ORIGINAL RESEARCH

Global Income Related Health Inequalities

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Abstract

Introduction: Income related health inequalities have been estimated for various groups of individuals at local, state, or national levels. Almost all of theses estimates are based on individual data from sample surveys. Lack of consistent individual data worldwide has prevented estimates of international income related health inequalities.

Methods: This paper uses the (population weighted) aggregate data available from many countries around the world to estimate worldwide income related health inequalities. Since the intra-country inequalities are subdued by the aggregate nature of the data, the estimates would be those of the inter-country or international health inequalities. As well, the study estimates the contribution of major socioeconomic variables to the overall health inequalities.

Results: The findings of the study strongly support the existence of worldwide income related health inequalities that favor the higher income countries. Decompositions of health inequalities identify inequalities in both the level and distribution of income as the main source of health inequality along with inequalities in education and degree of urbanization as other contributing determinants.

Discussion: Since income related health inequalities are preventable, policies to reduce the income gaps between the poor and rich nations could greatly improve the health of hundreds of millions of people and promote global justice.

Readers unfamiliar with the Concentration Index may consult page 31 of this article for a sidebar written by the author entitled: "**Understanding Measures of Health Inequality And the Concentration Index**

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Background

Health inequalities are increasingly recognized as an important public health issue throughout the world, more so in Europe and other industrialized countries than in other parts of the world[1]. This international attention was first expressed in the Declaration of Alma-Ata in 1978, where delegates found health inequalities politically, socially, and economically unacceptable[2]. Soon after, the influential *Black Report* from UK brought health inequality to international spotlight and triggered subsequent studies on health inequalities in many other countries[3]. Significant intellect was devoted to the study of the underlying processes and causes of such inequalities by the research community, leading to the development of the *social determinants of health* paradigm, where *social* is defined broadly to include *economic*, *political*, and *cultural* domains. In this paradigm, health is determined by the quantity and quality of a variety of resources that a society makes available to its members. These resources include – but are not limited to – conditions of childhood, income, education, availability of food, housing, employment and working conditions, social cohesion, cultural values, and health and social services[4,5]. The policy implications of such a paradigm are quite significant and have been brought to the forefront of health policy debates in many countries. Over the past couple of decades, the World Health Organization (WHO) has initiated a number of international venues to raise international awareness about health inequalities[6-8]. The most recent effort by the WHO was launching the Commission on Social Determinants of Health in March of 2005 in Santiago, Chile to bring together the experts in the field to search for potential policy interventions to reduce health inequalities[9]. The Commission has held subsequent meetings in Egypt, India, and Iran. It is working with partner countries to incorporate a Social Determinants of Health perspective into national policies across the Americas and in the Portuguese-speaking countries of Africa[10,11]. Many countries, especially in Europe, have already programs and policies in place to address health inequalities[12-16].

The complexity of the relationships among societal resources and health outcomes and the difficulty of measuring some of these resources - e.g. social cohesion or cultural values[17] - has directed significant research towards the links between income and health. Income is considered as a proxy for command over resources, or as a measure of socio-economic status. There is already a vast literature that documents health inequality along the income dimension[18-26, 4, 5, 27-29].

Income related health inequalities have been estimated for various populations in different countries at local, state, or national levels. There are few studies that include multiple country analysis for comparative purposes[30-35]. However, estimates of income related health inequalities are predominantly based on individual data obtained from sample surveys that measure health as perceived by individuals themselves (self rated health), or by some instrument - e.g. Short Form (SF36) or Health Utility Index (HUI). Exceptions include a few studies that have used aggregate data at the regional level for Brazil[36] and at the country level for the countries of the Americas[37,38] to estimate social inequalities in health. The lack of a consistent set of such individual data for the world population has impeded estimations of income related health inequalities at the global level. The latter has also been affected by the lack of due attention to global health inequalities by the wealthy nations, and to a lesser extent by international organizations. The recent attempts by the WHO to raise awareness about global health issues and the role of socioeconomic factors in this regard recognizes the importance of health inequalities worldwide. The world cannot afford to ignore global health inequalities in the wake of pending pandemics and the immense sufferings worldwide which threatens to undermine world security and peace.

This paper contributes to the income related health inequality literature by using the aggregate data available from 160 countries around the world that comprise the entire global income spectrum to estimate worldwide income related health inequalities for the first time. Since the *intra-country* inequalities are subdued by the aggregate nature of the data, the estimates would be those of the *inter-country* or international health inequalities proper. Pradhan et al[39] use standardized heights for young children as a measure of health status to measure global health inequality and decompose it into *within* and *between* country inequality. They conclude that within country inequality is the main source of total world inequality. It must be noted, however, that they examine only 55 *developing* countries. Moreover, almost 60% of their measured within country inequality is contributed by two countries, China and India as the two most populous countries of the world. The present study, however, decomposes the estimated income related international health inequalities into their contributing sources of socioeconomic health determinants. It provides estimates of health inequalities and their decompositions for ten measures of population health including six mortality rates and four life expectancies.

Methods

1. Measurement of health inequalities

Income related health inequalities have been estimated using a variety of measures. Two of these measures, the *relative inequality index* (RII) and the *Concentration index* (CI) have been shown to meet the three basic requirements of an index of inequality in health, namely i) being reflective of the socioeconomic dimension to inequalities in health; ii) being reflective of the experiences of the entire population; and iii) being sensitive to the changes in the distribution of population across socioeconomic groups[40]. A recent study on the welfare economics foundation of health inequality measures[41] questions the arbitrariness and acceptability of the equity weights implied in the CI. Nevertheless, I use the CI as a popular measure to estimate global income related health inequalities. The CI is defined in terms of a concentration (Lorenz) curve. The curve plots the cumulative proportion of the population ranked by income status (beginning with the lowest income country) against the cumulative proportion of ill health measured by a continuous index.

