden of disease estimates test the robustness of conclusions by analysing alternative, plausible scenarios, and present final figures with due caution. We also recommend that further progress be made on controlling for obvious confounders whenever appropriate and feasible.

8. Case study: absolute poverty and child malnutrition in Pakistan

8.1. Select an appropriate measure of socioeconomic position

In this guide, we selected income poverty as our measure of socioeconomic position. Child malnutrition was selected as the risk factor.

8.2. Determine the population distribution of the socioeconomic factor

The World Bank has estimated that 31.0% of the population of Pakistan lives on less than US$ 1 per day, 53.7% lives on US$ 1–2 per day, and 15.4% lives on greater than US$ 2 per day. (World Development Indicators, 2.6 Poverty; Ravallion, Datt & van de Walle, 1991; Chen & Ravallion, 2000). Although income poverty among the group that is affected by this particular risk factor (children 0–4 years of age) may vary from these overall population estimates, World Bank estimates are only available for the total population.

8.3. Determine the relative risks for the association between socioeconomic position and risk factor

We used an indirect method to estimate the association of income poverty with child malnutrition, our chosen risk factor.[1] This involved first determining the association of an asset score with child malnutrition (weighted for age), based on DHS survey data. An asset score is simply a composite index variable assigned to people or households, based on the number and types of assets they have. A low asset score equates to low socioeconomic position, and a high score equates to high socioeconomic position (see below for details). Having determined the association of asset scores with malnutrition, we then estimate (using the indirect method) the association of our actual socioeconomic exposure of interest, income poverty, with child malnutrition.

8.3.1. Determine the association of asset scores with child malnutrition

DHS data include a range of variables that may be used to construct an asset score. We constructed a global asset score (i.e. including all DHS countries, not just Pakistan), using four variables that were common to most countries with DHS data: urban–rural status; housing construction material (usually floor material); educational status of the mother; and availability of electricity. If these variables were missing for a particular country, a substitute variable was used as follows:

- for Pakistan, wall material was substituted for floor material
- for India, the number of rooms was substituted for floor material

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[1] Malnutrition may be considered either a risk factor or a health outcome in its own right. In this guide, we follow the convention used in the WHO Comparative Risk Assessment project and treat malnutrition as a risk factor.

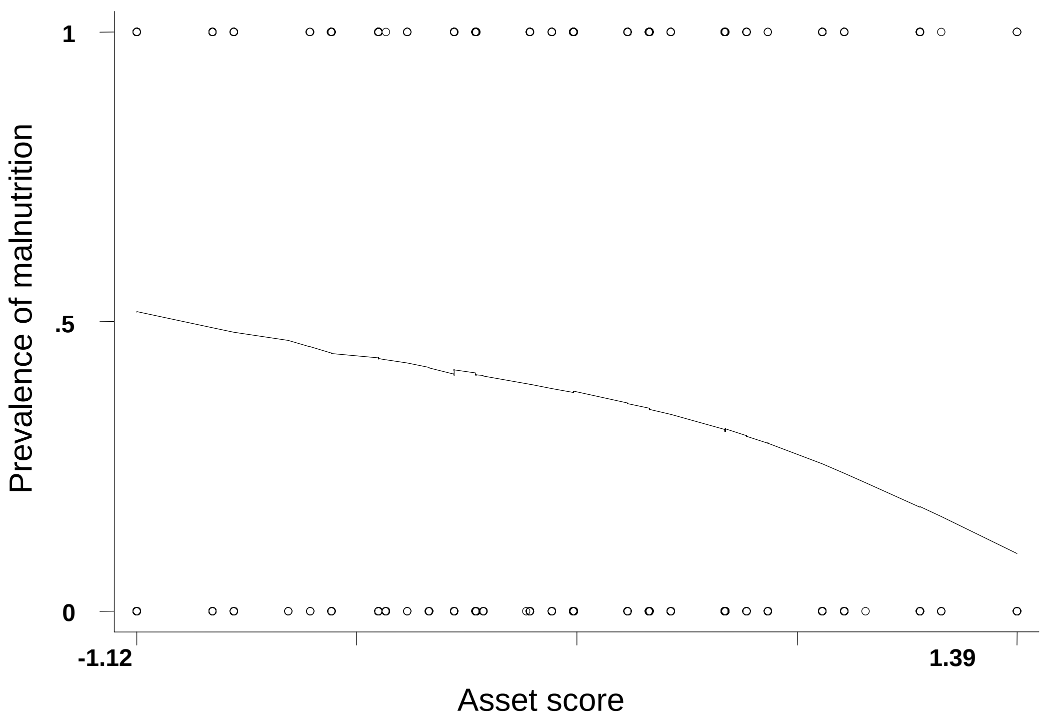
- for Burundi, the Dominican Republic, Liberia and Tunisia, possession of a radio was substituted for electricity supply.

