A Framework for Measuring Health Inequality

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Introduction

Health inequalities are prominent in the policy agenda (*1-22*). Average achievement is no longer considered a sufficient indicator of a country's performance on health; rather, the distribution of health in the population is also key. The World Health Organization (WHO) is interested in measuring health inequality as a distinct dimension of the performance of health systems (*23*). We define health inequality to be variations in health status across individuals in a population (*16*). This approach, which is consistent with the measurement of inequality in other fields, such as economics, allows us to perform cross-country comparisons and study the determinants of health inequality (*24*).

This paper addresses the question of measuring health inequalities as distinct from measuring the average levels of health. An important policy debate is the tradeoff between policies that improve the average level of health and policies that primarily reduce inequalities in health. How that tradeoff should be resolved is not, however, the subject of this paper.

In the first section, we ask what is the quantity that we would fundamentally want to be equally distributed in a population. In other words, we attempt to answer the classic question in the context of health: equality of what (*25*)? We believe it is critical for a clear debate on health inequality to first articulate what the quantity of interest is and why, and then proceed to measure it, depending on the available data. There has to be a clear definition and measurement framework before the applied work can be undertaken. In section two, we discuss various ways of summarizing the distribution of the quantity of interest and calculating an index of health inequality and address the three distinct normative issues that are raised. In section three, we talk about the overall WHO strategy for measurement and we conclude by highlighting the critical relevance to research and policy formulation that this approach of measuring health inequality will have.

Equality of what?

In addressing the question "What would we like to be equally distributed in the population?" several ethical and technical issues arise. Would we consider perfect equality to be when all individuals live the same number of years? When they enjoy the same level of health? When they have the exact same health status at all points in their lives? In this section we address some of the normative issues surrounding the choice of the quantity that we would like to have equally distributed in a population.

Equality of healthy lifespan

Imagine a cohort of individuals born in the year 2000. What would we need to observe to say that there was complete equality in health among the individuals in this cohort? One starting point might be to argue that everyone in the population should have the same healthy lifespan. In other words, we would like all members of a cohort to live the same number of years and for them to have had on average the same health status during their lives. Later, we will return to further considerations of equality of healthy lifespan.

Healthy lifespan is a summary measure of survival and of the non-fatal health outcomes weighted by their preference weights. Figure 1 illustrates the healthy lifespan for an individual *i*. The horizontal axis is the age of the individual; here the individual is assumed to live to an age of 100 years. On the vertical axis is the percent of full health enjoyed by the individual at each age. If the individual in the diagram lived for 100 years in full health and suddenly died at the age of 100, his healthy lifespan would be the whole area of the graph and would be equal to 100. If this individual during his lifetime experienced any sort of decrement from full health, then we would represent his healthy lifespan by a different curve, such as the one shown in Figure 1, which would take into account the time spent in health states less than full health that this individual experienced. The individual shown in Figure 1 was born in full health, had a motor vehicle accident at the age of 25, experienced diabetes at the age of 50 and Alzheimer's disease at the age of 65. The area under the curve represents the individual's healthy lifespan, or in other words, the number of years lived in full health that would be equivalent to the 100 years he/she lived with part of them in states worse than full health, individual *i*'s experience. The actual calculation of the healthy lifespan for individual *i* depends on the weights that one assigns to the various health states that are worse than full health; the methods and debates surrounding the measurement of health state weights are addressed elsewhere (*26-31*).

We need to distinguish between an individuals healthy lifespan and the set of health risks that they are exposed to at each age of their life. Health risks are the probabilities of death and incidence and remission of non-fatal health outcomes of differing severities that individuals face at each age. We are not able to measure health risks at the individual level, but we are developing methods to approximate them. By combining across all ages an individual's risks of being in a state less than full health we calculate health expectancy, i.e. the expected number of years lived in full health, given a set of health risks. A given level of health expectancy can result from more than one underlying patterns of health risks. Health risks can be seen as underlying healthy lifespan or healthy lifespan may be considered the realization of a set of health risks.

For all individuals in a cohort to have equal healthy lifespans, two conditions are necessary and sufficient: a. individuals all have equal health expectancies; and b. individuals' risks of death, and incidence and remission for non-fatal health outcomes are rectangular. Equal health expectancies mean that the area under the health survivorship function (Figure 2) is equal.[†] A rectangular risk curve means the risk of

[†] Some formal notation will be helpful for those familiar with survival analysis. *S(x)* is the traditional survivorship function defining the probability of being alive at age x given a set of mortality risks, $\mu(x)$ at each age. In addition to mortality risks, individuals face incidence and remission rates from full health into health states less than full health and transition probabilities between these states. This complex set of health risks can be summarized by the health survivorship function. This is the probability of being alive and in equivalent full health at each age. Formally, for an individual it is calculated by weighing the survivorship function (the probability of being alive at each age) by the probability of being in any health state j at each age by the severity weight for that health state:

$$HS(x) = S(x)\sum_j \left(P_{jx} \cdot W_{jx}\right)$$

where *HS(x)* is health survivorship at age *x*, *S(x)* is probability of being alive at age *x*, P_{jx} is the probability of being in state *j* at age *x* (which takes into account both incidence and remission for condition *j*) and W_{jx} is the severity weight attached to state *j* at age *x*, measured on a scale where 0 is like-death and 1 is full health. For heuristic purposes, if we assume that *HS(x)* monotonically declines with age, we can summarize the combination of health risks and the severity weight for different health states and mortality into one measure, *h(x),* health risk, which can be thought of as the sole hazard to which an individual would be exposed such that health survivorship would be *HS(x)*.

mortality, incidence and remission are either 0 or 1 at all ages.[‡] Because it is essentially impossible for all risks to be rectangular – for example, we will never be able to reduce the risk of injury to zero – the ideal of equal healthy lifespans will never be realized.

In addition, some may argue that differences in healthy lifespans that are strictly due to chance are not relevant to measuring health inequality. Individuals faced with exactly the same health survivorship function at each age may have very different healthy lifespans due to chance. Healthy lifespan is the realization of a health survivorship function. Figure 2a illustrates a particular health survivorship function by age which correspond to a health expectancy of 56.5 years and Figure 2b the distribution of healthy lifespans that may be observed in a population of 50,000 in which all individuals were exposed to the distribution of health risks shown. In Figure 2a, the y-axis is the average proportion of full health attained by the population at each age and the x-axis is age. In Figure 2b, the x-axis is healthy lifespan observed and the y-axis is the percent of individuals that achieved that value of healthy lifespan from a cohort of 50,000. At the onset, everyone in this cohort had a healthy life expectancy of 56.5 years, but due solely to chance healthy lifespans range from 1 to 110 years. It is impressive that all of the variation in healthy lifespan that is seen in Figure 2b has resulted from complete equality in health risks for the cohort of 50,000 individuals.