CI is defined as twice the area between the Lorenz curve and the diagonal. It takes a value of zero when there is no inequality (i.e. when the Lorenz curve coincides with the diagonal), a negative value when ill health is more concentrated in lower income countries (i.e. when the Lorenz curve lies above the diagonal), and a positive value when ill health is more concentrated in higher income countries (i.e. when the curve lies below the diagonal). For weighted data, following van Doorslaer and Jones[33], CI is computed as follows

$$CI = \frac{2}{\mu}\sum_{i=1}^{n} w_i \mu_i R_i - 1 \qquad (1)$$

Where $\mu = \sum_{i=1}^{n} w_i \mu_i$ is the weighted mean ill health rate, and R_i is the (weighted) relative fractional rank of the ith country defined as

$$R_i = \frac{1}{n}\left(\sum_{j=1}^{i-1} w_j + \frac{1}{2} w_i\right)$$

where $w_0 = 0$. CI can alternatively be derived as the estimate of γ in the following Weighted Least Squares regression[31].

$$2\sigma_R^2 \left(\frac{\mu_i}{\mu}\right)\sqrt{w_i} = \alpha\sqrt{w_i} + \gamma R_i \sqrt{w_i} + \varepsilon_i \qquad (2)$$

where $\sigma_R^2 = \frac{1}{n}\sum_{i=1}^{n} w_i \left(R_i - \frac{1}{2}\right)^2$ is the (weighted) variance of R_i.

The above formulations have been usually applied to individual or grouped data. That is why estimates of income related health inequalities have been limited to populations within a given area or country, where individual (or grouped) data are obtained from sample surveys. If one had a consistent set of sample survey data for various countries around the world, it would be feasible to estimate international health inequalities by pooling the country samples together. Despite some attempts by the WHO[42], such individual data is not yet available on a global basis.

In the absence of individual data, the present study offers an alternative approach to get around this problem. It uses aggregate level data from individual countries that are weighted by their respective population sizes. This approach abstracts from inequalities *within* the countries and focuses on the *between* the countries or international health inequalities along the income dimension.

Using (aggregate) population data also reduces the concern about the standardization of data (required for individual data to adjust for demographic factors such as age and gender) to the one that arises from any international differences in demographic structures among countries. The countries are ranked according to their average income (real GDP per capita) starting from the lowest income country. Each country's health outcomes (its measures of population health) are then weighted by the relative size of its population.

Moreover, I use multiple regression models to estimate the relationships between various socioeconomic determinants (namely, income, income inequality, education, and urbanization rate) and population health outcomes. These estimates are then used to decompose the overall income related health inequalities in terms of inequalities in the socioeconomic determinants of health and the elasticities of health with respect to these determinants. Following Wagstaff et al[43], the overall CI can be expressed as a weighted average of the inequalities in the determinants of health as in the following relationship

$$CI = \sum_k \left(\frac{\beta_k \bar{x}_k}{\mu}\right) CI_k + \frac{GCI_\varepsilon}{\mu} \qquad (3)$$

where β_k is the measure of association between health determinant k and health in a linear regression, $\bar{x}_k$ is the mean value of health determinant k, and μ is the mean value of health. The term in the bracket is the elasticity of health to health determinant k, and is the weight applied to the income related inequality (CI) in health determinant k. The last term in the above equation is the generalized CI, or the "unexplained" inequality attributable to any omitted variable(s) and the error term ε.

2. Data sources

The most recent cross sectional data available from 160 countries that account for over 95% of the world population are used in our initial analysis. The population health data are taken from the WHO 2005 Health Report[44]. They include infant (less than a year) mortality rate (IMR), child (under five years) mortality rates for males and females (CMRm, CMRf), maternal mortality rate (MMR), and adult mortality rates for males and females (AMRm, AMRf); as well as life expectancies at birth for males and females (LEBm, LEBf) and healthy life expectancies at birth, again for males and females (HLEm, HLEf). The healthy (health adjusted) life expectancies at birth is most easily understood as the equivalent number of years in full health that a newborn can expect to live based on current rates of ill-health and mortality[45].The data for MMR is for the year 2000, and those for HLEm and HLEf are for the year 2002. The rest of the data are for the year 2003.

Data on socioeconomic determinants of health were needed to estimate the relations between health outcomes and such determinants. These estimates are used to decompose measured income related health inequalities. The socioeconomic determinants considered in this study are income, education, income inequality, and the rate of urbanization. Data for income (real GDP per capita in PPP dollars), education (education index between 0 and 1), income inequality (Gini index between 0 and 1) urbanization rate (proportion of population living in urban areas), along with population data are taken from the United Nations Human Development Report 2005[46]. These data all belong to the year 2003.

The education index measures a country's relative achievement in both adult literacy and combined primary, secondary, and tertiary gross enrolment. It is a weighted average of two indices: the index for adult literacy, and the index for combined gross enrolment. The first index is given a weight of two-thirds, and the second is given a weight of one-third[47]. Table 1 provides a summary description of health data for the countries in our sample.