Principal factor analysis was used to calculate the asset score (Filmer & Pritchett, 1988). Briefly, factor analysis is a statistical technique to create a single scale or index from two or more variables that are highly correlated and give overlapping information about another property that we are interested in, such as poverty. In this instance, we use variables for different assets to create an index of overall asset wealth, which in turn we treat as a marker of socioeconomic position. The factor analysis identified a substantive first factor (Eigenvalue 1.53) with relatively equal loading from each of the four variables used in the factor analysis. Using the output of this factor analysis, it was then possible to assign to each DHS respondent an asset score based on the reported values of the four variables. Details of the method are published elsewhere (Blakely et al., 2004).

Focusing on Pakistan, it was possible to then fit a Lowess regression[2] to relate malnutrition to the asset score of the DHS data. This procedure fits a series of linear regressions of the dependent variable on the independent variable at sequential values of the independent variable. Each of the linear segments is fitted for a specified "bandwidth" of observations about a central value. The final product is a smoothed, curve. This method allowed for nonlinearity in the association of child malnutrition with asset score. The resulting plot is shown in Figure 2. The y-axis is the probability of child malnutrition. The lower the asset score (x-axis), the higher the probability (or prevalence in aggregate terms) of child malnutrition. We used Lowess regression because it is appropriate for describing nonlinear associations, such as the one observed here. However, if the association is linear in an absolute or log scale (for example), then one could equally well use ordinary linear regression or log-linear regression.

[2] Lowess regression is a nonparametric regression method for fitting smoothed curves to data (Cleveland, 1981).

Figure 2 Lowess regression curve of the probability of malnutrition by asset score, Pakistani children 0–4 years of age[a]



[a] Source: DHS data. Open circles indicate individual data points; the LOWESS regression is the solid curve

8.3.2. Estimate the association of income poverty with malnutrition

In the absence of data on the quantitative association of income poverty with child malnutrition, we simply assumed that the *rank* association of asset score with child malnutrition was the same as the *rank* association of income poverty with malnutrition. We based this assumption on the fact that, while individual socioeconomic factors may each have independent predictive contributions to risk factors, individually the univariate associations for the risk factors are often of similar *strength* (Sorlie, Backlund & Keller, 1995; Blakely et al., 2002). Put another way, the relative risks of disease states are often comparable for different socioeconomic factors. This is the major assumption underlying our method, and a necessary one to conduct international comparisons given limited data, but it warrants further examination. For developing countries, the comparability of different associations of socioeconomic factors with risk factors has been examined in more detail (Blakely et al., 2004).

We assume that the average prevalence of malnutrition for children with the lowest 31% of asset scores equates to the prevalence of malnutrition for those living on less than US$ 1 per day. This is equivalent to estimating the area under the curve in

Figure 2 that corresponds to the lowest 31% of asset scores, giving our estimated prevalence of malnutrition for children living on less that $1 per day. This method can be applied to all categories: in each case the area under the curve for each poverty interval gives the estimate of the prevalence of malnutrition in that income group. In Table 1 are shown the DHS-derived prevalences of child malnutrition in Pakistan by level of income poverty, as well as the corresponding relative risks. Relative risks are derived by dividing the prevalence in a given category by that in the category with the lowest risk (here US$ >2 per day).

Table 1 Estimated prevalence and relative risks of malnutrition in Pakistani children, by level of income poverty[a]

Poverty level (US$ per day)	DHS (*N*)	DHS-derived prevalence of malnutrition (%)	Relative risk
<1	614	49	2.58
1–2	1627	37	1.95
>2	405	19	1.00

[a] The data are derived from the DHS for children 0–4 years of age.

