The relative importance and stability of disease burden causes over time: Summarising regional trends on disease burden for 290 causes over 28 years

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Background Since the Global Burden of Disease study (GBD) has become more comprehensive, data for hundreds of causes of disease burden, measured using Disability Adjusted Life Years (DALYs), have become increasingly available for almost every part of the world. However, undergoing any systematic comparative analysis of the trends can be challenging given the quantity of data that must be presented.

Methods We use the GBD data to describe trends in cause-specific DALY rates for eight regions. We quantify the extent to which the importance of ‘major’ DALY causes changes relative to ‘minor’ DALY causes over time by decomposing changes in the Gini coefficient into ‘proportionality’ and ‘reranking’ indices.

Results The fall in regional DALY rates since 1990 has been accompanied by generally positive proportionality indices and reranking indices of negligible magnitude. However, the rate at which DALY rates have been falling has slowed and, at the same time, proportionality indices have tended towards zero. These findings are clearest where the focus is exclusively upon non-communicable diseases. Notably, large and positive proportionality indices are recorded for sub-Saharan Africa over the last decade.

Conclusion The positive proportionality indices show that disease burden has become less concentrated around the leading causes over time, and this trend has become less prominent as the DALY rate decline has slowed. The recent decline in disease burden in sub-Saharan Africa is disproportionally driven by improvements in DALY rates for HIV/AIDS, as well as for malaria, diarrheal diseases, and lower respiratory infections.

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1. Introduction

By grouping causes of death as ‘communicable, maternal, neo-natal and nutritional diseases (CMNN)’, ‘non-communicable diseases (NCDs)’, and ‘injuries’, Murray and Lopez (1997) summarized findings on causes of death for eight regions of the world using data from the 1990 wave of the GBD study. Although NCDs were generally found to be the leading causes of death worldwide, five of the top ten leading causes of death were the result of CMNN diseases. Both the probability of dying from CMNN diseases and from NCDs was significantly higher in developing regions such as sub-Saharan Africa than in developed regions. Over two decades after this initial study, two NCDs, ischemic heart disease (IHD) and stroke, remain responsible for by far the largest number of global deaths (GBD study, 2018a). CMNN diseases, especially pneumonia, neonatal conditions, and diarrheal diseases, are still important causes of death, particularly in developing regions. However, these broad similarities mask a more complex picture of the varying relative importance of death causes. The importance of some global causes of ‘disease burden’, measured in the GBD using Disability Adjusted Life Years (DALYs)\(^5\), has changed substantially. An example which clearly demonstrates this variation is the increase from 18.6% to 29.8% of total DALYs attributable to NCDs in Sub-Saharan Africa between 1990 and 2017 (Gouda et al., 2019). The declining importance of CMNNs is also visible at the global level (see Figure 1).

Health trends are continuously being analysed and presented by international collaborators (among others, GBD study 2018a; 2018b; 2018c; Jamison et al., 2018; World Health Organization (WHO), 2019), national academics and governments (among others, Bundhamcharoen et al. 2011; Fadwa 2011; Gilmour et al. 2014; Murray et al. 2013; New Zealand Ministry of Health 2016; Stevens et al. 2008; Wong et al. 2018; Zhou et al. 2019).

\[\text{FIGURE 1: Global DALY rates per 100,000 by broad cause of disease burden, 1990-2017}\]

\(^5\) DALYs are defined as the sum of years of life lost due to premature death (YLLs) and the years of life lived with a disability (YLDs). See GBD study (2018b).
However, presenting clear trend data from the GBD study is challenging because it requires summarizing data on a particular health metric across 28 possible years, 290 potential classifications of DALY causes for 195 countries and territories, i.e. for over a million data points. Recent publications (e.g. GBD study, 2018a; 2018b; 2018c; Mathers et al., 2018; WHO, 2019) have addressed this problem in one of two ways: (i) by presenting data for all classifications but for only one or two selected years and/or locations, or; (ii) by presenting trends over many years but only for selected causes, or very broad definitions of causes (e.g. CMNN diseases, NCDs, injuries). Due to the large number of classifications, the detailed appendices attached to the over 50-page GBD summary papers are close to 10,000 pages long (e.g. GBD study 2018a: Supplementary annex 2), and yet are required to be selective in the presentation of metrics and years.

We propose to make use of two quantitative measures that summarize 1) whether the growing or declining overall DALY rates over time is disproportionally attributable to the ‘major’ (e.g. Ischemic heart disease, stroke) or ‘minor’ (e.g. Ebola, osteoarthritis) DALY causes, and 2) whether there are substantial changes in the ranking of diseases in terms of severity. These two measures derive from a decomposition of the Gini coefficient. The Gini was originally developed to measure changes in income inequality and mobility. In this setting, the Gini captures the degree to which the disease burden is more or less concentrated among disease causes.

For policymakers, the two measures provide a helpful extension to existing trend data on cause-specific DALYs by summarizing a large amount of data that may otherwise be hard to interpret. First, the first measure broadly informs on the relative importance of disease causes. The analysis over time could therefore be instrumental in the process of deciding whether resources should be reallocated in response to the changing relative importance of major or minor causes. Second, it is widely accepted that increasing uncertainty should lead to the diversification of risks. Hence, with rising uncertainty on the importance of DALY causes, which is reflected in the variability of the measures over time, more different diseases should be prioritized (through e.g. R&D expenditures). Third, the summary measures provide more food for thought on how to reallocate resources (and how much). For example, the stability in the absolute ranking of diseases may provide suggestive evidence that also the ranking of prioritization and resources between disease causes should remain stable. Initiatives, and discussions on reallocation of attention and resources could be initiated by the WHO, the World Bank, but also by national governments.

The paper proceeds as follows. Section 2 explains the foundations of the Gini coefficient and its. It also describes the data and outlines how the data analysis is presented. Section 3 presents the results of the data analysis. Finally, Section 4 addresses the limitations of this study and section 5 concludes.

2. Methods and Data
2.1 Gini Coefficients

Measures of concentration such as the Gini coefficient have most frequently been used as tools to evaluate the degree of income or wealth inequality (e.g. Zanden et al., 2014; Davies et al., 2011). However, Gini-like measures have also been applied in many other areas, including in health economics (e.g. Wagstaff and Van Doorslaer, 2000; Van Doorslaer and Koelman, 2004; Erreygers and Van Ourti, 2011). In a recent article, Barrenho et. al. (2019) used data from the GBD to rank causes of DALYs according to their respective contributions towards the total number of global DALYs. They showed that Gini-like indices (i.e. the concentration index) can be used to estimate whether or not innovation is disproportionately concentrated in more highly ranked causes.

