

## SECTION 10

# INEQUALITIES AND METHODS OF MEASUREMENT

This section takes a more detailed and technical look at the way in which inequality can be measured, the properties of different indexes and their measurement; various approaches to summarising inequality; and how one might measure inequalities in health over time.

### 10.1 Introduction

This section will be of use mainly to practitioners who are more familiar with statistical concepts and who may be more interested in the theoretical basis for the development and evaluation of measures of inequality. As such, it may be used together with the practical sections giving guidance on how to apply or develop indexes and/or surveys on poverty, deprivation, health, disease and lifestyles (see [Sections 3–6 and 9](#)).

The section opens with a short introduction to some of the main issues in measuring inequalities (repeated from [Section 1](#)). [Section 10.3](#) then considers some properties of both indexes and methods of measurement that may be more appropriate to specific applications. [Section 10.4](#) examines different techniques for detecting and analysing inequality. [Section 10.5](#) highlights some issues in trying to measure (changes in) inequality over time.

### 10.2 Context

Two questions are central to the measurement of inequality – what is meant by inequality and how to measure it.

#### ***What is meant by inequality***

Three concepts are frequently used:

- ◆ Differences or variations in health (or income) between groups.
- ◆ Inequalities in health(or income).
- ◆ Inequities or the unfairness of differences.

Throughout, the term ‘variations’ is reserved for purely statistical usage and inequalities is used in its descriptive sense. Although the fairness of the differences in health between SEGs is not discussed here, the purpose of measuring inequalities is because they point to *likely* inequities.

Kunst and Mackenbach use the following working definition of health inequalities: “Differences in the prevalence or incidence of health problems between individual people of higher and lower socio-economic status” (1995)

It should be emphasised that although the definition refers to individuals, *the crucial characteristic is their membership of an SEG*. Whilst differences between individuals may well be interesting in themselves, they are only meaningful in terms of inequalities or inequities if those differences are linked to socio-economic status or some other dimension of differentiation (e.g. ethnicity or religion).

### ***How to measure inequality***

Most measurement of health inequality involves the use of indicators or indexes to measure health, but it also requires decisions on what groups or areas to compare and what is the most appropriate form of analysis for the question being investigated.

In short, devising a method for measuring inequalities requires answers to three questions:

- ◆ What is the comparator, are inequalities to be measured between:
  - Groups or populations of small areas ([Section 2](#)).
  - Countries or populations to which different socio-economic classification have been applied ([Sections 2 and 10](#)).
  - Similar groups or populations over time ([Section 10](#)).
- ◆ What type of inequality is of interest:
  - Relative or absolute inequality ([Sections 10 and 11](#)).
  - Risk based versus outcome based measure ([Section 10](#)).
- ◆ What is the intended use for index of inequality:
  - To monitor the impact of policies and practices (often governmental policies and practices) on specific populations ([Sections 10 and 11](#)).
  - To compile league tables ([Sections 10 and 11](#)).

### 10.3 Properties of Indexes and Measurements

When measuring inequality, the indexes and measurements will require different properties for different applications. We have examined the range of possible axes of differentiation (Section 2) and the adequacy of data from routine sources or from surveys for measuring health (Sections 3 and 4, respectively). We have discussed the technical properties of indexes in general (Section 8). In this section we discuss the technical properties of indexes of inequality. We consider below: simplicity, absolute or relative measures, and measurement of effect or of total impact.

#### Simplicity

Policy makers tend to ask for simple measures that can be readily understood, for example death as a measure of health, and employment status as a measure of socio-economic position. The problem with simple measures is that they may only partially capture what one is interested in. Death is a consequence of poor health, but is not the same; employment status is a very 'thin' description of inequality. Researchers and statisticians should try to compare results of analyses based on simple measures with the results of analyses using more sophisticated summary measures of the various components of the particular phenomenon. It is of course, preferable if the components of measures are easily understandable and logically linked to what is being measured.

#### Absolute or relative terms

The usual presentation of inequalities, is in *relative* terms, for example, the mortality rates of the lowest SEGs as a ratio to that of the highest SEG. The alternate presentation is in *absolute* terms for example, the differences between the mortality of the highest and the lowest SEG.

Both of these are important, and probably should be used in combination. It is common to assess the importance of difference in relative rather than absolute terms; however, a 50% higher rate of a rare health problem may be much less important to public health than a 10% higher rate of a frequent health problem. Presentation of the absolute difference would make this clear.