8.4. Determine the current distribution of risk factor levels within the population

In this example, the risk factor is malnutrition and the population is children 0–4 years of age. To determine the distribution of malnutrition in this population we used final estimates of the prevalence of child malnutrition determined in an assessment of the global burden of disease due to malnutrition (Blakely et al, 2004). In this instance, it would have actually been possible to use the DHS estimates directly. However, we wish to present a method that allows the integration of prevalences and relative risks from different data-sets. It was also a requirement in this assessment to use the prevalence estimates calculated for the other specific risk factors within the analysis of disease burden at global level. We then recalculated the actual prevalences of malnutrition for each level of poverty, based on the relative risk data and prevalence of poverty data (Table 1).

We used a matrix to represent the distribution of Pakistani children (0–4 years old) by malnutrition and income poverty (Table 2). Each of the values a–f in the shaded 2x3 matrix represents the percentage of children 0–4 years old in the corresponding malnutrition/income category (i.e. a + b + c + d + e + f = 100%).

Table 2 Distribution matrix for malnutrition and poverty level

Poverty level (US$ per day)	M (%)	Malnourished (%)	Not malnourished (%)
<1	M1	a	b
1–2	M2	c	d
>2	M3	e	f
Totals	100%	P	Q

M_1, M_2 and M_3 are World Bank estimates of the percentage of people in each level of income poverty. P is the external estimate of the overall prevalence of child malnutrition, in this case according to the WHO Global Burden of Disease project, in Pakistan (and Q is its complement). Thus, all the marginals in Table 2 are fixed (i.e. $M_1 + M_2 + M_3 = 100\%$; $P + Q = 100\%$). The section below outlines how to estimate all the fields contained in Table 2 on the basis of the known parameters. To solve the joint distribution within the table (i.e. percentages a–f) we used the relative risks estimated above, such that:

RR_1 = relative risk associated with poverty level US$ <1 per day, compared to that associated with a poverty level of US$ >2 per day

= $(a / M_1) / (e / M_3)$ *Equation 2*

RR_2 = relative risk associated with poverty level $US >1 per day but $US <2 per day, compared to that associated with poverty level $US >2 per day

= $(c / M_2) / (e / M_3)$ *Equation 3*

Since c = (P – a – e), Equation 3 can be solved for "e":

$$RR_2 = [(P - a - e) / M_2] / (e / M_3)$$

$$e = M_3(P - a) / (RR_2M_2 + M_3) \quad \textit{Equation 4}$$

Substituting for "e" (Equation 4) in Equation 2 and solving for "a" gives:

$$a = RR_1M_1P / ((RR_2M_2 + M_3) + RR_1M_1) \quad \textit{Equation 5}$$

Having calculated "a", the remaining percentages in Table 2 can be solved using the relative risks from Table 1, the external estimate of the overall prevalence of child malnutrition in Pakistan (40.4%), and World Bank estimates for the proportions of the population in the three poverty levels M_1, M_2, M_3 (31.0%, 53.7% and 15.4%, respectively). The estimated joint distribution is shown in the 2x3 matrix in Table 3.

Table 3 Estimated joint distribution for income poverty level and malnutrition in Pakistani children 0–4 years old

Poverty level (US$ per day)	M (%)	Malnourished (%)	Not malnourished (%)
<1	31.0	16.2	14.8
1–2	53.7	21.1	32.6
>2	15.4	3.1	12.3
	100.0	40.4	59.6

8.5. Calculate the population attributable risks and burdens

Using the counterfactual scenario that those people living on less than US$ 2 per day adopt the risk-factor profile of those living on more than US$ 2 per day, and the formula shown in Equation 1, the population attributable risk is:

$$PAR = [(0.310\times2.58 + 0.537\times1.95 + 0.154\times1.0) - (1.0\times1.0)] / (0.310\times2.58 + 0.537\times1.95 + 0.154\times1.0)$$

$$= 50\%$$

That is, 50% of childhood malnutrition is attributable to poverty under this counterfactual scenario. Had the counterfactual scenario been that those people living on less than $1 per day adopt the risk factor profile of those living on greater than US$ 1 per day, the population attributable risk would have been only 13% (the calculation is not shown, but is similar to the foregoing counterfactual example).

