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Measuring health inequality among children in developing countries: does the choice of the indicator of economic status matter?

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Abstract

Background: Currently, poor-rich inequalities in health in developing countries receive a lot of attention from both researchers and policy makers. Since measuring economic status in developing countries is often problematic, different indicators of wealth are used in different studies. Until now, there is a lack of evidence on the extent to which the use of different measures of economic status affects the observed magnitude of health inequalities.

Methods: This paper provides this empirical evidence for 10 developing countries, using the Demographic and Health Surveys data-set. We compared the World Bank asset index to three alternative wealth indices, all based on household assets. Under-5 mortality and measles immunisation coverage were the health outcomes studied. Poor-rich inequalities in under-5 mortality and measles immunisation coverage were measured using the Relative Index of Inequality.

Results: Comparing the World Bank index to the alternative indices, we found that (1) the relative position of households in the national wealth hierarchy varied to an important extent with the asset index used, (2) observed poor-rich inequalities in under-5 mortality and immunisation coverage often changed, in some cases to an important extent, and that (3) the size and direction of this change varied per country, index, and health indicator.

Conclusion: Researchers and policy makers should be aware that the choice of the measure of economic status influences the observed magnitude of health inequalities, and that differences in health inequalities between countries or time periods, may be an artefact of different wealth measures used.

Background

Reducing poor-rich disparities in the health and survival of children within developing countries has recently become a main target of national governments and international organisations [1,2]. A prerequisite for achieving this goal is to establish how large these differences are. To measure the magnitude of inequality in child survival, household level data on child mortality and economic status are needed.

Measuring household economic status in developing countries poses considerable problems. Data on two

frequently used indicators of wealth, household income and expenditure levels, are often unavailable or unreliable [3]. Moreover, in countries where a large part of the population works in self-subsistence agriculture or the informal sector, expressing income or expenditure levels in monetary values can be extremely time-consuming and suffers important reliability problems.

In developing countries, the assets that households have acquired are a good indicator of their 'long-run' economic status [4,5]. The World Bank has developed a tool to measure the relative economic position of households using data on durable consumer goods, housing quality, water and sanitary facilities and other amenities [6]. These assets are combined into an index of economic status using Principal Component Analysis (PCA). The PCA method has been shown to provide a measure of economic status that has a higher predictive value, at least with regard to fertility, then other proxies such as an index based on the value of goods owned, or occupation [5]. Using such an asset index, overviews of health indicators by population wealth quintile were made by The Bank for countries included in the Demographic and Health Surveys program (DHS) [6]. These reports have become an important source of information on poor-rich inequalities in child health in low- and middle-income countries.

While many other studies on health inequalities also use household asset ownership as an indicator of economic status [7], different researchers use different, often shorter, sets of asset items *c.f.* [8–14] Unfortunately there is no information yet on the extent to which the use of alternative lists of asset items leads to different outcomes [15]. For monitoring and intervention purposes, and for comparative and explanatory analysis it is important to know how large poor-rich inequalities are, and consequently, how sensitive the magnitude of poor-rich inequalities is to the asset index used. Our study aimed to assess, for a broad set of countries, the extent to which the magnitude of health inequalities is sensitive to the choice of the asset items included in the index.

Two issues related to the selection of specific indicators will be addressed. First, some variables used in the World Bank (WB) asset index have, apart from being an indicator of economic status, a direct impact on child health and survival. In explanatory research it can be important to make a conceptual distinction between factors that work *directly* on health, such as the exposure to infections, for instance through unhygienic sanitary facilities, and more distant determinants that only work *indirectly*, such as household wealth [16]. Whereas the definition of 'direct' and 'indirect' depends on the specific health outcome studied, in an explanatory analysis one would generally prefer an asset index without direct determinants. We expect poor-rich differences in child survival to be smaller when direct determinants of survival, such as water and sanitation facilities, are excluded from the measure of economic status. The magnitude of change, however, is unknown. Therefore, it is important to assess this sensitivity.

The second issue is related to the fact that some of the variables included in the WB index are publicly provided or are dependent on the availability of infrastructure on community level, while the purpose of the index is to measure household – and not community-wealth. While we acknowledge the importance of community resources for child survival, it can be similarly important to be able to separate community from household effects. Electricity is the most obvious variable usually provided on a community basis, but the same can be true for water and sanitation facilities. We expect health inequalities to be smaller when community level indicators of wealth are not included in the asset index. Again, since at present we don't know the extent to which outcomes would change, it is important to assess this sensitivity.

