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Department of Economics

"HEALTHY" HUMAN DEVELOPMENT INDICES

Merwan Engineer
Nilanjana Roy
Department of Economics, University of Victoria
Victoria, B.C., Canada V8W 2Y2
&
Sari Fink
Exeter Associates,
Columbia, Maryland, USA

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Abstract

In the Human Development Index (HDI), life expectancy is the only indicator used in modeling the dimension 'a long and healthy life'. Whereas life expectancy is a direct measure of quantity of life, it is only an indirect measure of healthy years lived. In this paper we attempt to remedy this omission by introducing into the HDI the morbidity indicator, "expected lost healthy years" (LHE), used in the World Health Report Though LHE is only weakly correlated with life expectancy and displays considerable variation across countries, the ranking of nations using the adjusted HDI is very similar to that from the HDI. Nevertheless, there are some outlier countries (including large countries like China and the United States) that experience notable changes in rank. Given the considerable variation in the morbidity data across gender, we also adjust the Gender-related Development Index (GDI) in a similar fashion. The ranking using the adjusted GDI is very similar to that from the GDI, but it has a lower rank correlation with the HDI.

Keywords: Human Development Index; Healthy Life Expectancy, Morbidity, Gender-related Development Index.
JEL Classifications: I00, I1, O5

Author Contact:
Nilanjana Roy, Dept. of Economics, University of Victoria, P.O. Box 1700, STN CSC, Victoria, B.C., Canada V8W 2Y2; e-mail: nroy@uvic.ca; ; Voice: (250) 472-4417; FAX: (250) 721-6214

1. Introduction

> Being able to survive is of course only one capability (though undoubtedly a very basic one) and other comparisons can be made with information on health, morbidity etc.
>
> Sen (1989, p.11)

The Human Development Index (HDI) was designed by the United Nations Development Program (UNDP) in 1990 to be a simple measure of the availability of the essential choices needed for human development. Three essential choices or ‘dimensions’ are identified: (1) ‘to lead a long and healthy life’, (2) ‘to acquire knowledge’, and (3) ‘to have access to resources needed for a decent standard of living’. In the HDI, each ‘dimension index’ respectively uses the following indicator variable(s): (1) life expectancy, (2) literacy and gross enrolment ratio, and (3) per capita gross domestic product (GDP). The HDI consists of an equally-weighted sum of the dimension indices based on each of these indicators.[1]

Though the HDI has arguably been successful in displacing per capita GDP as the standard measure for evaluating human well-being, it has not been without its critics.[2] The use of the per capita GDP indicator variable has been criticized for not being a direct measure of capabilities and also for not considering inequality. The education dimension index has come in for criticism for not using a sufficiently informative indicator variable. The UNDP has encouraged this constructive criticism and has responded with major revisions of the income and education dimension indices in the HDI. For example, an additional indictor, ‘gross enrolment ratio’, has been incorporated into the education index.[3]

In contrast, there are not many criticisms of the use of life expectancy in the HDI, and the dimension index has remained the same except for some adjustments in the goalpost values. Hicks (1997) focuses on the lack of inequality considerations especially in the longevity and education dimensions, and proposes a method to incorporate inequality in all three dimensions of the HDI. Anand and Sen (1994) provide a critical analysis of the role of life expectancy in the HDI. They discuss the possibility of modeling a higher upper bound (aspiration level) for female life expectancy since the evidence suggested that females on average live longer, *ceteris paribus*. The Gender-related Development Index (GDI) was introduced in the Human Development Report 1995. This index has the same components as the HDI but assigns females higher life expectancy bounds than males. Bardhan and Klasen (1999) criticize the GDI for not taking into account "an estimate of missing women in the estimate of gender bias in longevity" (p. 991).

This paper examines the adequacy of the use of life expectancy as an indicator for the ability 'to lead a long and healthy life'. Life expectancy in its role as a gauge of a 'long life' or longevity is arguably a good measure as it is directly derived from mortality patterns. However, life expectancy is supposed to do double service in the HDI and also proxy a 'healthy life'. According to Hicks (1997, p. 1285),

> "to be sure, indicators of longevity do not reveal directly the health-quality of those life spans. It is possible to live 80 years in poor health, or to live 20 or fewer years in perfect health before some unexpected death. Life expectancy is, of course, an aggregate measure for a population as a whole; on average, persons living in societies with higher life expectancies do tend to be in better health. To live a significant - and healthy - life span is seen as both a necessary means to other ends and as a good in itself. This indicator points to the more essential element of this dimension – the expansion of "life opportunity"."

On the other hand, Wolfson (1996, p. 41), claims, "they (*life expectancy estimates*) provide no indication of the quality of life, only the quantity". He argues that a country may very well have high life expectancy but its older citizens may be living with various illnesses associated with old age, and hence may be experiencing a relatively low quality of life. To address the issue of health quality of life differing from quantity of life, this paper empirically examines whether the inclusion of a measure of health in the HDI would yield a different ranking of nations.

The measure of health we focus on incorporating in the HDI is an indicator of morbidity. We focus on morbidity because it provides information on health status given patterns of mortality. We also focus on morbidity because there has been a tremendous amount of applied work done starting in the 1990s associated with the Burden of Disease Project (2002) that attempts to carefully assess the magnitude of morbidity associated with different health conditions and to develop an overall aggregate measure of morbidity that is comparable across countries. This aggregate morbidity measure is called "expected lost healthy years", denoted LHE. As explained in the World Health Report 2004, LHE "is the expected equivalent number of years of full health lost through living in health states other than full health".[4] We compare the rankings of nations by LHE and life expectancy and show that they are very different. Thus, LHE is a potentially useful indicator variable to be incorporated in a modified index.

To develop a modified human development index, we incorporate both LHE and life expectancy in the dimension index that is meant to capture the ability 'to lead a long and healthy life'. Thus, our dimension index includes both a mortality indictor (life expectancy) and a morbidity indicator (LHE). Since both LHE and life expectancy are in the same units of 'expected years', the natural way to aggregate the two indicators is to simply subtract LHE from life expectancy. Indeed, the combination can be thought of as a new indicator variable that captures a 'long and healthy life', which we denote LLHL. This new variable has the same definition as the well-known Healthy Life Expectancy (HALE), which also incorporates LHE but uses a different data series for life expectancy.

The LLHL indicator is used in place of life expectancy in the HDI to create a modified index. Since LHE is the only new component of the modified index, we denote this new index HDI_{LHE}. We compare the ranking of nations generated by HDI and HDI_{LHE}. The results show that adjusting for morbidity results in only very minor changes in the rankings of countries. We compare the rankings with another modified index, HDI_{HALE}, which includes HALE instead of life expectancy in the HDI. HDI_{HALE} includes different life expectancy data than HDI_{LHE}, and we find that the main source of the rank variation of HDI_{HALE} compared to the HDI comes from the new life expectancy data contained in HALE rather than the morbidity data contained in LHE.

We also consider a modification of the Gender-related Development Index (GDI) following a similar reasoning as with the HDI. The LHE data show that it is consistently higher for females compared to males for all countries in our sample. This variation across gender provides us with another motivation for including morbidity data into the

GDI. The impact of such modification on rankings of countries is similar to what we observed with HDI_{LHE}.

