Pergamon

S0277-9536(96)00073-1

Soc. Sci. Med. Vol. 44, No. 6, pp. 757–771, 1997

0277-9536/97 $17.00 + 0.00

MEASURING THE MAGNITUDE OF SOCIO-ECONOMIC INEQUALITIES IN HEALTH: AN OVERVIEW OF AVAILABLE MEASURES ILLUSTRATED WITH TWO EXAMPLES FROM EUROPE*

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Abstract—In this paper we review the available summary measures for the magnitude of socio-economic inequalities in health. Measures which have been used differ in a number of important respects, including (1) the measurement of "relative" or "absolute" differences; (2) the measurement of an "effect" of lower socio-economic status, or of the "total impact" of socio-economic inequalities in health upon the health status of the population; (3) simple versus sophisticated measurement techniques. Based on this analysis of summary measures which have previously been applied, eight different classes of summary measures can be distinguished. Because measures of "total impact" can be further subdivided on the basis of their underlying assumptions, we finally arrive at 12 types of summary measure. Each of these has its merits, and choice of a particular type of summary measure will depend partly on technical considerations, partly on one's perspective on socio-economic inequalities in health. In practice, it will often be useful to compare the results of several summary measures. These principles are illustrated with two examples: one on trends in the magnitude of inequalities in mortality by occupational class in Finland, and one on trends in the magnitude of inequalities in self-reported morbidity by level of education in the Netherlands. © 1997 Elsevier Science Ltd. All rights reserved

INTRODUCTION

There is consistent evidence throughout the world that people at a socio-economic disadvantage suffer a heavier burden of illness and have higher mortality rates than their better-off counterparts [1–3]. These socio-economic inequalities in health are a major challenge for health policy, not only because most of these inequalities can be considered unfair [4], but also because a reduction in the burden of health problems in disadvantaged groups offers great potential for improving the average health status of the population as a whole. Recognizing this, the Member States of the World Health Organization (WHO) in the European Region have adopted a strategy for Health for All (HFA) that has as its first "target":

By the year 2000, the differences in health status between countries and between groups within countries should be reduced by at least 25%, by improving the level of health of disadvantaged nations and groups [5].

This is clearly a very ambitious target, that may not be realistic everywhere. Nevertheless, it gives a clear focus to health policy and promotes the monitoring of quantitative changes over time in socio-economic inequalities in health, which is essential to assess the effects of health policy interventions. This will only work, however, if ways can be found of quantifying the "size" of socio-economic inequalities in health. Until recently, no indicators on the magnitude of health inequalities for use in monitoring progress towards the target had been specified, partly because of differences between countries in data availability and partly because of the conceptual and technical complexities involved in choosing these indicators. At the request of the European office of WHO we have prepared a set of guidelines for the measurement of socio-economic inequalities in health, especially in the context of monitoring changes over time [6]. Some of the results of this study will be summarized in this paper, and illustrated with two real-life examples drawn from different parts of Europe.

In this paper, the term "inequalities" is used in a purely descriptive sense. It is not intended to convey any message on the fairness of the differences in health between socio-economic groups, as implied by the term "inequities". Assessing to what extent certain inequalities are also inequities requires knowledge on the causes of the inequalities and a judgement as to the fairness of these causes (e.g. differences in the prevalence of specific genes between socio-economic groups would generally not be considered unfair) [4]. Therefore, inequities cannot be "measured" directly, whereas inequalities can.

Although socio-economic disadvantage occurs in many specific population groups (distinguished by

*This paper is based on a more extensive document prepared by the authors for the World Health Organization [6]. Parts of this paper were presented at the NIH conference on "Measuring social inequalities in health" (Annapolis, September 28–30, 1994).

occupation, employment status, race, sex, etc.), we focus on one generalizable dimension only: socio-economic status (SES). SES refers to an individual's relative position in the social hierarchy and can be operationalized as level of education, occupation and/or income. In this paper, socio-economic inequalities in health are defined as "differences in the occurrence of health problems between individuals of higher and lower SES".

Monitoring socio-economic inequalities in health implies repeated measurements of differences between socio-economic groups in the occurrence of health problems. This requires a large effort, even if one can use data being collected routinely, and therefore requires careful planning. A general strategy to implement a successful monitoring system could include the following steps [6]:

—assessment of data availability;
—collection of additional data, if necessary;
—analysis, interpretation and presentation of the data;
—formulating a policy response to the results, and identifying new data needs.

After the fourth step, the whole cycle may start again. In this paper, we will only deal with certain aspects related to the analysis of the data. We assume that for a target population the relevant data are available (e.g. health interview survey or mortality data by one or more SES indicators, such as level of education or occupational class) and fulfil basic criteria of internal validity, external validity and precision. We also assume that data analysis will start with a detailed description of the variation in morbidity and mortality between SES groups, and then proceed with summarizing the observed variation into one or more single figures, for example to facilitate comparisons over time or between populations. The aim of this paper is to discuss various quantitative measures of the magnitude of socio-economic inequalities in health which can be used to summarize the data.

SUMMARY MEASURES FOR THE MAGNITUDE OF SOCIO-ECONOMIC INEQUALITIES IN HEALTH: A THREEFOLD CLASSIFICATION

A wide variety of summary measures for the magnitude of socio-economic inequalities in health has been applied, and Table 1 briefly describes the 11 measures which we have identified in a search of the international literature. Table 1 also gives the relevant references. Most applications were aimed at some form of comparison, either over time or between (sub)national populations. A systematic analysis of the properties of these measures reveals that they differ substantially in a number of important respects, including:

1. The measurement of "relative" or "absolute" differences.

Most measures express the differences in the frequency of health problems between socio-economic groups in relative terms, e.g. as a percentage of the morbidity or mortality rate of the highest socio-economic groups (as in the case of rate ratios between two extreme groups), or as a percentage of

Table 1. An inventory of previously applied summary measures for the magnitude of socio-economic inequalities in health*

Basic measurement technique Index	Examples	Interpretation
Ratio of low vs high		
Extreme groups	Black Report [7], Kagamimori [8], Leclerc [9]	Morbidity rate of lowest socio-economic group as ratio of the highest group
Broad groups	Valkonen [10], Vågerö [11]	Morbidity rate of the lower broad group as ratio of the higher broad group
Percentile approach	Wilkins [12], Carr-Hill [13]	Morbidity rate of the lowest quintile as ratio of the highest quintile
Correlation and regression		
Product-moment correlation	Winkleby [14]	Correlation between morbidity rate and socio-economic status (SES)
Regression on SES	Valkonen [15], Kunst [16]	Increase in morbidity rate per one unit increase in SES
Regression on cumulative percentiles (Relative Index of Inequality; Slope Index of Inequality)	Pamuk [17, 18], Kunst [16, 19, 20]	Morbidity rate ratio (RII) or differences (SII) between the least and most advantaged person
Regression on z-values	Minder [21]	Morbidity rate difference between group with lower and higher-than-average morbidity rates (times 0.5)
Gini-like coefficients		
Pseudo-Gini coefficient	Leclerc [22]	0 = no morbidity differences between groups; 1 = all ill-health is in the hands of one person
Concentration Index	Wagstaff [23]	0 = no morbidity differences associated with SES; $-1/+1$ = all ill-health is in the hands of the least/most advantaged person
Other		
Population Attributable Risk	Leon [24], Mackenbach [25], Yeracaris [26]	% reduction in overall morbidity if all persons would have the morbidity rate of the upper group
Index of Dissimilarity	Koskinen [27], Pappas [28], Mackenbach [29]	% of overall morbidity that has to be redistributed in order to yield the same rate in each group

*Where "morbidity" is mentioned in this table, "mortality" also applies.

the morbidity or mortality rate of the population as a whole (as in the case of the Population-Attributable Risk). One can also express these differences in absolute terms, e.g. as the difference between the morbidity or mortality rates of the highest and lowest socio-economic groups.