In a similar way, we make use of the rankings of the causes of DALYs, but the aim here is to instead understand to what extent DALY rates are disproportionately concentrated in high versus low ranked causes. To illustrate
how this can be done, Figure 2 displays a Lorenz curve which makes use of the global DALY rates for 290 causes of disease burden in 2017. The causes are ranked from lowest to highest based on their contribution towards the total DALY rate. This ranking determines the horizontal axis in Figure 1; it represents the cumulative share of the total number of disease burden causes, with the lowest ranked cause representing the first point on this axis and each point along the axis representing a more highly ranked cause.

The cumulative share of the total disease burden resulting from each cause makes up the vertical axis. If all disease causes had equal shares of DALY rates, then the cumulative distribution would simply be the diagonal line picturing perfect equality. In reality, Figure 2 shows that in 2017 the 10% lowest ranked (29 out of 290) disease causes account for less than 1% of the total global DALY rate. By contrast, the 10% highest ranked disease burden causes were responsible for over 65% of the total global DALY rate in that year. That, expectedly, signals a very unequal distribution of burden.

The degree of inequality can be measured by a Gini coefficient defined as (twice) the area between the equality line and the Lorenz curve. The Gini is bounded between 0 and 1. A value that is close to 1 (0) indicates that the disease burden is more (less) concentrated in the major causes. (see Appendix A for a mathematical expression)

**2.2 A decomposition of the Gini Coefficient**

The Gini coefficient provides a fairly simple way to express the extent to which DALY rates are more or less concentrated in certain causes. It can also measure changes over time as a difference in Gini’s (ΔG) but the most interesting information can be obtained from decomposing this change in two parts. Jenkins and van Kerm (2006) proposed to decompose the change in Gini coefficient into a ‘Reranking’ and a ‘Proportionality’ component. Letting the subscripts 0 and 1 denote an earlier and later point in time, respectively, the decomposition of the change in the Gini can be shown to equal:

![Lorenz Curve Diagram](image)
\[ \Delta G \equiv G_1 - G_0 \equiv R - P, \quad (2) \]

where,

\[ R = G_1 - G_1^{(0)} \quad (3) \]

\[ P = G_0 - G_1^{(0)}. \quad (4) \]

\( G_0 \) and \( G_1 \) are the Gini coefficients in year 0 and year 1 respectively, and \( G_1^{(0)} \) is the coefficient for year 1 DALY rates calculated according to year 0 ranks (this is then a Concentration rather than a Gini index because the ranking variable is different from the quantity of interest). \( R \) represents the change in the Gini coefficient that can be attributed to ‘reranking’ and \( P \) the change in the Gini coefficient that can be attributed to ‘proportionality’\(^6\). The proportionality index, \( P \), can be defined as the change in the Gini coefficient that would have occurred if rankings had been held constant at their pre-distribution position.

Figure 3 illustrates this result graphically using the example of 1990 and 2017 global DALY rates. The inward shift of the Lorenz curve over the period shows that global DALY rates have become less concentrated in the leading causes over the period. This can especially be seen at the lower end of the distribution where a higher percent of DALYs is accounted for by the minor causes. Twice the area between the Lorenz curves for 1990 and 2017 is the change in the Gini coefficient, \( \Delta G \); this change can be broken down into two parts. The first is the difference between the Lorenz curve for 1990 DALY rates and the concentration curve for 2017 DALY rates constructed using 1990 DALY rate ranks. This summarizes the ‘proportionality’ of the DALY rate reductions: \(-P\) is twice the area between these two curves. One way to interpret this value is that it is the change in Gini coefficient that would have occurred had there been no change in the ranking. The second component is the difference between this concentration curve and the Lorenz curve for 2017, which summarizes the extent of reranking. \( R \) is twice the area between these two curves. The figure illustrates that the Gini has fallen in value over the period because \( P > R \).

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\(^6\) (See Appendix 1B for a demonstration of this result; \( P \) refers to progressivity in Jenkins and Van Kerm, but the term proportionality is more applicable here)
The interpretation of $P$ depends on whether aggregate DALY rates are growing or declining. Figure 4 illustrates that DALY rates have generally declined over the period 1990-2017. A positive (negative) $P$ value indicates that declines in the DALY rates from the high-ranked – ‘major’ (low-ranked – ‘minor’) causes are disproportionately responsible for the declining aggregate rates. For our example above, a positive $P$ is combined with reduced DALY rates, meaning that major diseases were disproportionately responsible for the declines disease burden.

Each of the potential interpretations of the sign of the proportionality index are summarized in Table 1. Because DALY rates have generally been in decline, these interpretations are indicated in bold.

### TABLE 1: Interpretation of the Jenkins-Van Kerm (JVK) proportionality index

| Aggregate DALY rate | Sign of Proportionality (P) Index | Causes disproportionately responsible for growth/decline |
|---------------------|-----------------------------------|--------------------------------------------------------|
| Growing             | Positive                          | Low-ranked                                             |
|                     | Negative                          | High-ranked                                            |
| Declining           | Positive                          | High-ranked                                            |
|                     | Negative                          | Low-ranked                                             |

The reranking index, $R$, now gives an indication of the importance of the change in ranks of disease burden causes. It therefore summarizes the “mobility” and stability of disease causes.

### 2.3 Data and presentation

The data used are taken from the 2017 GBD study which is publicly available and can be accessed by the query tool on the Institute for Health Metrics and Evaluation (IHME) website. Annual estimates of DALY

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7 A mathematical exposition for these interpretations can be found in Appendix 1Bf.
burdens are available from 1990 to 2017, for 195 countries and 290 causes of DALYs (Global Health Data Exchange, 2019).

In the presentation of our results, DALY rates are provided alongside the decomposition indices to facilitate the interpretation of the proportionality indices. The number of causes that are used in each decomposition calculation is presented in brackets within each table.

Colour shading indicates the relative size of the P indices. The range of values used to determine the percentile-based colour shading is determined by the P index values presented in each table, so is not consistent with shading in other tables. All computations were done using age-standardised DALY rates, as is appropriate in order to better account for the differences in age structures across the world and the changing age structures within regions over time (Ahmad et al., 2001). Moreover, rates rather than crude totals were used to account for population changes in the regions over time.

3. Results

Table 2 shows Gini coefficients, Gini changes and their decompositions presented across the 28 available years of data, for three 9-year periods, across the 7 GBD world regions, and for 290 DALY causes.