Table 1 shows substantial variations in all population health measures across the world. The extent of variation is different for various measures of health, however. Judged by the Coefficients of Variation (as given in the last column of the above table), mortality rates (especially infant, child, and maternal) show greater variation than life expectancies. These variations should not surprise us given the fact that countries around the world have vast differences in their socioeconomic, environmental and institutional structures.

In order to get a sense of the links between income and health outcomes, Table 2 presents the average health outcomes for groups of countries classified into seven income categories. The number of countries in each income category is roughly equal.

Fairly consistent gradients along the income dimension are observed for various health outcomes as shown in Table 2. Mortality rates decline as one goes up the income ladder step by step. The only exception is adult mortality rates for the income step (category) $4500-6499, where they show an increase from the previous step. On the other hand, life expectancies consistently improve with higher incomes. Such patterns of variation in health data and income suggest income related health inequalities exist and they seem to favor the countries with higher incomes.

The following section reports the estimated income related health inequalities, followed by decompositions of these inequalities into their contributing sources.

Results

1. Estimates of health inequalities

Estimates of income related health inequalities using the CI indices for ten measures of health outcome using equation (2) above are given in Table 3 below. These estimates are provided for a group of 122 countries for which the socioeconomic data were available. The latter are needed for decompositions of health inequalities.

To avoid any biases in inference that may result from heteroskedasticity, the White's Hetero-

Table 1. Summary description of health data

Health Measure	Minimum value	Maximum value	Mean	Coefficient of Variation
Infant mortality rate (per 1000 births) - IMR	3	166	41.41	0.95
Child mortality rate - female (per 1000 population) - CMRf	2	270	57.78	1.10
Child mortality rate – male (per 1000 population) - CMRm	3	297	64.49	1.07
Maternal mortality rate (per 100,000 live births) -MMR	0	2000	317.17	1.33
Adult mortality rate - female - (per 1000 population) - AMRf	45	839	209.03	0.84
Adult mortality rate – male (per 1000 population) - AMRm	73	912	287.22	0.61
Life expectancy at birth -female (in years) - LEBf	36	85	68.00	0.19
Life expectancy at birth -male (in years) - LEBm	33	78	63.14	0.18
Healthy life expectancy - female (in years) - HLEf	29.9	77.7	59.01	0.20
Healthy life expectancy - male (in years) - HLEm	27.2	72.3	55.83	0.19

Table 2. Average health outcomes for countries in different income categories

Health Outcomes										
Income Category	IMR	CMRf	CMRm	MMR	AMRf	AMRm	LEBf	LEBm	HLEf	HLEm
Less than $1500	99.72	162.44	176.68	988.8	437.4	496.56	49.32	47.04	41.98	40.47
$1500-2499	73.39	102.61	114.43	548.26	291.91	368.22	59.39	55.61	50.08	48.11
$2500-4499	37.81	45.09	49.62	199.25	184.05	264.66	68.66	64.05	59.20	56.33
$4500-6499	31.28	36.66	43.05	156.47	193.57	289.24	69.76	64.14	60.32	56.63
$6500-9999	25.00	27.38	32.95	94.58	160.86	258.28	72.19	66.24	62.74	58.64
$10000-24999	12.90	16.50	19.38	79.33	121.38	215.96	75.73	69.27	66.27	61.76
$25000 or more	4.31	4.52	5.56	9.43	57.91	104.43	82.17	76.69	73.49	69.82

Table 3. Estimates of income related health inequalities

Health Outcomes*	CI (γ)		
Mortality Rates	estimate	"t" Ratio	Adj. R^2
IMR	-0.1446	-11.71	0.966
CMRf	-0.1589	-13.67	0.968
CMRm	-0.1429	-13.68	0.973
MMR	-0.1599	-10.88	0.959
AMRf	-0.0538	-10.08	0.990
AMRm	-0.0306	-6.50	0.992
Life Expectancies			
LEBf	0.0164	9.98	0.999
LEBm	0.0142	7.93	0.999
HLEf	0.0191	12.19	0.999
HLEm	0.0158	8.54	0.999

* Health outcomes are measured in log form.

skedasticity-Consistent standard errors have been used. The estimated CI's for all mortality rates are negative as expected. Mortality rates, as *ill health* rates, are concentrated in the lower income countries (They favor the higher income countries). In contrast, the CI's for life expectancies are positive, that is, life expectancies, as *health* rates, are concentrated in the higher income countries. All the estimated CI's are statistically highly significant as indicated by the high "t" ratios.

2. Estimates of socioeconomic effects on health

The estimated effects of socioeconomic health determinants on various health outcomes are reported in Table 4. These estimates are based on a series of models that regress a health outcome as the dependent variable (in log form) on a common set of health determinants as independent variables. The set of health determinants includes income (log of GDP per capita), education (education index), income inequality (Gini index), and urbanization rate (in percentage form). Income and education are well-known socioeconomic factors that have positive influence on health outcomes[18-23, 26-30.] The Gini index captures the extent of income inequality in a country. Greater income inequality has been found to affect health adversely[19,28,48,49.] Urbanization rate is included as a proxy for the environmental factors (e.g access to safe water, public health measures, transportation and other amenities) that have bearing on population health. Other potentially relevant socioeconomic variables such as relative (to GDP) health expenditure, and public health expenditure were considered. But they did not appear to be statistically significant.

The socioeconomic variables appear to have the expected influences on health. Income, education, and urbanization rate have positive effect on health by reducing mortality rates and increasing life expectancies. In contrast, income inequality has negative impact on health. Greater income inequality increase mortality rates and reduce life expectancies. The estimated effects are all statistically significant, except for the effects of urbanization rate on CMRm and MMR, and the effect of education on AMRm.