Both perspectives are important: relative differences are usually more readily understood, but a 50% higher rate of a rare health problem may be much less important for the public's health than a 10% higher rate of a frequent health problem. Most of the relative measures mentioned in Table 1 can easily be transformed into absolute measures, and vice versa, and we argue that one should always look at both.

2. The measurement of an "effect" of lower SES on morbidity or mortality, or of the "total impact" which these inequalities in health have upon the health status of the population as a whole.

The main difference between these two perspectives is that the measures of "total impact" take into account not only the effect of decreasing SES on health but also the extent of inequalities in SES within the population, e.g. by using information on the size of the groups with lower SES. The larger the extent of inequalities in SES, the higher these measures of total impact will be. It can easily be seen that a ratio of the mortality rates among those with a low SES (measured as a fixed level, e.g. "primary school only") and those with a high SES (e.g. "university degree") gives a measure of "effect". On the other hand, if a low SES is measured as the educational level of the population quintile with the lowest educational level, and if a high SES is measured as the educational level of the population quintile with the highest educational level, as in the percentile approach mentioned in Table 1, one obtains an index of "total impact". The latter index is not only higher if the effect of one year of education on mortality is larger, but it is also higher if differences in level of education between the upper and lower quintiles are larger. Other measures of "total impact" in Table 1 are the Relative Index of Inequality and Slope Index of Inequality, both developed by Pamuk, the Gini-like coefficients, and the Population-Attributable Risk and Index of Dissimilarity.

It is very much a matter of a priori choices whether one should or should not take into account the extent of inequalities in SES within the population. The size of the groups with lower SES is largely outside the sphere of influence of public health policy, and this supports using a measure that focusses on the modifiable aspect: the effect of a lower SES on health. On the other hand, some features of the distribution of the population across socio-economic groups (e.g. the income distribution) can be addressed by policy-makers, and this speaks in favour of using the more comprehensive measures of total impact. We recommend using both types of measure and making a judgement based on a comparison of the results.

3. Simple versus sophisticated measurement techniques.

It is quite obvious from Table 1 that there are huge differences between the measures in degree of sophistication. Simple measures such as rate ratios or rate differences between a lower and a higher group, and the Population-Attributable Risk and Index of Dissimilarity have the advantages of easy calculation and straightforward interpretation, and in addition do not pose many restrictions on the data used in their calculation. More specifically, the required measurement scale for the independent variable, SES, is ordinal or even nominal only. The problem with these simple measures, however, is that they ignore parts of the available information. The rate ratio measures do not take into account the morbidity or mortality rates of the SES groups between the highest and lowest groups. The Population-Attributable Risk and the Index of Dissimilarity ignore practically all information on the nature of the association between SES and the frequency of health problems: they cannot distinguish between a systematic (e.g. linear) relationship and a non-systematic relationship.

More sophisticated measures, particularly the regression-based measures, do take more of the available information into account but only at the expense of greater complexity and more restrictions on the data used in their calculation. Regression-based indices require the SES variable to be measured on an interval scale, which may be problematic, especially for occupation as an indicator

Table 2. A systematic overview of possible summary measures for the magnitude of socio-economic inequalities in health. *In italics: "absolute" versions of measures*

Degree of sophistication	Indices of effect	Indices of total impact	
		No inequalities = everyone has (health of) high SES	No inequalities = everyone has (health of) average SES
Simple	Rate ratio of lowest vs highest group	Population Attributable Risk (PAR) (%)	Index of Dissimilarity (ID) (%)
	Rate difference of lowest vs highest group	*PAR (absolute version)*	*ID (absolute version)*
Sophisticated	Regression-based index of relative effect	Regression-based PAR (%)	Relative Index of Inequality (RII)
	Regression-based index of absolute effect	*Regression-based PAR (absolute version)*	*Slope Index of Inequality (SII)*

of SES. Perhaps a good recommendation is that policy-makers should always ask for simple measures but that researchers should always try to check the results obtained with simple measures against the results obtained with methodologically more refined measures.

Based on this analysis of summary measures which have previously been applied, we have developed the threefold classification presented in Table 2.

TWELVE DIFFERENT SUMMARY MEASURES

The three characteristics identified above can be combined into eight different classes of summary measures. Because, as will be shown below, the measures of "total impact" can be further subdivided in two groups on the basis of their underlying assumptions, we finally arrive at 12 types of summary measure, each represented by a cell in Table 2. For each type the table mentions our recommended example. Our preferences are partly based on our evaluation of the adequacy of each measure, and partly based on a desire to develop a set of indices which have clear interrelationships. For example, we ignore the pseudo-Gini coefficient because this does not adequately take into account the hierarchical nature of the SES variable [23]. We also ignore the Concentration Index, partly because of a number of practical problems (such as the difficulties of calculating a confidence interval and of adjusting for confounding variables), and partly because it has been shown to be mathematically similar to the Relative Index of Inequality [23], which is a regression-based measure and therefore relates clearly to the other regression-based measures in Table 2.

This systematic development of a set of possible measures identifies several measures that have not yet been applied (such as the absolute and sophisticated versions of the Population-Attributable Risk). We briefly describe each of these possibilities, which are numerically illustrated in the Appendix. We recommend reading this section together with the Appendix, because the latter contains details of calculations which are essential for understanding the measures. We start with four measures of "effect".

1. Rate ratio of lowest versus highest SES group.

There is substantial flexibility in the choice of the groups to be compared. For example, trends in inequalities in mortality in England and Wales have been studied by ratios comparing social classes V to I, by comparing classes IV + V to classes I + II, or by comparing manual to non-manual workers. As a general rule, the choice of the groups to be compared should be a compromise between two conflicting requirements. The two groups should not be so extreme that the summary measure ignores most of the existing health inequalities and is sensitive to the idiosyncrasies of the two groups, but the two groups should not be so broad that the summary measure conceals the real extent of health inequalities in the population.

2. Rate difference of lowest versus highest SES group.

The absolute equivalent to the ratio of the rates is the difference between the rates of two groups that are compared.

3. Regression-based relative effect index.

A drawback of indices 1 and 2 is that they only take into account health inequalities between the two socio-economic groups that are compared, and that they ignore all other health differences (either within the two groups, or with groups that are excluded from the comparison). For that reason, sophisticated indices have been developed that consider all socio-economic groups separately and that assess how morbidity and mortality rates vary according to the SES of these groups. A convenient way of doing this is to apply a regression analysis in which morbidity or mortality rates (the dependent variable) are related to SES (the independent variable). As mentioned before, this requires SES to be measured on an interval scale (e.g. years of education, average income level in monetary units). For occupation this is problematic, although one might consider using prestige or similar one-dimensional scales. Depending on the specifications of the regression model, this approach produces a relative effect index (as in logarithmic or logistic transformations of the dependent variable, where regression coefficients translate into Relative Risks or Odds Ratios), or a regression-based absolute effect index, as discussed next.