If some individuals have a healthy lifespan of 10 years and others 90 years simply due to chance, should this be reflected in a measure of health inequality? Clearly, for all populations that are large enough, the chance component of the distribution of healthy lifespans would be the same if the underlying set of health risks by age were the same. This argument about excluding luck from considerations of equality is familiar to the literature on equity. Sen (*25*), for example, argues that we should want individuals to have equality of capabilities and not equality of the realization of their capability which he calls a functioning.

Equality of healthy lifespan is not an achievable goal for a population. It could only be realized if risks of incidence and remission of non-fatal health outcomes and risks of mortality, were either zero or one for the entire population. Given that this is unfeasible and that it is unlikely that differences in level of health inequality observed across countries are due to different levels of luck/chance in those countries, we are more interested in the distribution of health risks across individuals in a population and comparing these distributions across populations.

Equality of health risks

Each individual has a profile of health risks by age that can be summarized in a health survivorship function (similar the one shown for a cohort in Figure 2a). This profile of health risks can be characterized by two distinct attributes. First, the area under the

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[‡] For mortality, rectangular risks means that all individuals have a zero risk of death until some age x, at which the risk becomes one for the entire population (i.e. they all die at the same age). For non-fatal health outcomes, rectangular risks mean that at a given age, the risk of incidence of a condition or remission from that condition is either zero or one for the entire population. This would correspond to no variance in the outcomes, as all individuals would be faced with the same set of conditions with certainty. Different individuals may have different rectangular risk curves as long as the health expectancy is the same. For different risk curves to have the same health expectancy, the duration of each condition would have to be the same, and if individuals had more than one condition, they would have to have the same comorbidity profile, despite different risk curves.

curve shown in Figure 2a is the health expectancy of the individual: the average healthy lifespan for an individual faced with a health survivorship function.[§] Different profiles of health risks by age can have equal health expectancies. In other words, health survivorship curves can differ in their shape while the area under the curve remains constant.

Both differences in the health expectancies across individuals and differences in the shape of health risks across age can contribute to unequal healthy lifespans above and beyond that contributed by chance. To help understand the contribution of these two factors to the inequality of healthy lifespans, we will take advantage of the often observed linear relationship between the log of age-specific mortality rates and age (*32, 33*).[**] The shape of the health risks which incorporate the probabilities of non-fatal health outcomes will be somewhat different but as there is a strong relationship between the prevalence of non-fatal health outcomes worse than full health with age (*34*), these curves will be used to illustrate the general point.

Figure 3a shows the log of the risk of an ill-health outcome or death for two different populations. In each of the populations all individuals have an identical set of ill-health risks (or health survivorship functions) by age, as shown, and health expectancy in each population is 56.5 years. Because the slope of the health risk curve in population A is lower than in population B, the distribution of healthy lifespan (shown in Figure 3b) for population A has a lower variance that the distribution for population B (variance of 437 for population A versus 568 for B), although they have the same mean.

Silber (*35*) and LeGrand (*36, 37*) have sought to measure the inequality in the age of death – not healthy lifespan, but the concept is the same, applied solely to risks of death -- due to variations in the slope of the log death rate. Figure 4 illustrates for women in the UK a generally observed phenomenon: as mortality declines the slope of the logarithm of the death rate increases. In other words, there is a strong relationship between the level of mortality and the inequality in the age of death (or years of life lived) that is contributed by the slope of the death rate. Not surprisingly, LeGrand and Silber conclude that as mortality declines inequality measured in this way declines.

If everyone in a population A and B has an identical health expectancy but the age profile of health risks differs only in the slope and intercept of the log of health risks as a function of age, is this contributor to the inequality in healthy lifespan relevant to measuring health inequality? There are a number of arguments that suggest that variation in the average pattern of health risks between populations may not be of

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[§] Formally:

$$HE = \int_0^L HS(x)dx$$

where *HE* is health expectancy, *HS(x)* is the probability of being in full health at age *x*, and *L* is the limit of human life.

[**] Gompertz' Law of Mortality(*32*) applies only to mortality rates above age 20. Risks of death from birth to age 20 decline with age. Recently, careful analyses of mortality rates over age 75 or 80 have shown that they do not increase as fast as the Law of Mortality would predict (*33*).

much substantive interest. First, there is across populations are strong relationship between the slope of the mortality risk and age – and presumably the health risk function and age – such that inequality measured in this way decreases as mortality declines. Second, holding health expectancy constant, there are few policies or interventions to alter the slope of this relationship and thus reduce inequality in healthy lifespan. Third, it is not at all clear that everyone would share a common preference for the age profile of health risks. Consider a choice of health risk profiles both with the same health expectancy of 54 years; in the first, there is a 10% probability of death in the first week of life, followed by 0% risk of death until the age of 60 and then a 100% risk of death; in the second, there is a 0% chance of death until age 20, when the risk of death is 10%, followed by 0% risk until the age of 57.8 years and then a 100% risk of death. Few would choose the latter as death at 1 day seems preferable to death at age 20, but consideration of the inequality of the distribution of realized lifespans (as in Figure 3b) would lead to preferring the latter scenario.

Studies of social group differences and small area analyses have shown that within a cohort there is great variation across individuals in health expectancy (*1, 14, 17, 38-40*). Some individuals face higher risks of ill health and mortality at every age and others face much lower risks. This variation in health expectancy across individuals at a given age is not reflected in the average health survivorship curve of the population. The health survivorship function shows the average probabilities, without any additional information on how these probabilities are distributed across the population.

Figure 5 illustrates the healthy lifespan for a population where individual health expectancies vary from 47 to 82 years but the slope of the log health risk function is the same for all individuals. All individuals' health survivorship functions lie in between the bounds shown, and are parallel to the bounds. The thicker curve in the middle, curve B, represents the average risk of ill-health for the population at each age, which corresponds to a health expectancy of 56.5 years. Figure 5b shows that a population in which health risk curves lie anywhere between the two bounds shown in Figure 5a, will have almost the same inequality in terms of healthy lifespans shown in Figure 5b, as a population in which all individuals have the same health risk curve, curve B in Figure 5a. So, in terms of healthy lifespan the two populations have almost the same amount of health inequality; however, looking at the distribution of expected lifespan, or health expectancy (Figure 5a) most would agree that the population where individuals lie anywhere in the range of 47 to 82 years has much greater health inequality than the population where health expectancy is 56.5 years for all individuals.