<Insert Table 2 here>

Along with DALY rates, Gini coefficients have generally fallen over the period. This is the result of disproportionate falls among the major causes. The table summarises changes in the relative importance of causes of disease burden. We focus here on two regions where rather dramatic changes occurred. Firstly, for the period from 1990 to 1999, Sub-Saharan Africa experienced increases in both overall DALY rates, and in the Gini coefficient. Underlying this are high reranking and negative proportionality indices which resulted from the sudden appearance of the HIV/AIDS epidemic during this period. HIV/AIDS first overtook malaria, then diarrheal diseases, then lower respiratory infections, and by 1999 it had become the leading cause of DALYs. In sharp contrast to this, the large positive proportionality index for the 2008 to 2017 period signals the steep falls in the HIV/AIDS DALY rate, as well as for malaria, diarrheal diseases, and lower respiratory infections. Secondly, the period 1999 to 2008 shows relatively large-sized and positive R and P indices in South East Asia, East Asia, and Oceania, combined with a particularly steep drop in total DALY rates. This is caused by the sharp fall for two of the leading causes of DALYs from 1999: chronic obstructive pulmonary disease and lower respiratory infections. These declines also led to reductions in their rankings which, in turn, led to IHD, intracerebral haemorrhage and stroke regaining their former places in the ranking.

While the retrospective information on longer-term trends is of interest, for the purpose of aiding policymakers in making investment and resource reallocation decisions, we now adopt a shorter-term view. In Table 3, Gini coefficients, reranking and proportionality indices are presented for the most recent year of available GBD data, 2017, and for the year 2007. Alongside these 10-year decompositions, year-on-year proportionality and reranking indices are presented, allowing for a more detailed inspection of the changes occurring in this period.

<Insert Table 3 here>

During this decade, the large decline in HIV/AIDS and, to a lesser extent, in malaria and tuberculosis, is responsible for the observed trends in the proportionality indices for Sub-Saharan Africa. While such trends

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8 Statistics Canada provides an explanation of age-standardisation of mortality rates: https://www.statcan.gc.ca/eng/dai/btd/asr
are less clear for other regions, some outliers are discernible. The 2009/10 Latin America and Caribbean and the 2007/08 South East Asia, East Asia, and Oceania proportionality indices correspond to the 2010 Haiti and 2008 Sichuan earthquakes respectively (Salomon et al., 2012; Zhou et al., 2016). The figures are large in magnitude, and italicised, which indicates that there were rises in total DALYs during those years, and that low ranked causes, especially ‘Exposure to the forces of nature’ were disproportionately responsible for this. These forces of nature also influence the reranking index since it is a major cause in one year and a minor cause in all other years.

More generally, regions experienced falls in rates of disease burden (see Figure 2). Table 3 indicates that these trends correspond to a general reduction in proportionality indices and, in some cases, negative $P$ indices, especially since 2013. This means that the falls in rates of disease burden in most regions are increasingly due to disproportionate falls among low ranked causes. Over time it can be seen that in North-Africa and the Middle East, much as in Sub-Saharan Africa, the size of the proportionality index is quite high in several years. This signals that there are substantial changes in relative importance of diseases. This finding is likely explained by conflict and violence in North-Africa and the Middle East.

In Tables 4 and 5 the Gini coefficients and decompositions are calculated for the groups of disease burden causes defined by the GBD\(^9\). This method has the advantage of allowing proportionality indices to show whether or not DALY rates are becoming more concentrated in the major causes within a particular group of disease causes. Reranking indices represent reranking of causes within groups of causes.

<Insert Tables 4, 5 here>

Table 4 presents Gini coefficients, reranking and proportionality indices for the groups of disease burden causes defined in the GBD as CMNN diseases. While sub-Saharan Africa and S&SE Asia have seen their burden of disease declining because of major CMNN diseases, the opposite is true for other world regions. Especially the high-income and South Asia region experienced relatively large declines in disease burden among minor diseases. The positive proportionality indices and falling DALY rates for the HIV/AIDS and STIs category in sub-Saharan Africa indicate that the cause HIV/AIDS resulting in other diseases fell far more steeply than other causes within that category. The South Asia region shows the second highest CMNN DALY rate after sub-Saharan Africa. The negative proportionality indices for this region within the Neglected tropical diseases and malaria category reflect the rises in DALY rates from dengue fever, which appear to outweigh the reductions in DALY rates from malaria.

Table 5 presents Gini coefficients and reranking and proportionality indices for the groups of causes defined in the GBD as NCDs. When considering NCDs as a whole, progressivity and reranking indices display very low values. Other NCD causes contribute less to the overall DALY rate but, nonetheless, there is a relatively high-magnitude and positive $P$ index for Neoplasms in Central and Eastern Europe. This may signal the steeper drops in lung and stomach cancer DALY rates relative to other cancers.

### 3. Discussion and Limitations

The importance and relevance of our suggested measures is apparent from the results for the period 1999 to 2008. For example, during this period, $R$ and $P$ indices were particularly large in South East Asia, East Asia, and Oceania. However, despite these large and important changes, the change in the overall Gini coefficient is almost negligible and does not reveal the underlying changes. Therefore, this example illustrates the usefulness of the decomposition for identifying changes in the relative importance of the causes.

\(^9\)Where a group contains fewer than 15 death causes, this group is excluded from the tables. The number of causes within a group are shown in brackets within each table.
Through year-on-year comparisons of proportionality indices, we found that minor diseases are becoming more and more important in explaining the declining disease burden. It is likely that the reduced rate of reductions in DALY rates due to IHD and the continuing rise in importance of causes such as Alzheimer's disease, especially in high-income countries, are among the most important contributors to this trend. The relative importance of already highly ranked causes has been rising in recent years because DALY rates for these causes have fallen at a slower rate than for minor causes. This could justify more resources being reallocated to the corresponding areas of health care. However, the small size of the reranking indices suggests that resources should not be reallocated in a way that allows for the amount of resources allocated to lower ranked causes to overtake that of the higher ranked. At the regional level, the large proportionality indices for Sub-Saharan Africa signal that the relative importance of diseases is quite variable over time.

Relating these findings to investment strategies, and after taking into consideration possible other explanations, it may be best for investments and resource allocation to be targeted across multiple causes of disease burden in order to best mitigate the risks associated with future uncertainty.

Cause-specific analyses suggested that the changing relative importance between disease causes is mainly driven by CMNN diseases because indices are generally higher than for NCDs. For most NCDs in regions, the proportionality indices are either relatively similar, or falling in more recent years. This is likely to reflect the effect of a slowing down in the reduction of IHD disease burden. This is also suggested in the Cardiovascular diseases category.

As with any analysis, our study suffers from some limitations. First, while the proportionality index is useful to identify which causes of disease burden are changing in importance relative to one another, its value will be close to zero if there are no changes in relative importance. This means that readers should be careful to note that just because the value of the index is low, this does not mean that there are no changes in the aggregate DALY rates, i.e. DALY rates could be rising or falling at the same rates for all causes. It is advisable, as is done in our tables, to view the index in conjunction with changes in aggregate rates. Secondly, we provide summary measures to interpret extensive data. Of course, the interpretation of these measures still needs scrutiny of the underlying data to evaluate what is driving the change in these measures to inform policy. Thirdly, there is uncertainty surrounding accuracy of the GBD data, and the GBD does contain 95% confidence intervals for each of its estimates on health metrics. For the purposes of this paper, only the central estimate has been used.