4. Regression-based absolute effect index.

In the case of regression analysis of untransformed morbidity or mortality rates on, for example, years of education or income in US$, an absolute measure of effect is generated. Usually, the absolute effect index can easily be transformed into a relative effect index (and vice versa) by relating it to the estimated rate of health problems in the reference category.

We continue with a number of measures of "total impact", all related to a measure familiar to epidemiologists, the Population-Attributable Risk.

5. Population-Attributable Risk (%).

Although the Population-Attributable Risk (PAR), sometimes also called the Etiologic Fraction, is part of the standard repertoire of epidemiology, its application to the study of health inequalities is fairly recent. This measure can be interpreted as the proportional reduction in overall morbidity and mortality rates that would occur in the hypothetical case that everyone experiences the rates of the highest socio-economic group. It is calculated as the difference between the overall rate and the rate for the highest socio-economic group, expressed as a percentage of the overall rate. The PAR not only reflects the morbidity and mortality rates of lower socio-economic groups (as compared with the highest socio-economic group) but also their population size: the larger the groups with high rates, the larger the potential reduction in overall rates is.

6. Population-Attributable Risk (absolute version).

Multiplying the PAR by the overall rate yields a measure of the absolute reduction in the overall rate in the hypothetical case that everyone experiences the rates of the highest socio-economic group.

7. Regression-based Population-Attributable Risk (%).

The simple calculation of the PAR is achieved at the price of ignoring the association between SES and morbidity and mortality among the socio-economic groups below the reference group. A more sophisticated index could be used—but has not yet been applied—that takes into account the association between SES and morbidity and mortality across the entire social hierarchy. Just as with the effect indices, this sophisticated version of the PAR can be calculated by means of a regression analysis. The first step is to calculate the regression-based effect index (3 or 4), and the next step is to recalculate the PAR. This calculation is identical to that of the "simple" PAR, except that the reference rate is not the observed rate of the highest socio-economic group, but the predicted rate estimated for some high SES value (e.g. 20 years of education). The corresponding interpretation is: the proportional reduction in overall morbidity and mortality rates that would occur in the hypothetical case that everyone experiences the rate that corresponds to 20 years of education or any other high SES value according to the regression model.

8. Regression-based Population-Attributable Risk (absolute version).

An absolute version of index 7 can be obtained by multiplying by the morbidity or mortality rate in the population as a whole.

Finally, we describe four alternative measures of "total impact". These measures were first used in the study of trends in inequalities in mortality in England and Wales and were applied to take into account the changing distribution of the population over social classes and, more specifically, to take into account the decrease over time in the proportion of workers in unskilled manual occupations. The calculation procedures that were developed account for the number of people in each social class. As a consequence, these measures, perhaps inadvertently, turned out to be measures of total impact.

9. Index of Dissimilarity.

The Index of Dissimilarity (ID) can be interpreted as follows: the percentage of all cases (e.g. ill individuals or deaths) that has to be redistributed to obtain the same morbidity or mortality rate for all socio-economic groups. The ID is larger if the groups with the highest and lowest rates are larger. This usually implies that the ID is larger if a relatively large part of the population are in the lowest and highest socio-economic groups and relatively few people occupy intermediate positions. In other words, the ID is larger if inequalities in socio-economic variables themselves are relatively large.

It is important to note that the ID's interpretation is subtly but significantly different from that of the PAR: whereas the ID reflects the extent to which the population distribution approaches the situation of an equal average socio-economic level for all, the PAR reflects the extent to which the population distribution approaches the situation of an equal high socio-economic level for all (e.g. post-secondary education, or a specific high income level). The choice between the ID and the PAR largely depends on which perspective is considered most appropriate in a specific situation. The assumption behind the ID is that socio-economic inequalities in health are a redistribution problem, which can be solved by lowering the morbidity or mortality rates of the lower socio-economic groups at the cost of raising the rates of the higher socio-economic groups. The assumption behind the PAR is, that socio-economic inequalities in health can be reduced by lowering the morbidity or mortality rates of the lower socio-economic groups to the level as observed in the higher socio-economic groups. In the case of health inequalities by income level the redistribution perspective may be appropriate, but in the case of health inequalities by educational or occupational level this is much less so and the PAR may be considered a more appropriate measure.

10. Index of Dissimilarity (absolute version).

Multiplying the ID with the overall rate yields a measure of the absolute number of cases that has tobe redistributed to obtain equality in morbidity/mortality.

11. Relative Index of Inequality.

A drawback of the ID is that it does not take into account whether high morbidity and mortality rates are found in the lower, the higher or intermediate socio-economic groups. This was a reason to develop the Relative Index of Inequality (RII), a sophisticated measure that takes into account both the population size and the relative socio-economic position of groups. It does so by regressing the morbidity or mortality rate of SES groups on a very specific measure of their relative position: the proportion of the population that has a higher position in the social hierarchy. The resulting figure can be interpreted as the ratio of the morbidity and mortality rates of those at the bottom of the social hierarchy compared with those at the top of the hierarchy, estimated on the basis of the systematic association between morbidity or mortality and SES for all groups. A large score on the RII implies large morbidity and mortality differences between high and low positions in the social hierarchy. This large morbidity and mortality difference can be attributed to:

—a large effect of SES on morbidity and mortality, that is, a large score on the effect index; and/or
—large differences between high and low social positions in the socio-economic indicator itself, that is, large inequalities in socio-economic variables themselves.

With regard to the latter component, the interpretation of the RII is analogous to that of the ID, and thus contrasts with that of measures similar to the PAR.

12. Slope Index of Inequality.

The absolute equivalent to the RII expresses the health inequality between the top and bottom of the social hierarchy in terms of rate differences instead of rate ratios.

EXAMPLE 1: TRENDS IN THE MAGNITUDE OF INEQUALITIES IN MORTALITY BY OCCUPATIONAL CLASS IN FINLAND

Finland has one of the best sources of data on mortality by SES in the world. Due to the use of a personal identification number, data on mortality from the national mortality registry can be linked to socio-economic characteristics of the deceased as registered at the last census. This linkage started with the 1971 census and involved following up for mortality persons enumerated during that census. For this illustration we use data collected during the period 1971–90. Although both occupational class and educational level are available in this material, we will only present data on mortality by occupational class, and we further restrict this illustration to the age-group 35–64 years. All data used were published by the Department of Sociology of Helsinki University (Professor Valkonen and co-workers), in collaboration with Statistics Finland [30].

Table 3 presents some basic data on the situation in 1971 and 1990, respectively. Four occupational groups are distinguished (except for a group of other occupations which consists mainly of self-employed persons other than farmers): upper white-collar employees, lower-white-collar employees, workers and farmers. Forming such broad groups achieves good comparability over time. The occupational data of the deceased (numerator) and of the living population (denominator) were obtained during the various censuses. Economically active people were classified according to the occupation reported during the census. Pensioners and unemployed people were classified according to their former occupation as reported during a previous census. Housewives and other family members were classified according to the head of household's occupation.