This paper proceeds as follows. Section 2 briefly describes the morbidity measure 'expected lost healthy years', LHE, and how it can be used in constructing new indicator variables which have both mortality and morbidity information. Section 3 develops the modified index HDI_{LHE} and examines how it ranks nations. Section 4 extends the analysis to consider the alternative modified index HDI_{HALE}. Section 5 considers the GDI and studies the rank changes associated with the incorporation of morbidity data into GDI. Section 6 concludes by discussing the value of including an aggregate morbidity indicator in such indices.

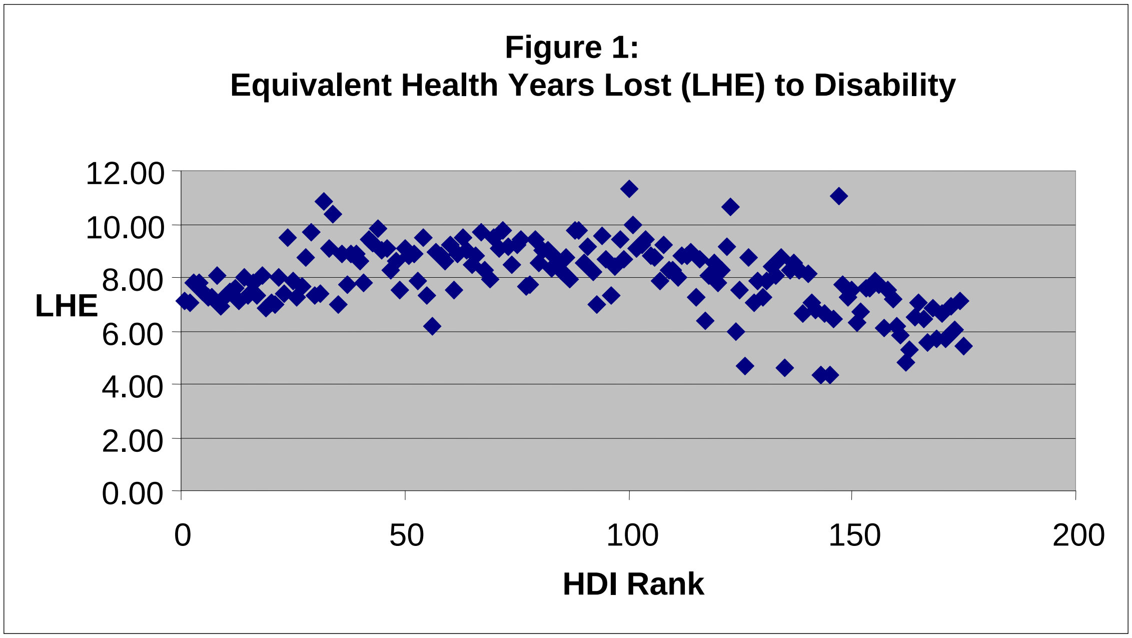
2. Indicators of Mortality, Morbidity, and a Long and Healthy Life

Life Expectancy (LE). Life expectancy at birth is defined as the number of years newborn children would live based on current rates of mortality. The particular life expectancy measure used in the HDI uses data from the United Nations Development Program (UNDP) and we refer to this series variable as LE. Our data for LE and HDI is for the year 2002 and is found in the Human Development Report 2004. Life expectancy estimates are calculated based on data on deaths and population counts. Life expectancy is a mortality indicator and does not include data on morbidity.

Healthy Life Expectancy (HALE). An indicator of health that includes information on both mortality and morbidity is the "disability-adjusted life expectancy", or DALE, introduced by the World Health Organization (WHO) in the World Health Report 2000. Soon thereafter, DALE was renamed the "health adjusted life expectancy", or HALE. Recently, HALE has been referred to as "healthy life expectancy". HALE is based on life expectancy but is adjusted for time spent in poor health. More specifically, HALE is "the equivalent number of years of full health that a newborn can expect to live based on current rates of ill-health and mortality" (World Health Report 2004, p. 96). HALE appears to nicely fit the description of a useful indicator for a 'long and healthy life' and we will use it in Section 4 in the creation of a development index HDI_{HALE}. Whereas HALE is an important alternative indicator to consider, it contains new life expectancy data that confounds the inference of the effect of morbidity on the HDI.

Expected Lost Healthy Years (LHE). The morbidity variable in which we are interested, expected lost healthy years (LHE), is a key component in HALE. Indeed, healthy life expectancy can be expressed simply as life expectancy less expected healthy years lost; i.e. $HALE = LE_{WHO} – LHE$, where LE_{WHO} is life expectancy as calculated by WHO. In our calculations, we follow the World Health Report 2004 and derive LHE as LE_{WHO} minus HALE using 2002 data. Our sample consists of 175 countries and contains all countries for which we have both LHE and HDI data.[5]

Figure 1 gives a sense of how LHE is distributed according to country HDI rank. In the sample of 175 countries, the minimum, maximum and average values of LHE respectively are: 4.3, 11.3 and 8.0. The standard deviation of LHE is 1.28 years. The relationship between LHE and HDI rank is quite flat with the countries with the lowest and highest LHE values being found in the range of countries ranked 100-150 according to the HDI. For our analysis it is important to note that the LHE series is clearly not strongly correlated with HDI rank and thus is potentially a useful variable with which to modify the index.[6]



Whereas LHE is readily available from existing publications, a tremendous amount of information and a great deal of thought have gone into its construction. This work started in the 1990s associated with the Burden of Disease Project (2002), which created 135 specific disease and injury cause categories.[7] Each cause category was assigned a certain weighting between 0 and 1 signifying its severity, and weightings were derived using a person trade-off methodology.[8] Years lost to disability (YLD) tables were then constructed using prevalence data by cause category, age cohort and sex from each member state weighted according to the derived severity. For discussion and references regarding sources and quality of data and construction of estimates, see The World Health Report 2004 – Changing History, Statistical Appendix, Explanatory Notes.

Mathers et. al. (2001) describe the methodology for calculating LHE. First, the YLDs are aggregated across cause categories in a way that controls for co-morbidity. The aggregate measure is by age cohort. It can be expressed as a "severity-weighted prevalence of disability" between ages x and x+5, denoted as $D_{x.}$ The years lost to disability in a cohort x is then just D_xL_x, where L_x is the total years lived by the life table populations between ages x and x+5. The LHE at age x is

$$\mathrm{LHE}_x = \left(\sum_{i=x}^{w} \mathrm{L}_i \mathrm{D}_i \right) / \mathrm{I}_x$$