4. Conclusion
The findings presented here demonstrate the usefulness of the Gini decomposition as a way of summarising the data on trends for the large number of disease burden causes. It has a major advantage which no current method of summarising the data manages to overcome: no matter how many of the 290 causes of disease burden are included in its calculation, it can summarise in a single statistic whether or not the leading causes of disease burden are rising or falling in importance, and whether any significant reranking is taking place.

For every region of the world, more recent years have witnessed lower - and in some cases negative - values of proportionality indices combined with a general deceleration in the rate of falls in disease burden rates. This finding implies that the rate of decline in the rates of disease burden of the leading causes has slowed relative to that of lower ranked causes.

The condensed nature of the presented data allows readers to more easily discover whether, for particular world regions, countries, or cause groups, the leading causes of disease burden are becoming more or less
important relative to lower ranked causes. For policymakers, the use of this summary measure could help to decide whether resources need to be reoriented to meet such a challenge.
List of abbreviations

| Abbreviation | Description |
|--------------|-------------|
| CMNN         | communicable, maternal, neo-natal and nutritional diseases |
| DALY         | Disability Adjusted Life Year |
| G            | Gini index |
| GBD          | Global Burden of Disease |
| IHD          | ischemic heart disease |
| IHME         | Institute for Health Metrics and Evaluation |
| JvK          | Jenkins-Van Kerm index |
| NCD          | non-communicable diseases |
| P            | Proportionality index |
| R            | Reranking index |
| S&SE         | South and South-East |
| STI          | Sexually Transmitted Infection |
| WHO          | World Health Organization |

Declarations

- Ethics approval and consent to participate
  
  Not applicable

- Consent for publication
  
  Not applicable

- Availability of data and materials
  
  Data are publicly available from [http://ghdx.healthdata.org/gbd-results-tool](http://ghdx.healthdata.org/gbd-results-tool)

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- Authors' contributions
  
  HD participated in the study design, analyzed and interpreted data, and drafted the first version of the paper. RVG initiated the design of the study, interpreted data and partially drafted the paper. EVD critically revised and interpreted the study.

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Appendices

Appendix 1A
The Gini is equal to one minus twice the area under the Lorenz curve, and is formally defined as:

\[ G = 1 - 2 \int_0^1 L(s)ds \]  

where \( G \) is the Gini coefficient and \( L \) is the Lorenz curve, which itself is a function of \( s \), the cumulative distribution function of the disease causes (O’Donnell et al., 2008).

Appendix 1B
This appendix provides a short proof for the result seen in equation 2. Letting \( G_0 \) and \( G_1 \) be the Gini coefficients in years 0 and 1, then

\[ \Delta G = G_1 - G_0 \]

Therefore, using equation 1

\[ \Delta G = 1 - 2 \int_0^1 L_1(s)ds - [1 - 2 \int_0^1 L_0(s)ds] \]

\[ = 2 \int_0^1 L_0(s) - L_1(s)ds \]

Let \( C_1^{(0)}(s) \) be the concentration curve of year 1 ordered according to year 0 ranks. Adding and subtracting from the above equation:

\[ \Delta G = 2 \int_0^1 L_0(s) - L_1(s)ds + C_1^{(0)}(s) - C_1^{(0)}(s)ds \]

\[ = 2 \int_0^1 C_1^{(0)}(s) - L_0(s)ds - 2 \int_0^1 C_1^{(0)}(s) - L_1(s)ds \]

\[ = R - P. \]

Appendix 1B
By integrating by parts and applying a change of variable, \( s = F(x) \), the equations in this paper for the Gini coefficients, their changes over time, and the decomposition of these changes, can be reformulated to demonstrate the roles of the mean DALY rates over all causes, the rankings of the individual causes, and the ‘proportional’ rates (i.e. the proportion of total DALY rates that each individual cause is responsible for). In this way, equation (4) can be reformulated to show that:

\[ P = 2 \iiint_{z_+} w(F(x_0)) \left[ \frac{z_+ - x_0}{z_+ - z_-} \right] h(x_0, x_1)dx_0dx_1 \]

In this equation, \( x_i \) and \( T_i \) represent the DALY rates for each DALY cause in year \( i \), and the total DALY rate in year \( i \). \( F(.) \) is the cumulative density function of the DALY causes and \( h(.) \) denotes the joint probability density function of the DALY causes in years 0 and 1. \( z_+ \) and \( z_- \) show the upper and lower limits of the domain of \( x_0 \) and \( x_1 \), so that \( z_+ = F^{-1}(1) \) and \( z_- = F^{-1}(0) \).

There are two key points to note about this equation. Firstly, \( F(x_0) \) is the proportion of DALY causes with a DALY rate less than \( x_0 \), and can therefore be considered as the ranking for each cause. Secondly, the weight \( w(.) \), is a decreasing function of \( F(.) \), i.e., lower ranked causes (causes responsible for fewer DALYs) are allocated a higher weighting.
In summary, the formula shows that the proportionality index, \( P \), should be thought of as the weighted average of the changes in proportional DALY rates between years 0 and 1 with the weights being determined by the rankings in year 0.

To relate the above equation to the interpretations made in Table 1, it is best to reformulate the above equation as follows.

Let \( \pi = \frac{T_1 - T_0}{T_0} \) be the proportional change in the total DALY rate. Also let a generalized Kakwani (1977)-type index be represented by:

\[
K = 2 \int \int (F(x_0)) \left[ \frac{x_1 - x_0}{T_1 - T_0} - \frac{5x_0}{T_0} \right] h(x_0, x_1) dx_0 dx_1
\]

Then \( P = \frac{\pi}{1+\pi} K \).

To obtain a positive proportionality index: If \( \pi > 0 \), \( P \) is positive only if \( K \) is also positive. Due to the greater weights allocated to lower ranked causes, growth in DALY rates among these causes must be high relative to higher ranked causes for \( K \) to be positive. Conversely, if \( \pi < 0 \), then reductions in DALY rates among the lower ranked causes must be low relative to higher ranked causes for \( K \) to be negative.