Table 4. Estimates of the effects of health determinants on health.

Dependent Variables (Health Outcomes)*	Independent Variables (Health determinants)					
	Constant	Income*	Education	Income inequality	Urbanization rate	Adj. R^2
Mortality rates						
IMR	9.119 (16.75)†	-0.6952 (-9.26)	-0.6757 (-2.16)	2.000 (4.13)	-0.5575 (-1.82)	0.834
CMRf	9.981 (19.32)	-0.7369 (-11.52)	-1.149 (-3.77)	2.257 (4.68)	-0.6479 (-2.02)	0.885
CMRm	10.05 (20.17)	-0.7517 (-12.55)	-0.9026 (-3.04)	2.141 (4.57)	-0.5313 (-1.68)	0.880
MMR	12.54 (18.10)	-0.9022 (-8.42)	-2.308 (-4.55)	3.861 (6.80)	-0.124 (-0.32)	0.866
AMRf	7.45 (13.69)	-0.2695 (-4.35)	-0.6132 (-2.50)	2.148 (3.88)	-0.9489 (-3.41)	0.758
AMRm	7.44 (16.37)	-0.2659 (-4.99)	0.1354 (0.58)	1.152 (3.33)	-0.7224 (-3.00)	0.644
Life expectancies						
LEBf	3.64 (20.61)	0.0492 (2.46)	0.3032 (3.88)	-0.6190 (-3.28)	0.2688 (2.67)	0.693
LEBm	3.54 (20.47)	0.0614 (3.24)	0.1747 (2.18)	-0.5527 (-3.02)	0.2539 (2.40)	0.655
HLEf	3.36 (22.33)	0.0604 (3.52)	0.3626 (4.78)	-0.5966 (-3.61)	0.2485 (2.79)	0.766
HLEm	3.31 (21.92)	0.0708 (4.24)	0.2513 (3.07)	-0.5868 (-3.58)	0.2225 (2.35)	0.728

* Dependent variables and income are in log form.
† Numbers in Brackets are "t" ratios.

3. Decomposition of health inequalities

The decompositions of health inequalities based on equation (3) above are provided in Tables 5 and 6 below. Income related inequalities in the determinants of health have been estimated for each of the four determinants along with the elasticity of health with respect to each of these determinants. These estimates are reported in Table 5.

Table 5. Health determinants inequalities (CI) and health elasticities.

	Health Determinants			
	Income* CI = 0.0612 SE = 0.0039	Education CI = 0.1035 SE = 0.0092	Income inequality CI = 0.0165 SE = 0.0202	Urbanization rate CI=0.1801 SE = 0.0179
Health Outcomes*	Elasticity	Elasticity	Elasticity	Elasticity
Mortality rates				
IMR	-1.878	-0.167	0.254	-0.095
CMRf	-1.878	-0.269	0.271	-0.104
CMRm	-1.831	-0.202	0.245	-0.081
MMR	-1.702	-0.400	0.343	-0.015
AMRf	-0.458	-0.095	0.172	-0.102
AMRm	-0.412	0.019	0.084	-0.071
Life expectancies				
LEBf	0.100	0.057	-0.059	0.034
LEBm	0.127	0.033	-0.054	0.033
HLEf	0.127	0.070	-0.059	0.033
HLEm	0.151	0.049	-0.059	0.030

* Health Outcomes and income are in log form.

The product of health elasticity and income related health inequality for each of the health determinants determines the share of each determinant in the overall income related health inequality. The relative share (contribution) of each of the four determinants in the overall health inequality (CI) is reported in Table 6. The last column of this table shows the proportion of "unexplained" or generalized inequality, which is due to the error term.

Table 6. Decompositions of health inequalities into contributing sources.

Health Outcome			Proportion of overall inequality (CI) due to:		
Mortality Rates	Income	Education	Income inequality	Urbanization rate	Unexplained CI
IMR	79.48%	11.95%	-2.90%	11.83%	-0.36%
CMRf	72.33%	17.52%	-2.81%	11.79%	1.17%
CMRm	78.41%	14.63%	-2.83%	10.21%	-0.42%
MMR	65.14%	25.89%	-3.54%	1.67%	10.84%
AMRf	52.10%	18.27%	-5.27%	34.14%	0.76%
AMRm	82.40%	-6.42%	-4.53%	41.79%	-13.24%
Life Expectancies					
LEBf	37.32%	35.97%	-5.93%	37.33%	-4.69%
LEBm	59.73%	24.05%	-6.27%	41.85%	-19.36%
HLEf	40.69%	37.93%	-5.09%	31.11%	-4.64%
HLEm	58.49%	32.10%	-6.16%	34.19%	-18.62%

Discussion

The estimates provided in Table 3 above clearly show that all income related health inequalities for all the six mortality rates are negative and therefore mortality is distributed in favor of the richer nations. At the same time, the CI estimates for all four life expectancies are positive, also showing that life expectancies are distributed in favor of the richer nations. The estimated CI's are all statistically highly significant (They are all significant at significance levels well below 1%).

The values of the CI estimates differ for different health outcomes. The estimates for mortality rates are numerically larger (ranging from -0.0306 for male adult mortality rate to -0.1599 for maternal mortality rate) than those for life expectancies (that only range from 0.0142 for life expectancy at birth for men to 0.0191 for health life expectancy for women). The statistical significance of these differences has been tested. The test results strongly reject the equality (similarity) of the CI's for mortality rates and those for life expectancies. Such differences are, in part, a reflection of greater variation in mortality rates compared to life expectancies as shown in Table 1 above.

