Soc Indic Res (2012) 105:309–322
DOI 10.1007/s11205-010-9778-1

An Index of Child Health in the Least Developed Countries (LDCs) of Africa

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Accepted: 21 December 2010 / Published online: 1 January 2011

Abstract In this article we present a new composite index of child health, applied to the Least Developed Countries (LDCs) of Africa, one of the areas of the planet most castigated by poverty. Our index has been constructed attending to the variables defined in the Goals of the Millennium Declaration. For this purpose we will use the P_2 distance method for the year 2008, the last year for which data are available. This index integrates variables of child health that permit a territorial ordering of the LDCs of Africa, in terms of those partial indicators.

Keywords Synthetic indicators · Territorial disparities · Child health · Least developed countries of African · Measurement of distance P_2

1 Introduction

In September 2000, leaders from 189 nations agreed on a vision for the future: a world with less poverty, hunger and disease, greater survival prospects for mothers and their infants, better educated children, equal opportunities for women, and a healthier environment; a world in which developed and developing countries worked in partnership for the betterment of all. This vision took the shape of eight Millennium Development Goals (MDG), which provide a framework of time-bound targets by which progress can be measured (UN 2005).

Reaching the MDG on reducing child mortality will require universal coverage with key effective, affordable interventions: care for newborns and their mothers; infant and young child feeding; vaccines; prevention and case management of diarrhoea, pneumonia and sepsis; malaria control; and prevention and care of HIV/AIDS. In countries with high mortality, these interventions could reduce the number of deaths by more than half More than 8 million children under five die every year. Almost 90% of all child deaths are

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attributable to just six conditions: neonatal causes, pneumonia, diarrhoea, malaria, measles, and HIV/AIDS. During 1960–1990, child mortality in developing regions was halved to one child in 10 dying before age five. The aim is to further cut child mortality by two-thirds by 2015 (UN 2008).

Gordon et al. (2003) estimate that, in developing countries, one billion children are severely deprived of at least one of the following seven elements: drinking water, sanitation, nutrition, health, shelter, education, or information. This represents about half of the population under 18 years of age. The child health states, both permanent and transitory, are affected significantly by factors such as parental education, socio-economic conditions, and health care variables (Shehzad 2006, pp. 531).

With some risk of generalization, we can identify two types of studies in relation to children who live in poverty: studies that look at the consequences of economic poverty for children's health and development and those that focus on the occurrence and causes of child poverty within and across countries (Bethlehem et al. 2009, pp. 73). The first group of studies have been conducted especially among psychologists and public health scholars in the United States. Until recently, the focus of these studies has been on describing the negative effects of poverty on children's outcomes, but despite this shift almost all of these studies depict children as passive victims and barely include their perspectives (Van der Hoek 2005).

While it is generally agreed that there is a causal connection between poverty and child health status, the size of the 'true' or 'pure' effect of poverty on child health is believed by some authors (e.g., Blau 1999; Mayer 1997) to be relatively small. Certainly, it seems unlikely that simply 'handing families more money' will solve all child health problems. Perhaps more plausible is the idea that low income often comes packaged with other attributes which may be limiting to child health (e.g., low education) (Phipps 2007, pp. 190).

The renewed interest in protecting and promoting both maternal and child health has led to the three-pronged approach of tackling malaria in pregnancy, namely: intermittent preventive treatment of malaria using an effective antimalarial drug to address the heavy burden of asymptomatic infections among pregnant women residing in areas of moderate or high transmission of *P. falciparum*; the use of insecticide treated nets by all pregnant women; and effective case management of malaria illness and anemia (World Health Organization 2004).

In areas of low or unstable malaria transmission, the emphasis is on prompt and effective case management of malaria and anaemia since malaria in a non-immune pregnant woman can progress rapidly to severe disease. The use of insecticide treated nets (ITN) reduces the level of exposure to infective bites from mosquitoes. Currently, the Global Funds for HIV/AIDs, Tuberculosis and Malaria is massively funding malaria interventions in African countries in a spirited move to drastically reduce the morbidity and mortality of malaria (Aghoghovwia and Obiora 2010).