8.6. Estimate uncertainties

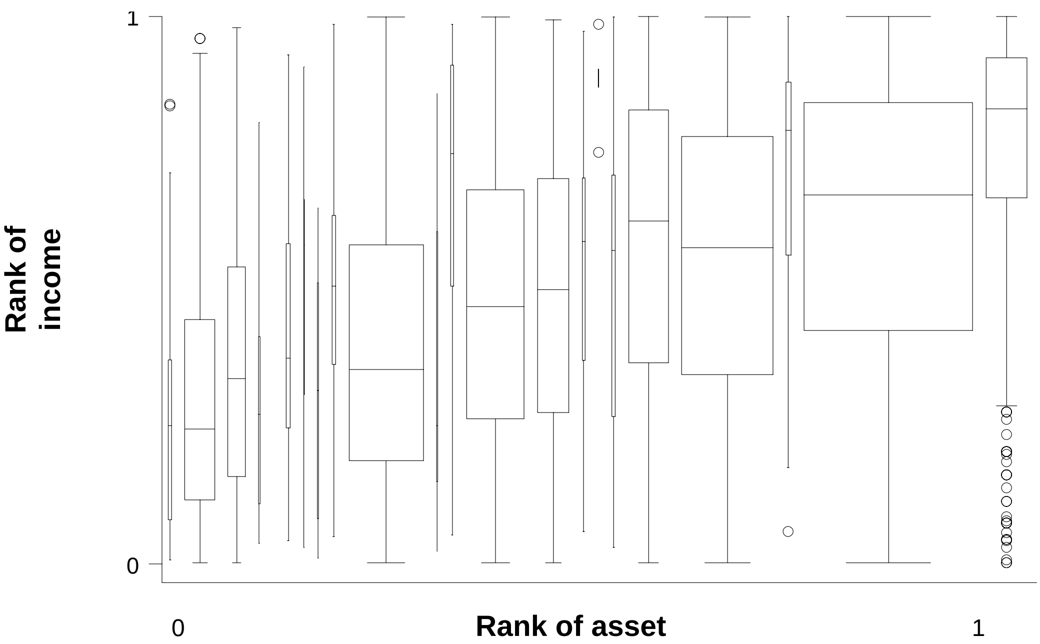
There are many uncertainties in this analysis. We present some sensitivity analyses about the main assumption: that ranking by income poverty approximates ranking by asset score. Other issues that could result in uncertainties have been addressed in Section 7.

The Pakistan Integrated Household Survey 1991, one of a series of LSMS conducted by the World Bank, included direct estimates of household income, as well as variables required to generate an asset score. Thus, we were able to examine the distribution of asset scores by income at the individual level within one country. Note that the available income data were not consumption data. Also, the asset score variables on the LSMS were not identical to those on the DHS data sets.

We calculated an asset score using a method similar to that described above, except that it was not possible to include a variable for urban–rural status, as there were no comparable data available from the LSMS.

A whisker plot of asset scores by rank of household income is shown in Figure 3.. Each box-whisker plot is for a given asset score. The boxes show the 25th and 75th percentiles of rank income for each asset score, and the whiskers show the 5th and 95th percentile ranks of income for that given asset score. It is evident that, while there is an association in the expected direction of rank asset score and rank household income, there is also considerable variation of household income ranks within a given asset score.

Figure 3 Whisker plot of the normalized rank of estimated household income by normalized rank of household asset score, for Pakistan[a]



[a] Source: LSMS data (http://www.worldbank.org/lsms). The boxes represent 25th and 75th percentiles, the whiskers 5th and 95th percentiles. Open circles represent individual data points outside of this range,

It is possible that the variation derived from poor measurements of income. Incomes also tend to be volatile, whereas assets are a more stable indicator of long-term income. This may actually be an advantage in using asset scores as the measure of income, as the analyses may be less prone to measurement error. Although the income and asset scores are not as tightly associated as we might wish, this does not mean that asset scores are an unsuitable proxy for income poverty. First, in rich countries we find similar associations between a range of socioeconomic factors and health, despite the imperfect correlation of these socioeconomic factors at the individual level (Blakely & Pearce, 2002; Blakely et al., 2002). Second, we treat income poverty as a categorical variable. Therefore, it may be more sensible to compare household income rank and asset score rank using the World Bank estimates. The result of this comparison is shown in Table 4.