Table 3. Distribution (%) of the Finnish population aged 35–64 years across occupational classes, 1971 and 1990

	Men		Women	
Occupational class	1971	1990	1971	1990
Upper white collar	7.9	15.7	6.4	11.6
Lower white collar	13.3	17.4	23.4	41.4
Workers	49.6	48.4	40.1	32.9
Farmers	21.6	9.2	21.9	7.3
All (including other occupations)	100.0	100.0	100.0	100.0

Source: [30].

Table 4. Standardized Mortality Ratios by occupational class, Finland, ages 35–64 years

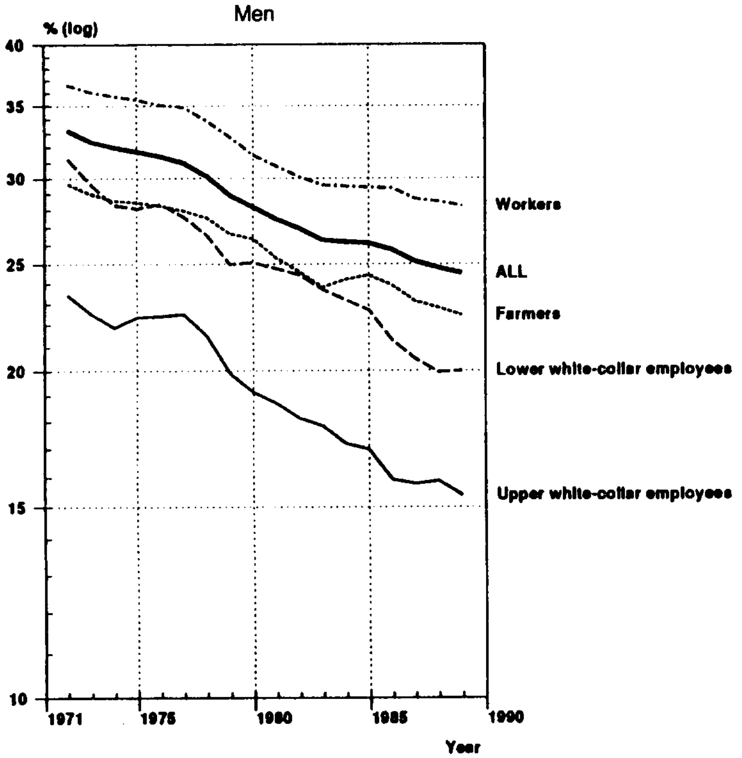
	Men		Women	
Occupational class	1971–75	1986–90	1971–75	1986–90
Upper white collar	65	57	82	80
Lower white collar	88	79	93	87
Workers	114	121	111	115
Farmers	88	92	92	104
All (including other occupations)	100	100	100	100

Source: [30].

Similar to many other occupational classifications, the Finnish classification is not strictly hierarchical. Upper white-collar employees are higher in the social hierarchy than lower white-collar employees, but the latter are not necessarily all higher than workers. The relative position of farmers is even more difficult to determine. This actually precludes the use of sophisticated summary measures for the size of socio-economic inequalities in health, because these require an unambiguous ordering of groups from high to low.

As a measure of mortality, Table 4 presents the Standardized Mortality Ratios for mortality between ages 35 and 64. This measure expresses the age-standardized mortality rate in a specific occupational class as a percentage of the mortality rate among all men or women between 35 and 64. For example, in 1971–75, men in upper white-collar occupations had a Standardized Mortality Ratio of 65, which implies that their mortality rate was 35% below the average for all men aged 35–64 years. When 1971–75 is compared with 1986–90 it appears that differences in mortality have increased, for both men and women. The gap between the Standardized Mortality Ratios of upper white-collar employees and workers has widened. As the Standardized Mortality Ratio measures mortality relative to the average for the whole population, it is not yet clear whether the absolute differences also increased.

Answering this question requires different measures of mortality, such as mortality rates (per 1000 person-years) or the probability of dying between the ages of 35 and 64 years. The latter, life-table based measure was used in Fig. 1, which shows the trends in mortality by occupational class between 1971 and 1989. Between 1971 and 1989 the probability of dying declined among men and among women and in all occupational classes. As these figures use a logarithmic scale, the increasing distance between the lines for workers and upper white-collar employees still only suggests widening relative



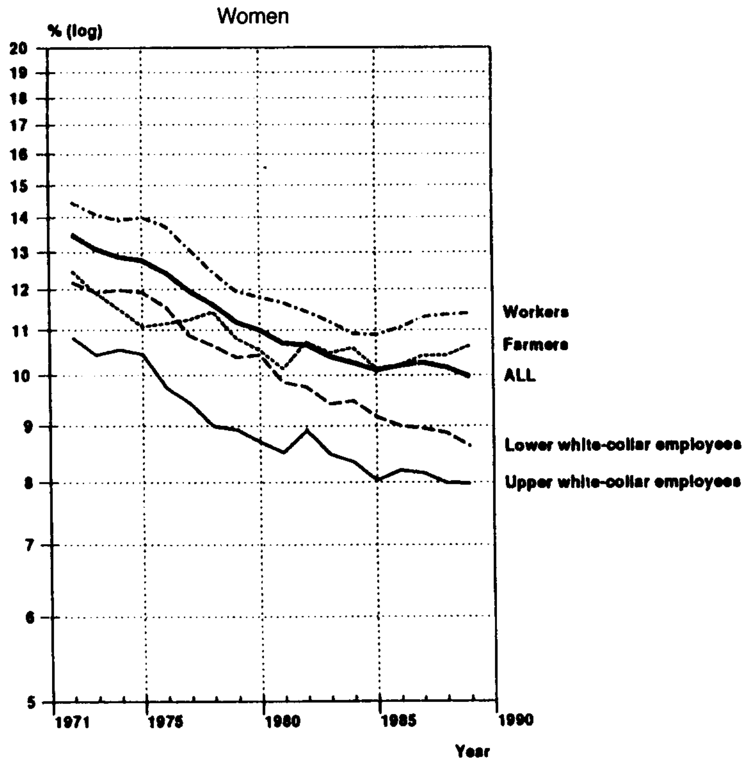


Fig. 1. Probability of dying between ages 35 and 65 of Finnish men and women, by occupational class, 1971–1990. Source: [30].