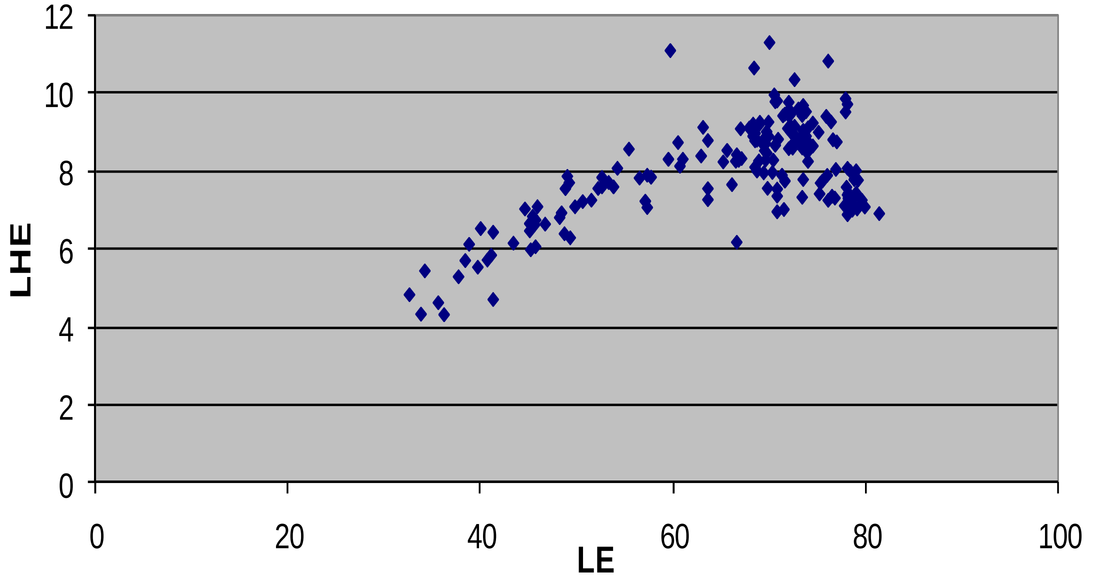
where *w* is the last open-ended interval in the life table and I_x is the survivors at age x. The LHE is constructed without discounting the future and without weighting age groups differently. The construction reveals that LHE is measured in expected years.

LHE is the successor to related aggregate measures such as 'quality adjusted life years' (QALY), and 'disability adjusted life years' (DALY). Like LHE, these previous measures are constructed from cause category YLDs. Criticisms by Anand and Hanson (1997, 1998) and Arnesen and Kapiriri (2004) of the earlier measures relating to time discounting and weighting groups by age, do not apply to LHE. However, they have three criticisms of the use of disability weights as a basis for allocating scare resources. First, there is no provision for establishing equity amongst different sub-groups in the population. Second, the measures on their own fail to incorporate relevant trade-offs with other choices for improving health (e.g. education). Third, the choice of weights is subjective and sensitive to different inputs. Roberge et. al (1999) assess the history of attempts to find morbidity measures that are comparable with life expectancy and find LHE the least problematical. In this paper, we concentrate on LHE both because it is the leading morbidity indicator and one that attempts to carefully assess the magnitude of morbidity associated with many different health conditions. Also, given that the UNDP (2009) in its latest Human Development Report published data on HALE and LHE (as a percent of total life expectancy) for 2007 in table N (p. 202), it shows that UNDP considers this to be useful information. Including this information in the HDI, as we suggest, is a natural step that should follow[9].

Indicator(s) for a 'Long and healthy life'. To model the dimension index that is meant to capture the ability 'to lead a long and healthy life', we incorporate LE, a mortality indictor, as well as LHE, a morbidity indicator. Combining the two indicators in the dimension index could be done in a number of ways. For example, in the education dimension index in the HDI, the indicators, gross enrolment ratio and literacy rate, enter separate sub-indices that are then added. The gross enrolment ratio sub-index receives 1/3 weight and the literacy sub-index receives the remaining weight. HDR does not provide a rationale for the weights. In principle, increasing enrollment flows increases literacy and can be related to the stock of literate people.

A key observation regarding the LE and LHE indicators is that both are in the same units of expected years of life. LHE was designed to be in the same units as life expectancy in order that they could be linearly combined. Instead of creating separate sub-indices and then aggregating, the most natural thing to do is to simply subtract from life expectancy the expected equivalent years lost. This linear combination of the indicators can be thought of as a new indicator variable that we term ‘long and healthy life’, denoted by LLHL, where LLHL= LE – LHE.

Figure 2
LHE versus LE



As LE is already contained in the HDI, using a new indicator LLHL instead of LE will only yield different results to the extent that LHE matters. Figure 2 plots these two variables that make up LLHL. The variables are clearly positively but imperfectly correlated. To compare how the two variables rank nations, we calculate the Spearman rank correlation coefficient and obtain a value of .3937, which suggests a weak correlation. This provides support for Wolfson’s (1995) argument and contradicts Hicks’(1997) claim that “persons living in societies with higher life expectancies tend to be in better health” (p. 1285). Our sample has 175 countries and we can statistically test and overwhelmingly reject that the variables are either independent or perfectly correlated.[10] Recall that LHE is subtracted from LE in forming LLHL. Thus, the fact that the variables are positively correlated means that there is a greater potential for LLHL and LE rankings to differ.

Similarly, we can examine the two components, LE_{WHO} and LHE, which comprise HALE. We find that the Spearman rank order correlation coefficient between LE_{WHO} and LHE is 0.3977. This value is very similar to the one above and only reflects the fact that we are using different life expectancy data. Again using our sample of 175 countries, we can statistically test and overwhelmingly reject that the variables are either independent or perfectly correlated.

Using both the LLHL and HALE series we now turn to constructing our modified human development indices. In our construction in the following sections, HDI_{LHE} and HDI_{HALE} differ only in that they incorporate different life expectancy measures. We look at both measures in order to isolate the impact of the additional use of morbidity data from that resulting simply due to the use of different life expectancy data.

3. Incorporating Equivalent Healthy Years Lost into the Human Development Index

Recall that the dimension "to lead a long and healthy life" in the HDI is modeled with the indicator LE in a life expectancy index. We denote this index LEindex. It is currently constructed in the HDI as follows:

$$\text{LEindex} = \frac{\text{LE} - 25}{85 - 25} \ .$$

The LEindex is an ‘achievement’ index with a lower bound goalpost of 25 years and an upper bound goalpost of 85 years. The choice of goalposts has varied over the years. Initially, the goalposts were the minimum and maximum values found in the data. Then the minimum value of the goalpost was set at 35 years and the maximum value was fixed at 85 to allow for intertemporal comparisons. Subsequently, the lower bound was decreased to 25 years, since life expectancy had fallen below 35 years in some African countries hit by the AIDS crisis. In our sample of 175 countries in 2002, Zambia has the lowest life expectancy at 32.7 years, which is below the previous minimum of 35 years but well above the current lower bound of 25 years. Japan has the highest life expectancy at 81.5 years.

In replacing the dimension index for LEindex, we use the composite indicator LLHL (= LE – LHE). We form the dimension index as follows:

$$\text{LLHLindex} = \frac{\text{LLHL} - 25}{85 - 25} .$$

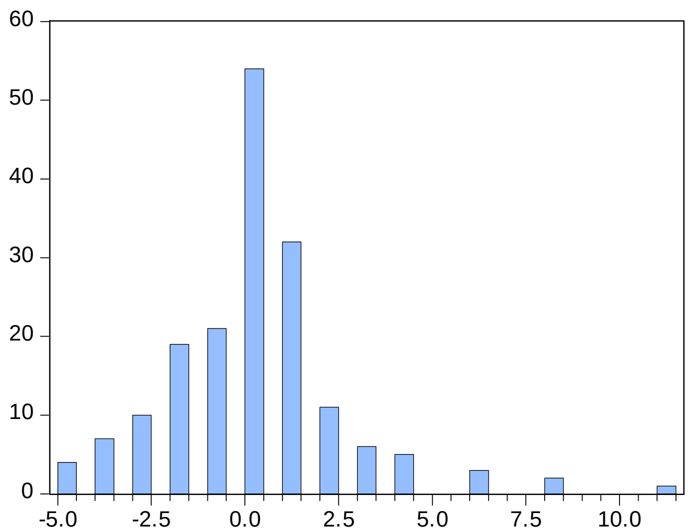
This formulation simply replaces LE with LLHL in the achievement index without changing the goalpost values. In our sample of 175 countries in 2002, Zambia still has the lowest value for LLHL, now 27.6, and Japan still has the highest value, now 74.9. These respective values are well within the goalpost values of 25 and 85. Zambia has one of the lowest values of LHE at 4.8 and, hence, the lowest value of LLHL does not fall by as much as the average value of LHE, which is 8. An advantage of not changing the form of the achievement index is that we can isolate the changes as originating solely from the introduction of the new indicator.[11]