Another interesting observation in Table 3 is the greater inequalities for females. All gender specific health inequalities are higher (in absolute terms) for females, which could also be due to slightly greater variation in the health outcomes for females. Here too, tests results strongly reject the equality of the CI's for females and males for all health outcomes.

The estimated effects of health determinants on various health outcomes in Table 4 show that all mortality rates are negatively related to income. That is, countries with higher income have lower mortality rates. The same is true for education, higher levels of education in a country lead to lower rates of mortality, with the exception of AMRm. Income inequality, however, has the reverse impact. Greater income inequality increases mortality rates. Urbanization, as well, appears to have a positive influence on all health outcomes. Except for a few cases (e.g. the effect of urbanization on CMRm and MMR, and the effect of education on AMRm) all the estimates effects are statistically significant. Turning to the results for the effects of health determinants on life expectancies in the bottom portion of Table 4, a complete reversal of the above relationships is observed. Here, as expected, income is positively related to life expectancies. At the same time, education and urbanization contribute positively to life expectancies. In contrast, income inequality has a negative impact on life expectancies. Overall, these regression results are plausible. Adjusted R^2 are relatively high, residuals are well behaved, and parameter estimates for key dependent variables are within very narrow ranges as required by Leamer's *extreme bound analysis* [50]. The details of the latter are available from the author. Lack of consistent data on correlates of income did not allow for the correction (e.g. by the Two-Stage Least Squares method) of potential endogeneity between health and income. A correction based on the existing exogenous variables in the model, had minor impact on the results.

The above findings are interesting and useful in their own rights. However, they were used to decompose the estimated health inequalities into their contributing sources, that is, inequalities in health determinants and health elasticities. As shown in Tables 5, the CI's for all health determinants are significant (standard errors for these CI's are given below each CI in the top row of the table). Elasticities of various health outcomes with respect to health determinants are given in the columns under each of the determinants. The CI's for income, education, and urbanization rate are positive and statistically significant. Therefore, these socioeconomic variables are concentrated in the higher income countries. The CI for income inequality is not statistically different from zero, however. The CI's for urbanization and education are larger in magnitude than those for income and income inequality. As expected, elasticities of mortality rates are negative with respect to income, education, and urbanization rate, but positive with respect to income inequality. The opposite holds for the elasticities of life expectancies. Health elasticities with respect to income are significantly larger than those for other determinants. They are also larger for mortality rates than life expectancies.

Such results translate to substantial contributions of income to overall health inequality, more so for mortality rates than life expectancies, as reported in Table 6. A quick glance at Table 6 identifies income as the major contributing factor to total (overall) inequalities. In other words, a significant proportion of health inequality is seen to be related to inequalities in the *levels* of income across the countries. This is the case for both mortality rates and life expectancies. Interestingly, the contributions of income to health inequalities are consistently greater for men than women. Education is the next major contributor to health inequalities, especially for infant, child, and maternal mortality rates. Contributions of education are greater for females than males for all measures of health. Urbanization takes over education as the second major contributor for adult mortality rates and most life expectancies.

The statistical significance of the above contributions (decompositions) is not provided as they are not straight forward to arrive at. However, they may be obtained by a bootstrapping method. The generally negative proportions of "unexplained" inequalities imply that the underlying regression models may have over-explained health inequalities. This is particularly a problem with male adult mortality rate and male life expectancies.

Conclusions

The results of this study strongly support the existence of income related health inequalities in various measures of population health across the countries worldwide. These inequalities are substantially greater for mortality rates than those for life expectancies. Moreover, the health inequalities are consistently greater for females than males. The results of the health regressions show income, education, income inequality, and urbanization as significant determinants of population health. Decompositions of health inequalities into (income related) inequalities in the determinants of health and health elasticities show that inequalities in urbanization and education exceed those of income and income inequality. Nevertheless, health elasticities with respect to income are significantly greater than those for other determinants. Consequently, income appears as the major contributor to the overall income related health inequalities, followed by education and urbanization.

These findings show that the health of populations in many poor and low income countries are still far below those with higher incomes, and that the *health divide* is still there despite efforts by the WHO and other international organizations in recent years. These inequalities are potentially preventable and considered as inequitable. Narrowing the global health divide as recognized in the United Nations' *Millennium Development Goals*, calls for national and international policies to raise incomes, expand education, and improve living environments in the poor and low income countries. Such policies (e.g. writing-off foreign debts, fair trade agreements, and long term investments in poor countries' human and physical infrastructures, to name a few) are more relevant today in the wake of recent globalization that is widening the socioeconomic gaps across the world.

1. **References**

2. Mackenbach JP. Health inequalities: Europe in Profile. London: UK Presidency of EU; 2005.
3. World Health Organization. Declaration of Alma-Ata. In: International Conference on Primary Health Care: 6-12 September 1978. Alma-Ata, USSR [cited 2006 May 10]. Available from:
4. http://www.who.int/hpr/NPH/docs/declaration_almaata.pdf
5. Black D. Inequalities in Health, The Black Report. London: DHSS;1980.
6. Navarro V, Muntaner C, editors. Political and Economic Determinants of Population Health and Well-Being. Amityville, New York: Baywood Publishing Company Inc.; 2004.
7. Raphael D, editor. Social Determinants of Health – Canadian Perspectives. Toronto: Canadian Scholars' Press Inc.; 2004.
8. World Health Organization. Health for all targets. The health policy for Europe, September 1991. Copenhagen: WHO;1993.
9. World Health Assembly. Fifty-first World Health Assembly. Health-for-all policy for the twenty-first century, 1998 [cited 2006 may 10]. Available from: http://www.who.int/archives/hfa/ear7.pdf

