Foreword
This is the first in a series of technical briefings to be produced by the Scottish Public Health Observatory. In Scotland – as in many other countries – there is currently considerable emphasis being placed on reducing socio-economic inequalities in health. But success in achieving such a reduction can only be gauged if the inequalities can be measured. This briefing paper therefore looks at several different methods available to measure inequalities and provides a commentary on each. It also comes with an Excel worksheet that will enable public health practitioners and analysts to interpret their own data.

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Scottish Public Health Observatory (ScotPHO) Collaboration

The ScotPHO team at ISD is part of a collaboration, which brings together key national organisations involved in public health intelligence in Scotland, led by ISD Scotland and NHS Health Scotland. We are working together closely to ensure the public health community has easy access to clear and relevant information and statistics to support decision-making. This report is our first technical briefing.

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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 Within Scotland in 2004, the all-cause mortality rate of the least deprived 10% of the population was less than half the rate of the most deprived 10% of the population.²

The Scottish Executive in their “Building A Better Scotland” report³ set targets “to improve the health and the quality of life of the people of Scotland and to deliver integrated health and community care services making sure there is support and protection for those members of society who are in greatest need” (page 33). In particular, one of the targets is to “reduce health inequalities by increasing the rate of improvement across a range of indicators (for adults: coronary heart disease, cancer, adult smoking, etc; for young people: teenage pregnancy and suicides) for the most deprived communities by 15%, by 2008”. When targets are set to reduce health gaps it is important to clarify how progress will be assessed. The way in which health gaps are measured and compared can affect the results.

Measures of socio-economic inequalities in healthcare are important markers for health and social policy and for society in general and attract the interest of a wide audience, including planners, policy makers, service providers, patients, academics, journalists and politicians. It is therefore important that indicators and comparisons are both accurate and presented in a way that minimises the chances of misinterpretation or unfair criticism.

Papers by Wagstaff et al⁴ and Mackenbach et al¹ provide very useful guides to measures of inequality. The first proposed that a good measure of inequality should meet the following minimal requirements: i) reflect the socioeconomic dimension to inequalities in health, ii) reflect the experiences of the entire population and iii) should be sensitive to changes in the distribution of the population across socioeconomic groups.

Aim

The aim of this paper is to provide a review of the main measures that have been used in the literature on inequalities in health and to identify which of these measures are more appropriate under different circumstances and for different audiences.

To explain these measures and illustrate their strengths and weaknesses, we have included a practical example using real data and have designed an Excel spreadsheet with an “easy guide” for calculating inequality measures.

1 What do we mean by health inequality?

Gakidou et al⁵ defined health inequality as the variations in health status across individuals in a population. They argue that it is critical for a debate on health inequality first to articulate what the quantity of interest is and why, and then to proceed to measure it, depending on the available data. The type of questions to address are: What would we like to be equally distributed in the population? Are we just interested in the difference between the extremes in a population (e.g. between deprivation deciles 1 and 10) or in the entire population? Against what markers of social grade do we wish to measure health inequality (e.g. by gender, across age bands, social class or deprivation)?, etc.

In the NHS, measurement of performance involves the collection, analysis and presentation of data in the form of performance indicators often defined against desirable targets. In this paper we will only deal with the description and interpretation of a range of methods to measure inequalities, assuming that data are available.
2 Methods to measure inequalities in health

At this point we recommend that the reader open the accompanying spreadsheet guide (in the publications sections of www.scotpho.org.uk) and view the examples given for each method, while reading the following sections. Also notice that section 3 contains a practical example where all the methods have been applied.

2.1 The range

This is the most commonly used measure of inequality in health. It involves comparing the experience of the top and bottom socioeconomic groups. Sometimes this comparison is presented in the form of the range itself (Absolute Range) but more often it is presented as the ratio of one extreme value to the other (Relative Range).

These are very simple and straightforward measures. One of the advantages of the Relative Range compared to the Absolute Range is that it is scale neutral, i.e. inequality can be compared for rates of outcome measured on different scales. On the other hand the range overlooks changes in the intermediate groups and it does not take into account the sizes of the groups being compared.