On basis of the above considerations, we decided to construct three alternative indices to the WB index. In the first two alternative indices, important direct determinants of child survival (water supply/sanitation and housing standards respectively) are excluded. The third version also excludes electricity, an item that is strongly determined by supply factors at community level.

In this study we aimed to assess the extent to which the magnitude of inequality in health indicators is sensitive to the use of these three alternative measures of economic status. We analysed inequality with regard to under-5 mortality, which is an important indicator of child health in developing countries. We also analysed inequality with regard to measles immunisation coverage, since not only health but also health care utilisation is an important outcome variable in inequality research and policy making. As water, sanitation and housing operate differently on health and health care utilisation, it is important to check sensitivity for both types of outcomes.

Methods

Data

The DHS program provides household-level data on health, health care utilisation and ownership of assets for about 60 low- and middle-income countries in three subsequent periods. The data are based on nationally representative surveys. In most countries, between 5,000 and 10,000 women aged 15 to 49 years were interviewed. From the Macro International web-site we obtained the most recent data (surveys held between 1991–1998) for 10 countries [17]. Bolivia, Brazil, Indonesia, Cameroon,

Chad, Kenya, Malawi, Pakistan, Tanzania, and Uganda were included in the study. These countries represented a broad range of contexts in terms of region and under-5 mortality rates. They were also representative of a wider range of countries in terms of the magnitude of mortality inequalities and the pattern of under-5 mortality rates across the quintiles (with both linear and non-linear patterns included) [6]. Furthermore, we chose countries with a relatively large sample size.

Methods

When constructing an index, one of the basic decisions concerns the weights that should be given to each of the index-items. "Equal weights have the appeal of simplicity and apparent objectivity, but these qualities only mask the fact that the imposition of numeric equality is completely arbitrary" [4]. The Bank used factor scores derived through Principal Components Analysis (PCA) as the weights of the items in its asset index. Factor scores are a measure of the strength of the association of an item with the first principal component. It is assumed that this first factor represents economic status. Sample weights were not used during the PCA operation, but were used when constructing population wealth quintiles. Using this method, The Bank made for each country a separate index. In our study, we adhered to this often-used method of PCA for constructing indices.

Before we compared the World Bank (WB) index with the alternative indices, we attempted to replicate the WB index by applying PCA, using SPSS 9.0, to the same items as The Bank used. A fairly close replication of the World Bank results as reported by Gwatkin et al. [6] could be achieved. Subsequently, a series of three alternative indices was constructed by leaving out the following items: 1) all water supply and sanitation items; 2) items under 1 plus all housing items; 3) items under 1 and 2 plus electricity. In alternative Index 3 for most countries only durable consumer goods were included. The alternative indices were constructed applying the same PCA method to the shorter list of items.

The indices were compared in the following respects. First, we calculated the percentage of variance in the asset items that could be explained by the first principal component. This indicates the extent to which the variation in asset items between households can be explained by one single measure of economic status. The second feature we examined was whether it was possible to stratify the population into five, about equally large, wealth groups. Quintiles are commonly used in social epidemiology and health economics to compare health outcomes of wealth groups. It allows for a precise description of the association between wealth and health along the whole wealth gradient.

Then, we studied the changes in the categorisation of households when using the alternative indices compared to when using the WB index. Using cross tabulations we calculated the percentage of households remaining in the same quintile, the percentage that moved to the adjoining two quintiles and the percentage that moved to the furthest two quintiles.

Finally, the alternative indices were compared to the WB index in terms of their association with under-5 mortality. We calculated the under-5 mortality rates for the five wealth groups for each of the indices. Under-5 mortality was defined as the proportion of deaths under age 59 months per 1,000 live births of those born during the last 10 years preceding the survey. To have an overall measure of the magnitude of inequality across all wealth groups, we computed the Relative Index of Inequality (RII) for each of the asset indices. We compared the RII's of the alternative indices with the RII of the WB index. The RII was calculated with logistic regression using a Generalised Estimating Equations (GEE) model (using SAS 8.2) to correct for the fact that some mothers contribute more than one child to the set of observations, and that the children born to one mother are not statistically independent. The RII is a summary measure of the differences in mortality experience between *all* five wealth groups, and can be interpreted as the (estimated) ratio in odds between the poorest and the richest household. This estimate captures only the linear relationship between wealth and health [18].

We performed analogous analyses for coverage rates in measles immunisation. For pragmatic reasons we used the rate of children *not* immunised against measles as outcome measure. The use of this negatively stated measure facilitates comparison with under-5 mortality, also a negatively stated indicator. The rate of children not immunised against measles, here called "immunisation coverage" in short, is defined as the rate of children aged 12–23 months during the survey who were not immunised against measles. We calculated and compared this rate for all five wealth groups using each of the asset indices. We also calculated and compared the RII.