#### Measures of effect and measures of total impact

The crucial distinction here is between the measure of the effect of changes in socio-economic status on health status, compared to a measure of total impact on the health of the whole population, taking into account the distribution of socio-economic characteristics within the population.

Of course, the size of SEGs makes a difference and with changes in the occupational structure, the groups change, so that similar segments of the population are not being compared.

Where summary measures are used, it is preferable if the components of the measures are easily understandable and linked to what is being measured.

### Statistical properties of indexes

Some aspects of the properties of indexes' domains have already been discussed in [Sections 2 and 4](#) on measures of health and [Sections 5 and 6](#) on measures of deprivation. [Section 7](#) provides a more detailed account of the statistical characteristics of indexes, particularly tests for reliability and validity. Notions of reliability and validity, especially the latter, can be interpreted in many ways, and particular interpretations might be relevant to particular applications, e.g. an instrument that was valid or reliable for one purpose, might not be for another.

Different methods make different demands on their data. It may be that an instrument that generates data suitable for making summaries of overall inequality between individuals is not suitable for making comparisons between groups. Or it may be that a policy-orientated application encourages the use of simple measures, but such measures may not have the responsiveness to detect likely levels of inequalities.

## **10.4 Approaches to Summarising Inequality**

### **10.4.1 Simple Inequality Measures**

The first discussions on inequalities in health relied on relatively simple comparisons between specific groups, for example, a comparison between the death rates of Social Classes I and II compared to the death rates in Social Classes IV and V. These are still used by many, but they do have problems. In particular, because they focus on particular groups, such comparisons ignore some of the information about the distribution of health between all the members of the population. In this section, we discuss the advantages and disadvantages of indexes that attempt to summarise the way in which health is distributed across the *whole* population.

#### ***Measures that compare two groups***

##### Range

This involves comparing the experiences of the top and bottom SEGs. The comparison is commonly presented as the ratio of one extreme value to the other.

It is of course, crucial to know what aspect of health is being compared between the two groups. Clearly, disparities in the risk of early death are important, and, in a situation where many die early, it may well be the only dimension of 'health' worth examining. But, when more people are living

**Table 10.1.** Age-specific annual mortality rates per 100,000 between 25 and 64 and survivors at age 65 and 85 (1960 and 1981)

	Annual mortality rate per 100,000				% of survivors of a cohort age 65 with these death rates	Proportion of population age 85+
	25–34	35–44	45–54	55–64		
<i>1960</i>						
Men	112	241	717	2140	73	0.2
Women	73	173	435	1060	84	0.6
<i>1981</i>						
Men	88	179	600	1732	77	0.5
Women	51	124	374	929	86	1.6

beyond 65, the variation in age at death among those over 65 will decrease, so that 'inequalities in health' – measured by differences between the average age at death for different social groups – will also decrease.

One could continue to argue that early deaths are so important that the conventional measure is to be preferred, but it needs to be understood that it refers to only a small proportion of deaths. Inequalities in death are not the only possible focus. If one looks at inequalities in survivorship beyond 65, one gets rather a different picture (Table 10.1). Whilst the death rates for men are always at least 39% higher than those for women in each age group, the proportion of women who survive beyond 65 is only 12% larger. Similarly whilst inequalities in survivorship between social classes persist, there has been only a small reduction from 15% to 12% in the difference between the percentage *not* surviving to 75, and a halving of the percentage difference in those not surviving to 85 (Table 10.2).

The statistical defects of focussing only on the differences between extreme groups should be obvious. First, what goes on in intermediate groups is ignored. For example, the gap between top and bottom groups might remain unchanged, but the extent of inequality between the intermediate groups might well be diminishing (or increasing). The second problem with the range is that it takes no account of the size of the groups being compared. In one of the favourite comparisons between social

**Table 10.2.** Social class and survival beyond 65. England and Wales

	Percentage not survived to 75 years			Percentage survival to 85 years		
	1951	1971	1981	1951	1971	1981
Manual	55.5	56.8	60.7	11.5	13.0	16.2
Non-manual	63.7	63.0	67.9	20.8	21.0	22.7

classes, this is crucial as the size of these groups vary substantially over time. As Illsley [217] put it, “if we wished to compare two countries over time, our first step would be to check the boundaries”.

The impact of this on comparisons of death rates has been examined by Carr-Hill [218]. Whilst one may be more interested in comparisons of morbidity rates than in the comparison of death rates between geographical areas, the general point about the potential impact of the changes in composition of populations in, for example, communities on the validity of comparison over time, is very important.