Table 4 Income poverty level in Pakistan according to LSMS data[a]

		Allocation to level of poverty, by household asset score rank		
		US$ <1	**US$ 1–2**	**US$ >2**
Allocation to level of poverty, by household income rank	**US$ <1**	17%	14%	1%
	US$1–2	16%	35%	3%
	US$ >2	1%	10%	3%

[a] LSMS = Living Standards Measurement Studies.

Assuming that the income measure is a "gold standard", only 55% (i.e. 17% + 35% + 3%) of households are correctly assigned to an income category using asset score rankings.

We recommend that other researchers and analysts who might wish to pursue the methodology we have developed further investigate the appropriateness of using asset scores (or other proxies) to assign individuals to levels of income poverty.

9. Conclusions and policy implications

We have presented a method to quantify the association of risk factors with socioeconomic position, in particular, income poverty. The main reasons for undertaking this analysis are:

- to monitor inequalities in health over time within countries
- to compare inequalities in health between countries and regions
- to estimate the potential health benefits of eradicating poverty.

While we have not directly quantified the associations between socioeconomic status and health outcomes, we reasoned that differences in risk-factor profiles likely link low socioeconomic status and poor health. We therefore investigated inequalities in risk-factor prevalence as a first step towards assessing inequalities in health.

To quantify the health impact of poverty eradication on risk-factor prevalence, we used an epidemiological measure, the "population impact fraction" (or "population attributable risk"). In the absence of rigorous controls for confounding, these impact fractions may overstate the impact of poverty eradication alone. For example, it may be that if everybody living on less than US$ 2 per day in Pakistan (the example in this guide) was lifted out of poverty, then the prevalence of child malnutrition may not decrease by 50% as indicated by the impact fractions (Section 8.5, *Calculate the population attributable risks and burdens*), as persistent aspects of socioeconomic deprivation (e.g. lack of access to education) may prevent all of this gain from being realized. Nevertheless, the impact fractions reinforce the importance of income poverty as a determinant of risk-factor prevalence and, consequently, health.

The proportion of the burden of disease attributable to socioeconomic position (i.e. the impact fractions derived using the method in this chapter), and the total disease burden in a given country would decrease under either of two conditions:

- a smaller proportion of the population lives in lower socioeconomic circumstances;
- the association of socioeconomic position with the disease burden is lessened.

The results presented in this chapter highlight what might happen if income poverty is lessened (e.g. by conducting wider public-health programmes targeted at poor communities). But in practice, reducing the poverty level may not necessarily reduce the association between poverty and disease burden. This idea is supported by analyses of other risk factors for most WHO subregions (Blakely et al., 2004) The findings suggest that poverty is a major underlying determinant of health, but that poverty eradication alone will not be the panacea for improving health. Rather, both poverty eradication and appropriate public-health policies are required.

Given that reducing poverty will likely bring improvements in a range of other social and health outcomes, and for reasons of equity, poverty eradication is a desirable way to lessen health inequalities and improve the overall health status of populations. However, we should not forget that public-health policies that impact all socioeconomic groups, but in particular lower socioeconomic groups, have the potential to reduce socioeconomic inequalities in health. Providing safe water and sanitation in poor areas is a good way to lessen health inequalities between the rich and poor.