Table 5. Summary measures on inequality in mortality by occupational class among Finnish men and women aged 35–64 years, 1971–75 and 1986–90

Summary measure (95% confidence interval)[a]	Men 1971–75	Men 1986–90	Women 1971–75	Women 1986–90
Ratio of probability of dying[b]	1.58 (1.52–1.64)	1.86 (1.80–1.92)	1.34 (1.26–1.42)	1.41 (1.33–1.49)
Difference between probability of dying (%)[b]	13.2 (11.9–14.6)	13.3 (12.9–13.7)	3.6 (2.7–4.5)	3.3 (2.7–4.0)
Population attributable risk (%)[c]	30.0 (27.2–32.8)	38.0 (35.8–40.0)	19.5 (17.6–21.5)	20.4 (15.9–24.6)
Population-attributable risk × overall probability of dying (%)	9.8 (8.9–10.7)	9.5 (8.9–9.9)	2.6 (2.3–2.9)	2.1 (1.6–2.5)
Index of Dissimilarity (%)	7.5	11.7	4.9	7.4
Index of dissimilarity × overall probability of dying (%)	2.5	2.9	0.7	0.8

[a] Only approximate confidence intervals could be estimated with the published data. No formula is available to calculate confidence intervals for the index of dissimilarity.
[b] Workers versus upper white-collar employees.
[c] Upper white-collar employees as reference category.

differences, and not necessarily widening absolute differences.

Table 5 shows that the ratio of the probability of dying among workers as compared with upper white-collar employees increased among both men and women, although among women the confidence intervals for the two periods overlap. The absolute differences, however, remained more or less the same among men and have decreased among women. This is explained by the strong decline of mortality over time. It should be noted, however, that in recent years the mortality decline has reversed and mortality rates are increasing among some groups of women (Fig. 1).

The Population-Attributable Risk (PAR) (%) also increased, along with the increase of the relative differences. Thus, despite the declining proportion of Finns classified as workers, the percentage of all deaths which can be avoided by lowering the mortality rate of the whole population to that of upper white-collar employees has gone up, especially for men. This increase in the total impact of inequalities in mortality only occurred in relative terms. Due to the decline of mortality over time, the absolute version of the PAR became smaller.

Finally a large increase is observed for the ID (%). Even the absolute version of this index increased for both men and women. This increase in the ID (%) can be explained by an increase in the variation within the population in occupational status. As shown in Table 3, many men and women were workers in 1971, whereas by 1990, the spread over occupational classes was much more even. This implied an increase in the proportion of men and women in jobs with higher status (thus contributing to a more modest increase of the PAR (%)) but also a larger overall variation within the population in occupational status (thus leading to a large increase in the ID (%)).

This shift of the population towards higher occupational classes thus is valued differently by the PAR and by the ID. The PAR reflects the fact that, because of this shift, more people assume the favourable mortality pattern of the higher occupational classes, whereas the ID reflects the fact that the differences in occupational status relative to the population average have increased. Policy-makers may decide which of these two perspectives should be chosen in this case.

This experience of widening relative inequalities in mortality at adult ages in Finland is by no means unique. In several other countries, a widening of the mortality gap has been reported too [7, 18, 27, 28, 31, 32]. Most of these reports, however, come from the 1970s, and Finland was the first country for which individual-level data on trends in inequalities in mortality during the 1980s were available.

The report from which these data come shows that the widening of relative inequalities in mortality can also be demonstrated by using education as a socio-economic indicator instead of occupational class. The trend of mortality in the higher occupational and educational groups is more favourable, largely because mortality from cardiovascular diseases declined more than in the lower groups. No decline was seen among farmers. Inequalities in total mortality at older ages (≥ 65 years) were roughly stable between 1971 and 1990 [30].

EXAMPLE 2: TRENDS IN THE MAGNITUDE OF INEQUALITIES IN SELF-REPORTED MORBIDITY BY LEVEL OF EDUCATION IN THE NETHERLANDS

Statistics Netherlands has conducted a continuous, national health interview survey since 1981. It is conducted among a random sample from the non-institutionalized population of nearly 10,000 respondents each year and contains questions on a number of health indicators as well as on such socio-economic characteristics as level of education, occupation and household income [33, 34]. It is the major continuous source of information on socio-economic inequalities in health in the Netherlands, because no data on mortality according to SES are routinely collected. Since 1981, data have accumulated and now permit an assessment of changes over time in the size of socio-economic inequalities in

Table 6. Percentage of the survey population with perceived general health less than "good" according to level of education in the Netherlands, aged 16, 1983–1985 and 1992–1993

	Distribution of sample according to educational level		% less than "good"	
Educational level	1983–85	1992–93	1983–85	1992–93
Elementary	25.2	21.7	29.7	34.5
Secondary, low	30.1	23.1	20.3	22.4
Secondary, high	30.9	36.7	16.6	17.4
Post-secondary	13.8	18.5	13.5	13.3
Total	100.0 (n = 22,229)	100.0 (n = 14,369)	20.6	21.5

Source: Unpublished data of Statistics Netherlands.

health. Jaap van den Berg of Statistics Netherlands kindly made available the data used here.

We focus on trends in the magnitude of health inequalities according to educational level. Comparing trends in health inequalities according to income level or occupational status is more difficult because, respectively, the income classes distinguished in survey questionnaires change, and because information is lacking on the last occupation of part of the economically inactive population.

The health indicator used is perceived general health. This indicator is based on a single item question included in the Netherlands' Health Interview Survey since its start in 1981: "How is your health in general", after which the respondent may choose between "very good", "good", "fair", "sometimes good, sometimes poor" and "poor". Slightly different response categories were distinguished in the first two survey years (1981–82), and because this could lead to biased estimates of changes in the magnitude of health inequalities after 1981–82, our trend analysis starts with later years (1983–85).

Table 6 presents some basic data on differences in perceived general health, measured as the percentage of respondents rating their health as less than good, according to level of education.

Figure 2 illustrates these differences graphically. All data are age- and sex-standardized and apply to ages 16 and over. A clear gradient existed in both 1983–85 and in 1992–93: the percentage rating health as less than "good" declined regularly with increasing educational level. Over time the prevalence of "less-than-good" perceived general health increased in most educational groups. The important thing is that the prevalence rate in the lower educational groups has not declined as prescribed by the Health for All target. At the same time, the relative size of each of the educational groups has changed substantially.