The methodology employed is based on the construction of a Synthetic Index in terms of a set of intermediate variables, which contribute to quantifying some aspect of the concept that it is desired to synthesize; in our case, the fulfillment of the UN Millennium Development Goals of child health. We make no attempt to argue that they constitute an 'ideal' list. Rather, they represent 'reasonable choices' given limited availability of comparable measures of child health status. In this sense, as against the dissemination of information that may be derived from one-dimensional indicators, Synthetic Indicators, which we apply in our study, integrate all the information on the variables related to the level of child health, with the synthetic indicator DP_2.

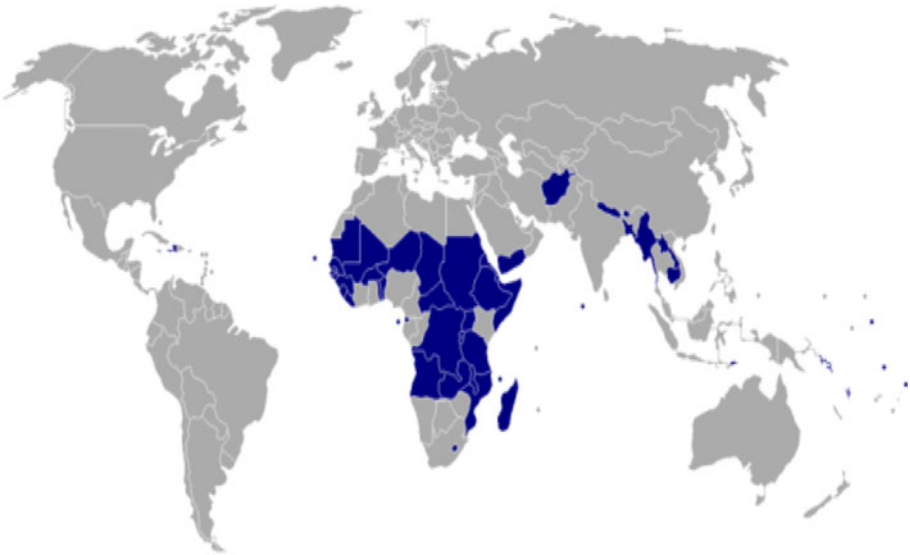

Fig. 1 Least developed countries. *Source*: UN (2009)

Others have been inspired by the DP_2 distance method of Pena (1977, 2009), which we use in our study, this would be the case of other studies such as Vicéns and Chasco (2001), López (2003), Sánchez and Rodríguez (2003), Escobar (2006), Somarriba and Pena (2008, 2009), Cuenca and Rodríguez (2010), Cuenca et al. (2010).

For this purpose, first we set out the methodology of the synthetic indicator DP_2 and its principal mathematical properties. Third, with the aim of having an instrument that would enable us to assess the degree of fulfilment of the Millennium goals of child health of the UN for the case of the Least Developed Countries (LDCs) of Africa, one of the areas of the planet most castigated by poverty, we propose to construct an overall indicator of child health, using for this purpose the P_2 distance method. Finally, we present the results obtained and the main conclusions drawn. The paper also offers ways forward for future research.

As such, the LDCs are considered to be in need of the highest degree of attention on the part of the international community. Since 1971, the United Nations has denominated "Least Developed Countries" (LDCs) a category of States that are deemed highly disadvantaged in their development process (many of them for geographical reasons)[1](Fig. 1), and facing more than other countries the risk of failing to come out of poverty. The UN gives a strong signal to the development partners of these countries, and points to the need

[1] The criteria on which the Development Policy Committee (DPC) based its revision in 2006 of the list of the Less Developed Countries were as follows: (a) A " low income", measured by the gross national income (GNI) per capita (average of three years, 2002–2004), with thresholds of 750 dollars for the inclusion of countries in the list and of 900 dollars for their exclusion; (b) The "stocks of human assets", measured by a composite index (the human assets index) based on indicators of: (i) nutrition (percentage of the population under-nourished); (ii) health (infant mortality rate); (iii) schooling (gross rate of secondary schooling); and (iv) literacy (adult literacy rate); and (c) "Economic vulnerability", measured by a composite index (index of economic vulnerability) based on indicators of: (i) natural shocks (index of instability of agricultural production; percentage of the population displaced by natural disasters); (ii) commercial shocks (index of instability of exports of goods and services); (iii) vulnerability to shocks (part of GDP corresponding to agriculture, forestry and fishing; index of concentration of exports of goods); (iv) small size of the economy (population expressed in logarithms); and (v) remoteness.