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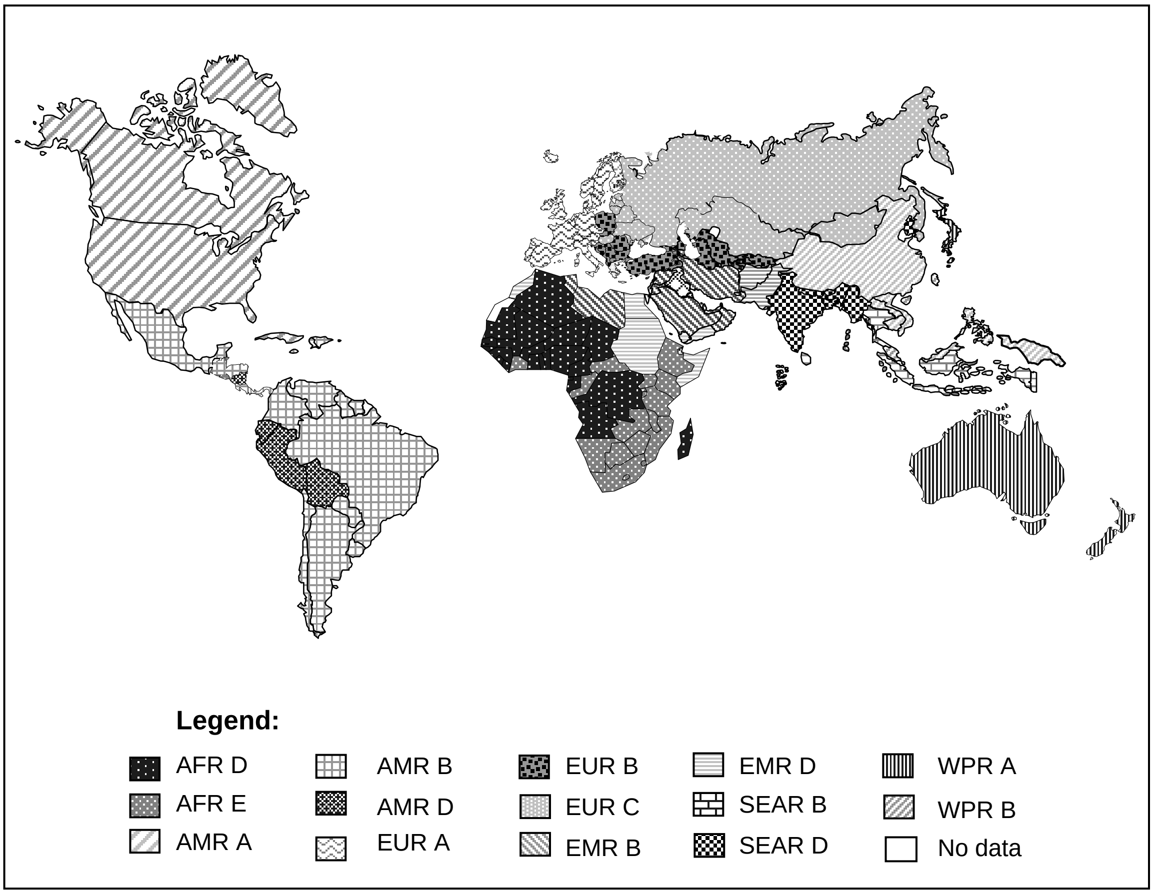
Annex 1. WHO subregions for the Global Burden of Disease study

For the purpose of the global analysis of disease burden associated with selected risk factors to health, subregions were defined by geographical region and mortality level (Figure A1.1 and Table A1.1).

Figure A1.1 WHO subregional country groupings for the Global Burden of Disease study



This is only a schematic representation. The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Table A1.1 Country grouping for the 14 WHO subregions used in the Global Burden of Disease study[a]