For the reasons detailed above, our concern about variation across individuals in health expectancy seems much more important than differences between populations in the slope of the average health risk curve as a function of age.

Figure 5 also illustrates an important phenomenon in observing any cohort. The average health expectancy in Figure 5a is 56.5 years but the realized average cohort lifespan is 58.7 years. The high risk individuals tend to die at younger ages so the realized mortality at older ages reflects the risks of those with better health expectancies. This selection effect which can be substantial in populations with considerable inequality leads to the paradoxical situation that inequality in health expectancy will increase the average realized cohort lifespan.

It is notable that the difference between the distributions of health expectancy is very large in the populations in Figure 5a, ranging from no variation for population B to large variation for population A. The difference in the distribution of the outcome, i.e. healthy lifespan, resulting from these very different distributions of risk, is not that large. A remarkable increase in inequality of health expectancy has a relatively small effect on the distribution of healthy lifespan. This indicates that the chance component in the realization of the expectation is large.

We believe that the distribution of health expectancy for a cohort is of more interest for studying health inequality than the distribution of healthy lifespans. Likewise, we think that the shape of the average health risk curve or variation in the shape of health risk curves holding health expectancy constant may be of interest; however, for the study of health inequality we find it to be less relevant than simply the distribution of health expectancy.

The distribution of health expectancy attributable to unavoidable factors or choice

One might argue that we should be uninterested in two components of the distribution of health expectancy for a cohort: the component that is not amenable to change and the component that arises from fully informed choices of individuals to decrease their health expectancy through the pursuit of risky activities.

If there were differences in health expectancy that could never be remedied either with current or future technology, one could perhaps persuasively argue that we should be uninterested in this just as we have argued we are uninterested in the dispersion of healthy lifespans strictly due to chance. If such differences were measurable and common, it would be a strong argument to measure inequality in terms of health gaps rather than health expectancies. (Health gaps would be the difference between maximum achievable health expectancy for a given individual and actual health expectancy.) But which component of the distribution of health expectancy is not amenable to intervention? That due to genes? That due to chance during birth? In both cases, the argument that we cannot intervene to change the effects on the distribution of health expectancy is most likely specious. With current improvements in technology and future progress, it is likely that these components of the distribution of health expectancy will become amenable to change and thus should not be excluded from a measure of health inequality. Perhaps as important is the argument that there is little evidence of significant cross-population variation in the contribution of genes etc. There exists no convincing evidence at the health expectancy level that any population group has a lower distribution of health expectancy due to factors that are impossible to change. The component of health expectancy distribution due to unavoidable factors is likely to be small and completely impossible to assess. From here on, we will assume it is best to not worry about this aspect.

What about volition? How much of the distribution of health expectancy for a population is due to fully informed choices of individuals who have a taste for risky behaviour? This seems like a very slippery slope. What real choices affecting health are fully informed? Would we exclude the effects of tobacco on health expectancy which are likely to be very great because smoking is a choice? In most cases it is not a well informed choice when a minor takes up the addictive habit. But in those cases where we can claim it is an informed choice, should it be excluded? We would argue that it should not be excluded.

First, in most cases health risks are not adopted because of a love of risky behaviour but rather for other less informed reasons.[††] Second, the true volitional component of the distribution of health expectancy is likely to be very small and can well be ignored. This argument is similar to ones in the field of income inequality, where the variation in the distribution of income due to different leisure income trade-offs in the population is routinely ignored in the measurement of income inequality.

From cohort to period measures of health expectancy

If we could directly measure every individual's risks of incidence, remission and mortality at each age, we would be able to construct the distribution of health expectancies for a cohort. To estimate each individual's cohort health expectancy, we would in principle need to know the health risks for individuals who by chance may have died at a young age. These would have to be estimated in some way but in principle a reasonably good estimate of the distribution of health expectancy for the cohort could be obtained. From a policy perspective waiting over 100 years to measure health inequality for each birth cohort would not be useful. Since health inequality is a critical component of measuring health system performance we need to measure health inequality using only information collected in one period of time. In other words, we need to conceptualize a period measure of the distribution of health expectancy.

In the estimation of a period measure, however, we only have information on individual i at one age a. To estimate the distribution of health expectancies, we need to relate this measurement to the distribution of risks at another age for a different set of individuals. In order to relate risks for different groups of individuals across time, there has to be a formal principle for linking observed risks of different individuals to estimate the health expectancy of a hypothetical birth cohort, exposed to currently observed risks. In order to estimate the period distribution of health expectancy, we could follow one of two strategies: 1) Use some other variable, such as a socioeconomic status indicator that can be used to link individuals at different ages. This approach would underestimate the distribution of health expectancies in a period because it assumes that all variation in health risks is predicted by the socio-economic variable selected. 2) Assume an arbitrary correlation of risk between age groups, less than or equal to one.

It is clearly a bigger issue to address the basic challenge of estimating risk distributions since they are largely unobservable, but nevertheless, the development of standardized and comparable health inequality measures will require some explicit method of developing a period distribution of health expectancy from various age-specific distributions of health risks.

[††] The cost of being fully informed about the health consequences of different choices may and often is prohibitively high. The need for continuing medical education just to keep practicing physicians informed of recent developments in health knowledge is indicative of the challenge of keeping abreast of information on health risks. In reality, most individuals are forced to make choices that affect their health with incomplete or incorrect information. When the choice to take on risk and the outcome are separated in time, the rate at which individuals discount the future can profoundly influence choices about health. We, for example, would argue that health inequalities brought about by actions influenced by individuals with high discount rates should be included in a measure of population health inequality. Some philosophers (*41*) and economists (*42*) have long argued that discounting or myopia is a defect of human judgement and can be self-defeating.

In summary, we argue that the most relevant quantity of interest for studying health inequality is the distribution of health expectancy across individuals, constructed for a period, using a clearly defined method for linking the distributions of health risks at different ages.