When examining sensitivity, a problem arises if the sizes of the wealth groups differ between the indices. The comparison between indices of group-specific rates is only possible when the groups that are compared are of the same size. If the group size is different, the change in rate could be an artefact, and conclusions can be stated with less certainty. When comparing the RII's between the indices, different group sizes are generally not a problem as this measure takes into account the size and relative position of the wealth groups.

Table 1: Asset items included in the indices (Indonesia)

	WB index	Index 1	Index 2	Index 3
electricity	X	X	X	
radio or tape recorder	X	X	X	X
television	X	X	X	X
refrigerator	X	X	X	X
bicycle	X	X	X	X
motorcycle or motorboat	X	X	X	X
car	X	X	X	X
gas stove	X	X	X	X
kerosene stove	X	X	X	X
electric stove	X	X	X	X
public toilet	X			
private toilet	X			
bush, field as latrine	X			
other latrine	X			
drinking water piped in residence	X			
drinking water piped into yard	X			
drinking river, canal, surface water	X			
drinking from public faucet (piped)	X			
drinking from well with pump	X			
drinking rainwater	X			
other drinking water	X			
drinking from protected well	X			
drinking from unprotected well	X			
dirt, sand, dung floor	X	X		
wood, plank floor	X	X		
ceramic, marble floor	X	X		
brick floor	X	X		
bamboo floor	X	X		
cement, ceramic tile floor	X	X		
other floor	X	X		
tile roof	X	X		
concrete roof	X	X		
asbestos or zinc roof	X	X		
wooden roof	X	X		
leaves roof	X	X		
other roof	X	X		
wall of bamboo or wood planks	X	X		
other wall	X	X		
bamboo wall	X	X		
clay brick wall	X	X		

X shows the items that were included in the respective asset indices

Results

Table 1 shows the asset items that were included in the four indices for Indonesia. Similar lists of assets were used for the other countries.

The proportion of variance between households in the ownership of assets that is explained by the WB index is quite low (between 12 and 20%). The percentage of explained variance increased upon exclusion of items from the index to an average of 35% in the third, shortest, alternative index including only consumer goods (Table 2).

Using the WB index and Index 1 it was possible to distinguish five, equally sized, wealth groups for all countries (Table 3). When using Index 2 and 3, consisting of much shorter lists of items, this was not always possible. In these cases, some wealth groups became very large, while others small or even empty. An extreme example is Chad, where, when using Index 2 and 3 it became impossible to distinguish between the poorest 59% of the population. The reason is that none of the households in this group owned durable consumer goods or electricity, the only items included in Index 2 and 3. Only for Indonesia and Uganda it was possible to make a refined stratification when using all the indices. For Uganda this was depend-

Table 2: Percentage of variance explained by the first factor

Country	WB index	Index 1	Index 2	Index 3
Bolivia	17	20	43	43
Brazil	13	15	40	43
Cameroon	20	29	38	36
Chad	19	30	39	38
Indonesia	14	17	31	32
Kenya	17	23	37	37
Malawi	18	24	25	27
Pakistan	20	27	38	40
Tanzania	16	24	36	36
Uganda	12	19	25	23

Table 3: Percentage of household members in each wealth group

		Wealth Group				
Country	Wealth Index	Poorest	Second	Middle	Fourth	Richest
Bolivia	WB Index	20	20	20	20	20
	Index 1	20	20	20	20	20
	Index 2	27	11	25	17	21
	Index 3	10	26	26	18	21
Brazil	WB Index	20	20	20	20	20
	Index 1	20	20	20	21	19
	Index 2	20	20	31	1	29
	Index 3	20	20	31	1	29
Cameroon	WB Index	20	20	20	20	20
	Index 1	20	21	19	20	20
	Index 2	34	8	18	19	21
	Index 3	6	31	31	12	20
Chad	WB Index	21	19	20	20	20
	Index 1	22	19	19	20	20
	Index 2	a	59	a	27	15
	Index 3	a	59	a	27	14
Indonesia	WB Index	20	20	20	20	20
	Index 1	20	20	20	20	20
	Index 2	20	19	22	19	20
	Index 3	20	20	21	20	20
Kenya	WB Index	20	20	20	20	20
	Index 1	20	20	20	20	20
	Index 2	28	4	31	18	19
	Index 3	28	5	33	18	16
Malawi	WB Index	19	21	20	20	20
	Index 1	20	22	18	20	20
	Index 2	11	42	9	18	20
	Index 3	11	42	2	26	19
Pakistan	WB Index	20	20	20	20	20
	Index 1	20	20	20	20	20
	Index 2	23	24	11	22	20
	Index 3	37	a	23	21	20

Table 3: Percentage of household members in each wealth group *(Continued)*

Tanzania	WB Index	20	20	20	20	20
	Index 1	20	20	21	20	20
	Index 2	40	a	15	16	29
	Index 3	40	a	16	19	25
Uganda	WB Index	20	20	20	20	20
	Index 1	20	20	20	20	20
	Index 2	18	21	23	19	20
	Index 3	18	21	21	20	20

Notes: due to rounding off, the rows may not add up to 100%; a due to clustering of households into large groups, no households are categorised in this wealth category.