### Comparing groups of equal size

The problem with all discrete classifications, is that the population distribution changes in both size and significance over time. The only real solution to this problem, is to compare the bottom 10% (or 20%) with the top 10% (or 20%) at different points in time. Clearly the ‘bottom’ and ‘top’ deciles or quintiles have to be defined in terms of some socio-economic criterion. The ideal characteristic would be continuous such as income. If a continuous variable is not available, then members of the population have to be classified and ranked in terms of categorical criteria such as education, occupation or geographical area.

### **10.4.2 More Complicated Measures**

Because of the problems with discrete classifications, increasing numbers of researchers have developed measures based on continuous variables.

#### ***The Lorenz curve and the Gini coefficient***

One of the proposed ‘solutions’ has been to examine an aggregate measure of inequalities between individuals such as the Gini coefficient, as is done in assessing inequalities in the distribution of income and wealth [219]. Le Grand [219] proposed comparing global measures of dispersion between individuals, not between strata. The coefficient he used is based on the Lorenz curve.

#### ***Lorenz curve***

The ‘pure’ Lorenz curve is a graphical representation showing the degree of inequality of a frequency distribution in which the cumulative percentage of the variable under study (e.g. morbidity or mortality) is plotted on the Y-axis against the cumulative percentage of the population ordered/ranked

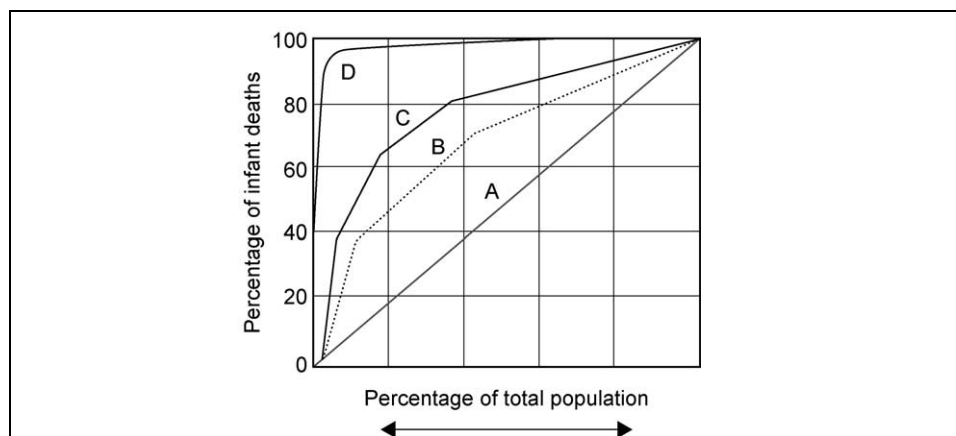
(along the X-axis) according to the variable under study. A straight line rising at an angle of  $45^\circ$  from the origin on the graph will indicate perfect equality; for instance, if the 10% with the lowest incomes account for 10% of the deaths, 20% with the lowest incomes account for 20% of the deaths and so on.

If, however, the distribution is not precisely egalitarian then the curve will be above or below the diagonal. The greater the distance of the curve from the diagonal line, the greater the inequality. When the variable considered is beneficial to the population, for example, access to healthy lifestyles, the curve is found below the diagonal line. In contrast, when the variable is prejudicial, for example deaths, it is found above the line. So, where there is a larger rate of deaths among men with lower incomes and a smaller rate of deaths among those with higher incomes, the distribution is unequal. When such a distribution is plotted, a curve will be traced above the  $45^\circ$  line and the degree of curvature will be greater, the greater the inequality (Figure 10.1).

This line is the Lorenz curve and can be expressed mathematically. The Gini coefficient ranges from 0 to 1 (0 representing perfect equality and 1 total inequality). It corresponds to twice the area between the Lorenz curve and the diagonal (Figure 10.1).

Although the level of inequalities is reflected in the value of the Gini coefficient itself, the interpretation of the coefficient is usually done in comparative terms, by contrasting the calculated value to that of other geographic units, population groups, etc. Again, a coefficient of 0.2 will represent a lower level of inequality than a coefficient of 0.4. The cumulative proportions of both variables (the 'health' variables and the SEG variables) can also be read directly from the graphical representation of the Lorenz curve.

**Figure 10.1.** Lorenz curves. Notes: A = line of equality; B = Country 1; C = Country 2; D = line of absolute inequality.