2.2 Population Attributable Risk

Population Attributable Risk (PAR) is a measure of disease frequency widely used in epidemiology. It measures the proportion of disease in the study population that is attributable to the exposure and thus could be eliminated if the exposure were eliminated. For example, we could determine the proportional decrease in the population mortality rate, in the hypothetical situation that all individuals had the same deprivation level as those in the highest socioeconomic category. The rate also reflects the population size, i.e., the larger the groups with high rates, the larger the potential reduction in overall rate. It is obtained by calculating the level of increased mortality in each exposed group and summing across groups. The resulting statistic is often expressed as a percentage,

\[
\frac{P_e (RR - 1)}{1 + P_e (RR - 1)} \times 100
\]

where \( P_e \) = proportion of the total population in the exposed group

\( RR \) = relative risk for the exposed group, compared to a risk of 1 for the unexposed group

The PAR requires choosing one of the groups as the unexposed or reference group. The same value can be achieved whether the increased mortality is in the moderately deprived group or the extremely deprived group.

2.3 The Slope and Relative indexes of inequality

The Slope Index of Inequality (SII) can be used to reflect the socioeconomic dimension to inequalities in health. The approach involves calculating the mean health status of each socioeconomic group and then ranking classes by their socioeconomic status (not by their health). The slope index of inequality (SII) is the linear regression coefficient that shows the relation between the level of health or the frequency of a health problem in each socioeconomic category and the hierarchical ranking of each socioeconomic category on the social scale. For this purpose, a variable is created from a series of values assigned to the different socioeconomic categories with reference to a range. For example, if the socioeconomic variable is deprivation level, and the category with the highest educational level includes 10% of the
population, the range of the individuals in this category would be from 0 to 0.10, giving a mid point of 0.05, which would be the value assigned to this category; if the next highest deprivation level category includes 20% of the population, its range is from 10% to 30%, thus it would be assigned a value of 0.20, and so on. When deprivation deciles are used the method is much simpler as all the categories contain 10% of the population (and the values would be 0.5, 1.5, 2.5,..., 9.5). The SII can be interpreted as the absolute effect on health of moving from the lowest socioeconomic level through to the highest.

When working with grouped data the regression equation has to be transformed to avoid heteroskedasticity* of the error term. The Weighted Least Squares (WLS) estimate of the SII can be obtained by using the following formula:

\[ Y = a + b \times \sqrt{a} \]

where \( a \) is the proportion of people in each group, \( Y \) is the health score and \( b \) is the relative rank variable. This transformed equation can be estimated using the Excel regression function.

The SII is sensitive to the mean health status of the population. Suppose that everyone’s health doubled then the SII would double, i.e., absolute differences have widened but relative differences have remained the same. If we are interested in relative differences then the SII can be divided by the mean level of health. This index is called the Relative Index of Inequality (see example in Excel worksheet).

### 2.4 The Concentration Index

As with the Slope Index of Inequality, a population is ranked not by its health but by its socioeconomic status, beginning with the most disadvantaged (on the left, see spreadsheet). The curve plots the cumulative proportion of ill-health against the cumulative proportion of the population. If ill-health is equally distributed across socioeconomic groups, the concentration curve will coincide with the diagonal. If poor health is concentrated in the lower socioeconomic groups, the health concentration curve lies below the diagonal. The further the curve lies from the diagonal, the greater the degree of inequality in health.

The Concentration Index (C) is defined as twice the area between the concentration curve, \( L(p) \), and the line of equality (the 45° line running from the bottom-left corner to the top-right). In the example we have calculated C from grouped data using the following formula:

\[ C = (x_1 L_2 - p_1 L_2) + (x_2 L_3 - p_2 L_3) + \ldots + (x_{T-1} L_T - p_{T-1} L_{T-1}) \]

where \( p \) is the cumulative percent of the sample ranked by deprivation, \( L(p) \) is the corresponding concentration curve ordinate and \( T \) is the number of deprivation groups.

The health concentration index provides a measure of the extent of inequalities in health that are systematically associated with socioeconomic status. It takes values between \(-1\) (this occurs when all the population’s ill-health is concentrated among the most disadvantaged person) and \(+1\) (this occurs when all the population’s ill-health is concentrated in the least disadvantaged person).

The C has the disadvantage of lacking a straightforward interpretation. However Koolman and Doorslaer\(^10\) showed that by multiplying the absolute value of C by 75 it can easily be translated into the percentage redistribution required from the advantaged group to the disadvantaged group to make estimated inequality equal to zero i.e. the redistribution required to remove health differences.