Summarizing the distribution of health expectancy in a measure of health inequality

Figure 6 illustrates the distribution of health expectancies for three populations, A, B and C. Which distribution represents a more unequal distribution of health expectancy? If the x-axis in the graph were income, rather than health expectancy, most people would agree that distribution B is less unequal than C and A. This simple conclusion is based on the concept of decreasing marginal utility of income, namely that an extra dollar generates less utility as income rises. Distribution B has the same variance as A, but a higher mean, so that if this were income the variance would have less importance. In terms of a commonly used measure of inequality, the Gini coefficient, Distributions A and C have the same amount of inequality, while Distribution B has lower inequality than A and C. While for income some people may be in agreement that Distributions A and C have equal amounts of inequality, for health, this finding may be met with less agreement. The notion of declining marginal utility does not apply as persuasively. Some would say C is clearly worse than A or B and that they cannot distinguish between A and B. The vast literature on measuring income inequality (*25, 43-46*) is very helpful in the design of a health inequality measure, but this simple example illustrates that health has some fundamental differences from income that require special consideration. To date in the literature on measuring health inequality, there has been little substantive discussion on summary measures of distributions of health.

Two families of health inequality measures

Based on the wide array of measures used to summarize the distribution of income (*46*) and taking into account the fact that absolute, and not just relative, differences in health expectancies may matter, we propose two families of measures: individual mean differences and inter-individual differences.

a. Individual-mean differences

Measures of individual-mean differences compare each individual's health to the mean of the population. The general form is:

$$IMD(\alpha,\beta) = \frac{\sum_{i=1}^{n} \left| y_i - \mu \right|^{\alpha}}{n\mu^{\beta}}$$

where y_i is the health of individual *i*, *u* is the mean health of the population, and *n* is the number of individuals in the population. The parameter α changes the significance attached to differences in health observed at the ends of the distribution, compared to differences observed near the mean of the distribution. The parameter β controls the extent to which the measure is purely relative to the mean or absolute. Common examples of individual-mean differences are the variance when α = 2 and β =0, and the coefficient of variation when α = 2 and β =1. However, many other individual-mean difference measures are possible. When β=1, the measure is strictly relative and when β=0 it is measuring absolute deviations from the mean but β could be any value between 0 or 1, reflecting some mix of concern between relative and absolute individual-mean difference.

b. Inter-individual differences

Another family of measures is based on comparing each individual's health (or income for that matter) to every other individual's health rather than comparing each individual to the mean of the population. We propose the general form of these measures to be:

$$IID(\alpha, \beta) = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left|y_i - y_j\right|^{\alpha}}{2n^2\mu^{\beta}}$$

where y_i is the health of individual *i* and y_j is the health of individual *j*, μ is the mean health of the population and *n* is the number of individuals in the population. The parameters α and β are the same as for the individual-mean measures described above. A well-known example of this family is the Gini coefficient (*47*) often used to measure income distribution, where α = 1 and β =1. The Gini is often represented as being derived graphically from the Lorenz curve (*48*) of a population, but in fact is algebraically equal to the equation above. It is worth noting that when α = 2 the individual-mean difference and the inter-individual difference for any given population distribution are identical. For any other values of α they are different.

Choosing a single index of health inequality

For standard comparisons we need to choose a single index of health inequality to summarize the distribution of health expectancy for a population. This choice requires the resolution of three fundamentally normative issues: which family of measures, what should be the value of α and what should be the value of β. These choices are normative choices, and individual's preferences for these can be elicited through a series of questions that isolate the effect of each on the index of inequality.

We will provide illustrative examples of what these choices entail. For simplicity reasons we will use a population of 7 individuals (which can also be thought to be 7 homogeneous groups of individuals). In each example we will transfer a specified amount of years of health expectancy from an individual who is better-off (i.e. higher health expectancy) to an individual who is worse-off. The transfers will be described in the text and are also depicted in Figures 7-9. There are three types of choices to be made. For each choice we will present two populations and the question will be "Which represents a greater decrease in inequality: the transfer in population A or the transfer in population B"?

β: Relative versus absolute inequality

One of the key choices that has to be explicitly made is whether we are more concerned about absolute differences in health, relative differences in health, or a mix of both with some weights, depending on our preferences. Figure 7 illustrates reductions of health inequality in two populations brought about by transferring equivalent years of health expectancy from the better off to the worse off. With this question we can attempt to measure the extent to which individuals are concerned about relative inequality, absolute inequality or some mixture. The situation depicted in Figure 7 is the following: Populations A and B have similar distributions of life expectancy across the seven individuals, but at different levels. In population A the mean is 20 years, while in population B the mean is 60 years. In population A, 5 years of life expectancy are transferred from an individual whose life expectancy is 35 years to an individual whose life expectancy is 5 years. In population B, 5 years of health expectancy are transferred from an individual with health expectancy of 75 years (highest in the population) to an individual with health expectancy of 45 years (lowest in the population). Which of the two transfers results in a greater decrease of health inequality?

With questions such as this, we can elicit people's preferences for a value of β, between 0 and 1.

α: *Intensity of health gain/loss*

The second normative choice has to do with whether gains or losses of health that occur at the ends of the distribution should be treated differently from gains or losses of health that occur near the mean. Consider the two reductions in health inequality depicted in Figure 8. Both populations are at the same level of health expectancy, with a mean value of 20 years. In population A, 5 years of health expectancy are transferred from the individual with the highest value (35 years) to the individual with the lowest value (5 years). In population B, 5 years of health expectancy are transferred from the individual with health expectancy of 30 years to the individual with a health expectancy of 10 years. Which of the two transfers represents a greater decrease in health inequality?

If scenario A is chosen, then the measure used would need to weigh more heavily transfers of health occurring at the ends of the distribution. If the respondent is indifferent, then all transfers of the same amount should be weighed equally, regardless of which part of the distribution they occurred in. If the choice is A, then α will be greater than one; if the respondent is indifferent between the two scenarios, then α =1. By constructing other questions where the amount of health expectancy that is transferred is different in magnitude, the exact value of α could be elicited.

Inter-individual versus individual-mean differences

The third choice refers to the family of measures: individual-mean or inter-individual comparisons. In the calculation of inequality in a population all measures include a difference between individual *i* and another entity. In Figure 9, the two reductions in health inequality illustrate the choice. Both populations have the same mean value of health expectancy (both before and after the transfer) and the exact same amount of health is transferred in both cases. The initial distribution of health is different in the two populations. In both populations 15 years of health expectancy are transferred from the individual in the upper end of the distribution (35 years) to the individual at the lower end of the distribution (5 years). The question again is "which of the two scenarios represents a greater decrease in inequality?" Those who prefer A are expressing a view that what counts is not only where the individual starts and where they end up, but also where the rest of the population is. Those who are indifferent between A and B believe that what is really important is the absolute change achieved, regardless of where other people are in the distribution. In the first case, we would use a measure of inter-individual comparisons, while in the second case we would use a measure of individual-mean differences.