To obtain a negative proportionality index: If \( \pi > 0 \), \( P \) is negative only if \( K \) is negative. Due to the greater weights allocated to lower ranked causes, growth in DALY rates among these causes must be low relative to higher ranked causes for \( K \) to be negative. Conversely, if \( \pi < 0 \), then reductions in DALY rates among the lower ranked causes must be high relative to higher ranked causes for \( K \) to be positive.
| SE&E Asia, Oceania | C&E Europe, C Asia | High-income | L America, Caribbean | N Africa, Middle East | South Asia | Sub-Saharan Africa |
|-------------------|-------------------|-------------|---------------------|----------------------|-----------|-------------------|
| Southeast Asia, East Asia, and Oceania | Central Europe, Eastern Europe, and Central Asia | High-income | Latin America and Caribbean | North Africa and Middle East | South Asia | Sub-Saharan Africa |
| China | Armenia | Brunei | Antigua and Barbuda | Algeria | Bangladesh | Angola |
| North Korea | Azerbaijan | Japan | The Bahamas | Bahrain | Bhutan | C. African Republic |
| Taiwan | Georgia | South Korea | Barbados | Egypt | Congo | DR Congo |
| Cambodia | Kazakhstan | Singapore | Belize | Iran | Nepal | Pakistan |
| Indonesia | Kyrgyzstan | Australia | Cuba | Iraq | Equatorial Guinea | Gabon |
| Laos | Mongolia | New Zealand | Dominica | Jordan | Burundi | Comoros |
| Malaysia | Tajikistan | Andorra | Dominican Republic | Kuwait | Ethiopia | Djibouti |
| Maldives | Turkmenistan | Austria | Grenada | Lebanon | Eritrea | Ethiopia |
| Myanmar | Uzbekistan | Belgium | Guyana | Libya | Kenya | Madagascar |
| Philippines | Albania | Cyprus | Haiti | Morocco | Malawi | Mozambique |
| Sri Lanka | Bosnia and Herzegovina | Denmark | Jamaica | Palestine | Mauritius | Namibia |
| Thailand | Bulgaria | Finland | Saint Lucia | Oman | Somalia | South Africa |
| Timor-Leste | Croatia | France | St Vincent, Grenadines | Qatar | Seychelles | Swaziland |
| Vietnam | Czech Republic | Germany | Suriname | Saudi Arabia | Somalia | Tanzania |
| Fiji | Hungary | Greece | Trinidad and Tobago | Syria | Tanzania | Uganda |
| Kiribati | Macedonina | Iceland | Bolivia | Tunisia | Uganda | United Arab Emirates |
| Marshall Islands | Montenegro | Ireland | Ecuador | Turkey | United Kingdom | United Kingdom |
| Micronesia | Poland | Italy | Peru | United States | Vanuatu | United States |
| Papua New Guinea | Samoa | Serbia | Columbia | Yemen | American Samoa | Venezuela |
| Solomon Islands | Slovakia | Slovenia | Costa Rica | Afghanistan | Guam | Vieques |
| Tonga | Vanuatu | Belarus | El Salvador | Sudan | N. Mariana Islands | Virgin Islands, U.S. |
| American Samoa | Estonia | Spain | Mexico | Zambia | American Samoa | Cote d'Ivoire |
| Guam | Latvia | France | Nicaragua | Zimbabwe | Guam | The Gambia |
| N. Mariana Islands | Lithuania | Switzerland | Panama | Benin | Malaysia | Ghana |
| Russia Federation | Moldova | United Kingdom | Paraguay | Burkina Faso | Mauritania | Guinea |
| Ukraine | Russian Federation | Argentina | Brazil | Cameroon | Niger | Guinea-Bissau |
| United States | United States | Chile | Bermuda | Cape Verde | Nigeria | Liberia |
| Greenland | Greenland | Canada | Puerto Rico | Chad | Mali | Malawi |
| South Africa | South Africa | South Africa | South Africa | South Africa | Mauritania | Namibia |
| Swaziland | Swaziland | Swaziland | Swaziland | Swaziland | Niger | Nigeria |
| Zimbabwe | Zimbabwe | Zimbabwe | Zimbabwe | Zimbabwe | Sao Tome and Principe | Senegal |
| Benin | Benin | Benin | Benin | Benin | Sierra Leone | Togo |
| Burkina Faso | Burkina Faso | Burkina Faso | Burkina Faso | Burkina Faso | Togo | South Sudan |
**Table A2: Causes of DALYs in the GBD**