10. Health 21. The health for all policy framework for the WHO European Region. Copenhagen: World Health Organization; 1999.
11. WHO Commission on Social Determinant of Health. Social determinants of health: measuring progress & evaluating evidence: 21-24 March 2005; Santiago, Chile.
12. Irwin A, Valentine N, Brown C, Loewenson R, Solar O, Brown H, et al. The Commission on Social Determinants of Health: Tackling the Social Roots of Health Inequities. PLoS Medicine 2006; 3(6):0749-0751. e106. doi: 10.1371/journal.pmed.0030106. Available from: www.plosmedicine.org
13. National Commission on Social Determinants of Health. PAHO/WHO, Brazil, March 15, 2006. Available from: http://www.determinants.fiocruz.br/programa.htm
14. Acheson D, editor. Independent Inquiry into Inequalities in Health Report. London: The Stationary Office; 1998.
15. Mackenbach JP, Bakker M, editors. Reducing Inequalities in Health. A European Perspective. London & New York: Routledge; 2002.
16. Mackenbach JP, Stronks K. The development of a strategy for tackling health inequalities in the Netherlands. Int J Equity Health. 2004 [cited 2006 May 10]; 3(11). Available from: http://www.equityhealthj.com/content/3/1/11
17. Judge K, Platt S, Costongs C, Jurczak K. Health Inequalities: a Challenge for Europe. London: The UK Presidency of EU; 2005.
18. Crombie I, Irvine L, Elliot L, Wallace H. Closing the Health Inequalities Gap: an international Perspective. WHO Regional Office for Europe; 2005.
19. Forbes A, Wainwright SP. On the methodological, theoretical and philosophical context of health inequalities research: a critique. Soc Sci Med. 2001; 53:801-16.
20. Preston SH. The changing relation between mortality and level of development. Popul Stud. 1975; 29(2):231-48.
21. Rodgers GB. Income and inequality as determinants of mortality: An international cross-section analysis. Popul Stud. 1979; 32(2):343-51.
22. Townsend P, Davidson N, Whitehead M, editors. Inequalities in health: The Black report and the health divide. New York: Penguin; 1992.
23. Marmot M, Kogevinas M, Elstom MA. Social/economic status and disease. Annu Rev Public Health. 1987; 8:111-35.
24. Feinstein JS. The relationship between socioeconomic status and health: a review of the literature. Milbank Q. 1993; 71:279-322.
25. van Doorslaer E, Koolman X. Explaining the differences in income-related health inequalities across European countries. Health Econ. 2004; 13:609-28.
26. Lynch JW, Kaplan GA, Cohen RD, Tuomilehto J, Salonen JT. Do cardiovascular risk factors explain the relation between socioeconomic status, risk of all-cause mortality, cardiovascular mortality, and acute myocardial infraction? Am J Epidemiol. 1996; 144: 934-42.
27. Marmot M, Wilkinson R, editors. Social determinants of health. Oxford: Oxford University Press; 1999.
28. Wildman J. Income related inequalities in mental health in Great Britain: analyzing the causes of health inequality over time. J Health Econ. 2003; 22: 295-312.
29. 27. Frijters P, Haisken-DeNew JP, Shields MA. The causal effect of income on health: Evidence from German reunification. J Health Econ. 2005; 24:997-1017.
30. Ram R. Income inequality, poverty, and population health: Evidence from recent data for the United States. Soc Sci Med. 2005; 61:2568-76.
31. Ram R. Further examination of the cross-country association between income inequality and population health. So Sci Med. 2006; 62:779-91.
32. van Doorslaer E, Wagstaff A, Bleichrodt H, Calonge S, Gerdtham UG, Gerfin M, et al. Income related inequalities in health: Some international comparisons. J Health Econ. 1997; 16:93-112.
33. Kakwani N, Wagstaff A, van Doorslaer E. Socio-economic inequalities in health: Measurement, computation, and statistical inference. J Econom. 1997; 77:87-103.
34. Wagstaff A. Socioeconomic inequalities in child mortality: comparisons across nine developing countries. Bull World Health Organ. 2000; 78(1):19-29.
35. van Doorslaer E, Jones AM. Inequalities in self-reported health: validation of a new approach to measurement. J Health Econ. 2003; 22:61-87.
36. Houweling TAJ, Kunst AE, Mackenbach JP. measuring health inequality among children in developing countries: does the choice of the indicator of economic status matter? Int J Equity Health. 2003 [cited 2006 Apr 20]; 2:8. Available from: http://www.equityhealyhj.com/content/2/1/8
37. Yngwe MA, Fritzell J, Burström B, Lundberg O. Comparison or Consumption? Distinguishing between different effects of income on health in Nordic welfare states. Soc Sci Med. 2005; 61:627-35.