Because of the nature of the inter-individual comparison measures, the normative choice about the intensity of the transfer and about the family of measures are not completely separable. Inter-individual comparison measures, even when α =1, are more sensitive to equivalent transfers of risk farther from the mean.

Through a series of such questions, we could elicit individual's values for the design of a summary index for the distribution of health expectancy. Population surveys or convenience samples could provide information from a wide range of individuals. How should such measurements be used to develop a WHO index of health inequality? We do not propose empirical ethics as a blind tool for resolution of normative choices; rather we believe that the results of measuring these values for a broad range of individuals will be a useful input to a deliberative process for choosing an index of health inequality for regular use by WHO in its work with countries.

Based on initial limited investigation, we suspect that most persons will prefer a measure with a mix of absolute and relative inequality, with a bigger weight for differences farther from the mean, and with a consideration of intervening individuals. Yet, these questions clearly require broader empirical assessment of the values held by different persons.

Operationalizing the measurement of inequality in health expectancy

While we have argued that the quantity of interest for measuring health inequality is the distribution of period health expectancy, how can this be measured? Risk is not observed, only outcomes. An individual with a 10% chance of death is either alive or dead at the end of a time period; this fact provides us with no information as to what his/her risk of death actually was. Nevertheless, we believe that the distribution of health risks can be reasonably approximated through a variety of techniques. The combination of these techniques lays out a reasonable strategy to estimate the distribution of health expectancy. The strategy can be divided into four distinct approaches: measuring the distribution of child mortality risk, measuring the distribution of adult mortality risk, measuring the distribution of life expectancy and health expectancy directly through small area analyses, and measuring the distribution of non-fatal health outcomes.

Child mortality risk

While we cannot observe child mortality risk, we can observe the variation in the proportion of a mother's children who have died, which provides information at a very fine level of aggregation (namely households) on the distribution of child death risk. Using simulation, we can evaluate the difference in the distribution of outcomes from that which would be expected based on a distribution of equal risk. Data on children ever born and children surviving for women of different ages are widely available from the Living Standards Measurement Studies (LSMS)(*49*), the Demographic and Health Surveys (DHS)(*50*) and many censuses and surveys. We have implemented this strategy for measuring child mortality (*24*).

Adult mortality risk

For children, grouping data by mother provides fine grained information on the distribution of mortality risks in the population. Unfortunately, we have no such handle to measure the distribution of adult mortality. Similar information on the survivorship of siblings could in principle be used but it would refer to average mortality experience over decades and the technical challenges have yet to be solved. Other strategies need to be developed.

Distribution of life expectancy or health expectancy for groups

One method to approximate the distribution of health expectancy in the population is to divide the population into groups that are expected to have similar health expectancies and measure directly the health expectation for those groups. Inevitably, this will underestimate the distribution of health expectancy in the population even if the groups are perfectly non-overlapping in terms of their individual health expectancies. The more refined the groupings the more we will approximate the true underlying distribution of health expectancy. Small area analyses hold out the promise of being one of the most refined methods for revealing the underlying distribution of health expectancy in a population. For example, a detailed age-sex-race group analysis of counties in the US has revealed a range in life expectancy across counties of 41.3 years (*17*).

The distribution of non-fatal health outcomes

Measurement of non-fatal health outcomes on continuous or polychotomous scales provides more information from which to estimate the distribution of risk across individuals. Numerous surveys provide information on self-reported health status using a variety of instruments. The main problem to date with this information is the comparability of the responses across different cultures, levels of educational attainment and incomes. For example, the rich often report worse non-fatal health outcomes than the poor (*51, 52*). Problems of comparability must be resolved before such datasets can be used to contribute to estimation of health expectancy in the population

For WHO, the way forward will be to simultaneously pursue the development of methods and datasets to measure these different dimensions of the distribution of health expectancy. We recognize there is a great need for new methods to integrate these different measurements into one estimation of the distribution of health expectancy in populations.

Conclusions

This paper has proposed an innovative approach to the measurement of health inequality, which is based on four key notions. First, we start with the principle that health is an intrinsic component of well-being and thus we should be concerned with inequality in health, whether or not it is correlated with inequality in other dimensions of well-being. Second, we propose that since any measure of health inequality should reflect the complete range of fatal and non-fatal health outcomes in order to capture the rich complexity of health. We operationalize this notion through the concept of healthy lifespan. Third, we propose health expectancy as an improved measure compared to healthy lifespan, since it excludes those differences in healthy lifespan that are simply due to chance. In other words, the quantity of interest for studying health inequality is the distribution of health expectancy across individuals in the population. Fourth, the inequality of the distribution of health expectancy can be summarized by measures of individual-mean differences or inter-individual differences. The exact form of the measure to summarize inequality depends on three normative choices. A firmer understanding of people's views of these normative choices will provide a basis for deliberating on the final WHO measure of health inequality.

Our approach contrasts with that proposed by LeGrand (*36, 37*) and Silber (*35*). Their primary concern is not with variation in the set of age-specific health risks that individuals are faced with, but with the shape of the average population mortality rate as a function of age. This approach concludes that on average health inequality is decreasing worldwide. This finding is entirely attributable to the fact that the shape of average mortality risks across ages changes in a predictable fashion as life expectancy increases. We argue that we should focus on the distribution across individuals of health expectancy. In these terms there is no reason to expect that this distribution steadily narrows as average health expectancy increases. The enormous variation in life expectancy (*17*) in the US across small areas is one indication of this. Early results on the distribution of child death risks across countries indicate that there is no relationship between the level of child death and the distribution of risk across individuals (*24*).

A focus on the inequality of age-specific health risks (inputs to the distribution of health expectancy) may re-invigorate interest in some health problems. For example, many specific occupational exposures are not major contributors to average levels of population health expectancy but they may contribute to markedly elevated risks for a small minority. Such increases in risks will contribute to the inequality of health expectancy. As we better quantify the distribution of health expectancy the role of occupational and local environmental exposures in contributing to risk inequality may become apparent. Interest in inequality in health risks in developed countries may also draw attention to the impressive inequality in adult male mortality risk. In a country like the US, there is considerably more inequality in adult male mortality risk than in child or adult female mortality risks (*17*).

The task of measuring the distribution of health expectancy will need to make use of cross-sectional survey data on the prevalence of various non-fatal health outcomes. Measuring health inequality is fundamentally about comparing the distribution of the health status of individuals within populations and comparing distributions of different populations. If self-reported responses from the application of various health status surveys using instruments such as SF-36, EUROQOL, or activities of daily living are to be used in estimating health expectancy, special attention will need to be paid to the comparability of these responses across cultural groups. There is evidence that current instruments for measuring health status in surveys may not be comparable (*52-54*). Hopefully the work on inequality will improve comparability of health status survey responses across cultural groups.