| Category | Causes |
|----------|--------|
| HIV/AIDS and STIs | Other sexually transmitted infections, syphilis, HIV/AIDS |
| Infections | Neonatal and maternal disorders, infections, jaundice, pneumonia |
| Respiratory infections | Respiratory infections, lower respiratory infections, upper respiratory infections |
| Other maternal disorders | Maternal sepsis, maternal and neonatal disorders, other maternal disorders |
| Neonatal infections | Other neonatal infections, neonatal tetanus, neonatal malnutrition |
| Enteric infections | Measles, cholera, enteric infections, diarrheal diseases |
| Malnutrition | Malnutrition, dietary iron deficiency, vitamin A deficiency, iodine deficiency |
| Neurological disorders | Neurological disorders, Alzheimer's disease, Parkinson's disease, stroke, epilepsy |
| Substance use and other drug use disorders | Alcohol use disorders, other drug use disorders, cannabis use disorders |
| Skin and subcutaneous diseases | Psoriasis, skin diseases, viral skin diseases, bacterial skin diseases |
| Cardiovascular diseases | Myocardial infarction, stroke, rheumatic heart disease, chronic obstructive pulmonary disease |
| Infectious diseases | Other infectious diseases, HIV/AIDS, tuberculosis |
| Respiratory infections | Other respiratory infections, lower respiratory infections, upper respiratory infections |
| Maternal and neonatal disorders | Maternal and neonatal disorders, other maternal disorders, maternal sepsis |
| Other non-communicable diseases | Other non-communicable diseases, obesity, diabetes, hypertension |
| Reproductive and urogenital diseases | Reproductive and urogenital diseases, male infertility, female infertility |
|cardiorespiratory diseases | Other non-respiratory conditions, other chronic obstructive pulmonary disease |
| Nutritional deficiencies | Protein-energy malnutrition, other nutritional deficiencies, vitamin A deficiency, iron deficiency |
| Digestive diseases | Cirrhosis - hepatitis B, cholecystitis, other diseases, inflammatory bowel disease |
| Musculoskeletal disorders | Musculoskeletal disorders, rheumatoid arthritis, osteoarthritis |
| Mental disorders | Mental disorders, schizophrenia, depression, anxiety disorders |
| Substance use disorders | Alcohol use disorders, opioid use disorders, cocaine use disorders |
| Skin and subcutaneous diseases | Psoriasis, viral skin diseases, bacterial skin diseases, fungal skin diseases |
| Cardiovascular diseases | Myocardial infarction, stroke, rheumatic heart disease, chronic obstructive pulmonary disease |
| Infectious diseases | Other infectious diseases, HIV/AIDS, tuberculosis |
| Respiratory infections | Other respiratory infections, lower respiratory infections, upper respiratory infections |
| Maternal and neonatal disorders | Maternal and neonatal disorders, other maternal disorders, maternal sepsis |
| Other non-communicable diseases | Other non-communicable diseases, obesity, diabetes, hypertension |
| Reproductive and urogenital diseases | Reproductive and urogenital diseases, male infertility, female infertility |
|cardiorespiratory diseases | Other non-respiratory conditions, other chronic obstructive pulmonary disease |
| Nutritional deficiencies | Protein-energy malnutrition, other nutritional deficiencies, vitamin A deficiency, iron deficiency |
| Digestive diseases | Cirrhosis - hepatitis B, cholecystitis, other diseases, inflammatory bowel disease |
| Musculoskeletal disorders | Musculoskeletal disorders, rheumatoid arthritis, osteoarthritis |
| Mental disorders | Mental disorders, schizophrenia, depression, anxiety disorders |
| Substance use disorders | Alcohol use disorders, opioid use disorders, cocaine use disorders |
| Skin and subcutaneous diseases | Psoriasis, viral skin diseases, bacterial skin diseases, fungal skin diseases |
| Cardiovascular diseases | Myocardial infarction, stroke, rheumatic heart disease, chronic obstructive pulmonary disease |
| Infectious diseases | Other infectious diseases, HIV/AIDS, tuberculosis |
| Respiratory infections | Other respiratory infections, lower respiratory infections, upper respiratory infections |
| Maternal and neonatal disorders | Maternal and neonatal disorders, other maternal disorders, maternal sepsis |
| Other non-communicable diseases | Other non-communicable diseases, obesity, diabetes, hypertension |
| Reproductive and urogenital diseases | Reproductive and urogenital diseases, male infertility, female infertility |
|cardiorespiratory diseases | Other non-respiratory conditions, other chronic obstructive pulmonary disease |
| Nutritional deficiencies | Protein-energy malnutrition, other nutritional deficiencies, vitamin A deficiency, iron deficiency |
| Digestive diseases | Cirrhosis - hepatitis B, cholecystitis, other diseases, inflammatory bowel disease |
| Musculoskeletal disorders | Musculoskeletal disorders, rheumatoid arthritis, osteoarthritis |
| Mental disorders | Mental disorders, schizophrenia, depression, anxiety disorders |
| Substance use disorders | Alcohol use disorders, opioid use disorders, cocaine use disorders |
| Skin and subcutaneous diseases | Psoriasis, viral skin diseases, bacterial skin diseases, fungal skin diseases |
| Cardiovascular diseases | Myocardial infarction, stroke, rheumatic heart disease, chronic obstructive pulmonary disease |
| Infectious diseases | Other infectious diseases, HIV/AIDS, tuberculosis |
| Respiratory infections | Other respiratory infections, lower respiratory infections, upper respiratory infections |
| Maternal and neonatal disorders | Maternal and neonatal disorders, other maternal disorders, maternal sepsis |
| Other non-communicable diseases | Other non-communicable diseases, obesity, diabetes, hypertension |
| Reproductive and urogenital diseases | Reproductive and urogenital diseases, male infertility, female infertility |
|cardiorespiratory diseases | Other non-respiratory conditions, other chronic obstructive pulmonary disease |
| Nutritional deficiencies | Protein-energy malnutrition, other nutritional deficiencies, vitamin A deficiency, iron deficiency |
| Digestive diseases | Cirrhosis - hepatitis B, cholecystitis, other diseases, inflammatory bowel disease |
| Musculoskeletal disorders | Musculoskeletal disorders, rheumatoid arthritis, osteoarthritis |
| Mental disorders | Mental disorders, schizophrenia, depression, anxiety disorders |
| Substance use disorders | Alcohol use disorders, opioid use disorders, cocaine use disorders |
| Skin and subcutaneous diseases | Psoriasis, viral skin diseases, bacterial skin diseases, fungal skin diseases |
| Cardiovascular diseases | Myocardial infarction, stroke, rheumatic heart disease, chronic obstructive pulmonary disease |
| Infectious diseases | Other infectious diseases, HIV/AIDS, tuberculosis |
| Respiratory infections | Other respiratory infections, lower respiratory infections, upper respiratory infections |
| Maternal and neonatal disorders | Maternal and neonatal disorders, other maternal disorders, maternal sepsis |
| Other non-communicable diseases | Other non-communicable diseases, obesity, diabetes, hypertension |
| Reproductive and urogenital diseases | Reproductive and urogenital diseases, male infertility, female infertility |
|cardiorespiratory diseases | Other non-respiratory conditions, other chronic obstructive pulmonary disease |
| Nutritional deficiencies | Protein-energy malnutrition, other nutritional deficiencies, vitamin A deficiency, iron deficiency |
| Digestive diseases | Cirrhosis - hepatitis B, cholecystitis, other diseases, inflammatory bowel disease |
| Musculoskeletal disorders | Musculoskeletal disorders, rheumatoid arthritis, osteoarthritis |
| Mental disorders | Mental disorders, schizophrenia, depression, anxiety disorders |
| Substance use disorders | Alcohol use disorders, opioid use disorders, cocaine use disorders |
| Skin and subcutaneous diseases | Psoriasis, viral skin diseases, bacterial skin diseases, fungal skin diseases |
| Cardiovascular diseases | Myocardial infarction, stroke, rheumatic heart disease, chronic obstructive pulmonary disease |
| Infectious diseases | Other infectious diseases, HIV/AIDS, tuberculosis |
| Respiratory infections | Other respiratory infections, lower respiratory infections, upper respiratory infections |
| Maternal and neonatal disorders | Maternal and neonatal disorders, other maternal disorders, maternal sepsis |
| Other non-communicable diseases | Other non-communicable diseases, obesity, diabetes, hypertension |
| Reproductive and urogenital diseases | Reproductive and urogenital diseases, male infertility, female infertility |
|cardiorespiratory diseases | Other non-respiratory conditions, other chronic obstructive pulmonary disease |
| Nutritional deficiencies | Protein-energy malnutrition, other nutritional deficiencies, vitamin A deficiency, iron deficiency |
| Digestive diseases | Cirrhosis - hepatitis B, cholecystitis, other diseases, inflammatory bowel disease |
| Musculoskeletal disorders | Musculoskeletal disorders, rheumatoid arthritis, osteoarthritis |
| Mental disorders | Mental disorders, schizophrenia, depression, anxiety disorders |
| Substance use disorders | Alcohol use disorders, opioid use disorders, cocaine use disorders |
| Skin and subcutaneous diseases | Psoriasis, viral skin diseases, bacterial skin diseases, fungal skin diseases |
| Cardiovascular diseases | Myocardial infarction, stroke, rheumatic heart disease, chronic obstructive pulmonary disease |
| Infectious diseases | Other infectious diseases, HIV/AIDS, tuberculosis |
| Respiratory infections | Other respiratory infections, lower respiratory infections, upper respiratory infections |
| Maternal and neonatal disorders | Maternal and neonatal disorders, other maternal disorders, maternal sepsis |
| Other non-communicable diseases | Other non-communicable diseases, obesity, diabetes, hypertension |
| Reproductive and urogenital diseases | Reproductive and urogenital diseases, male infertility, female infertility |
|cardiorespiratory diseases | Other non-respiratory conditions, other chronic obstructive pulmonary disease |
| Nutritional deficiencies | Protein-energy malnutrition, other nutritional deficiencies, vitamin A deficiency, iron deficiency |
| Digestive diseases | Cirrhosis - hepatitis B, cholecystitis, other diseases, inflammatory bowel disease |
| Musculoskeletal disorders | Musculoskeletal disorders, rheumatoid arthritis, osteoarthritis |
| Mental disorders | Mental disorders, schizophrenia, depression, anxiety disorders |
| Substance use disorders | Alcohol use disorders, opioid use disorders, cocaine use disorders |
| Skin and subcutaneous diseases | Psoriasis, viral skin diseases, bacterial skin diseases, fungal skin diseases |
| Cardiovascular diseases | Myocardial infarction, stroke, rheumatic heart disease, chronic obstructive pulmonary disease |
| Infectious diseases | Other infectious diseases, HIV/AIDS, tuberculosis |
| Respiratory infections | Other respiratory infections, lower respiratory infections, upper respiratory infections |
| Maternal and neonatal disorders | Maternal and neonatal disorders, other maternal disorders, maternal sepsis |
| Other non-communicable diseases | Other non-communicable diseases, obesity, diabetes, hypertension |
| Reproductive and urogenital diseases | Reproductive and urogenital diseases, male infertility, female infertility |
|cardiorespiratory diseases | Other non-respiratory conditions, other chronic obstructive pulmonary disease |