Using LLHLindex, the modified HDI is then recalculated as follows:

$$HDI_{LHE} = (1/3)LLHLindex + (1/3)GDPindex + (1/3)Edindex ,$$

where the GDPindex and Edindex are the other dimension indices found in the original HDI. To analyze the impact of the modification on the rankings of countries[12], we first calculate the Spearman rank correlation between the HDI and HDI_{LHE}. The rank correlation is very high and is equal to 0.9989, which means that the rankings will generally be in the same direction and there will not be much change in ranks.

Figure 3:
Histogram of Rank Difference
HDI Rank less HDI_{LHE} Rank



Series: RANKDIFFLHE	
Sample 1 175	
Observations 175	
Mean	0.000000
Median	0.000000
Maximum	11.00000
Minimum	-5.000000
Std. Dev.	2.356210
Skewness	0.975508
Kurtosis	6.399091
Jarque-Bera	112.0021
Probability	0.000000

Next we provide a histogram of the rank changes between the HDI and our proposed HDI_{LHE} in Figure 3. There is no change in rank in 54 countries (approximately 31%); 60 countries (approximately 34%) show a positive change in rank (implying improved rank under HDI_{LHE}), while 61 countries (approximately 35%) show a negative change in rank (implying worsening of rank under HDI_{LHE}). Only 6 countries (approximately 3%) show a rank change that is greater than 5 in absolute value. The mean of the absolute value of the rank change is 1.57.

Table 1 in the Appendix lists all the values for the HDI_{LHE} for 2002 and the ranking of countries. As expected, all of the values decreased slightly from that of the HDI, as the index is now decreasing in morbidity (measured by LHE). Table 1 also shows how much each country's rank order changed from the HDI ranking. In the top 20 ranked countries the most substantial changes in rank were Canada (-3), United States (-4), and Finland (+3).[13] The most dramatic gainers were China (+11), Zimbabwe (+8) and Lesotho (+8).[14] The maximum drop in ranks was by 5 and the countries in that list were Jordan, Paraguay, Pakistan and Sudan. Still overall, the change in the ranking of nations is relatively small. We now turn to see if using HALE as an indicator gives similar results.

4. A Modified Development Index with Healthy Life Expectancy (HALE)

An indicator of health that includes information on both mortality and morbidity is the HALE. In the World Health Report 2004, HALE is described as "the equivalent number of years of full health that a newborn can expect to live based on current rates of ill-health and mortality". HALE appears to nicely fit the description of an indicator for a 'long and healthy life' and we will use it here in developing an alternative modified development index denoted HDI_{HALE}.

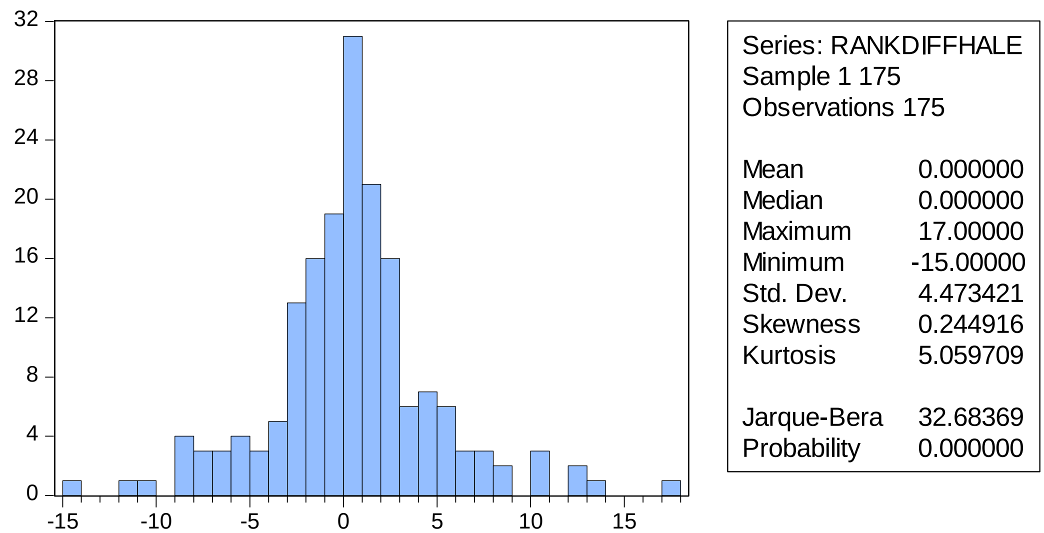
In particular, we consider HALE as an alternative indicator variable to our previous LLHL indicator, which also captured mortality and morbidity. We form the dimension index for 'a long and healthy life' as follows:

$$\text{HALEindex} = \frac{\text{HALE} - 25}{85 - 25}.$$

This formulation is the same as above except that HALE replaces LLHL as the indicator in the index. Again, the goalpost values are unchanged from those in the original HDI. We find that the sample minimum HALE value is 28.56 years and the sample maximum is 74.99 years, which is very close to the minimum and maximum for LLHL. The HALE values are well within the goalposts of 25 and 85 years. Using goalposts that are identical to those in the LEindex has the same limitations that were discussed with respect to the LLHLindex, but has the advantage of allowing a ready comparison.

First we calculate the Spearman rank correlation between the HDI and HDI_{HALE}, and find a very high positive rank correlation of 0.9961. Figure 4 provides a histogram of the rank changes between the HDI and HDI_{HALE}. Out of the sample of 175 countries, 31 (approximately 18%) show no change in rank, 71 (approximately 41%) show a positive change in rank (implying improved rank under HDI_{HALE}) and 73 (approximately 42%) show a worsening of rank under HDI_{HALE}. 32 countries (approximately 18%) show a rank change that is greater than 5 in absolute value. The mean of the absolute value of the rank change is 3.06, which is almost twice as large as with HDI_{LHE}.

Figure 4:
Histogram of Rank Difference
HDI Rank less HDI_{HALE} Rank



Examining the HDI_{HALE} values for 2002 and the ranking of countries, we find noteworthy changes in the top tier for 20 countries are: Switzerland (+7), United Kingdom (-5), Belgium (-4), , New Zealand (-3), United States (-3), and Finland (+3). Relative to the rankings with just morbidity, the United Kingdom drops 4 ranks whereas Switzerland and Canada gain 6 and 3 ranks respectively. Outside of the top 20 ranked countries, China moves up substantially by 13 ranks, 2 ranks more than when just morbidity was considered. Other large movers are: Azerbaijan (-12), Bahamas (+10), Dominican Republic (+12), Equatorial Guinea (+12), Grenada (+17), Kenya (+10), Lebanon (-15), Turkmenistan (-11) and Zimbabwe (+10). Overall the rank differences are bigger than when comparing the HDI_{LHE} rank to the HDI rank. We now isolate the reason for the different ranking.