There is growing consensus that improvements in average levels of health is not a sufficient indicator of health system performance. The distribution of such improvement is an equally important dimension of performance. In order to place health inequality at the center of the policy debate, we must develop better ways of measuring it. That will be the only way of ascertaining the true magnitude of the problem and of monitoring progress towards its solution.

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Table 1. Calculation of measures of health inequality for three distributions of health expectancy

		Distribution A		Distribution B		Distribution C	
		Alpha =1	*Alpha =2*	*Alpha =1*	*Alpha =2*	*Alpha =1*	*Alpha =2*
Individual-Mean	*Beta =0*	2.40	9.26	2.40	9.26	4.68	34.47
Differences	*Beta =1*	0.06	0.23	0.03	0.11	0.06	0.43
Inter-individual	*Beta =0*	1.71	9.26	1.71	9.26	3.31	34.47
Differences	*Beta =1*	0.04	0.23	0.02	0.11	0.04	0.43

Figure 1. Healthy lifespan for an individual

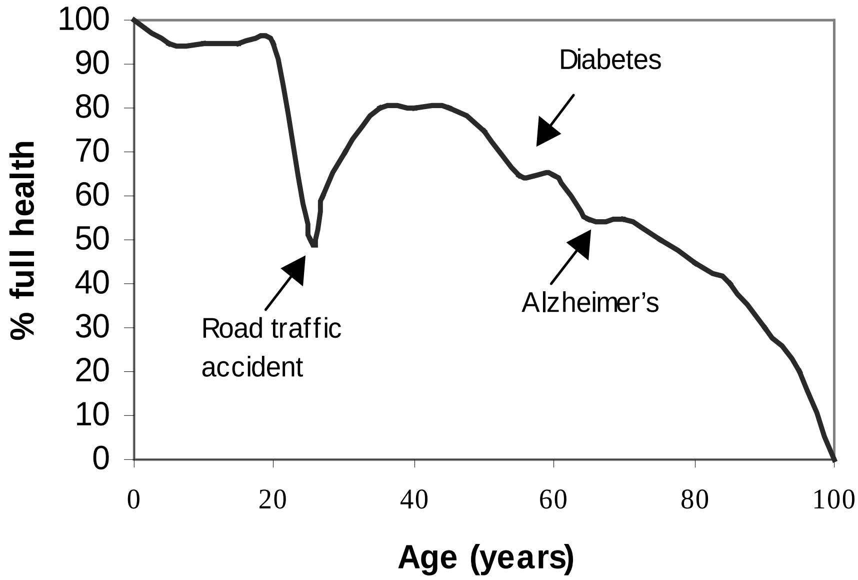


Figure 2a. Health survivorship function

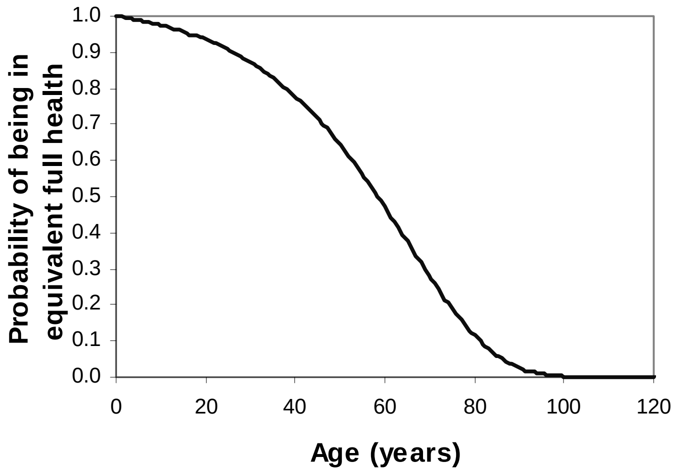
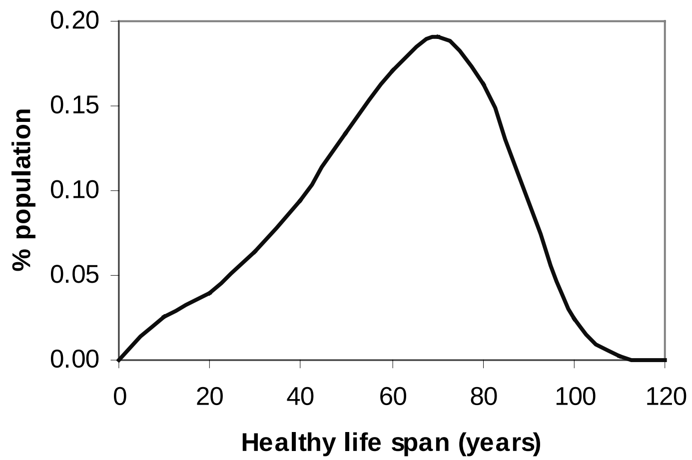