**Note:** Italicised causes are classified as DALY causes but not death causes within the GBD.
### TABLE 2: All DALY causes, by GBD world region. Gini coefficients and DALY rates, 1990, 1999, 2008, 2017; 9-year Gini changes and reranking and proportionality indices, 1990-1999, 1999-2008, 2008-2017.

| Region                        | 1990 DALY rate | 1990-1999 | 1999 DALY rate | 1999-2008 | 2008 DALY rate | 2008-2017 | 2017 DALY rate |
|-------------------------------|----------------|-----------|----------------|------------|----------------|------------|----------------|
|                               | G | ΔG | R | P | G | ΔG | R | P | G | ΔG | R | P | G | ΔG | R | P | G | ΔG | R | P | G | ΔG | R | P | G | ΔG | R | P | G | ΔG | R | P |
| SE&E Asia, Oceania            | 41,075 | 0.75 | -0.014 | 0.006 | 0.020 | 36,023 | 0.74 | -0.006 | 0.030 | 0.036 | 29,335 | 0.73 | -0.005 | 0.008 | 0.013 | 25,077 | 0.73 |
| C&E Europe, C Asia            | 37,777 | 0.77 | -0.001 | 0.010 | 0.010 | 40,008 | 0.77 | -0.006 | 0.005 | 0.011 | 36,487 | 0.76 | -0.011 | 0.002 | 0.013 | 30,576 | 0.75 |
| High-income                   | 25,564 | 0.73 | -0.004 | 0.002 | 0.006 | 23,098 | 0.73 | -0.003 | 0.002 | 0.006 | 21,107 | 0.72 | 0.002 | 0.001 | -0.001 | 20,252 | 0.73 |
| Latin America, Caribbean      | 39,319 | 0.73 | -0.014 | 0.016 | 0.030 | 33,977 | 0.72 | -0.008 | 0.006 | 0.014 | 29,118 | 0.71 | -0.004 | 0.002 | 0.006 | 26,895 | 0.70 |
| N Africa, Middle East         | 48,724 | 0.77 | -0.013 | 0.003 | 0.016 | 41,686 | 0.76 | -0.008 | 0.006 | 0.014 | 35,190 | 0.75 | 0.000 | 0.004 | 0.004 | 31,321 | 0.75 |
| South Asia                    | 64,065 | 0.79 | -0.021 | 0.012 | 0.033 | 55,327 | 0.77 | -0.013 | 0.004 | 0.017 | 46,666 | 0.75 | -0.007 | 0.005 | 0.012 | 39,718 | 0.75 |
| Sub-Saharan Africa            | 82,766 | 0.78 | 0.011 | 0.009 | -0.002 | 84,635 | 0.79 | -0.005 | 0.004 | 0.009 | 70,479 | 0.79 | -0.040 | 0.003 | 0.042 | 51,979 | 0.75 |
| Region                        | 2007 DALY Rate | 2007 | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | 2015/16 | 2016/17 | 2007/17 | 2017 DALY Rate | 2017 G |
|------------------------------|----------------|-------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------------|------|
| S&SE Asia, Oceania          | 29,131         | 0.73  | 0.021   | 0.004   | 0.000   | 0.000   | 0.001   | 0.002   | 0.000   | 0.000   | 0.001   | 0.017   | 0.002   | 0.019   | 25,077       | 0.73  |
| C&E Europe, C Asia          | 37,056         | 0.76  | 0.021   | 0.004   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 30,576       | 0.75  |
| High-income                 | 21,289         | 0.72  | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 20,252       | 0.73  |
| L. America, Caribbean      | 29,269         | 0.71  | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 26,895       | 0.70  |
| N Africa, Middle East      | 35,973         | 0.75  | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 31,321       | 0.75  |
| S Asia                      | 47,398         | 0.75  | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 39,718       | 0.75  |
| Sub-Saharan Africa         | 72,786         | 0.79  | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 51,979       | 0.75  |