Variation resulting from using the WHO life expectancy measure

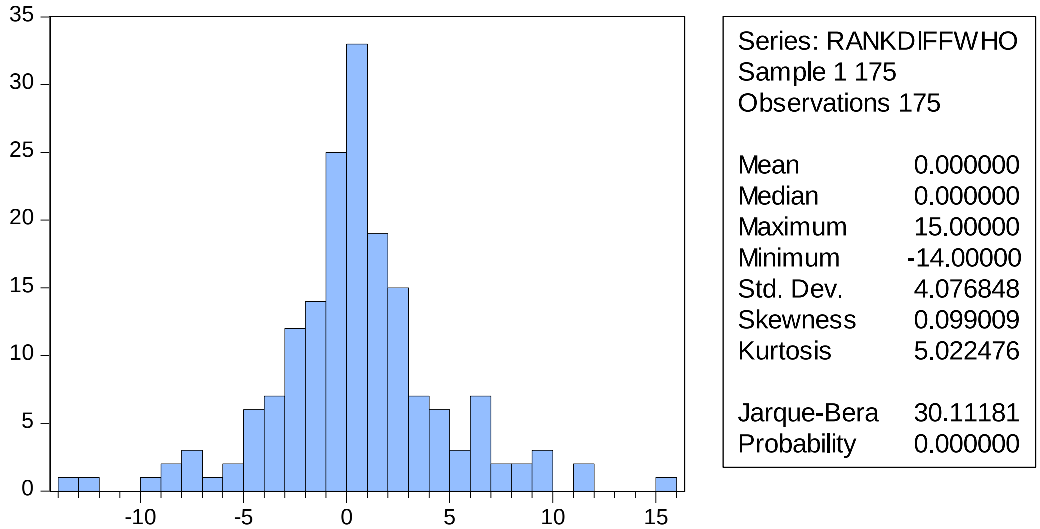
HALE and LLHL use the same measure of morbidity, LHE, but use different life expectancy series. Since there is no difference in the form of the dimension index, the sole source of the difference in the rankings of the modified HDI indices with the HDI is the use of different life expectancy series. In this section, we examine this source of variation directly. First, we use the WHO life expectancy series, which we denote LE_{WHO}, to create a new index. In particular, we use LE_{WHO} in place of LE in the calculating a modified HDI, denoted HDI_{WHO}, as follows:

$$HDI_{WHO} = (1/3)LEindex_{WHO} + (1/3)GDPindex + (1/3)Edindex$$

where $LEindex_{WHO} = (LE_{WHO} - 25)/(85-25)$.

Figure 5 provides a histogram of the rank changes between UNDP's HDI and HDI_{WHO} given above. Out of the sample of 175 countries, 33 (approximately 19%) show no change in rank, 67 (approximately 38%) show a positive change in rank and 75 (approximately 43%) show a negative change in rank. 28 countries (approximately 16%) show a rank change that is greater than 5 in absolute value. It is interesting to note that even with a simple change in data source for life expectancy, we see some large swings in rank between the HDI and this modified version of it. For example, we see the following large rank changes :Azerbaijan (-14), Dominican Republic (+11), Grenada (+15), Paraguay (+11), Kenya (+10), Lebanon (-13), and Turkmenistan (-10). The mean of the absolute value of the rank change is 2.80. We also calculated the rank correlation between HDI and HDI_{WHO} and found it to be 0.9968. These results suggest that it is the different measures of life expectancy that are responsible for most of the difference between the rankings of HDI and HDI_{HALE}.

Figure 5:
Histogram of Rank Difference
HDI Rank less HDI_{WHO} Rank



The ranking differences are mainly due to the fact that the HDI uses UN life expectancy series whereas HDI_{HALE} incorporates the WHO life expectancy series. The UN model life tables uses self-reported mortality data from countries that contain vital registration systems.[15] The complete UN life tables are then extrapolated from this for countries that do not report mortality data. The UN life table system utilizes single parameter demographic techniques that may not adequately reflect the present circumstances that exist in the world today. These circumstances include the impact of AIDS in the developing world and the 'graying' of the population in the developed world. The WHO, on the other hand, uses a multi-parameter equation system with region-specific standards (Murray et al., 2000). These life tables incorporate data that are collected from the ongoing survey systems developed by the WHO.[16] The fact that using a different life expectancy in the human development index yields larger variations in rankings than including LHE suggests that including morbidity information, as a practical concern, is not the first issue for concern.

5. A Modified Gender-related Development Index (GDI)

While examining LHE values, disaggregated by gender, we find noticeable differences across gender, with LHE for females being higher than that for males for each of the 175 countries for which we have such data. The average value for females is 8.89 years and that for males is 7.16 years with an average difference of 1.73 years or 24%. We do not know of any intrinsic biological explanation that might explain such a large difference.[17] Given that the UNDP created the GDI in 1995 to capture variations across gender, it is useful to investigate the implication of modifying the GDI with LHE data.

Like the HDI, the GDI is an equally weighted sum of the three dimension indices. It differs from the HDI, in three ways. Each dimension index includes a female sub-index and a male sub-index. The functional form of the dimension index incorporates a degree of inequality version. Finally, the health and long life dimension index has asymmetric life expectancy bounds as found in the respective female and male sub-indices:

$$\frac{LE_f - 27.5}{87.5 - 27.5} \quad \text{and} \quad \frac{LE_m - 22.5}{82.5 - 22.5} \, .$$

The different goalpost values for females and males are intended to capture the female advantage in life expectancy.[18] If life expectancy for females is not higher than its male counterpart by 5 or more years, then there is a presumed gender bias against females in life expectancy.

We undertake a similar exercise as before, and calculate the modified GDI, called GDI_{LHE}, by simply replacing the LE_g variable with the $LLHL_g = LE_g - LHE_g$ variable in the gender sub-index for g = f,m. In modifying the index we do not modify the goalposts for the same reasons we made when creating HDI_{LHE}. As we are subtracting LHE_f from LE_f and $LHE_f > LHE_m$, we are magnifying the existing gender gap. For example, if LE_f = 53 and LE_m = 50, then there is a 2 year gender gap against women. Now, if LHE_f = 8 while LHE_m = 7, then a bigger gender gap of 3 years exists (LLHL for females and males being 45 and 43 respectively).

The Spearman rank correlation between the GDI[19] and the GDI_{LHE} is 0.9990 while that between HDI and GDI_{LHE} is 0.9966. These are very high correlations but so is the correlation between HDI and GDI which is 0.9979. A closer examination of the ranking of countries shows that out of our sample of 143 countries for which we have data on GDI and GDI_{LHE}, 47 (approximately 33%) show no rank change, another 47 show a positive rank change and 49 countries have lost in rank. Only 2 countries (approximately 1%) have changed rank by more than 5 places. The average for the absolute rank change is 1.26. This suggests that the impact of the inclusion of LHE in GDI is similar to that from modifying HDI with LHE, except the range of rank changes with GDI is much smaller compared to that of HDI. The largest gainers here are Lesotho (+7) and Zimbabwe (+6) and the biggest losses are encountered by Bangladesh (-5) and Columbia

(-5). It is interesting to note that China which experienced large gains in HDI rank with the inclusion of LHE only gains 2 ranks when the GDI is modified with the morbidity information.