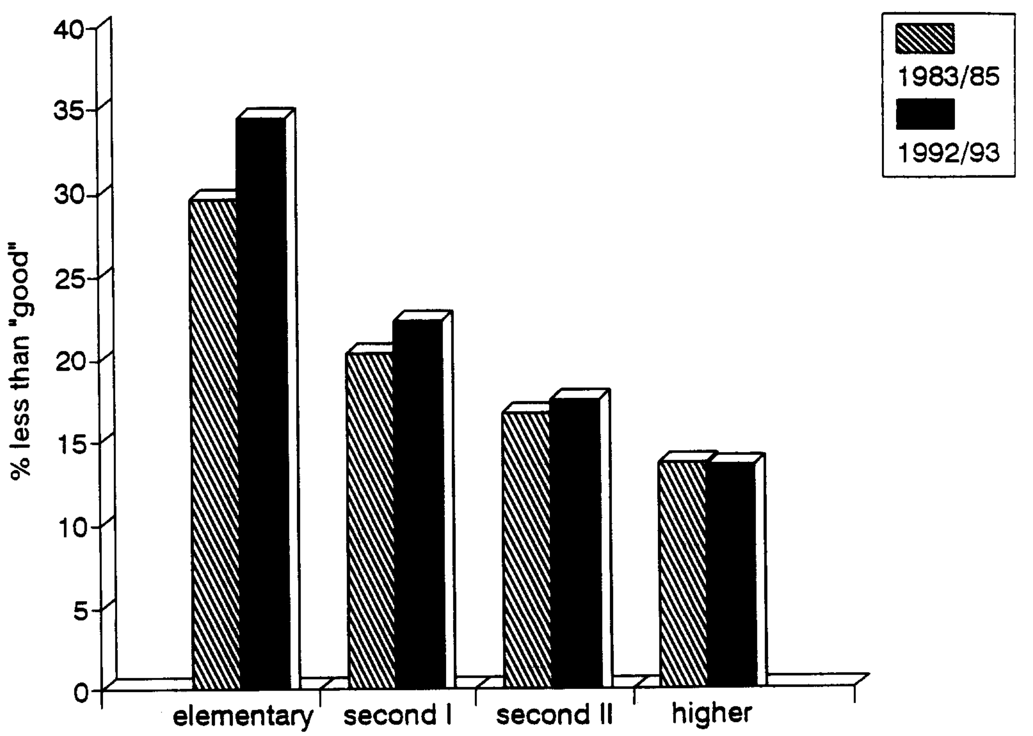


Fig. 2. Perceived general health less-than-"good" by level of education in the Netherlands, men and women combined, ages 16 +, 1983–85 and 1992–93.

Table 7. Simple summary measures on inequalities according to level of education in perceived general health in the Netherlands, 1983–85 and 1992–93

Summary measure (95% confidence interval)	1983–85	1992–93
Rate Ratio[a]	2.20 (1.99–2.43)	2.59 (2.34–2.88)
Rate Difference[a] (%)	16.2 (13.4–19.3)	21.2 (17.8–25.0)
Population Attributable Risk[b] (PAR; %)	34 (29–40)	38 (32–44)
PAR × overall rate (per 100 persons)	7.1 (6.0–8.2)[c]	8.2 (6.9–9.5)[c]
Index of Dissimilarity (ID; %)	11.7[d]	14.1[d]
ID × overall rate (per 100 persons)	2.3[d]	3.0[d]

[a] Elementary education versus post-secondary education.
[b] Post-secondary education as reference category.
[c] Confidence intervals are calculated with formula given in [35].
[d] No formulas are available for the calculation of confidence intervals.

The lower two groups have become smaller, and the higher two groups have become larger (Table 6).

Table 7 presents some simple summary measures for the magnitude of socio-economic inequalities in perceived general health in 1983–85 and in 1992–93. Such measures of effect as the Rate Ratio (a relative measure) and the Rate Difference (an absolute measure), appear to demonstrate a substantial increase in inequalities in health. The gap in perceived general health between those with elementary school only and those with post-secondary education has become larger.

A slightly different picture emerges from the PAR (%) and the product of the PAR and the average prevalence rate. The PAR increased, but to a smaller extent than the Rate Ratio, because the increase in the Rate Ratio was in part compensated for by the diminishing size of the lower educational groups. The proportion of the overall prevalence of perceived ill-health attributable to the higher prevalence in lower educational groups thus increased only slightly.

The ID (%) and the product of this index and the average prevalence rate increased much more. This increase occurred not only because the Rate Ratio increased, but also because the inequality within the population in educational level increased. As shown in Table 6, the share of the population having a low educational level declined (thus preventing a large increase in the PAR), but the variation in educational level in general increased (thus contributing to the large increase in the ID).

The same pattern emerges from Table 8, which presents the sophisticated summary measures calculated using the same data. To calculate the regression-based measures of effect, the educational levels had to be converted into some numerical measure. The minimum number of years of education needed to achieve these educational levels was used for this (6, 9, 12 and 17 years, respectively, for each of the four educational levels). The regression-based index of relative effect is 1.104 in 1983–85, which implies that one year of education less increased the prevalence of less-than-good perceived general health by 10.4%. (Actually, the index refers to the prevalence odds and not to the prevalence rate.) The estimate for 1992–93 is 12.6%, which implies an increase of about 20%. The confidence interval estimates hardly overlap, which shows that this increase is probably not simply a matter of random variation.

The regression-based PAR yields estimates that are larger than the simple PAR measure. This is because the observed rate of health problems in the group with post-secondary education (13.5 and 13.3 in the two periods) is higher than the rate expected in this group based on regression analysis (11.4 and 11.2 in the two periods). The regression-based PAR increased over time by about 7%. This suggests that the overall importance of health inequalities increased slightly over time, as the result of two opposing developments: the substantial increase in the effect of educational level on morbidity rates and the diminishing size of the groups with less education.

The RII increased from 3.45 to 4.69, that is, by about one half of its initial value (less 1). This increase is even larger than the increase in its simple

Table 8. Sophisticated summary measures on inequalities by level of education in perceived general health in the Netherlands, 1983–85 and 1992–93

Summary measure (95% Confidence Interval)	1983–1985	1992–1993
Regression-based measure of relative effect[a]	1.104 (1.093–1.115)	1.126 (1.113–1.139)
Regression-based measure of absolute effect[b]	1.03 (0.92–1.14)	1.24 (1.11–1.37)
Regression-based PAR (%)[c]	44.7 (40.0–49.4)	47.9 (43.0–52.8)
Regression-based PAR (absolute version; per 100 persons)[c]	9.2 (8.2–10.2)	10.3 (9.2–11.4)
Relative Index of Inequality[d]	3.45 (3.06–3.90)	4.69 (4.04–5.45)
Slope Index of Inequality[e]	19.9 (16.7–23.6)	25.3 (20.8–30.5)

[a] Odds ratio for one year less education.
[b] Predicted rate difference (per 100 persons) between those with 17 and 16 years of education.
[c] 17 years of education as reference value.
[d] Predicted odds ratio for bottom vs top of educational hierarchy.
[e] Predicted rate difference (per 100 persons) between those at the bottom and at the top of the educational hierarchy.

equivalent, the ID. The confidence intervals show that this increase is not simply a matter of random variation.

Is the increase in inequalities in less-than-good perceived general health an artefact related to changes in reporting behaviour? The increase in the prevalence of less-than-good perceived general health among groups with less education could have resulted from, for example, an increasing propensity to complain or changes in the criteria against which one's own health status is evaluated. Although this suggestion is purely speculative, it indicates the necessity to look, for example, at other, possibly more objective health indicators as well.

The results convey the disappointing message that the effect of educational level on less-than-good perceived general health increased substantially in the Netherlands between 1983–95 and 1992–93. This increasing effect was accompanied by an increase in the total impact of health inequalities on the prevalence of less-than-good perceived general health in the general population. Whether this increase in total impact is small or large depends on the perspective chosen. If one wants to emphasize the fact that the variation in educational levels within the total population has increased, the conclusion should be drawn that the total impact of health inequalities has increased substantially. In this case, however, we prefer the PAR perspective, which emphasizes the decline in the share of people that are in groups with less education. According to this perspective, the impact of the observed health inequalities on the prevalence of less-than-good perceived health in the Netherlands has only increased modestly.

The unfavourable development observed here should prompt the examination of trends in health inequalities in the Netherlands in more detail, for example, by considering more specific health indicators of physical, mental or social health and by looking at changes in health differences between people with high and low income or occupational status.