38. Durate EC, Schneider MC, Paes-Sousa R, Ramalho WM, Sardinha LMV, Da Silva Jr. JB, et al. Epidemiologia das desigualdades em saude no Brasil – um estudo exploratorio. PAHO, Brazil, 2002. Available from: http://portal.saude.gov.br/portal/arquivos/pdf/epi_desigualdades.pdf
39. Alleyne GAO, Castillo-Salgado C, Schneider MC, Loyola E, Vidaurre M. Overview of social inequalities in health in the Region of the Americas, using various methodological approaches. PAJPH 2002; 12(6):388-397.
40. Schneider MC, Castillo-Salgado C, Bacallao J, Loyola E, Mujica OJ, Vidaurre M, et al. Methods for measuring inequalities in health. PAJPH 2002; 12(6):398-414.
41. Pradhan M, Sahn DE, Younger SD. Decomposing world health inequality. J Health Econ. 2003; 22:271-93.
42. Wagstaff A, Paci P, van Doorslaer E. On the measurement of inequalities in health. Soc Sci Med. 1991; 33:545-57.
43. Bleichrodt H, van Doorslaer E. A welfare economics foundation for health inequality measurements. J Health Econ. 2006 [cited 2006 May 15]; Available from:
44. http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B6V8K-4J72YPD-1-1G&_cdi=5873&_user=1067466&_orig=browse&_coverDate=02%2F08%2F2006&_sk=999999999&view=c&wchp=dGLbVzb-zSkzV&md5=c47b299923ce3c13aabf8cbe6d28a6bc&ie=/sdarticle.pdf
45. 42.Üstün TB, Chatterji S, Villanueva M, Bendib L, Celik C, Sadana R, *et al.* The WHO Multicountry Household Survey Study on Health and Responsiveness 2000–2001. In: Murray CJL, Evans D, editors. Health systems performance assessment: debates, methods and empiricism. Geneva: World Health Organization 2003.
46. Wagstaff A, van Doorslaer E, Watanabe N. On decomposing the causes of health sector inequalities with an application to malnutrition inequalities in Vietnam. J Econom. 2003; 112:207-23.
47. WHO. The World Health Report 2005 – Statistical Annex. [cited 2006 Feb 10]. Available from: http://www.who.int/whr/2002/annex/en/
48. Matters, C D. Healthy life expectancy in 191 countries, 1999. Lancet, 2001, 357: 1685-91.
49. United Nations. Human Development Report 2005 – Human Development Indicators. [cited 2006 Feb 10]. Available from: http://hdr.undp.org/reports/global/2005/indicator/index.html
50. United Nations. Human Development Report 2005 – Human Development Indicators. Technical Note 1 [cited 2006 Feb 15]. Available from: http://hdr.undp.org/reports/global/2003/pdf/hdr03_backmatter_2.pdf
51. 48. Flegg AT: Inequality of income, illiteracy and medical care as determinants of infant mortality in underdeveloped countries. Pop Stud (Camb).1982; 36(3):441-58.
52. Waldman RJ: Income distribution and infant mortality. Q J Econ.1992; 107(4):1283-1302.
53. Leamer E. Specification Searches: Ad Hoc Inference with Nonexperimental Data. New York: John Wiley & Sons; 1978.

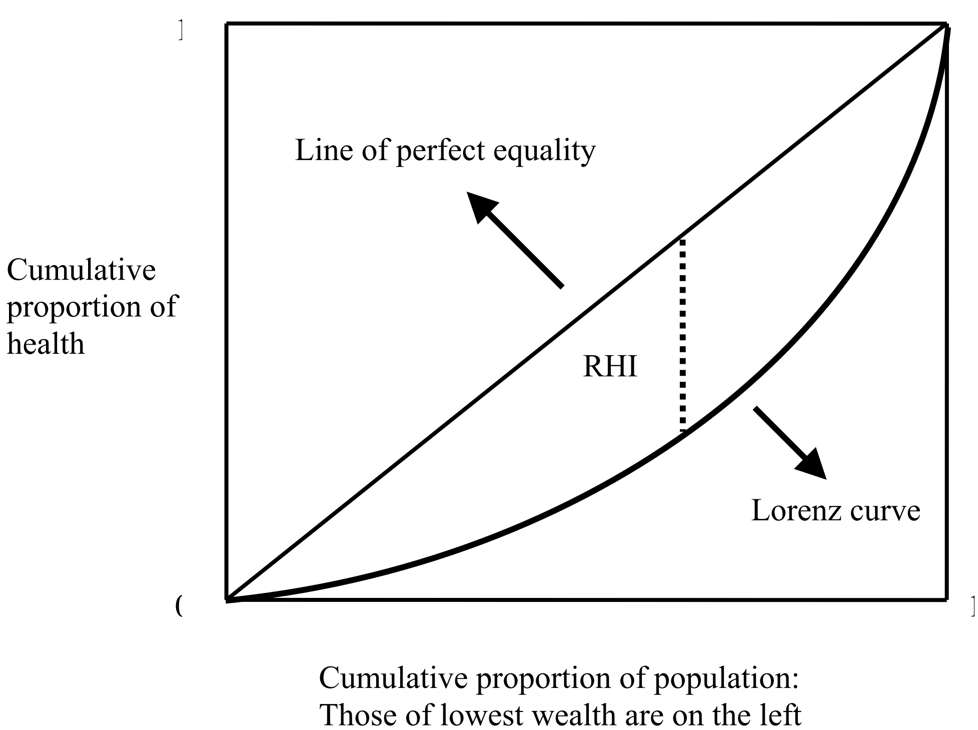
Understanding Measures of Health Inequality And the Concentration Index

Health inequalities have been measured using a variety of indices. Three of such indices are defined with reference to the so called Lorenz curve. The Lorenz curve was originally developed to measure inequalities or concentrations in the distribution of wealth and income[1]. It plotted the cumulative proportional wealth (income) against the cumulative proportion of households in a given population, where households were ranked from the lowest to the highest wealth (income). It has been adapted to measure inequality in other dimensions such as health. The three measures of health inequality that are related to the Lorenz curve are the Gini index (GI), the Robin Hood Index (RHI), and the Concentration Index (CI). The following figure depicts a Lorenz curve and shows how each of theses three indices are defined.