Table 4: Change of households to other wealth groups when using alternative indices as compared to WB Index

Country	Wealth Index	% in same wealth group	% moving 1 wealth group	% moving 2 or more wealth groups
Indonesia	Index 1	73	27	0
	Index 2	53	38	9
	Index 3	50	37	13
Uganda	Index 1	72	24	3
	Index 2	56	35	9
	Index 3	54	36	10

Note: due to rounding off, the rows may not add up to 100%

ent on the inclusion of one specific item in the index, i.e. food sufficiency. Upon exclusion of this item from the indices, heaping of the poorest 40% occurred when using Index 2 and 3.

The categorisation of the households into wealth groups was sensitive to the measure of economic status used (Table 4). The results are only shown for Indonesia and Uganda, the countries for which a refined stratification could be made using all the indices. For these two countries, on average 27% of the households was categorised into a different quintile when using Index 1. Largest changes were observed when using Index 2 and 3, where on average about 47% of the households had shifted to another quintile. Most of these households moved to an adjoining quintile, while on average 10% of all households moved to a further quintile. When considering all ten countries, at least 18% of the households was categorised into a different quintile when using Index 1 (results not shown).

Similar results were obtained when excluding those cases for which the change in RII could be an artefact. This is the case for some countries when using Indices 2 and 3, due to (a) the lack of a fine stratification of the population over five groups of equal size in combination with (b) a non-linear character of the association between mortality and the relative wealth measure. These cases are indicated in Tables 5 and 6 within parenthesis.

For almost all countries, the magnitude of inequality in mortality was sensitive to the use of at least one of the alternative indices (Table 5). For four of the ten countries, we observed a minor (10–30%) change in RII, while for five other countries the change was substantial (>30%). While for five countries inequality decreased when using alternative indices, for some (2) countries inequality increased compared to the WB index, and for others (2) there was a mixed pattern of an increase in inequality when using some alternative indices, and a decrease in inequality when using others.

The magnitude of inequality in immunisation coverage changed for all countries when using alternative wealth measures (Table 6). For five of the ten countries there was a minor (10–30%) change in RII, while for the remaining countries the RII was substantially (>30%) sensitive. Inequality decreased for five of the countries, when using an alternative index. For one country there was an increase, and for four countries a mixed pattern of increase when using some indices, and a decrease when using others. When excluding the countries where the RII estimates for Indices 2 and 3 may be biased due to reasons mentioned above, the conclusions remained roughly the same.

Table 5: Under-5 mortality rates per wealth group and Relative Index of Inequality (RII)