DISCUSSION

In this paper we presented a framework for measuring the magnitude of socio-economic inequalities in health, which was developed in the context of the efforts of the WHO European region to monitor changes over time. We believe that this framework will prove to be useful in other contexts and in other continents too. The framework identifies the different perspectives which can be chosen, recognizes the complementarity of simple and more sophisticated approaches, and suggests a whole series of summary measures, none of which should be considered to be intrinsically superior. The examples from Finland and the Netherlands show that it is indeed useful to compare the results obtained with different summary measures.

A previous review of measures of socio-economic inequalities in health [23] assessed six different measures, using the following three "minimal requirements . . . : that it reflect the socio-economic dimension to inequalities in health; that it reflect the experiences of the entire population (rather than just, say, social classes I and V); and that it be sensitive to changes in the distribution of the population across socio-economic groups." The authors, Wagstaff *et al.*, evaluated the following measures: the "range" (equivalent to what we have called the rate ratio or rate difference between two extreme groups); the Gini-coefficient (not considered by us because this does not measure socio-economic inequalities in health but the total amount of inter-individual inequality in health in the population); the pseudo-Gini coefficient; the Concentration Index; the Index of Dissimilarity; the Slope (and Relative) Index of Inequality. They concluded that only the Concentration Index and the SII and RII fulfilled the three "minimal requirements" and that the other measures may produce misleading results.

While we agree with many of Wagstaff *et al.*'s remarks, and indeed regard their paper as a milestone in the history of the measurement of socio-economic inequalities in health, we hold different views with regard to the intrinsic value of some of the summary measures which they rejected, especially the "range" and the ID. In passing, it is worth noting that the regression-based indices of effect and the PAR in its various forms were not included in Wagstaff *et al.*'s review.

The main reason why our evaluation of the summary measures sometimes differs from Wagstaff *et al.*'s, is that we do not agree with their "minimal requirements", especially with the third one, which states that a measure of the size of inequalities in health should be sensitive to changes in the distribution of the population across socio-economic groups. As we have argued in this paper, measuring the "effect" of lower SES on health is not less legitimate than measuring the "total impact" which socio-economic inequalities have on the health of the population as a whole. Both are important and, for health policy in a narrower sense of the word, measures of "effect", which ignore the distribution of the population across socio-economic groups, may be more relevant, e.g. for the evaluation of specific interventions, than measures of "total impact".

Also, although we share Wagstaff *et al.*'s criticism of the "range" and the ID, we think that a judicious use of these simple and straightforward measures should complement the use of more sophisticated measures. Some of these, especially the SII, RII and Concentration Index, have a complex interpretation and can easily lead to misunderstandings. The study of socio-economic inequalities in health frequently aims at informing policy-makers, who are quite right in preferring simple and straightforward measures. Nevertheless, it is true that the "range" measure ignores the experience of the in-between social groups and that the results of the easily comprehensible "range" measure should be checked against the results of, for example, the regression-based effect indices. It is also true, as Wagstaff *et al.* write, that the ID does not accurately reflect the socio-economic dimension of socio-economic inequalities in health: for example, a negative and a positive gradient will produce the same value for the ID. This can, however, easily be remedied by looking at the data before the calculations are done and by comparing the results with those obtained using the RII or SII.

We would like to end with a few words of caution. We have presented a framework consisting of a consistent set of 12 summary measures for the size of socio-economic inequalities in health. This may give the wrong impression, that the most important issue in measuring the size of these inequalities relates to the choice of a particular summary measure. It does not. The choice of such a measure is only a problem to those who find themselves in the rather luxurious situation of having data of reasonable quality, and it is only in a few countries that this is the case, especially if one is interested in monitoring trends in the size of socio-economic inequalities in health. Nevertheless, when data are available, our framework may help facilitate a mental grasp of the size of these inequalities and their changes over time.

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Table A1

Educational level	Number of persons (1)	Population share (2)	Number of persons with health problems (3)	Rate of health problems (per 10,000 population) (4)	Rate ratio (5)	Rate difference (per 10,000 population) (6)
Post-secondary	10,000	0.10	50	50	1.0	0
Secondary, upper level	20,000	0.20	120	60	1.2	10
Secondary, lower level	30,000	0.30	240	80	1.6	30
Elementary	40,000	0.40	400	100	2.0	50
Total	100,000	1.00	810	81	n.a.	n.a.

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APPENDIX

The calculation of 12 different summary measures for the magnitude of socio-economic inequalities in health.

Table A1 contains a fictitious example of socio-economic inequalities in health at one point in time. It describes differences in the prevalence of health problems by educational level in a population of 100,000 persons. In column 4 of Table A1, the prevalence rate in each of the four educational groups is given, this figure being calculated from the numbers of persons with health problems in column 3, and the total number of persons in column 1. In order to reduce the complexity in this example, it is assumed that the age composition of each of the four groups is identical, so that age standardization is not necessary. From the figures in column 4, both rate ratios (a measure of relative differences, column 5) and rate differences (a measure of absolute differences, column 6) have been calculated.

Rate ratio and rate difference of lowest vs highest SES group. Using the data that are presented in Table A1, various measures can be calculated to summarize the size of the effect of educational level on the frequency of health problems. A simple measure is the rate ratio or rate difference of the lowest vs the highest educational group: 2.0 and 50 (cases per 10,000 population) in this example.

Regression-based relative and absolute effect indices. The calculation of a regression-based measure of absolute effect is illustrated in Fig. A1. Rates of health problems are related to the following SES measure: the number of years of education that is minimally required to complete a specific educational level. In this example, the number of years corresponding to elementary education was 6 years. For higher levels, the required numbers of years were 9, 12 and 16. The frequency of health problems decreases nearly linearly with increasing number of years of education. The line in Fig. A1 is the regression line, which relates the rate of health problems (dependent variable) to the number of years of education (independent variable). Its slope has the value of -5.07, which implies that one

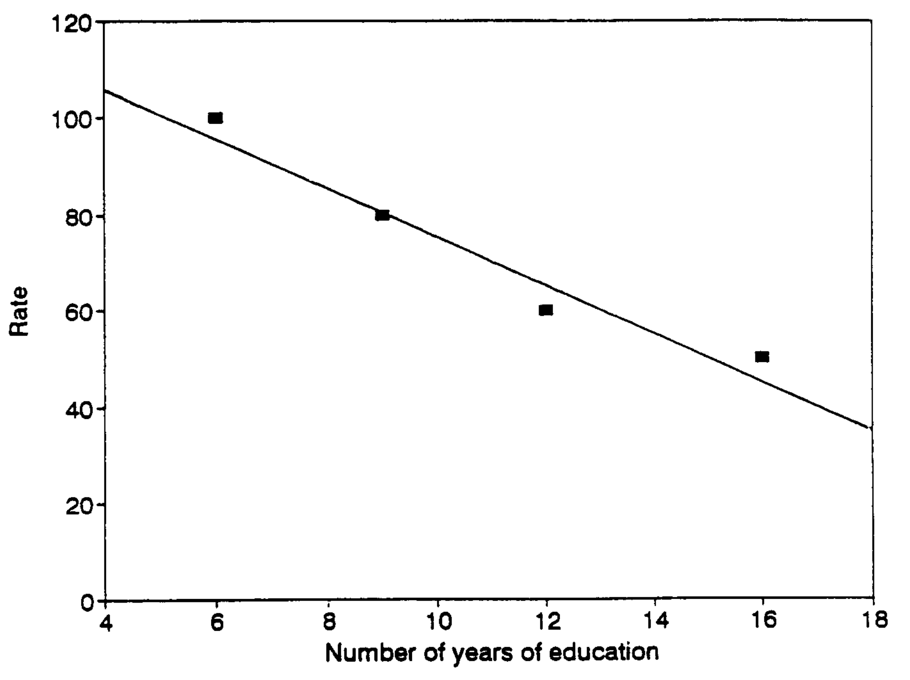

Fig. A1. Number of years of education.