Figure 2b. Distribution of healthy lifespan



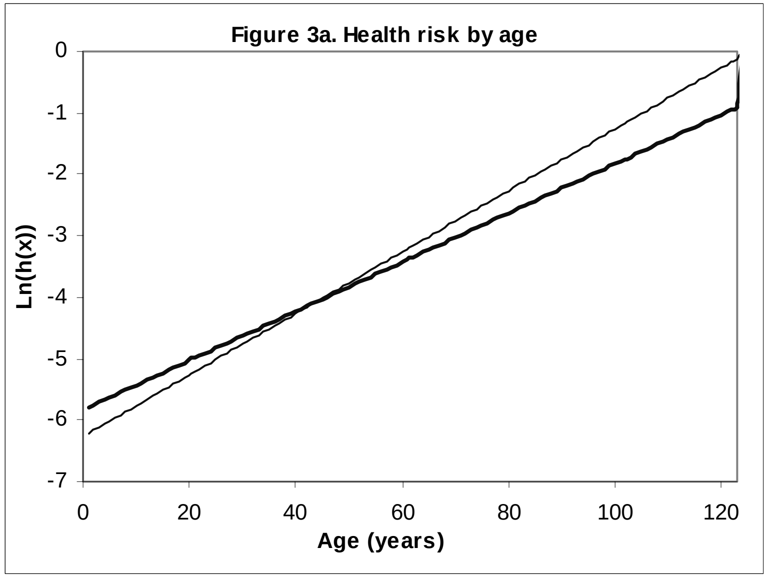


Figure 3a. Health risk by age

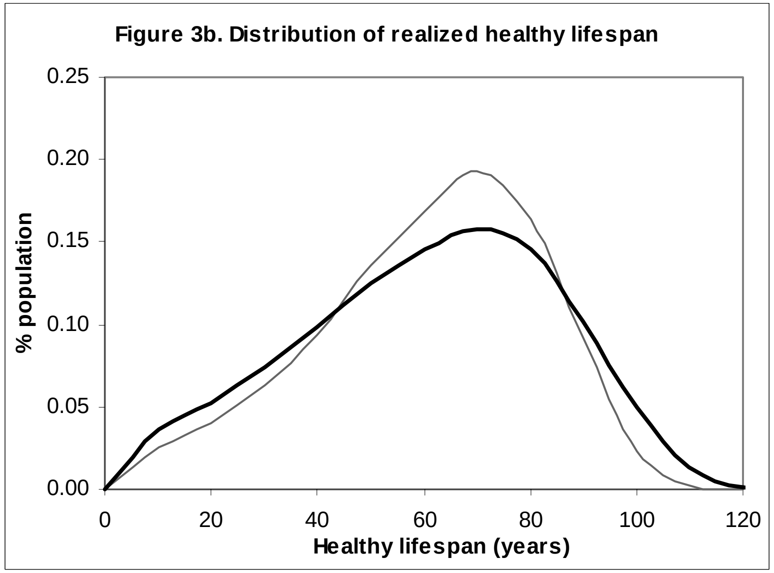
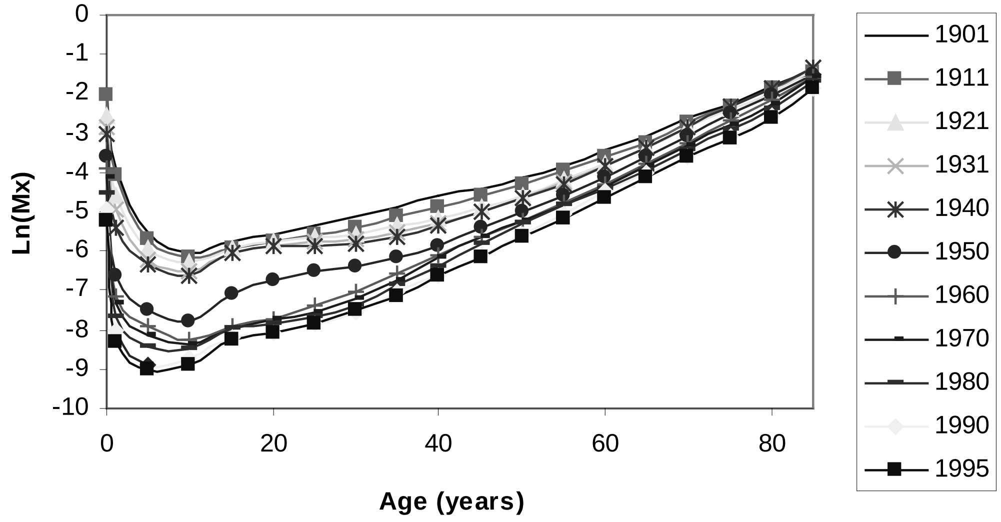