		Under-5 mortality rates (per 1,000 live births)						95% CI for RII	
Country	Wealth Index	Poorest	Second	Middle	Fourth	Richest	RII	low	up
Bolivia	WB Index	135.1	106.0	93.4	39.8	32.2	6.30	4.76	8.34
	Index 1	134.6	103.0	96.0	45.0	28.8	6.04	4.58	7.97
	Index 2	130.1	99.3	94.2	44.1	32.7	5.89	4.43	7.83
	Index 3	126.2	120.7	92.4	46.4	32.7	5.29 +	4.02	6.96
Brazil	WB Index	89.4	52.5	36.2	26.1	29.3	6.41	4.02	10.22
	Index 1	88.3	49.4	36.6	27.2	33.0	5.55 +	3.51	8.78
	Index 2	89.8	47.7	38.7	a	27.0	[5.60 +]	3.66	8.58
	Index 3	90.6	47.5	38.7	a	26.8	[5.71 +]	3.73	8.74
Cameroon	WB Index	160.0	145.0	120.3	102.5	75.0	2.84	2.08	3.87
	Index 1	174.9	144.4	113.1	95.4	72.4	3.34 +	2.41	4.61
	Index 2	146.9	168.0	115.4	99.7	74.4	2.77	2.03	3.78
	Index 3	a	140.2	130.6	78.3	75.8	2.78	2.02	3.82
Chad	WB Index	151.8	207.2	175.2	165.0	155.0	1.08	0.91	1.28
	Index 1	146.8	186.4	232.5	154.4	153.7	1.00 ++	0.85	1.18
	Index 2	b	184.6	b	157.3	133.9	[1.71 ++]	1.40	2.10
	Index 3	b	184.2	b	157.4	132.4	[1.70 ++]	1.39	2.09
Indonesia	WB Index	97.9	67.1	58.0	44.2	25.6	4.65	3.55	6.09
	Index 1	94.4	67.5	59.6	42.6	32.2	3.89 +	2.95	5.14
	Index 2	89.7	75.3	62.8	37.1	31.5	3.90 +	3.03	5.03
	Index 3	81.2	82.1	65.6	39.4	31.9	3.34 ++	2.61	4.28
Kenya	WB Index	128.0	120.9	79.3	72.9	54.6	3.29	2.43	4.46
	Index 1	126.3	120.0	76.3	86.8	52.6	3.10	2.29	4.21
	Index 2	112.0	141.6	87.8	106.6	52.3	[2.11 ++]	1.57	2.82
	Index 3	112.3	141.1	84.8	104.9	53.1	[2.00 ++]	1.50	2.68
Malawi	WB Index	220.0	203.4	225.5	214.6	159.2	1.31	1.04	1.64
	Index 1	193.4	228.9	233.4	216.5	157.3	1.17 ++	0.95	1.45
	Index 2	259.2	211.5	183.9	211.1	172.0	[1.49 ++]	1.16	1.90
	Index 3	257.5	211.2	a	167.0	176.1	[1.50 ++]	1.17	1.91
Pakistan	WB Index	116.2	133.8	120.7	110.5	68.7	1.80	1.37	2.37
	Index 1	119.2	122.4	134.9	117.9	64.9	1.59 +	1.22	2.08
	Index 2	126.6	117.9	134.8	113.8	69.2	[1.83]	1.39	2.42
	Index 3	118.3	b	133.3	99.3	71.7	[1.61 +]	1.22	2.13
Tanzania	WB Index	124.2	162.1	125.7	136.2	85.5	1.48	1.20	1.83
	Index 1	121.4	157.9	151.3	121.1	86.0	1.49	1.21	1.82
	Index 2	149.6	b	133.5	115.4	102.5	[1.91 ++]	1.51	2.41
	Index 3	b	149.3	132.3	105.7	106.9	[1.82 ++]	1.44	2.30
Uganda	WB Index	162.7	132.8	136.0	134.6	95.7	1.72	1.38	2.15
	Index 1	157.4	145.3	133.6	129.3	98.5	1.76	1.41	2.19
	Index 2	157.6	144.3	136.3	126.9	99.9	1.77	1.42	2.21
	Index 3	157.6	144.2	135.2	130.3	98.9	1.76	1.41	2.20

Notes: [] RII's in parentheses indicate that results may be an artefact due to combination of population heaping and a non-linear association of under-5 mortality with wealth; **a** rates are not shown due to small sample size (smaller then 500), referring to the denominator, i.e. live births during the last 10 years preceding the survey; **b** empty cell due to heaping (see Table 2); **+** 10–30% change in RII compared to the WB index; **++** >30% change in RII compared to WB index

Table 6: Measles immunisation rates per wealth group and Relative Index of Inequality (RII)