There are different methods to calculate the Gini coefficient. One example, provided by Brown, to calculate the Gini coefficient and prepare a graph demonstrating inequalities between geographic units, the Lorenz curve [220]:

1. Sort the geographic units by the health variable (e.g. infant mortality rate) from the worst situation (highest rate), to the best situation (lowest rate).
2. Calculate the number of infant deaths for each geographic unit.
3. Calculate what proportion of the total of all infant deaths and what proportion of the total of all live births is observed in each geographical unit.
4. Calculate the cumulative proportion of each of the two variables.
5. Calculate the Gini coefficient using the formula.
6. Graph the curve using the *X* axis for the proportion of the cumulative population (live births) and the *Y* axis for the proportion of cumulative health variable observations (infant deaths).

The Lorenz curve reflects the experiences of all the persons rather than only those in specific groups, and the size of this dispersion may well be crucial in assessing the overall importance of the issue. For example, deaths from bronchitis, influenza, pneumonia and respiratory tuberculosis, which used to be one of the major public health issues during the first half of this century, have now fallen to a very low level overall, even though their distribution is very unequal. Changes in the size of the dispersion (or the gap) do influence our assessments about inequality, but so does the overall level or trend of the problem.

Regardless of the magnitude, the dispersion between individuals cannot be the basis for assessing the inequity of a distribution. This is because dispersion per se cannot be a basis for deciding whether or not a characteristic is unequally distributed in social terms. The absence of a stratifying variable means that the Gini coefficient is addressing a different question from that being addressed in the bulk of the literature—to what extent are there inequalities in health that are systematically related to socio-economic status? This is because a change in the distribution of health where a sick person gets less sick and a healthy person gets less well so that they are both near the mean level of health is registered as a reduction in inequality irrespective of the socio-economic status of the persons concerned. Inequality measured by the Gini coefficient would still fall even if the sick person getting healthier were rich and the healthy person getting sicker were poor.

Most authors therefore argue that measuring health inequality across individuals without taking into account any dimension of (socio-economic) differentiation is not interesting:

“the main problem is that such a measure (of individual inequality) answers a different – possibly rather uninteresting – question about generalised

variability within a society distinct from systematic variability based on social stratification within society” [221].

Nevertheless, it should be noted that the measures of health inequality proposed by Murray et al. [222] as part of the recent WHO ranking of health systems are of the same type.

### ***The ‘pseudo’ Lorenz curve and the index of dissimilarity***

The problem is circumvented by constructing a ‘pseudo’ Lorenz curve based on the grouped data, where the groups are occupational classes (or could be classes grouped according to any other socio-economic criterion). The occupational classes are grouped by their health status and then the ‘Lorenz’ curve graphs the cumulative percentage of the population in their occupational class groups, against the cumulative percentage of death. Although not usually a problem – because the classes are grouped according to their health status – the approach cannot differentiate between a situation when the sickest SEG is made up of rich people versus poor people.

The Index of Dissimilarity (ID) is developed from this curve. It is based on the notion that under complete equality, everyone’s share of health ( $S_H$ ) would be equal to their population share ( $S_P$ ). Suppose there are five SEGs  $S_1, S_2, S_3, S_4, S_5$ . Then the ID is calculated as half the sum of the absolute values of the differences:

$$ID = \frac{1}{2} [(S_{1h} - S_{1p}) + (S_{2h} - S_{2p}) + (S_{3h} - S_{3p}) + (S_{4h} - S_{4p}) + (S_{5h} - S_{5p})]$$

The problem is that the ID, although apparently incorporating a socio-economic dimension, is actually insensitive to the socio-economic dimension of inequalities in health, like the ‘pure’ Lorenz curve. What matters in the ID is simply how each SEG’s share of the population’s health compares with its share of population, and not how this disparity compares with a group’s socio-economic status.

The Gini coefficient, and similar indexes, can be used correctly in this context – for such a measure can be used to summarise the differences between the levels and/or rates in each population stratum adjusting, where appropriate, for the different sizes of the strata. Note this is a different interpretation of the Gini coefficient to that given above. Preston et al. [223] used the Gini coefficient to assess trends over time, and showed how other coefficients – the ID and an index derived from the regression of age standardised class death rates with the proportions of the population in each social class – gave similar results.