for special international support measures and concessions in their favour, with particular attention to eliminating the pattern of excess and preventable mortality among girl infants and children (UN 2001).

2 Methodology: A Synthetic Social Indicator of Child Health: The P_2 Distance

One of the major problems of constructing child health indicators is determining an appropriate aggregation method for incorporating multi-dimensional child health variables into an overall index. In our study we will use the P_2 distance method, an overall synthetic indicator. The great advantage of this indicator is that it resolves the question of aggregation of variables expressed in different measures, arbitrary weighting and the duplication of information (Zarzosa 1996).

The first difficulties emerging in the construction of synthetic indicators are the refining of the size effect, the treatment of the units of measurement and the weighting assigned to each observable variable in the synthetic index. As regards the size effect, in general, the larger the country the higher the values of the observable variables, therefore, to relativize the observed values, it is enough to express the variables as a function of the population or of the surface area, according to whether their respective values increase with the population or with the surface area.

As to the treatment of the units of measurement and the weighting assigned to each observable variable in the synthetic indicator, the indicator synthetic DP_2 resolves both issues with the factor (d_i/σ_i), as when the distance is divided by the standard deviation (σ_i) the partial indicator can be expressed in abstract units and, at the same time, is weighted by the inverse of the standard deviation, so that in the determination of the synthetic indicator the distances corresponding to the components whose values present greatest dispersion from the mean will have less importance.

In addition, by means of a correction factors $(1 - R^2_{i,i-1,\ldots,1})$ the new information is retained by incorporating the only new information and avoiding the duplicated one. These factors are the weights of the partial indicators. Therefore, the differences in the i-th variable between a country and the reference base are weighted by the percentage of new information (not facilitated by the other variables) that that variable provides.

2.1 Description of the Statistical Model

The P_2 distance, defined by Professor Pena (1977), is a synthetic indicator that adds the information contained in a set of social indicators and it is designed to make inter-spatial and inter-temporary comparisons. A synthetic or overall indicator is a mathematical function of partial indicators in the form $I = F(X_1, X_2, \ldots X_n)$, where I is the synthetic indicator, while n is the number of variables or partial indicators that contribute information. The DP_2 indicator calculates the distances of each country with respect to that theoretical country of reference. Its computation is based on adding up the differences between the value of each indicator and its minimum value, which is referred as the distance. A theoretical country that reaches the worse variable values of the object of study is taken as a reference.

We take as reference a theoretical country that achieves the worst values of the variables being studied. Thus, if "m" is the number of countries, there will exist a matrix X of observations, of the order "$n \times m$", in which the element X_{ij} will represent the state of variable i in country j. In this matrix of observations X, the partial indicators that are

negatively related to child health must be shown with a negative sign (−), and those bearing a positive relationship with a positive sign (+). In our study, the increases (or decreases) of the values of any variable would correspond to an improvement (or worsening) of the child health.

The DP_2 indicator will give us the distances of each country from this theoretical country of reference and is defined as follows:

$$DP_{2i} = \sum_{i=1}^{n} \frac{d_{ij}}{\sigma_i}\left(1 - R^2_{j;1,\ldots,j-2,j-1}\right)$$

with = 1,…,*n* and, by definition, $R_1^2 = 0$.

The reference base is $X = (X_1, X_2,\ldots,X_n)$, and where $d_{ij} = x_{ij} - x_{i\ (1)}$, is the difference between the value taken by the *i*-th variable in the country and the minimum of the variable in the least desirable theoretical situation, taken as reference base; where m is the number of countries; *n* is the number of variables; X_{ij} is the value of the variable *i* in the country *j*; σ_i is the standard deviation of the variable *i*; and $R^2_{i,i-1,\ldots1}$ is the coefficient of determination in the regression of X_i over X_{i-1}, X_{i-2},…, X_1.