		% children aged 12–23 months not immunised against measles						95% CI for RII	
Country	Wealth Index	Poorest	Second	Middle	Fourth	Richest	RII	low	up
Bolivia	WB Index	59.5	59.2	54.3	47.3	33.6	3.15	2.02	4.93
	Index 1	58.6	62.6	51.0	48.0	33.3	3.30	2.10	5.18
	Index 2	59.9	60.9	53.9	43.9	35.4	3.43+	2.18	5.41
	Index 3	60.5	59.8	54.5	44.0	35.4	3.46+	2.18	5.48
Brazil	WB Index	26.7	15.0	7.7	8.4	10.2	7.14	2.76	18.46
	Index 1	26.4	14.4	7.5	10.9	8.4	6.55	2.65	16.17
	Index 2	26.3	14.5	8.8	a	9.0	[5.87 +]	2.51	13.74
	Index 3	26.2	14.3	8.8	a	9.0	[5.98+]	2.54	14.06
Cameroon	WB Index	58.0	59.7	56.5	39.2	23.5	7.02	3.81	12.94
	Index 1	60.5	62.8	53.1	33.1	27.0	8.71 +	4.51	16.82
	Index 2	60.5	61.8	49.6	40.1	27.4	[6.92]	3.72	12.86
	Index 3	a	62.0	48.9	44.3	27.3	[5.35+]	2.89	9.91
Chad	WB Index	89.9	86.7	82.1	72.2	65.9	7.39	4.43	12.35
	Index 1	84.9	90.0	81.9	76.6	64.8	5.45 ++	3.22	9.21
	Index 2	b	87.3	b	73.6	60.1	10.23 ++	5.93	17.63
	Index 3	b	87.4	b	73.6	59.2	10.70 ++	6.20	18.46
Indonesia	WB Index	46.3	35.4	33.3	28.7	16.1	4.74	3.24	6.95
	Index 1	45.7	36.0	30.4	30.6	18.3	4.13 +	2.81	6.06
	Index 2	43.2	42.3	29.4	27.6	18.2	4.55	3.11	6.65
	Index 3	42.2	42.0	29.2	29.3	18.3	4.08 +	2.78	5.98
Kenya	WB Index	41.8	33.8	18.5	20.5	15.4	6.13	3.43	10.95
	Index 1	39.7	35.5	20.6	20.5	15.3	6.02	3.39	10.66
	Index 2	34.5	43.7	22.7	28.8	17.5	[2.80++]	1.62	4.83
	Index 3	34.0	42.2	21.8	28.6	20.0	[2.35++]	1.36	4.08
Malawi	WB Index	30.2	23.4	25.3	20.7	11.8	2.89	1.55	5.38
	Index 1	32.1	20.8	26.7	19.0	12.0	3.26 +	1.77	6.02
	Index 2	26.3	26.8	21.4	19.4	15.8	[2.37+]	1.22	4.61
	Index 3	26.3	26.8	a	18.7	17.6	[2.23++]	1.13	4.39
Pakistan	WB Index	75.2	61.6	52.0	52.6	28.0	9.00	5.13	15.77
	Index 1	76.9	62.0	52.3	51.7	28.3	9.48	5.50	16.33
	Index 2	76.9	59.7	53.5	50.0	29.8	[9.96+]	5.45	18.21
	Index 3	66.5	b	60.9	48.5	30.0	[7.01+]	3.98	12.31
Tanzania	WB Index	40.6	30.6	30.2	18.0	13.4	5.80	3.60	9.35
	Index 1	36.7	31.3	31.4	21.9	12.3	4.22 ++	2.67	6.68
	Index 2	33.0	b	36.8	21.1	17.1	3.45 ++	2.13	5.57
	Index 3	b	32.5	36.7	18.0	19.6	2.85 ++	1.76	4.62
Uganda	WB Index	53.8	58.0	42.1	45.6	28.4	3.49	2.29	5.31
	Index 1	50.5	51.5	48.2	49.9	27.8	2.47 ++	1.64	3.73
	Index 2	54.4	46.7	48.9	46.1	34.0	2.18 ++	1.45	3.28
	Index 3	54.4	46.7	47.9	47.1	34.0	2.11 ++	1.40	3.18

Notes: [] RII's in parentheses indicate that results may be an artefact due to combination of population heaping and a non-linear association of immunisation coverage with wealth; **a** rates are not shown due to small sample size (smaller then 50) referring to the denominator, i.e. children aged 12–23 months at the time of the survey. **b** empty cell due to heaping (see Table 2); **+** 10–30% change in RII compared to the WB index; **++** >30% change in RII compared to WB index

When comparing the non-artefactual changes in inequality in immunisation coverage with those in under-5 mortality, we saw that for most countries the magnitude of inequality of both under-5 mortality and immunisation coverage was sensitive. For one country (Uganda), nevertheless, inequality in under-5 mortality was not sensitive, while inequality in immunisation coverage was substantially sensitive. Furthermore, the direction of change in the two health indicators was not always the same. For Malawi and Bolivia, there was a decrease in inequality in mortality when using the 1st and the 3rd alternative index respectively, while the use of the same indices for immunisation gave rise to an increase in inequality.

Discussion

This study shows that the ranking of households into wealth groups and the magnitude of poor-rich inequality in under-5 mortality and immunisation coverage are sensitive to the measure of economic status used. The size and direction of change, however, varied per country and alternative index, in some cases ranging up to a 60% change in observed inequality.

Our results seem to contrast to the findings of Filmer and Pritchett, who found that the ranking of households is robust to the items included [4]. However, their conclusions are based on the analysis of only one country (India). Furthermore, they did not analyse the sensitivity of the association of such ranking with a health outcome such as mortality.