Subregion[b]		WHO Member States
AFR	D	Algeria, Angola, Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Comoros, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Madagascar, Mali, Mauritania, Mauritius, Niger, Nigeria, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Togo.
AFR	E	Botswana, Burundi, Central African Republic, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, South Africa, Swaziland, Uganda, United Republic of Tanzania, Zambia, Zimbabwe.
AMR	A	Canada, Cuba, United States of America.
AMR	B	Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Brazil, Chile, Colombia, Costa Rica, Dominica, Dominican Republic, El Salvador, Grenada, Guyana, Honduras, Jamaica, Mexico, Panama, Paraguay, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela.
AMR	D	Bolivia, Ecuador, Guatemala, Haiti, Nicaragua, Peru.
EMR	B	Bahrain, Cyprus, Iran (Islamic Republic of), Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, United Arab Emirates.
EMR	D	Afghanistan, Djibouti, Egypt, Iraq, Morocco, Pakistan, Somalia, Sudan, Yemen.
EUR	A	Andorra, Austria, Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, San Marino, Slovenia, Spain, Sweden, Switzerland, United Kingdom.
EUR	B	Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Bulgaria, Georgia, Kyrgyzstan, Poland, Romania, Slovakia, Tajikistan, The Former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Uzbekistan, Yugoslavia.
EUR	C	Belarus, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Ukraine.
SEAR	B	Indonesia, Sri Lanka, Thailand.
SEAR	D	Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Maldives, Myanmar, Nepal, Timor Leste.
WPR	A	Australia, Brunei Darussalam, Japan, New Zealand, Singapore.
WPR	B	Cambodia, China, Cook Islands, Fiji, Kiribati, Lao People's Democratic Republic, Malaysia, Marshall Islands, Micronesia (Federated States of), Mongolia, Nauru, Niue, Palau, Papua New Guinea, Philippines, Republic of Korea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu, Viet Nam

[a] Source: WHO (2002).

[b] Subregions: AFR = Africa; AMR = Americas; EMR = Eastern Mediterranean; EUR = Europe; SEAR = South-East Asia; WPR = Western Pacific; A: Very low child, very low adult mortality; B: Low child, low adult mortality; C: Low child, high adult mortality; D: High child, high adult mortality; E: High child, very high adult mortality.

Annex 2. Estimating the effect of socioeconomic status on health risks at the global level

The global comparative risk assessment (CRA) for socioeconomic status stratified global levels of selected risks by levels of poverty (US$ <1, US$ 1–2 and US$ >2 per day) as well as by age, sex and WHO epidemiological subregion (as described in Annex 1). This work is conducted using individual-level data – not just comparisons of regional characteristics. The mapping of risk factors by poverty was conducted for:

- childhood protein energy malnutrition
- water and sanitation
- lack of breast-feeding
- unsafe sex
- alcohol
- tobacco
- overweight
- indoor air pollution
- outdoor air pollution

In addition, available data were summarized on the links between poverty and high blood pressure, cholesterol, physical inactivity, exposure to lead, and use of illicit drugs.

Methods

The percentage of the population living on less than US$ 1, US$ 1–2, and US$ >2 was estimated for each of the 14 WHO subregions, using World Bank sponsored estimates of poverty by country. The counterfactual scenario was no absolute poverty in the world. Data on the prevalence of risk factors were obtained from parallel assessments for the specific risk factors, carried out during the CRA exercise (WHO, 2002). The associations of absolute poverty with nine risk factors were determined by an indirect method, using asset scores calculated from DHS data, and income from the World Bank LSMS and from China. First, the joint association of the asset score or income variable with the risk factor was determined for each WHO subregion. Second, the percentage estimates of poverty by WHO subregion were overlaid upon the ranked asset scores and income variables. For example, if 20% of people in a WHO subregion were estimated to be living on less than $1 per day, then the prevalence of each factor among these impoverished people was assumed to be that observed for the 20% of people with lowest asset or income scores. Third, the relative risks for each risk factor were estimated by level of poverty, based on this overlay. Finally, the proportion of each risk factor attributable to poverty for each WHO subregion (i.e. population IFs) was estimated for cut-offs of $1 and $2 per day. For each cut-off, two counterfactual scenarios were specified: (i) everyone beneath $2 was redistributed by income above $2 per day in the same proportionate manner as that observed; (ii) everyone beneath $2 was shifted to an income of exactly $2 per day.

Results

Approximately one fifth of the world's population lives on less than $1 per day and nearly one half lives on less than $2 per day. Of the 14 WHO subregions, three (EUR A, AMR A, and WPR A) had negligible levels of absolute poverty and were excluded from all subsequent analyses. In the EMR B subregion, 9% of the population lives on less than $2 per day (2% less than $1 per day), but the estimates for this subregion were based on sparse data. There were, however, more data supporting estimates for the remaining 10 WHO subregions, where the corresponding percentages ranged from 18% (3%) for EUR B to 85% (42%) for SEAR D and 78% (56%) for AFR D.