6. Conclusion

A weakness in the implementation of the human development index (HDI) is that the dimension index that is meant to capture 'a long and healthy life' is based solely on a mortality indicator, the life expectancy measure used by the UNDP. This measure of life expectancy (LE) is arguably a good indicator of the quantity of life but is only an indirect measure of a healthy life. To capture the quality of life given longevity, we consider 'expected lost healthy years ' (LHE), which is the leading morbidity indicator. Aggregating the mortality indicator LE and the morbidity indicator LHE, yields an indicator which we termed 'long life and health life' LLHL.

We argue that it is appropriate to modify the HDI by simply replacing the LE indicator with LLHL in the index. We denoted this morbidity-augmented index HDI_{LHE}. Comparing the rankings of nations given by HDI and HDI_{LHE} gives us a basis for assessing whether the added morbidity information matters. The ranking of a few countries change considerably (e.g. China gains 11 ranks and the United States loses 4 ranks). However, overall, we find that there is only a very minor change in the rank ordering of the series. Indeed, the changes associated with the inclusion of our morbidity indicator are smaller than those associated with simply using an alternative life expectancy series, one created by the World Health Organization (WHO).

In our analysis, the inclusion of a morbidity indicator in the human development index did not substantially alter the overall ranking of nations. Of course, the generality of the result depends on whether there is a good alternative morbidity indicator to LHE, and whether there is a better way of including the indicator into the index. We cannot think of an alternative broadly conceived morbidity indicator. LHE is the result of a great deal of careful work in both collecting health data across health conditions and countries. It is also the outcome of a careful methodology that explicitly weighs and aggregates health conditions making allowance for country specific cultural differences. Further, given that LHE is measured in expected years, combining it linearly with life expectancy is the natural way to include LHE into the development index.

It is tempting to conclude that while modifying the HDI to include morbidity information is in principle an important extension, in practice it does not matter much. However, this conclusion would be premature. Our analysis is for one specific year 2002. In the future, the LHE variable might contain more variation (from the spread of new life sustaining medicines and methods), which would make it more relevant. Secondly, though the LHE morbidity indicator does not move the index much, it does add information to the index. Given that the dimension “a long and health life” has only one-third weight in the HDI, it is perhaps not surprising that adding a second indicator to the dimension fails to alter the relative rankings substantially. Finally, including morbidity into the HDI provides balance to the index. With the inclusion of an indicator for health, policy makers can better gauge the state of development and use potential improvements in the index as a guide in trading off expenditures towards the competing development goals.[20]

The argument for modifying the Gender-related Development Index (GDI) is perhaps more compelling. Given that morbidity, as measured by LHE, is consistently higher for females compared to males in our sample for no obvious reason, it makes sense to include this gender variation information in the GDI which was created to take into account gender differences in the first place. Indeed, the innovation of the GDI (apart from inequality aversion by gender) was to modify the dimension for a long and healthy life to represent intrinsic differences between the genders. Including a "healthy" component in this dimension is consistent with this aim especially when there are obvious differences between the genders in terms of healthiness. Whereas including a health component makes relatively little difference to the GDI ranking, the adjusted GDI has a lower rank correlation with the HDI. This morbidity adjustment to the GDI helps to conceptually and empirically distinguish it from the existing HDI.

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Appendix

Table 1: Rank Comparison of HDI and Modified HDI

Country	**HDI**	**HDI rank**	**LHE**	**HDILHE**	**HDILHE rank**	**Rank change**
Norway	0.957	1	7.11	0.917	1	0
Sweden	0.946	2	7.08	0.907	2	0
Australia	0.946	3	7.81	0.902	3	0
Canada	0.944	4	7.77	0.900	7	-3
Belgium	0.942	5	7.27	0.902	4	1
Netherlands	0.942	6	7.43	0.900	6	0
Iceland	0.941	7	7.25	0.900	5	2
Japan	0.939	8	6.91	0.900	8	0
United States	0.938	9	8.04	0.894	13	-4
Ireland	0.936	10	7.30	0.896	9	1
United Kingdom	0.936	11	7.58	0.894	12	-1
Switzerland	0.936	12	7.43	0.894	11	1
Finland	0.935	13	7.11	0.895	10	3
Austria	0.934	14	7.99	0.890	16	-2
Luxembourg	0.933	15	7.29	0.892	14	1
Denmark	0.932	16	7.35	0.892	15	1
France	0.932	17	7.78	0.889	17	0
New Zealand	0.926	18	8.07	0.881	20	-2
Germany	0.925	19	6.88	0.887	18	1
Spain	0.922	20	7.03	0.883	19	1
Italy	0.920	21	6.99	0.881	21	0
Israel	0.908	22	8.01	0.864	22	0
Greece	0.902	23	7.39	0.861	23	0
Singapore	0.902	24	9.51	0.849	26	-2
Portugal	0.897	25	7.89	0.853	25	0
Slovenia	0.895	26	7.25	0.855	24	2
Barbados	0.889	27	8.75	0.840	28	-1
Korea, Rep. of	0.888	28	7.69	0.845	27	1
Cyprus	0.883	29	9.71	0.829	30	-1
Malta	0.875	30	7.31	0.835	29	1
Czech Republic	0.868	31	7.41	0.827	31	0
Brunei Darussalam	0.867	32	10.82	0.807	33	-1
Estonia	0.855	33	7.01	0.816	32	1
Argentina	0.854	34	9.10	0.803	35	-1
Seychelles	0.853	35	10.34	0.796	38	-3
Poland	0.852	36	8.91	0.802	36	0

Hungary	0.848	37	7.74	0.805	34	3
Slovakia	0.844	38	7.78	0.801	37	1
Saint Kitts and Nevis	0.843	39	8.89	0.794	40	-1
Lithuania	0.843	40	8.59	0.795	39	1
Bahrain	0.842	41	8.89	0.793	41	0
Chile	0.839	42	9.40	0.787	42	0
Kuwait	0.838	43	9.26	0.787	43	0
Qatar	0.834	44	9.09	0.783	45	-1
Costa Rica	0.833	45	9.85	0.779	48	-3
Uruguay	0.833	46	8.99	0.783	46	0
Croatia	0.829	47	8.24	0.784	44	3
Latvia	0.825	48	7.54	0.783	47	1
United Arab Emirates	0.824	49	8.64	0.776	49	0
Bahamas	0.815	50	9.08	0.765	50	0
Cuba	0.810	51	8.80	0.761	52	-1
Mexico	0.802	52	8.85	0.753	55	-3
Trinidad and Tobago	0.801	53	7.89	0.757	53	0
Antigua and Barbuda	0.800	54	9.52	0.747	57	-3
Russian Federation	0.796	55	6.17	0.762	51	4
Bulgaria	0.796	56	7.35	0.755	54	2
Libyan Arab Jamahiriya	0.794	57	8.95	0.745	59	-2
Malaysia	0.793	58	8.80	0.744	60	-2
Macedonia, TFYR	0.793	59	8.59	0.745	58	1
Belarus	0.792	60	7.55	0.750	56	4
Panama	0.791	61	9.23	0.740	61	0
Tonga	0.787	62	8.89	0.738	62	0
Mauritius	0.785	63	9.49	0.732	65	-2
Albania	0.782	64	9.04	0.732	66	-2
Bosnia and Herzegovina	0.781	65	8.48	0.734	63	2
Suriname	0.780	66	8.81	0.731	68	-2
Ukraine	0.778	67	7.95	0.734	64	3
Venezuela	0.777	68	9.68	0.724	72	-4
Romania	0.777	69	8.28	0.731	67	2
Saint Lucia	0.777	70	9.49	0.724	70	0
Brazil	0.775	71	9.10	0.725	69	2
Colombia	0.773	72	9.76	0.719	76	-4
Oman	0.770	73	9.15	0.720	75	-2
Samoa (Western)	0.769	74	8.46	0.722	73	1
Thailand	0.768	75	9.25	0.717	77	-2
Saudi Arabia	0.767	76	9.42	0.715	78	-2
Kazakhstan	0.766	77	7.65	0.724	71	6