Bollen et al. [5] compared a broad set of proxies for economic status, including a PCA-based consumer goods index, education and occupation for two countries, using fertility as outcome variable. They concluded that the effect of economic status varied with the measure used, and that the PCA-based method was most predictive. Our in-depth comparisons of different PCA-based indices show that even for this specific type of measure, the specific indicators used influence the magnitude of observed inequalities. In addition, our analyses of a broad set of countries showed that the extent and direction of sensitivity varies between countries. Moreover, our findings for both mortality and immunisation demonstrate that sensitivity also can vary with the outcome measures studied.

Which weight should we attribute to the sensitivity observed? While observed inequalities changed for most countries, in many of these cases the order of magnitude remained the same: large inequalities remained large, small inequalities small. Moreover, the confidence intervals of the RII's were large and overlapping. While this can not be interpreted as a lack of statistical significance – the RII's have not been calculated on basis of independent groups – it does indicate that the importance of the sensitivity found should not be overestimated. Furthermore, the reliability of the retrospective surveys used is not such to allow for very precise estimation of poor-rich differences in health. So in many cases, the changes in inequality found when using alternative measures of economic status, are not alarming. However, in a number of cases the measure of economic status used did make an important difference, ranging up to a 60% change in RII. Therefore, it is important to be aware that the measure of economic status used can affect observed poor-rich differences in health and health related outcomes.

We expect also for other developing countries and health outcome measures inequality to be sensitive to the measure of economic status used. The countries included in our study are diverse in terms of region, average mortality levels and pattern of inequality [6]. Yet, since the size and direction of change varied by country, index and health indicators, it is difficult to predict this a priori for specific cases.

An issue that needs to be mentioned is related to the method of PCA for constructing indices. Even though PCA can be a useful measure for constructing composite indices, it may produce odd results when applied to short lists of items as in Index 2 and 3. In Cameroon, for example, the item 'bicycle' got a negative factor score. As a consequence, households owning only a bike, were categorised as poorer compared to households owning nothing. The question arises whether in such cases the asset index is still conceptually valid. While this problem could have influenced the results in such specific cases, it is not likely to have influenced our overall conclusions.

It also needs to be mentioned that the distinction between direct and indirect determinants is not always clear-cut. One could, for example, argue that since the type of stove owned can have a direct effect on respiratory illnesses, it should have been excluded from the alternative indices. The additional exclusion of these items, will, most likely, lead to even larger sensitivity than reported. Generally, in explanatory studies, it should be made explicit, for instance by using a conceptual framework, which factors are considered as direct and which as indirect determinants.

Finally, it must be remembered that in this study we examined poor-rich differences, and their sensitivity to the measure of economic status, in a descriptive way. It was not the purpose of this study to establish whether the wealth and health are causally related. Readers should keep this in mind when interpreting the results.

Explaining the results

Sensitivity of inequality to alternative constructions of the WB index is likely to be related to the low common variance of the items in the WB index. This low common variance can be explained by the fact that the WB includes a broad range of different items, each of which has its own determinants besides economic status. Upon exclusion of items from this index, the common variance increased. The reason is that the new lists were shorter and consisted of more homogeneous sets of items. As a consequence, the categorisation of households into wealth groups changed, leading in its turn to different mortality rates per wealth group.

Even though the observed sensitivity is understandable, it is more puzzling why the use of alternative indices had different effects for different countries as well as for different outcome indicators. Below, we will forward some explanations.

We hypothesised that inequality in under-5 mortality would decrease upon exclusion of water and sanitation items from the WB index and would further decrease upon exclusion of housing items. This is because we expected that part of the relationship between wealth as measured by the WB index and under-5 mortality would be explained by variables that have a direct effect on child mortality, apart from their indirect effect as indicators of economic status [7]. For a number of countries we saw this expected decrease. This supports the hypothesis that for some countries part of inequality in mortality measured using the WB index can be attributed to direct determinants of health rather then to economic status alone.

This hypothesis, however, cannot explain the decrease in inequality in immunisation coverage observed for some countries upon exclusion of direct determinants of health from the index. The reason is that housing characteristics, and water and sanitation facilities only influence immunisation coverage as indicators of economic status, and don't have a 'direct' impact that is comparable to their effect on mortality. An alternative hypothesis would be that water and sanitation facilities and housing characteristics are also indicators for regional development or rural/urban residence. For instance, using the bush as latrine probably indicates rural residence, whereas using a private toilet is probably more related to urban residence. Therefore, the decrease in observed inequality in both mortality and immunisation may also in part be explained by the fact that the WB index captures rural-urban differences in both wealth and the health indicators.