The Gini Index (GI), after the Italian Statistician Corrado Gini[2], is defined as twice the area surrounded by the Lorenz Curve and the diagonal (the line of perfect equality). It takes a value between zero (perfect equality) and one (perfect inequality). The GI has been extensively used in studies of income distribution.

The Robin Hood Index (RHI), also known as Pietra ratio, is defined as the maximum distance between the Lorenz Curve and the diagonal.[3] It is roughly the proportion of health that needs to be redistributed from the healthier half of the population to the less healthy half. It is shown by a broken vertical line on the graph. RHI can also take a value between zero and one with similar implications as the GI.

Figure 1. The Lorenz curve



Both GI and RHI measure what is called total inequality in health[4]. The Concentration Index (CI), however, measures inequality in health which is related to some socioeconomic conditions. As such, it is considered to be measuring *preventable* health inequality, once data are adjusted (standardized) for demographic factors. It is measured similar to the GI, except that the cumulative proportion of population (on the horizontal axis) is ordered according to the socioeconomic position of populations, starting with the lowest socioeconomic position (like income).

The CI is one of the only two measures of health inequality that has been shown to meet the three basic requirements of an index of inequality in health, namely i) being reflective of the socioeconomic dimension to inequalities in health; ii) being reflective of the experiences of the entire population; and iii) being sensitive to the changes in the distribution of population across socioeconomic groups[5].The other measure satisfying those requirements is the Relative Index of Inequality (RII). However, unlike RII, CI has a visual appeal. CI is quite versatile since it allows for the measurement of socioeconomic position along different dimensions such as education, income, wealth, consumption, employment and so on.

The CI takes a value between -1 and +1. Negative values for CI are obtained when the Lorenz (concentration) curve lies above the diagonal. This happens when *ill health* (e.g. mortality) is concentrated in lower socioeconomic individuals or groups. Positive values of CI are obtained when the Lorenz (concentration) curve lies below the diagonal. This is the case when *health* (e.g. life expectancy) is concentrated in people with higher socioeconomic ranking. CI takes a value of zero when the concentration curve and the diagonal coincide, where there is no inequality.

CI can be measured in different ways. For weighted data, the following formulation has been provided by van Doorslaer and Jones[5]:

$$CI = \frac{2}{\mu} \sum_{i=1}^{N} w_i y_i R_i - 1,$$

where $\mu = \sum_{i=1}^{N} w_i y_i$,

$$R_i = \frac{1}{N} \sum_{j=1}^{i-1} w_j + \frac{1}{2} w_i,$$

and $w_0 = 0$

In the above formulations, y_i is a measure of health or ill health, w_i is the (sampling) weight of individual i, N is the size of the sample or population (depending on the nature of data), μ is the weighted mean, and R_i is the (weighted) relative fractional rank of the *i*th individual. ($w_0 = 0$)

The following example shows the calculation of CI based on the above formulation. To keep it very simple, let's assume there are only 7 countries with different average incomes, infant mortality rates per 1000 live births (y_i), and population sizes (used as weights) as given in Table 1.

Table 1. Hypothetical country data and calculations for CI

Country *i* Income	w_i	y_i	R_i	$w_i y_i R_i$
$1000	491	103	0.041	2073.5
$2500	501	72	0.084	3030.0
$3500	1568	38	0.306	18232.7
$5500	1469	35	0.569	29255.1
$8250	779	25	0.761	14820.5
$12500	258	10	0.850	2193.0
$25000	801	4	0.941	3014.9
	$N=\sum w_i = 5867$	$\mu = \sum w_i y_i = 222903$		$\sum w_i y_i R_i = 72619.7$

Using the results in Table 1, the CI can now be easily calculated as:

CI = (2/222903)(72619.7) -1 = - 0.348

This value of CI indicates a considerable degree of ill health (infant mortality rate) inequality as related to income. In other words, the low income countries have higher infant mortality rates than higher income countries.

In the above explanatory example, CI was obtained by direct calculation. The CI's for various measures of health (ill health) in the paper, however, are obtained from regression formulations discussed in the paper. Also, they are based on log values of health outcomes, rather than the original values as in the above example. As estimates they are accompanied by a measure of statistical significance, the "t" ratio (See Table 3 in the paper). This is the ratio of the estimated CI to its standard error. A "t" value of 2 or greater indicates statistical significance in this case. The adjusted R^2s in the last column of that table indicate the "goodness of fit" for regression equations. A perfect fit would give an R^2 of 1.

References

1. Lorenz, M. O. (1905). Methods of Measuring the Concentration of Wealth. Publications of the American Statistical Association. 9:209-219.
2. Gini C. Variabilita e mutabilita. (1912). Reprinted in *Memorie di metodologia statistica,* (Ed.), Pizetti E, Salvemini T. Rome: Libreria Eredi Virgilio Veschi, 1955.
3. Kondor Y. An old-new measure of inequality. (1971). *Econometrica*, 39:1041-1042.
4. van Doorslaer E., Jones, A. M. (2003). Inequalities in self-rated health: validation of a new approach to measurement. *Journal of Health Economics*, 22:61-87.
5. Wagstaff A., Paci P., van Doorslaer E. (1991). On the measurement of inequalities in health. Social Science & Medicine, 33:545-557.