As the objective is to measure the level of child health in different countries to establish comparisons, the synthetic indicator DP_2 captures the disparities in child health, as in each of the partial indicators the value (*Xij*) corresponding to the country registering the lowest value is taken as reference base.

A theoretical country that reaches the worse variable values of the object of study is taken as a reference, i.e., where its partial indicators or variables attain minimum values. A higher value of DP_2 therefore expresses a higher level of child health, as it represents a greater of each country with respect to that theoretical country of reference.

2.2 Mathematical Properties of the Synthetic Indicator DP_2

A synthetic indicator should have a series of mathematical properties to be able to provide a good measurement or estimation of the object to be measured. The synthetic indicator DP_2 fulfils these properties, as analyzed by Pena (1977, p. 49), (Zarzosa 1994; Cuenca et al., 2010, p. 474):

a) Existence and determination of the synthetic indicator for all the partial indicators. Given the mathematical function defined by DP_2, it exists and takes a certain value provided that the variance of each and every one of the partial indicators is finite and other than zero.
b) Monotony, in the sense that if an improvement occurs in any of the partial indicators, the rest remaining constant, the synthetic indicator must reflect that improvement.
c) Uniqueness, so that for a given situation the synthetic indicator must provide a single value or in other words, verify the invariance to changes of origin and/or scale.
d) Grade one Homogeneity of the DP_2 function in order to reflect cardinality, i.e., if the partial indicators are multiplied by a constant, the synthetic indicator is also multiplied by that same constant.
e) Transitivity, i.e., given three values of the synthetic indicator, if the first is greater than the second, and the second in turn greater than the third, it must be verified that the first is greater than the third. Since DP_2 is a numerical value, it verifies this property.
f) *Neutrality*. The weight of each single indicator would be given by the useful information contained in each one, according to the explained.

Besides these properties, the indicator solves a large number of problems such as the aggregation of variables expressed in different measures, arbitrary weights and duplicity of information.

The method of principal components has been used by several authors as a tool for constructing synthetic indicators (Slottje et al. 1991). However, several authors have criticised Principal Component Analysis as a valid procedure for obtaining synthetic indicators (Pena 1977; Ram 1982; Zarzosa 1996; Mishra 2007, among others). The main criticisms against this methodology as an instrument for constructing synthetic indicators are the following (Somarriba and Pena 2009, pp. 117): The synthetic indicator derived from this procedure is exclusively an ordinal type indicator, and the weights of partial indicators lack socio-economic interpretation.

Additionally, this procedure does not take into account all the non-redundant information as it only explains the variance in the first component and can therefore remove useful information in the synthetic indicator. It also presents some difficulties if one wishes to construct a single index of the variables that are not very highly correlated, the method has a tendency to pick up the subset of highly correlated variables to make the first component and assign marginal weights to relatively poor correlated subsets of variables. Moreover, the principal components analysis does not allow making inter-spatial or inter-temporary comparisons, except in ordinal comparisons.

Data Envelopment Analysis is useful for constructing synthetic indicators and it facilitates spatial and temporary comparisons. The last few years have seen several works that employ this method for obtaining synthetic indicators of well-being and quality of life, namely, Hashimoto and Kodama (1997), Murias et al. (2006), Chaaban (2009), among others. However, one of the disadvantages of this procedure is that the programme can assign a zero or very low weight to a specific factor which, from a theoretical point of view, is very important. Furthermore, this method does not define in a sufficiently precise manner which the data is output and which is input within the context of measurement of child health, therefore when the variables are defined by the investigator as input or output some arbitrariness may be introduced into the model. On the other hand, this method can show multiple virtual solutions (virtual inputs and outputs) and the existence of restrictions could cause problems of non-feasibility.