We expected a further decrease in inequality upon subsequent exclusion of electricity from the index. Electricity can be an indicator of community wealth. Regional disparities in the availability of electricity probably run parallel to disparities in access to and quality of health care services and disparities in mortality. When excluding electricity from the asset index, these regional disparities in wealth and mortality as measured through electricity, are given less weight. Doing so, one can expect a decrease in inequality in mortality. We saw that indeed for a number of the countries, inequality in under-5 mortality decreased upon exclusion of electricity from the wealth index. This may indicate that health inequality as measured by the WB index, through electricity, also captures for some countries some of the regional disparities in wealth and health.

The hypotheses above, however, cannot explain why in some cases inequality was not sensitive, and why in one case inequality in under-5 mortality increased, instead of decreased. Additional explanations therefore need to be sought.

Inequality in under-5 mortality was robust to changes in the measure of economic status used for Uganda. This is related to the fact that Uganda was the only country for which items on food sufficiency were included in the WB index. When doing an additional analysis, excluding food sufficiency from all four indices, the RII became slightly sensitive also for this country (the largest change in RII being 14%, from 1.68 when using the WB index to 1.77 when using Index 1). Sensitivity thus may depend on the specific items included in the asset index.

The slight increase in inequality in under-5 mortality in Cameroon upon exclusion of water and sanitation items could not be attributed to the above factors. As already mentioned, household ownership of assets is also determined by other factors besides economic status, such as local availability and preferences. These factors can act as confounders in the relationship between household wealth and child mortality. Apparently, these confounders are in some cases more difficult to disentangle than in others. Multivariate analysis would be needed to gain more insight into these relationships, and thus into the underlying mechanisms linking wealth and health.

Implications

Our study shows that researchers and policy makers should be aware that the choice between alternative indicators of economic status often does affect, and in some cases to an important extent, the observed magnitude of poor-rich differences in health and health-related outcome measures. It also shows that it is difficult to predict the size and direction of sensitivity.

This is important in the present context in which monitoring and tackling poor-rich inequalities in developing countries have become increasingly important policy objectives, and in which many studies are being published on this issue. One of the major difficulties this new field is facing, is determining who is rich and who is poor. An index based on household ownership of assets is an often-used way to do so. Different researchers, however, use different sets of asset items. Our study shows that who is defined as poor and who as rich, varies with the asset items included in the index.

Our study implies that we should be extremely careful comparing results of studies using different indicators of economic status, as differences between countries and trends over time may in part be an artefact of the different indicators used. This is important both for monitoring health inequalities, evaluating the effects of policy interventions on these inequalities, and for targeting the poor in health policies. The choice of the measure of economic status should therefore be carefully made.

For descriptive and monitoring purposes we advise to use a comprehensive list of asset items such as used by the World Bank. A good alternative would be a much more extended list of consumer goods. In countries or regions where durable consumer goods are hardly accessible to anyone, or where investments in housing and amenities are given priority, the latter can be important indicators of economic status or wealth. Moreover, surveys such as the DHS only include a limited number of durable consumer goods, whereas items that the poor and inhabitants of rural areas are likely to own (e.g. chair, plastic recipients, animals, farming tools) are not included. In such cases, the inclusion of water, sanitation and housing items facilitates stratification of households at the lower end of the wealth ladder. For these reasons, it would generally be advisable to use a comprehensive list of asset items for descriptive and monitoring studies.

For explanatory studies, though, it can be important to analyse the different sets of asset items separately, and not to combine them into one index. It enables the assessment of the relative importance of different components of material wealth, especially water and sanitation versus housing versus consumer items versus indicators of community wealth. Estimates of the relative importance of these components can contribute to the detection of causal mechanims that are most responsible for high child mortality among poor families. This information is important for intervention purposes, since it addresses questions such as: would it be more effective to invest in income generating projects or in housing, water and sanitation programs; and should development efforts be focussed on the household level or the community level? For such explanatory studies it would be advisable to use multiple regression, path analysis or similar multivariate techniques.

For those designing new surveys intending to measure economic status in developing countries, we advice to also include items that poor households are likely to own and indicators of economic status in rural areas, such as the ownership of land, animals, and farming tools. Also the inclusion of context-specific indicators of economic status, as shown by the example of 'food sufficiency' in Uganda, would be useful when aiming to make a refined stratification along the lines of economic status. The inclusion of 'rural' and context specific items can also be important for making a proper identification of target groups for health policies.

Conclusions

Since data on household income or expenditure are often unavailable or unreliable as measure of economic status in developing countries, the use of an asset index is a good alternative to distinguish wealth layers within a population. Users of an asset index should, however, be aware that choice of assets influences the outcomes observed. Therefore, researchers should carefully select the items they include in the index, using the considerations mentioned above, and should be very careful when comparing results of studies using different indices.

Competing interests

No competing interests.

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