For all WHO subregions there was a strong gradient of increasing malnutrition with increasing absolute poverty. The strength of the association varies little across subregions, people living on less than $1 per day generally having 2–3 -fold higher relative risks compared with people living on more than $2 per day.

Unsafe water and sanitation, and indoor air pollution are also strongly associated with absolute poverty. For unsafe water and sanitation, the relative risks for those in households with an income of less than $1 per day, compared to those in households with an income greater than $2 per day, ranged from 1.7 (WPR B) to 15.1 (EMR D), with considerable variation between subregions. For the association of poverty with indoor air pollution, relative risks vary considerably both between and within WHO subregions. In the subregions of Africa, there is both a high prevalence of exposure to indoor air pollution and little relative difference between the impoverished and nonimpoverished.

The associations of poverty with tobacco and alcohol consumption, lack of breast-feeding, and unsafe sex (unprotected sex with nonmarital partner), are weaker and more variable between subregions. There is considerable variation between subregions in tobacco consumption, and within subregions there is a relatively weak association of tobacco consumption with poverty at the individual level. Similarly, there is a more marked variation in alcohol consumption between WHO subregions than within WHO subregions, by individual-level absolute poverty. In none of the WHO subregions analysed was there a suggestion of increasing alcohol consumption among the more impoverished. But in two WHO subregions AFR E (South Africa data only) and AMR B (Panama data only) impoverished people had approximately half the alcohol consumption of non-impoverished people. These analyses, and literature reviews, were consistent with little or no association of alcohol or tobacco with poverty in poor countries. However, these results were based on household survey data recording expenditure on alcohol (not consumption) that may not have fully captured individual consumption and consumption of nonmanufactured sources, such as alcohol distilled locally. Findings were also consistent with the higher socioeconomic groups in poor countries having more-adverse lipid profiles, high blood pressure and overweight than the poor. However, if the trends seen in the industrialized world are repeated, these patterns will reverse with economic development.

Potential impact on risk-factor levels of shifting poverty distributions

In addition to estimating the association of risk factor prevalence by poverty, population IFs of poverty on the risk factors were estimated. If people living on less than $2 per day had the same risk factor prevalence as people living on more than $2 per day, then protein-energy malnutrition, indoor air pollution and unimproved water and sanitation would be reduced by 37%, 50%, and 51% respectively (see Table A2.1). These total population impact fractions would be reduced to 23%, 30%, and 36%, if the impoverished have the same risk factor prevalence as people living on exactly $2 per day.

Other risks present a more variable pattern, although data gaps particularly limit certainty of conclusions. Nonetheless, these analyses suggest that the prevalence of alcohol consumption and being overweight would increase by approximately 20–60% in Africa overall if the prevalences of these factors among the poor matched those among the better-off. The population IFs for breastfeeding, unsafe sex and tobacco were more moderate, and even varied in direction across subregions.

Table A2.1 Population impact fractions by subregion for counterfactual scenario of population moving from living on US$ <2 per day to US$ >2 per day[a]

WHO subregion	Protein energy malnutrition (%)	Water (%)	Lack of breast-feeding (%)	Unsafe sex, men (%)	Unsafe sex, women (%)	Indoor air pollution (%)	Tobacco (%)	Alcohol (%)	Body weight (%)
AFR D	44	84	24	-17	-34	10	5	-19	-58
AFR E	42	65	-0.7	19	-9	38	-15	-38	-39
AMR B	24	68	-3	3	-5	58	4	-13	-3
AMR D	43	69	4	3	-0.4	77	-16	-6	-5
EMR B	8	17	-0.5	-	-	-	-	-	
EMR D	32	85	10	-	-	60	24	-	-17
EUR B	10	24	7	-	-	4	-4	-5	-3
EUR C	24	68	-3	-	-18	9	1	-5	
SEAR B	409	26	-19	-	-	-	-	-	
SEAR D	43	75	13	-	-	65	-	-	-65
WPR B	13	19	-34	-	-	-	0.4	-8	0.7
Totals	37	51	-2	5	-13	50	0.5	-9	-9

[a] The total population IFs apply only to subregions with population IF estimates.