Jamaica	0.764	78	7.74	0.721	74	4
Lebanon	0.758	79	9.42	0.706	83	-4
Fiji	0.758	80	8.52	0.710	79	1
Armenia	0.755	81	9.00	0.705	85	-4
Peru	0.753	82	8.70	0.704	86	-4
Maldives	0.752	83	8.32	0.706	82	1
Philippines	0.752	84	9.01	0.702	87	-3
Turkmenistan	0.752	85	8.27	0.706	84	1
Turkey	0.751	86	7.96	0.707	80	6
Jordan	0.751	87	9.79	0.696	92	-5
Paraguay	0.751	88	9.78	0.696	93	-5
St. Vincent & the Grenadines	0.751	89	8.77	0.702	88	1
Azerbaijan	0.747	90	8.57	0.699	89	1
Tunisia	0.745	91	9.14	0.695	94	-3
China	0.745	92	6.95	0.707	81	11
Grenada	0.744	93	8.23	0.699	91	2
Dominica	0.744	94	9.59	0.690	97	-3
Sri Lanka	0.740	95	8.68	0.691	95	0
Georgia	0.740	96	7.33	0.699	90	6
Dominican Republic	0.738	97	8.42	0.691	96	1
Belize	0.737	98	9.41	0.684	99	-1
Ecuador	0.735	99	8.66	0.687	98	1
Iran, Islamic Rep. of	0.732	100	11.29	0.670	100	0
El Salvador	0.720	101	9.95	0.665	103	-2
Guyana	0.719	102	9.12	0.668	101	1
Cape Verde	0.717	103	9.25	0.666	102	1
Syrian Arab Republic	0.709	104	9.46	0.656	106	-2
Uzbekistan	0.708	105	8.81	0.659	104	1
Algeria	0.704	106	8.76	0.655	107	-1
Equatorial Guinea	0.703	107	7.86	0.659	105	2
Kyrgyzstan	0.702	108	9.20	0.650	108	0
Indonesia	0.692	109	8.25	0.646	109	0
Viet Nam	0.691	110	8.26	0.645	110	0
Moldova, Rep. of	0.682	111	8.00	0.637	111	0
Bolivia	0.681	112	8.78	0.633	112	0
Honduras	0.671	113	8.79	0.622	115	-2
Tajikistan	0.670	114	8.96	0.621	116	-2
Mongolia	0.668	115	7.26	0.628	114	1
Nicaragua	0.668	116	8.70	0.619	117	-1
South Africa	0.665	117	6.39	0.630	113	4
Egypt	0.653	118	8.10	0.608	118	0

Guatemala	0.650	119	8.53	0.603	120	-1
Gabon	0.649	120	7.82	0.605	119	1
São Tomé and Principe	0.645	121	8.28	0.599	121	0
Solomon Islands	0.624	122	9.18	0.573	123	-1
Morocco	0.620	123	10.64	0.561	125	-2
Namibia	0.606	124	5.98	0.573	122	2
India	0.595	125	7.55	0.553	126	-1
Botswana	0.589	126	4.71	0.563	124	2
Vanuatu	0.570	127	8.77	0.522	129	-2
Cambodia	0.568	128	7.06	0.529	127	1
Ghana	0.568	129	7.84	0.524	128	1
Myanmar	0.551	130	7.23	0.511	130	0
Papua New Guinea	0.543	131	7.89	0.499	131	0
Bhutan	0.536	132	8.38	0.489	134	-2
Lao People's Dem. Rep.	0.534	133	8.07	0.489	133	0
Comoros	0.530	134	8.73	0.481	135	-1
Swaziland	0.519	135	4.62	0.494	132	3
Bangladesh	0.510	136	8.30	0.463	139	-3
Sudanae	0.504	137	8.56	0.456	142	-5
Nepal	0.503	138	8.30	0.457	140	-2
Cameroon	0.501	139	6.64	0.464	138	1
Pakistan	0.497	140	8.12	0.452	145	-5
Togo	0.495	141	7.08	0.456	144	-3
Congo	0.494	142	6.80	0.456	143	-1
Uganda	0.493	143	6.62	0.457	141	2
Lesotho	0.493	144	4.32	0.469	136	8
Zimbabwe	0.491	145	4.33	0.467	137	8
Kenya	0.488	146	6.46	0.452	146	0
Yemen	0.481	147	11.08	0.420	151	-4
Madagascar	0.469	148	7.70	0.426	148	0
Nigeria	0.466	149	7.25	0.426	149	0
Mauritania	0.465	150	7.55	0.423	150	0
Haiti	0.463	151	6.29	0.428	147	4
Djibouti	0.454	152	6.74	0.417	152	0
Gambia	0.452	153	7.59	0.410	153	0
Eritrea	0.438	154	7.59	0.396	155	-1
Senegal	0.437	155	7.83	0.393	156	-1
Timor-Leste	0.436	156	7.70	0.393	157	-1
Rwanda	0.431	157	6.12	0.397	154	3
Guinea	0.425	158	7.55	0.384	158	0
Benin	0.421	159	7.22	0.381	159	0

Tanzania, U. Rep. of	0.406	160	6.15	0.372	160	0
Côte d'Ivoire	0.399	161	5.84	0.366	161	0
Zambia	0.389	162	4.83	0.362	162	0
Malawi	0.388	163	5.29	0.359	163	0
Angola	0.381	164	6.52	0.344	164	0
Chad	0.379	165	7.03	0.340	165	0
Congo, Dem. Rep. of the	0.365	166	6.43	0.329	167	-1
Central African Republic	0.362	167	5.53	0.331	166	1
Ethiopia	0.358	168	6.84	0.320	169	-1
Mozambique	0.355	169	5.70	0.323	168	1
Guinea-Bissau	0.350	170	6.65	0.313	170	0
Burundi	0.339	171	5.72	0.307	171	0
Mali	0.326	172	6.93	0.287	172	0
Burkina Faso	0.302	173	6.06	0.268	173	0
Niger	0.291	174	7.08	0.252	174	0
Sierra Leone	0.273	175	5.44	0.243	175	0

Note: The last column is the difference between column 3 and column 6. Therefore, a positive number indicates that the country is worse off under the HDI ranking.