TABLE 3: All DALY causes, by GBD World Region. Gini coefficients and DALY rates, 2007 and 2017; Yearly proportionality indices, 2007/08-2016/17; 10-year reranking and proportionality indices, 2007-2017.
| Region                        | 2007 G | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | 2015/16 | 2016/17 | 2017 G |
|-------------------------------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|--------|
| **All CMNNs (79)**            |        |         |         |         |         |         |         |         |         |         |         |        |
| S&SE Asia, Oceania           | 6,222  | 0.82    | 0.000   | 0.000   | 0.000   | 0.001   | 0.003   | 0.001   | 0.000   | 0.003   | 0.003   | 0.015   | 3,946  |
| C&E Europe, C Asia           | 4,918  | 0.87    | 0.001   | 0.000   | 0.000   | -0.001  | 0.000   | 0.000   | 0.001   | 0.000   | 0.000   | 0.000   | 3,811  |
| High-income                  | 1,721  | 0.86    | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 1,547  |
| L. America, Caribbean        | 5,937  | 0.83    | 0.001   | 0.001   | -0.002  | 0.001   | 0.000   | 0.000   | 0.001   | 0.000   | 0.000   | 0.000   | 4,596  |
| N Africa, Middle East        | 8,014  | 0.84    | 0.000   | 0.000   | 0.001   | 0.002   | 0.001   | 0.001   | 0.000   | 0.001   | 0.000   | 0.000   | 5,476  |
| S Asia                       | 19,730 | 0.80    | -0.001  | -0.001  | -0.001  | -0.002  | -0.001  | -0.002  | -0.003  | -0.001  | 0.000   | -0.005  | 13,197 |
| Sub-Saharan Africa           | 44,793 | 0.83    | 0.001   | 0.002   | 0.003   | 0.004   | 0.003   | 0.003   | 0.008   | 0.001   | 0.002   | 0.002   | 26,492 |
| **Neglected tropical diseases and malaria (23)** |        |         |         |         |         |         |         |         |         |         |         |        |
| S&SE Asia, Oceania           | 279    | 0.74    | -0.004  | -0.003  | -0.002  | -0.003  | -0.004  | -0.004  | -0.003  | -0.004  | -0.005  | -0.007  | 220    |
| C&E Europe, C Asia           | 71     | 0.87    | -0.001  | -0.001  | -0.001  | -0.001  | -0.002  | -0.002  | -0.003  | -0.002  | -0.004  | -0.004  | 66     |
| High-income                  | 17     | 0.82    | -0.006  | -0.005  | -0.004  | -0.001  | 0.001   | 0.000   | -0.001  | -0.002  | -0.004  | -0.003  | 16     |
| L. America, Caribbean        | 237    | 0.68    | -0.003  | -0.003  | -0.004  | -0.002  | -0.002  | -0.002  | -0.003  | -0.004  | -0.009  | -0.030  | 205    |
| N Africa, Middle East        | 211    | 0.73    | 0.011   | 0.009   | 0.003   | 0.001   | 0.004   | 0.000   | 0.000   | 0.000   | 0.006   | 0.006   | 143    |
| S Asia                       | 716    | 0.77    | -0.002  | -0.003  | -0.005  | -0.002  | -0.008  | -0.010  | -0.008  | -0.006  | -0.003  | -0.035  | 477    |
| Sub-Saharan Africa           | 6,639  | 0.89    | -0.001  | 0.001   | 0.002   | 0.003   | 0.000   | -0.001  | 0.031   | -0.002  | -0.002  | -0.002  | 3,822  |
TABLE 5: NCD-specific DALY causes, by GBD world region. Gini coefficients and DALY rates, 2007 and 2017; Yearly proportionality indices, 2007/08-2016/17; 10-year reranking and proportionality indices, 2007-2017.

| Yearly proportionality indices, 2007/08-2016/17 | 2007 | Rate | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013/14 | 2014/15 | 2015/16 | 2016/17 | 2017 | Rate |
|------------------------------------------------|------|------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|------|------|
| **All NCDs (181)**                             |      | P    | R        | P        | R        | P        | R        | P        | R        | P        | R        | P    | R    |
| S&SE Asia, Oceania                            | 19,825 | 0.71 | 0.001   | 0.000   | 0.000   | 0.001   | 0.001   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.001 | 0.006  |
| C&E Europe, C Asia                            | 26,395 | 0.73 | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000 | 0.002  |
| High-income                                   | 17,048 | 0.67 | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000 | 0.001  |
| L. America, Caribbean                         | 19,272 | 0.66 | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000 | 0.007  |
| N Africa, Middle East                         | 23,796 | 0.73 | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000 | 0.001  |
| S Asia                                        | 23,374 | 0.72 | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001 | 0.008  |
| Sub-Saharan Africa                            | 23,583 | 0.67 | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000 | 0.001  |
| **Neoplasms (40)**                            |      |      | P        | R        | P        | R        | P        | R        | P        | R        | P        | R        | P    | R    |
| S&SE Asia, Oceania                            | 3,253  | 0.64 | 0.003   | 0.002   | 0.002   | 0.002   | 0.001   | 0.001   | -0.001  | -0.001  | 0.000   | 0.000   | 0.002  | 0.013  |
| C&E Europe, C Asia                            | 3,869  | 0.60 | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000 | 0.002  |
| High-income                                   | 3,117  | 0.59 | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000 | 0.004  |
| L. America, Caribbean                         | 2,667  | 0.54 | 0.001   | 0.001   | 0.001   | 0.002   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001   | 0.001 | 0.013  |
| N Africa, Middle East                         | 2,383  | 0.58 | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000 | 0.002  |
| S Asia                                        | 2,214  | 0.54 | 0.001   | 0.001   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000 | 0.004  |
| Sub-Saharan Africa                            | 2,990  | 0.56 | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000 | 0.004  |
| **Cardiovascular diseases (17)**               |      |      |      | P        | R        | P        | R        | P        | R        | P        | R        | P        | R    |      |
| S&SE Asia, Oceania                            | 5,019  | 0.75 | -0.001  | -0.001  | -0.001  | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.001 | -0.001 |

**Note:** Gini coefficient values are not provided in the table.
| Region                          | Sub-Regions | Income | P-value | R-value |
|--------------------------------|-------------|--------|---------|---------|
| Sub-Saharan Africa             |             | 2,293  | 0.026   | 0.007   |
| S Asia                         |             | 952    | 0.41    | 0.02    |
| N Africa, Middle East          |             | 7,115  | 0.32    | 0.003   |
| L. America, Caribbean          |             | 3,755  | 0.71    | 0.001   |
| High-income                    |             | 2,698  | 0.68    | 0.005   |
| South & Southeast Asia, Oceania|             | 10,000 | 0.77    | 0.001   |
| C&E Europe, C Asia             |             | 722    | 0.42    | 0.003   |
| C&E Europe, C Asia             |             | 722    | 0.42    | 0.003   |
| Sub-Saharan Africa             |             | 2,142  | 0.42    | 0.003   |
| S Africa                       |             | 1,646  | 0.44    | 0.001   |
| L. America, Caribbean          |             | 1,264  | 0.32    | 0.002   |
| High-income                    |             | 697    | 0.32    | 0.000   |
| Sub-Saharan Africa             |             | 5,551  | 0.73    | 0.003   |
| Digestive (16)                 |             |        |         |         |
| S Asia                         |             | 1,466  | 0.44    | 0.001   |
| N Africa, Middle East          |             | 1,120  | 0.44    | 0.002   |
| L. America, Caribbean          |             | 1,264  | 0.32    | 0.001   |
| High-income                    |             | 697    | 0.32    | 0.003   |
| Sub-Saharan Africa             |             | 2,142  | 0.42    | 0.002   |
| Other (37)                     |             |        |         |         |
| S Asia                         |             | 1,706  | 0.67    | 0.005   |
| C&E Europe, C Asia             |             | 1,624  | 0.64    | 0.003   |
| High-income                    |             | 1,171  | 0.60    | 0.005   |
| L. America, Caribbean          |             | 1,795  | 0.67    | 0.001   |
| N Africa, Middle East          |             | 2,594  | 0.69    | 0.002   |
| S Asia                         |             | 1,844  | 0.61    | 0.001   |
| Sub-Saharan Africa             |             | 2,507  | 0.62    | 0.001   |