Figure 3b. Distribution of realized healthy lifespan

Figure 4. Mortality rates by age, UK females, 1901-1995



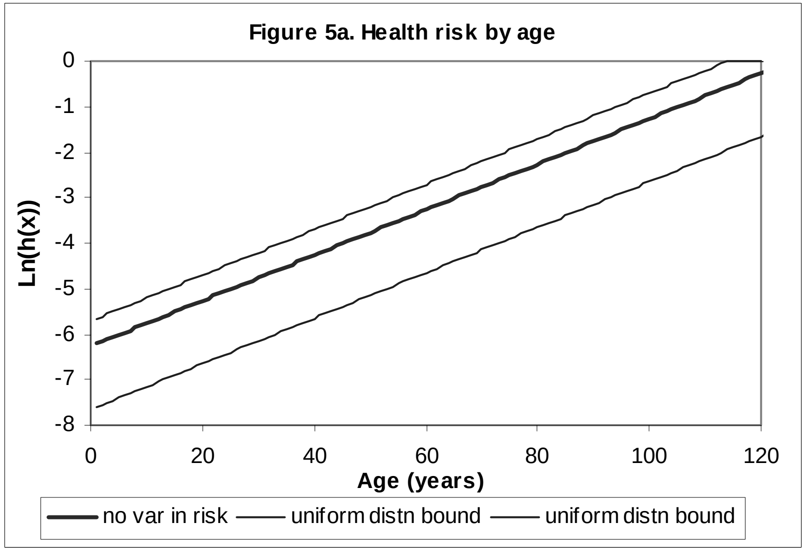


Figure 5a. Health risk by age

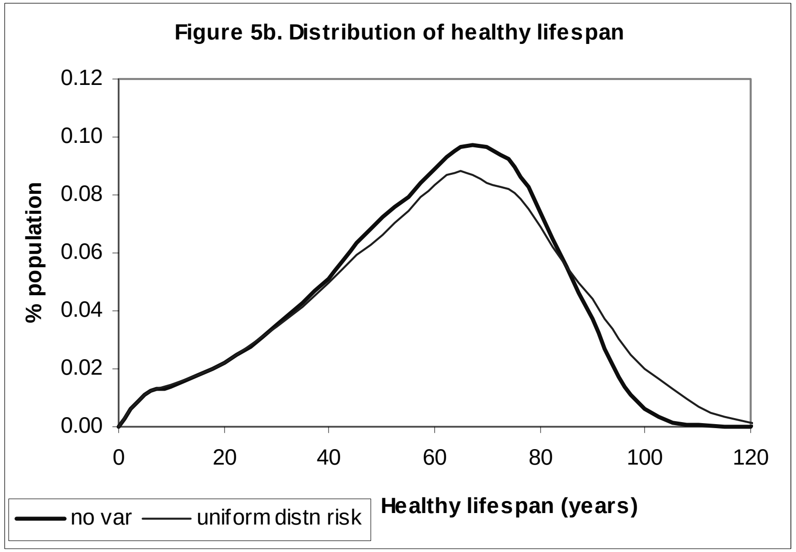


Figure 5b. Distribution of healthy lifespan

Figure 6. Distribution of health expectancy

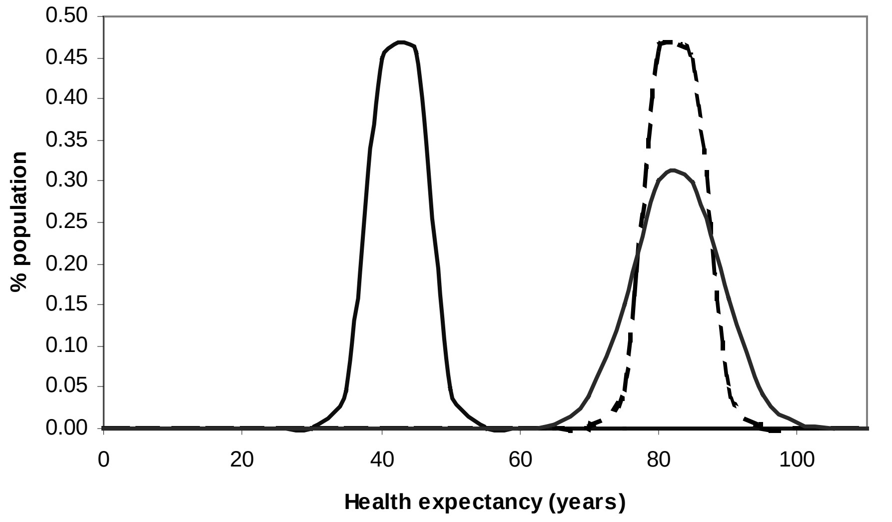
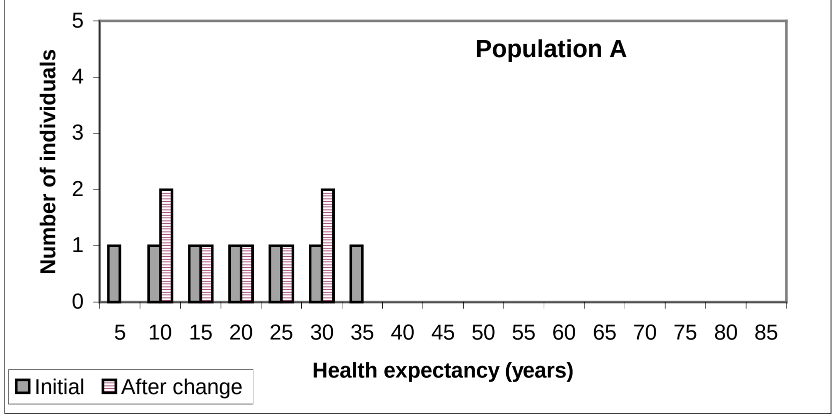


Figure 7. Transfer of health expectancy



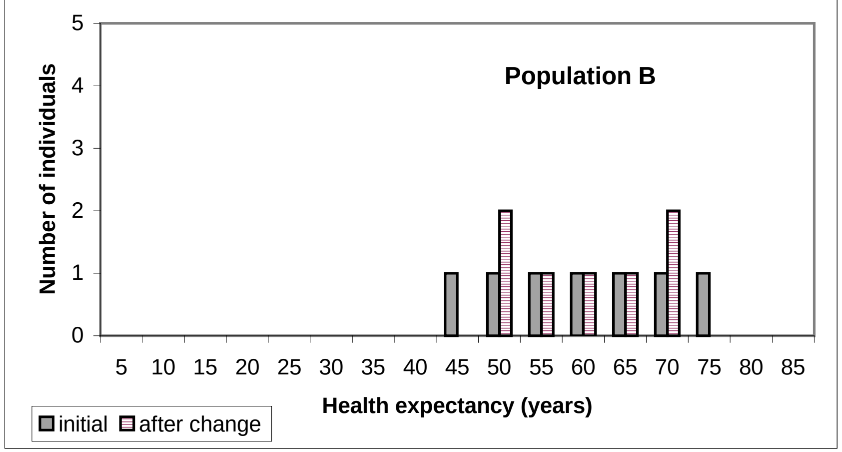
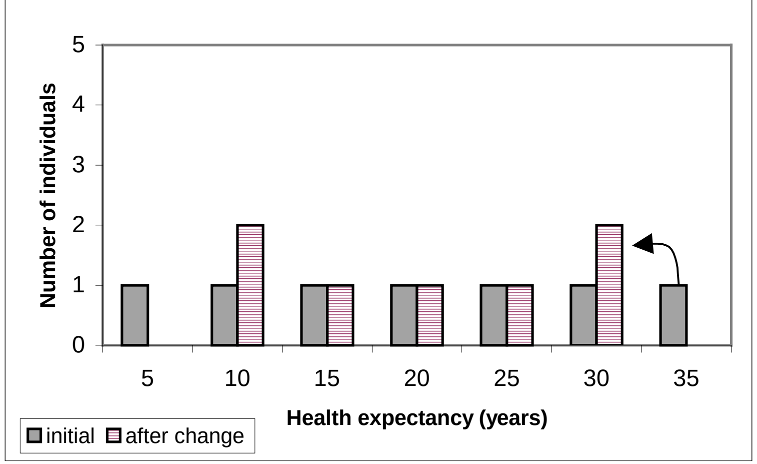


Figure 8. Transfer of health expectancy



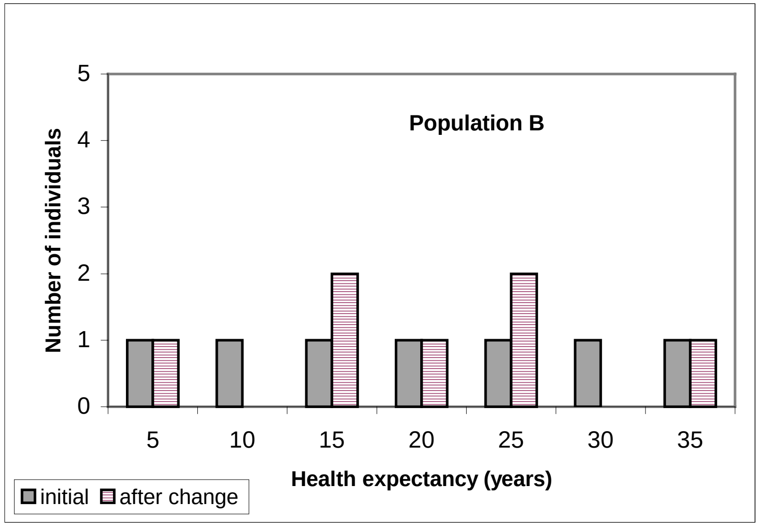


Figure 9. Transfer of health expectancy