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* In statistics, a sequence or a vector of random variables is heteroscedastic if the random variables in the sequence or vector may have different variances. When using a Weighted Least Square model one of the assumptions is that the error term has a constant variance.
3 Inequalities in Mortality in Scotland: A Practical Example

In our practical example, we used mortality data to illustrate how to use the different methods. Data on the number of deaths was obtained from General Register Office for Scotland. The Scottish Index of Multiple Deprivation11 2004 (SIMD) was used as the measure of deprivation. Direct standardisation, by age, sex and deprivation deciles was used for the year 2005 with the European population as reference. In this case we used grouped data for a sub-population comparison rather than an over-time comparison although these methods can also be used for trend analysis.

In this example we define socio-economic inequalities in health as the difference in all-cause mortality rates between deprivation deciles.

![Figure 1: All-cause age and sex standardised mortality rates (European Standard Population)](image)

Figure 1 shows that there is variation between the deprivation deciles. In Scotland, the all-cause mortality rate for year 2005 of the least deprived deciles was less than half the rate of the most deprived deciles.

<table>
<thead>
<tr>
<th>Measure of Inequality</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute Range</td>
<td>614</td>
</tr>
<tr>
<td>Relative Range</td>
<td>2.23</td>
</tr>
<tr>
<td>Slope Index of Inequality</td>
<td>600</td>
</tr>
<tr>
<td>Relative Index of Inequality</td>
<td>0.80</td>
</tr>
<tr>
<td>Concentration Index</td>
<td>0.13</td>
</tr>
<tr>
<td>%PAR</td>
<td>34%</td>
</tr>
<tr>
<td>No. of death attributable</td>
<td>12,829</td>
</tr>
</tbody>
</table>

Table 1: Summary table of measures of inequality

The range is applied as a simple and commonly used description of inequality. The Absolute Range is 614 deaths per 100,000. The Relative Range is 2.23, indicating that those in the most deprived group have more than double the mortality rate of the most affluent group.
Both the Slope Index of Inequality and its relative version take account of the total impact of inequalities as they look at the whole distribution, not just the top and bottom of the range. The mortality rate difference between the top and bottom SIMD deciles is 600 deaths per 100,000 populations. According to the regression equation the rate among those at the bottom is 0.80 times higher than the average.

The Concentration Index (C) reflects the higher mortality amongst poorer people. Using the methods of Koolman and Doorslaer we estimate that 9.9% redistribution is required from the affluent to the deprived in order for mortality to be equally distributed across the deprivation groups (i.e. for the concentration curve to coincide with the diagonal).

**Figure 2: Concentration Curve**

In Figure 2 the diagonal line is what the plot would look like with health equally distributed. The fact that the curve is below the diagonal indicates that poor health is concentrated in lower socioeconomic groups.

Table 1 also contains the Population Attributable Risk (PAR) which estimates that 34% of deaths are attributable to deprivation. Multiplying the PAR by the overall standardised rate we obtained a total number of 12,829 deaths that are attributable to deprivation. All the measures applied so far (except for the range) compare each socio-economic group with the average group. However in the PAR we are looking at the hypothetical case that all individuals have the same level of health as those in the least deprived category.

Further examples exploring the use of these methods with indicators that present a weaker linear relationship will be published on the Scottish Public Health Observatory website.
Conclusions

Amongst the different methods reviewed in this paper, some are simple and straightforward but others are more complex to construct and interpret. We have designed the Excel file to facilitate the calculation and cross-validation of results emerging from the use of different approaches.

The Range and the PAR are measures that only compare certain groups. They are both simple and easy to calculate and more suitable for measures that cannot be ranked in terms of their level of deprivation and might therefore be deemed more appropriate for inequalities across categorical dimensions, such as ethnicity. The SII, RII and Concentration Index are sensitive to the changes in the entire population. They are mathematically related and one can be derived from the other (see Ref [8] for further details).

Both approaches are important and the selection of the best method needs to reflect health policy. We recommend comprehensive data exploration before calculations are done and comparison of the results obtained using the different measures. The use of simple and straightforward measures may complement more sophisticated ones.
References