The evaluation of child health implies the simultaneous use of many social indicators. In this multidimensional evaluation, defining an appropriate aggregation method to combine multi-dimensional in an overall index is extremely important. In our opinion, DP_2 constitutes an optimum and appropriate method for applying the social indicators approach to the measurement of child health as the result of a multivariate set of factors.

2.3 Hierarchy of Variables

A further aspect to be taken into account in drawing up the synthetic indicator DP_2 is that the result varies when the order of entry of the components, variables or partial indicators changes. For this reason, it is necessary to establish an order or hierarchy, in terms of the information that each of them contributes to the DP_2.

The first partial indicator incorporated would be that which contributes most information, and so on.

The order of entrance of the partial indicators and the determination of the weights of each variable is determined through an iterative algorithm that reaches convergence when the indicator fulfils a set of desirable properties. The order of entrance of the partial

indicators is obtaining in accordance to the absolute values of the coefficients of linear correlation between the values of the indicators and the synthetic indicator.

Once the first re-ordering has been obtained, the indicator of distance P_2 is calculated, in a first stage for each of the m countries, called DP_2. When we calculate the indicator for the first stage the correlations of each variable with DP_2 are re-calculated and re-arranged in the new order. At this point we verify that the difference between the maximum value of DP_2 and DP_2 is not lower than our stop criterion, which is a value close to zero. i.e.,:

$$DP2^{(t-1} - DP2^{(t} < \delta_{0^+}$$

With a stop value (d_0^+) defined in a positive area around zero, i.e., a low value close to zero, in our model 0.01.

The process continues iteratively until the difference between the two contiguous DP_2's is nil, i.e., when in two successive iterations, the same value of DP_2 is obtained, so the definitive result would be obtained, with a stop value defined in a positive area around zero, in our model 0.01. If convergence is not achieved, so that the results of DP_2 do not stabilize, the first DP_2 obtained $DP_2^{(1)}$ can be chosen, or the average of the DP_2 calculated in various iterations.

2.4 Discriminating Power of the Variables

With Frechet's process of calculation as described above, we obtain the value of the indicator DP_2 for each of the countries; however, this estimation does not ensure the convergence of the indicator, as it may happen that two variables have the same correlation with the synthetic indicator, and it is maximum, so we may ask ourselves which of these two results offers values closest to reality.

The most correct decision will be to select the indicator that provides most information.

In this sense, the "Ivanovic Discrimination Coefficient" permits us to measure such information, on the basis that the indicator DP_2 will be good if it has a high power of discrimination in the set of countries observed (Ivanovic 1974), and also contains a high volume of new information on the level of child health. Furthermore, this coefficient will also serve to quantify the discriminant or informative power of each of the variables.

For the calculation of this coefficient the variables do not have to be typified, as it does not exist when $\bar{x}_j = 0$. Nonetheless, this criterion is good when the variables are independent, as it contains redundant information.

For this reason, we construct the "Ivanovic—Pena Overall Information Coefficient" (IC) Zarzosa (1994). The coefficient therefore indicates the quantity of information provided by the variable. The values of this indicator vary between 0 and 2.

The lowest value is taken when all the values of the variables are equal and other than zero, and the highest value when all the values are nil except one of them. That is to say, that a variable is considered to be more informative the more it discriminates: if a variable is constant throughout the set of countries, it will have zero discriminating power (IC = 0), and its information is not relevant for evaluating the relative levels of child health. On the other hand, if a variable is totally discriminating (IC = 2), it provides very important information on the differences in the degree of child health the countries observed.

Below, we will introduce the measurement of the P_2 distance approach into the concept of "child health", a synthetic indicator that adds the information contained in a set of social indicators which is designed to make inter-spatial and inter-temporary comparisons (Somarriba and Pena 2009, p. 116). In our study, it is applied to the LDCs of Africa for 2008.

3 The Synthetic Indicator of Child Health in the Countries of the LDCs of Africa for 2008

3.1 Initial Considerations

As has already been indicated, the aim of this study is to draw up a synthetic indicator of child health to permit comparison among thirty-one of the Countries of the LDCs of Africa and the analysis of the disparities existing in 2008, using as reference the Millennium Development Goals (MDGs) by the UN of child health (Table 1).