### **The Slopes and Relative Index of Inequality**

Both these indexes, in contrast, are based on the socio-economic dimension to inequalities in health. Classes or groups are ranked by their socio-economic status and these graphical presentations display both their mean health status (represented by the height of the bar) and their share of the population (represented by the width of the bar). The Slope Index of Inequality (SII) is then defined as the slope of the regression line showing the relationship between a class or group's health status and its rank in socio-economic terms. It can be interpreted as the *absolute* effect on average health of moving up one unit in the socio-economic scale.

Because the data are grouped, one cannot equate a one unit change to a shift of one rank with socio-economic scale. This means that the calculation of the SII is not entirely straightforward, requiring the use of weighted least squares. This can be done by summing Ordinary Least Squares on the following equation:

$$h_j\sqrt{n_j} = \alpha\sqrt{n_j} + \beta\chi_j\sqrt{n_j} + u_j$$

where  $h_j$  is the health score in class  $j$ ,  $n_j$  is the size of class  $j$ ,  $\chi_j$  is the relative rank of class  $j$ .

SII avoids the defects of the range measure; it reflects the experience of the entire population and it is sensitive to the distribution of the population across SEGs.

Note that, if everyone's health improves, as over the past two centuries, then the index can change in value, even though it will be unclear whether one would want to say inequality had changed. Thus, if everyone were sick on half as many days per year as before, then the value of the index would double because the absolute differences have widened. Because this makes comparisons over time difficult, Pamuk [224] proposed dividing the SII by the mean level of health and this is called the Relative Index of Inequality (RII).

### **The Concentration Index**

This index is based on a curve. It is superficially similar to the Lorenz curve, but avoids its problems because people are ranked – as with the SII and the RII – by their socio-economic status and not by their health. The curve plots the cumulative proportions of the population (beginning with the most disadvantaged and ending with the least disadvantaged) against the cumulative proportion of health. The Concentration Index is then calculated in the same way as the Gini coefficient, but it varies between  $-1$  and  $+1$ . The values are negative when the curve is above the diagonal and positive when they are under the diagonal. If the order resulting from sorting by the socio-economic and health variables are the same,

the Concentration Index will have the same absolute value as the Gini coefficient.

If health is equally distributed, the Concentration curve will coincide with the diagonal. If poor health is concentrated in lower SEGs, the Concentration curve lies below the diagonal.

The Health Concentration Index – usually denoted by  $C$  – is defined as twice the area between the concentration curve and the diagonal.

The same approach can be used for assessing inequalities in ill health, and is, perhaps, easier to understand in this context. The Illness Concentration Index is positive when the Concentration curve lies below the diagonal (illness is concentrated amongst the higher SEGs) and negative when it lies above the diagonal (illness is concentrated among lower SEGs).

The Concentration Index refers to cumulative *proportions* of health and so is insensitive to changes in the mean level of health. It can be generated by graphing the cumulative percentage of the population (along the X-axis) against the cumulative *amount* of health (along the Y-axis). The *Generalised Concentration Index* is then defined as twice the area between the generalised concentration curve and the diagonals.

## 10.5 Measuring Inequalities in Health Over Time

Understandably, there is considerable interest in measuring in inequalities in health over time. This poses particular problems of interpretation and validity if there is the likelihood of the measure having changed its meaning over the period in question.

For this reason, measuring inequalities in morbidity and making comparisons over time are even more difficult than making comparisons between SMRs. This is basically because health means different things to different people, and meanings change over time.

## 10.6 Summary and Conclusions: Choosing between the Measures

These various indexes and methods of measurement can be summarised in terms of the properties that we outlined in the beginning: simplicity, whether or not one is interested in absolute or relative measures, and measurement of effect or of total impact. The results of this comparison are shown in [Table 10.3](#). Some of the similarities in the properties are unexpected, as it can be shown that the Concentration Index and the RII are related, as are the Generalised Concentration Index and the SII.

**Table 10.3.** Characteristics of indexes for analysing inequality

<i>Degree of complexity</i>	<i>Indexes of effect</i>	<i>Indexes of total impact comparison with</i>	
		<i>Healthiest</i>	<i>Average</i>
Simpler	Rate ratio of lowest versus highest group	Population-attributable risk (%)	Index of Dissimilarity (%)
	Rate difference of lowest versus highest group	Population attributable risk (N)	Index of Dissimilarity (N)
More complex	Regression-based index of relative effect	Regression-based population attributable risk (%)	Relative Index of Inequality
	Regression-based index of absolute effect	Regression-based population attributable risk (absolute version)	Slope Index of Inequality