Table A2

Educational level	Number of persons (1)	Rate of health problems (2)	Number of persons with health problems: observed (3)	Number of persons with health problems: in case of equality (4)	Absolute difference |(3) – (4)| (5)
Post-secondary	10,000	50	50	81	31
Secondary, upper level	20,000	60	120	162	42
Secondary, lower level	30,000	80	240	243	3
Elementary	40,000	100	400	324	76
Total	100,000	81	810	810	152

additional year of education is estimated to be associated with a decrease in the rate of health problems by 5.07 (cases per 10,000 population). In relative terms, this decrease with each additional year of education is 5% of the rate of health problems in the group with the lowest level of education.

Population-Attributable Risk (*relative and absolute version*). The simplest way to calculate the PAR is to subtract the rate in the reference category from the rate in the total population, and then to divide by the rate in the total population:

$$PAR = \frac{81 - 50}{81} = 0.38 \text{ or } 38\%$$

PAR is estimated to be 38%, which implies that the total rate of health problems would be 38% lower if all persons were to experience the rate of those with post-secondary education. PAR is a relative measure, and its absolute equivalent can be obtained by multiplication with the rate in the total population (or by simply taking the numerator of the calculation given above):

$$PAR \times 81 = 31 \text{ (cases per 10,000)} = 81 - 50$$

Regression-based PAR (*relative and absolute versions*). Calculation of the regression-based version of the PAR starts with estimating the frequency of health problems that could be expected for the highest educational level, taking into account the linear association between level of education and morbidity rates over all educational groups. According to the regression model presented above, the rate of health problems that corresponds to 16 years of education (the educational level of the highest group) is 45 (cases per 10,000 population). The corresponding PAR is calculated as (81 – 45)/81, which gives a figure of 0.44 or 44%. Thus, approximately the same PAR value is observed when the association between level of education and rates over all educational groups is taken into account in its calculation. The small difference between the simple PAR (0.38) and the regression-based PAR (0.44) is caused by the fact, that the observed rate of health problems in the group with post-secondary education (50) is higher that the rate expected in this group on the basis of the regression model (45).

Index of Dissimilarity (*relative and absolute versions*). The calculation of the ID is illustrated in Table A2.

Column 4 gives the number of cases that would occur in an educational group if that group would have the same rate of health problems as observed in the total population (i.e. 81 cases per 10,000 population). The difference between this number and the observed number of cases is given in column 5. It represents the number of cases that should be added or subtracted in order to get the same rate as in the total population. Summing that number over all educational groups gives a figure of 152. Since each case has been counted twice in that sum (one time for leaving a group and one time for entering another group), that total number of cases is divided by two. The resulting figure, 76, is the absolute version of the ID. It means that

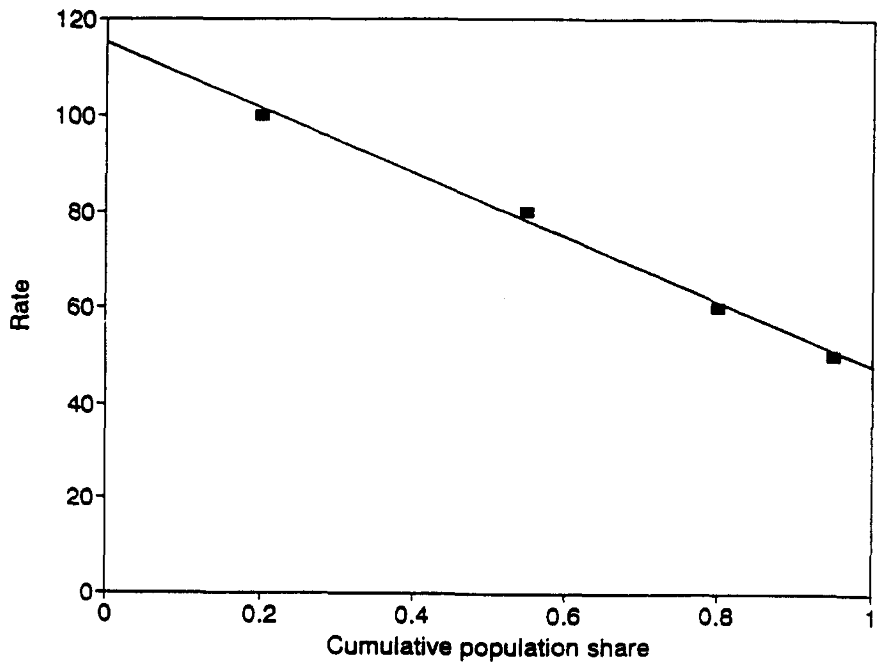

Fig. A2. Cumulative population share.

76 cases have to be redistributed between educational groups in order to obtain the same rate (81/10,000) for each educational group.

The relative version, the ID properly speaking, expresses the absolute number of cases to be redistributed as a percentage of the total number of cases (810). This gives a figure of 9.4%. Thus, taking the ID calculation literally, complete equality in health could be attained by redistributing 9.4% of all cases.

Relative Index of Inequality and Slope Index of Inequality. The calculation of the absolute version of the regression-based index of total impact, the Slope Index of Inequality (SII), is illustrated in Fig. A2. By means of regression analysis, the rate of health problems is related to a measure of the SES of educational groups. That SES measure takes into account the population size of educational groups. More precisely, SES is equated to the proportion of the population that has a lower position in the social hierarchy. For example, for the highest educational level, which comprises 10% of the population, that proportion ranges from 1.0 to 0.9, the average being 0.95. According to the same procedure, the SES for lower educational levels is estimated to be 0.80, 0.55 and 0.20. Rates of health problems increase linearly with this SES measure. The fitted regression line has a slope of -67.4, which implies that according to the regression equation the health difference between those at the top of the social hierarchy (at 1) and those at the bottom (at 0) amounts to 67.4 (cases per 10,000 population).

The original version of the relative equivalent of the SII, the Relative Index of Inequality (RII), is calculated as the quotient of the SII and the overall mortality or morbidity rate. In order to achieve consistency within our set of summary measures, we use a slightly modified calculation procedure. We first calculate the quotient of the SII and the rate of health problems that is predicted for those at the top of the social hierarchy (at SES value 1). This gives a figure of $(67.4/47.2) = 1.43$, which implies that according to the regression equation the rate among those at the bottom (at SES value 0) is 1.43 times higher than the rate among those at the top of the social hierarchy. We then express this as a rate ratio by adding 1, which gives a (modified) RII of 2.43, indicating that the rate at the bottom is 2.43 times as high as the rate at the top.