The next step in our investigation was to select the partial indicators or variables, taking into account that a partial indicator must as a priority possess two properties:

A high power of discrimination, as otherwise it would make very little contribution to the measurement of child health;

And that the greater the quantity of information contributed by an indicator that is not contained in the overall information of the indicators already incorporated into the synthetic indicator, the better the partial indicator.

In our study, all the characteristics are satisfactorily covered, both in quantity and in quality, by virtue of the detailed statistical information contributed by the report on the Millennium Development Goals (MDGs) (UN 2008) and taking as reference the greater or lesser fulfillment of the Millennium Goals of child health.

3.2 Selection of Variables or Partial Indicators

For this stage, we followed the methodology of the OECD (2002) to approach the concept of child health. This methodology consists of dividing the concept into various areas or domains that are objectively considered to be its components, in this study the four millennium objectives of the UN of child health variables, and each of these areas is in turn subdivided into sub-areas and the disaggregation continues until minimum levels are reached. In our study, we used 10 social indicators or variables associated with each of the millennium goals related to child health.

From a fairly high initial number of variables, ten were selected, which we distributed among the Millennium Goals, as detailed in Table 1, with the latest data available. The year of analysis is 2008, but for those variables where information was not available for that date, the nearest year was taken as alternative.[2]

Finally, it should be pointed out that the variables that bear a negative relation to child health i.e., those, whose increases may be associated with reductions in child health, are reflected in the matrix of observations X with negative sign. Specifically, the variables with negative sign are those associated with goals:

1a) Percentage of children under 5 severely underweight;
4a) Infant mortality rate (0–5 year) per 1.000;
4b) Infant mortality rate (0–1 year) per 1.000;
and 6a) Malaria death rate per 100.000 population, ages 0-4 (Table 1).

[2] This has occurred in the variables: Average life expectancy at birth; Proportion of births attended by skilled health personnel and the Percentage of children under 5 fever being treated with anti-malarial drug, whose available information is from 2007, while for the Percentage of children under 5 severely underweight we use that existing in 2006.

Table 1 Variables of child health by UN Millennium Development Goals (MDGs) and sign of the relationship of the variables to the increase in child health

Goal 1. To eradicate extreme poverty and hunger
a) Percentage of children under 5 severely underweight (negative sign −)
Goal 4. Reduce child mortality
a) Infant mortality rate (0–5 year) per 1.000 (negative sign −)
b) Infant mortality rate (0–1 year) per 1.000 (negative sign −)
c) Proportion of 1 year old children immunised against DPT3 (positive sign +)
d) Proportion of 1 year old children immunised against measles (positive sign +)
e) Average life expectancy at birth (positive sign +)
Goal 5. Improve maternal health
a) Proportion of births attended by skilled health personnel (positive sign +)
Goal 6. Combat HIV/AIDS, Malaria and other diseases
a) Malaria death rate per 100.000 population, ages 0–4 (negative sign −)
b) Percentage of children under 5 sleeping under insecticide-treated bed nets (positive sign +)
c) Percentage of children under 5 fever being treated with anti-malarial drug (positive sign +)

Own preparation UN(2008)

4 Results of Synthetic Indicator DP_2 of Child Health in the LDCs of Africa: Year 2008

In this part of the study, we propose to carry out, as our own contribution, an application of the synthetic indicator Distance-P_2 to the case of the LDCs of Africa.

4.1 Results of Indicator DP_2: Classification by Countries

When interpreting the results, it should be borne in mind that we took as reference the "worst" theoretical situation of a country, i.e., where its partial indicators or variables attain minimum values. In consequence, a higher value of a country's DP_2 implies an improvement as regards the child health situation, because it represents a greater distance from the "least desired" theoretical situation.

From the results obtained, it is noted that Togo in West Africa was the country with the best real child health situation in 2008, with a distance from the baseline equal to 19.18 (Table 2). It was followed by the Benin (17.17), Sudan (17.05), United Republic of Tanzania (16.70), Liberia (16.19) and Senegal (16.01), with values higher than the average distance (13). In this regard, given the high relative values of these countries in most of the variables analyzed, their high position is not unexpected.