Endnotes

[1] For a detailed description see http://hdr.undp.org/statistics/indices/. The importance of the long and healthy life dimension is stressed in the initial Human Development Report, UNDP (1990), p. 11, Box 1.2 “What price human life?”

[2] The criticisms and responses are reviewed by Raworth and Stewart (2005). Also, see Hicks (1997), Noorbakhsh, (1998c), Mazumdar (2003), Cahill, (2005), Osberg and Sharpe (2005), and Engineer et. al. (2008).

[3] Initially, the literacy rate was the only indicator used in the education index. ‘Years of schooling’ was added as an indicator to show differences between industrial countries that are close to 100% literacy rate (Raworth and Stewart (2005)). Later ‘combined gross enrolment ratio’ replaced years of schooling in the education index.

[4] For an explanation of LHE see The World Health Report 2004 – Changing History, Statistical Appendix, Explanatory Notes, p. 97. LHE is a comprehensive morbidity measure which includes most important health conditions. More generally, morbidity is a narrow conception of the lack of quality of health. There is no general definition of health. The WHO (2006) in their constitution defines: “Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.”

[5] In the Human Development Report 177 jurisdictions are listed. Of these, all but two jurisdictions (Hong Kong and Occupied Palestian Territories) are not on the list of 192 countries in the World Health Report 2004.

[6] In contrast, Cahill (2005) finds that all the dimension indices of the HDI are highly correlated with the HDI, each with a Spearman rank-order correlation greater than .92. He argues that the high correlation makes some of the dimension indices redundant.

[7] These categories attempt to comprehensively cover the most important diseases and injury conditions. For example, 14 conditions are listed under the Neuropsychiatric Conditions, including well known conditions like schizophrenia, Alzheimer and other dementias, and less obvious conditions like insomnia and panic attacks. These conditions are usually associated with mental health but there is no attempt to define mental health. Innovations in the Burden of Disease Report (2002) include using new data and methodology to control for comorbidity. Efforts made to make sure the data and estimation are complete and accurate for all countries have lead to considerable delays.

[8] The WHO convened a series of expert panels consisting of professionals from numerous different occupations in the health care field. According to Mathers et. al. (2003), there was a surprising amount of consensus among all the different groups on what the weights should be.

[9] Data on LHE are internationally comparable and available for 175 countries for 2002. Its inclusion in a table in the latest Human Development Report suggests that the UNDP considers such data to be of acceptable quality.

[10] Kendall and Stewart (1979) contain a description of the Spearman rank order correlation coefficient and tests of the coefficient. All the Spearman rank correlations reported in this paper were calculated using the "spearman" command in STATA (StataCorp, 2005). The test of whether the ranks have zero correlation is well known. For the test of perfect correlation, we undertook the same statistical test as Kanbur and Mukherjee (2007), following Rao (1973).

[11] The average value for LHE is 8 years. We can decompose LHLHindex = LEindex - [8 + (LHE – 8)]/(85-25). The constant term does not change the ranking of the HDI. Only the deviation of LHE from its mean changes the ranking. This deviation is weighted by the reciprocal of the difference in the goalposts which is 60. Lowering both the upper and lower values of the goalposts by the same number, say the average 8, would leave the difference at 60. However, LHE forms an inverse U shape against LE (in Figure 2). Countries with the lowest life expectancy have LHE roughly at about 4.5 years; whereas countries with the highest life expectancy have LHE roughly 7 years. Using these numbers to adjust the bounds yields a smaller difference of 57.5. Compared to this benchmark, using the original bounds would slightly underestimate the effect of the inclusion of LHE.

[12] There are a few data related details that are well-worth discussing here. The data on the first two indicator variables (life expectancy and adult literacy) in table 1 of HDR 2004 are reported with 1 place of decimal while the gross enrolment ratio is given with no decimal points. The sub-indices in the same table are reported with 2 places of decimal and finally, the HDI is presented with 3 places of decimal. When we summed up the sub-indices and divided it by 3 in order to obtain the HDI value, our values were different

from those of the HDI values reported in the table, due to the rounding off in reporting. More problematic is the fact that the HDI derived that way resulted in numerous ties. Given this, if we went ahead and calculated our modified HDIs by creating a modified LE index but still using the reported values from the table for the other two sub-indices (education and income) and compared that to the original HDI rankings, then some of the differences would be attributable to rounding off errors again and would not be simply due to any change in the definition of the index. In order to avoid this, we decided to recalculate the sub-indices and then the HDI based on the data on the indicator variables in the table and we carried all the decimal points through. This way we did not get any ties based on the HDI values from our calculations. Similarly, we calculated all the modified indices using the education and the income sub-indices as calculated by us and not those reported in the original table. So all the comparisons of the modified HDI indices with the HDI, uses rankings based on our own calculation using only the values of the indicator variables from table 1 of HDR 2004.

[13] A WHO (2000) press release discussed the rankings of countries by DALE and reported the low ranking of United States (24th) by that measure. The release listed a number of reasons for the low US ranking prominent of which was the lack of adequate medical care for many US residences.

[14] An examination of the 'years lost to disability' cause category tables show very low rates of heart disease, obesity, and underweight/malnutrition for China relative to similarly ranked countries.

[15] For the calculation of life expectancy, the UN uses the Manual X published in 1983 and the Model Life Tables for Developing Countries published in 1982. For more information, see:
http://www.un.org/esa/population/publications/Manual_X/Manual_X.htm
http://www.un.org/esa/population/publications/Model_Life_Tables/Model_Life_Tables.htm.

[16] For more information about ongoing WHO survey systems see: http://www.who.int/topics/health_surveys/en/

[17] Tsuchiya and Williams (2005) are unaware of biological estimates of intrinsic differences in morbidity but list a number of possible non-biological reasons for the quite different mortality and morbidity experiences of the genders. It might be argued that women have greater morbidity because they tend to live longer and are believed to have a slight greater life span, *ceteris paribus*. An examination of the five countries where men live longer than women (Maldives, Zimbabwe, Nepal, Zambia and Pakistan) reveals that two of those countries (Maldives and Nepal) have morbidity of females exceeding that of males by more than one year and in one (Pakistan), the difference is more than 2 years. Therefore, not all of the higher morbidity is due to women living longer than men. Considering the sub-set of eighteen countries in our sample that have a morbidity difference of more than 2.5 years, we find that four of those (United Arab Emirates, Macedonia, Oman and Morocco), that is, about 22%, have a female-male gender gap in life expectancy of less than 5 years. This shows some relatively high morbidity differences in countries where gender bias (against women) in life expectancy already exists.

[18] UNDP uses a 5 year life expectancy advantage for women but there is controversy regarding the exact magnitude of this advantage as indicated by Bardhan and Klasen (1999) and the references therein.

[19] The GDI values in this paper are based on our own calculations using gender disaggregated data on life expectancy, adult literacy, gross enrolment ratio and estimated earned income from table 24 of HDR (2004) and data on male population shares calculated from UN (2007), as the latter are not reported in HDR (2004). The disaggregated LHE data for calculating GDI_{LHE} have been obtained using data on HALE and life expectancy by gender from World Health Report 2004.

[20] Anand and Hanson (1997) and Arnesen and Kapiriri (2004) show that using a morbidity indicator on its own leads to lopsided development planning. Engineer et. al. (2008) examine how expenditures can be best allocated to improve broad-based development using the HDI.