By contrast, Ethiopia in Horn of Africa and Democratic Republic of the Congo in Central Africa, which represent over 30% of the population of the region, are among the worse theoretical situations, with a distance from the baseline of 11.80 and 11.71, respectively. This means that the maximum distance inter-country, between the maximum and minimum value obtained, was almost 15, which shows that the disparities between the countries surveyed were high. Another way to express these differences clearly is through the coefficient of openness (quotient between the maximum and minimum values) which reached a value of 4.2.

Table 2 Synthetic indicator of child health in African LDCs. 2008 Countries in order of relative DP_2

Country	DP_2 indicator	% of total population of African LDCs (%)	Geographical area of continent
Togo	19.18	1.33	West Africa
Benin	17.17	1.83	West Africa
Sudan	17.05	7.83	Horn of Africa
United Republic of Tanzania	16.70	8.21	East Africa
Liberia	16.19	0.75	West Africa
Senegal	16.01	2.51	West Africa
Zambia	15.76	2.43	Southern Africa
Eritrea	15.43	0.98	Horn of Africa
Uganda	15.26	6.21	East Africa
Malawi	15.00	2.83	Southern Africa
Mozambique	14.76	4.36	Southern Africa
Lesotho	14.75	0.42	Southern Africa
Isle of Madagascar	14.23	3.99	Indian Ocean
Gambia	14.14	0.35	Africa West
Rwanda	14.00	1.97	East Africa
Djibouti	13.97	0.17	Horn of Africa
Guinea	13.93	1.91	West Africa
Burkina Faso	12.94	2.99	West Africa
Guinea-Bissau	12.01	0.33	West Africa
Ethiopia	11.80	16.83	Horn of Africa
Democratic Republic of the Congo	11.71	12.59	Central Africa
Mauritania	11.50	0.62	West Africa
Mali	11.45	2.49	West Africa
Sierra Leone	11.20	1.18	West Africa
Equatorial Guinea	10.53	0.10	Central Africa
Central African Republic	10.44	0.89	Central Africa
Niger	10.27	2.85	West Africa
Burundi	9.93	1.70	Africa East
Angola	9.18	3.45	Southern Africa
Somalia	6.57	1.75	Horn of Africa
Chad	4.57	2.18	West Africa

Own preparation, UN (2009)

Countries like Burundi, Angola, Somalia and Chad have child health levels below the average, since most of the variables analyzed reflected relatively low values close to the threshold reference.

In this same line, the low position of three other countries of West Africa—Niger, Mauritania, Mali and Sierra Leone—of Central Africa- Equatorial Guinea and Central African Republic- is also significant, with values of less than the average and relatively close to the minimum threshold of reference.

Zambia is the only country of Southern Africa that reached a high position in the list, with relatively high results in the majority of the variables studied.

Finally, it should be noted that Sudan is the country among the most populous in the region, which reached a relatively high position, with positive data in most of the partial indicators studied, above the average value.

4.2 Power of Discrimination of the Variables of Child Health

In this section we use the results of the Ivanovic-Pena Coefficient of Discrimination (IC). Table 3 represents the IC values corresponding to the variables, taking into account that the contribution of one variable to the evaluation of child health is the greater; the greater is the quantity of information not contained in the overall information of the variables already introduced.

In particular, the power of discrimination of each of the variables considered was estimated (Table 3). The column of the table, IC (i), shows the quantity of information contributed by each variable to the final indicator. The lowest value of IC (i) represents the case of zero power of discrimination and the highest value the theoretical case of maximum power of discrimination (variable that presents the value zero in all countries but one).

In view of these results (Table 3), the partial indicators that contribute most information of child health, i.e., the most discriminating, are in order:

Malaria death rate per 100.000 population, ages 0–4, with a IC of 0.41;

Infant mortality rate (0–1 year) per 1.000, with 0.28;

Infant mortality rate (0–5 year) per 1.000, with 0.22;

and Percentage of children under 5 severely underweight, with 0.15.

In this case, there are outstanding differences in the value of the variables among the countries.

Furthermore, it can be seen that there exist three minimally informative variables, with a practically nil power of discrimination:

Percentage of children under 5 sleeping under insecticide-treated bed nets;

Average life expectancy at birth;

And proportion of births attended by skilled health personnel.

Table 3 Quantity of information of the variables of child health

Variable	Millennium goal	IC(i)
Malaria death rate per 100.000 population, ages 0–4	6	0.41
Infant mortality rate (0–1 year) per 1.000	4	0.28
Infant mortality rate (0–5 year) per 1.000	4	0.22
Percentage of children under 5 severely underweight	1	0.15
Proportion of 1 year old children immunised against DPT3	4	0.07
Proportion of 1 year old children immunised against measles	4	0.06
Percentage of children under 5 fever being treated with anti-malarial drug	6	0.06
Percentage of children under 5 sleeping under insecticide-treated bed nets	6	0.05
Average life expectancy at birth	4	0.04
Proportion of births attended by skilled health personnel	5	0.03

Own preparation, UN (2009)

Finally, if we analyze the power of discrimination of the partial indicators distributed by Millennium Goals, the high values of the variable associated with goal 6 (Combat HIV/AIDS, Malaria and other diseases) stand out. In this component, the most significant characteristic is the malaria death rate per 100.000 population, ages 0–4, which is a variable that contributes important information on the differences in the degree of child health of the countries analyzed in 2008.

5 Conclusions

The contribution of this study has been an approach to the measurement of the child health of the LDCs of Africa in 2008, with the construction of an overall synthetic indicator of child health.

As has been demonstrated, DP_2 is an objective indicator of child health. It is a quantitative synthetic indicator, by means of statistical methods of synthesis of information permitting comparisons to be established among different territories at a given time.

The iterative method of Pena synthetic indicator DP_2, which possesses all the mathematical properties, required of a good synthetic indicator and allows the estimation of territorial disparities. Also, this method solves by means of a scientific method the principal limitations of this approach, namely the disaggregated character of the measures and the redundancy of the information.

In our study, starting from ten variables, previously selected and referring to the child health, we have calculated the indicator of child health in thirty-one LDCs countries of the Africa, grouped into 5 geographical divisions of the continent (Central Africa; East Africa; West Africa; Horn of Africa and Southern Africa).

The principal results obtained in the procedure permit us to draw the following general conclusions:

All the variables analyzed contribute relevant information for the determination of the child health of the LDCs of Africa.

Togo, situated on the West Africa, is the country that reaches the highest degree of child health in 2008. It is followed by the Benin in West Africa, with a relatively small population, so it affects a relatively small proportion of the inhabitants of the area. These countries could be considered the ones that most fulfil the Millennium Goals up to 2008 of child health. It is followed by Sudan in Horn of Africa, and United Republic of Tanzania in East Africa, with a relatively high population.

The most populated, Ethiopia and Democratic Republic of the Congo, present a lowest child health index in that year and are closest the least desirable theoretical situation, i.e., the countries that presented the lowest values in the variables incorporated into our overall indicator. This worsens the situation of these countries as a whole, as they form a very high proportion of the total population.

The values of the indicator DP_2 show the existence of territorial disparities with regard to child health of the LDCs of Africa in 2008. At the top of our classification figure countries such as Togo and Benin, in an intermediate position territories like the Djibouti and Guinea, and in the lowest positions, Chad, and Somalia. This should be taken more into account in the programming of international organizations to raise the standards of child health in these countries.

We detect a high informative power for measuring the child health of the LDCs of African of variables that are not usually included in others indices drawn up with similar objectives. In this sense, the variables with greatest differences in their values between

countries are the Malaria death rate per 100.000 population, ages 0–4, Infant mortality rate and percentage of children under 5 severely underweight.

Finally, these conclusions should have implications for the development aid strategy of international organisations, especially the UN, with the aim of reducing territorial inequalities among the LDCs of African, which without doubt would result in greater child health. This is important to further the understanding of the particular plight of children in poverty and solutions to address this situation, in the broader context of health sector reform, with particular emphasis on maternal/child health.

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