Infant mortality in Sudan: Health equity, territorial disparity and social determinants of health

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Abstract

Recognition of, and acting on, Social Determinants of Health is crucial for reducing health inequalities and territorial disparities and hence improving health of the whole population. Although Sudan was among the first countries which adopted a roadmap for Health in All Policies, health inequity remains an important challenge for health makers in this country. This paper illustrates the urgent need to reduce health inequalities in Sudan by acting on Social Determinants of Health. Descriptive statistics and Principal Components Analysis were used to get summarized multidimensional data information. Statistical significance of differences was tested by Pearson's chi-squared. A large territorial disparity was found between the 18 states. Infant mortality rate is more than three times higher in East Darfur (88.5) than in River Nile (28.1). Ratios of 1.9 and 1.6 were indicated for income and mother education respectively. A lower gap was seen for milieu (1.2) and gender (1.34). The difference was statistically significant for states (p-value <0.0001), income (p-value <0.001) and education (p-value <0.005). Urgent strategies are needed by acting sufficiently on social determinants of health like milieu, gender, education, income and territoriality in order to reduce avoidable heath inequalities and unacceptable territorial disparities in Sudan.

Introduction

It is now well recognized that action on social determinants of health (SDH) is crucial for reducing and reversing the growing unfair territorial disparities and remediable inequalities in health.[1-6] In its 2008 report, the World Health Organization Commission on SDH stressed that "reducing health inequities is an ethical imperative and that social injustice is killing people on grand scale".[4] In 2011, the Rio Political Declaration on Social Determinants of Health indicated five key points to reduce health inequalities: (1) better governance, (2) participation, (3) reorienting the health sector, (4) global governance and (5) progress monitoring.[5] Following the technical meeting held in 2016 on measuring and monitoring action on the social determinants of health, a framework and a basket of core indicators were proposed.[6,7] Independently of the economic level, governments are called worldwide to act on SDH and use the framework for country action to promote Health in All Policies (HiAP).[8,9] Despite being one of the first countries which adopted a roadmap for Health in All Policies, Sudan needs pragmatic and efficient actions to reduce health inequalities and territorial disparities.

Considering life expectancy, infant mortality, stunting, adequacy of food consumption, teenage birth rates and vaccination coverage for young children, Omer et al. found in their study on the effect of household assets inequality and conflict on population health in Sudan, that outcomes were significantly worse in the states with more unequal asset distribution and worse outcomes was also predicted by conflict status.[10] The main objective of this paper is to show how health indicators in general and infant mortality rate in particular are related to social determinants of health like territorial context (between states), income, education and milieu (rural-urban) in Sudan. In terms of implementing HiAP to reduce health inequalities between and within the 18 states of Sudan, it should be stressed that analyzing data provided by the Multiple Indicator Cluster Survey (MICS5) carried out by UNICEF in 2014,[11] will constitute a starting point for comparison with MICS6 planned for 2020.

Materials and Methods

Descriptive statistics are used to get summarized information on 13 health-related variables observed on 18 states as given by the Multiple Indicator Cluster Survey (MICS5) carried out by UNICEF in 2014 (Table 1).[11] Pearson's chi-squared was used to test statistical significance of differences according to milieu (rural-urban), education, income, sex and territoriality (between states). Principal Components Analysis (PCA) was used to select the first and second factors (F1 and F2). The corresponding eigenvalues give the percentages of information summarized by these factors respectively. Variables are then projected on the circle of correlation and countries on the first plan (F1 × F2). The more the variables are near the circle, the better will be the interpretation. In the meantime, a projection of states on the first plan should lead to a classification according to the scores of each state with regard to the variables under consideration. Additional information may be obtained by the third and fourth axis, but the interpretation is then conditional to what was given by the precedent factors.

Results and Discussion

In Sudan, inequalities in health are seen directly in access to health services and health care like vaccination, healthy nutrition, contraception, antenatal visits, delivery assistance and postnatal care. Consequently, gaps are found in impacts like life expectancy and mortality. However, health inequalities are also linked to variables like education, early childbearing, access to drinking water and sanitation.

Territorial disparity is one of the main problems challenging health authorities in Sudan. Indeed, huge gaps and unacceptable health inequalities are found between the 18 states. Table 2 shows that relatively large standard deviations are seen for all vari-

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ables. For instance, a large standard deviation (6.89) is associated with the low mean of contraceptive use (11.01%) indicating that beyond the fact that contraceptive use is low in all states, it drops from 26.5% in Khartoum to 2.9% in Central Darfur. Similarly, on the top of a high mean home delivery (71.07%), the standard deviation is nearly 20 and the values vary from 27.1% in Northern to 91.4% in West Kordofan. Early childbearing (girls between 15-18 years of age) is nearly three times higher in Blue Nile (23.4%) than in Northern (8.6%) and early education shows a high standard deviation (14.11) for a low mean (21.77%).

As illustrated by Figure 1, infant mortality rate shows a noticeable difference by milieu (rural-urban); gender (boys-girls); education level; income (approximated by household assets) and territorially by states. Indeed, children are 3.15 times more likely to die before their first birthday in East Darfur (88.5 deaths per 1000 live births) than in River Nile (28.1 deaths per 1000 live births). Comparing IMR according to income (poorest quintile: 64.9 vs richest quintile: 33.9) indicates a ratio of nearly 2. The level of mother education (no education:55.3 vs higher: 34.8) also shows a relatively high ratio. Finally, a lower gap is seen between rural infant (54.5) and their urban counterparts (45.1) and between boys (59.4) and girls (44.2). Precisely, the Pearson's chi-squared test shows that the difference is statistically significant for states (p-value <0.0001), income (p-value <0.001) and

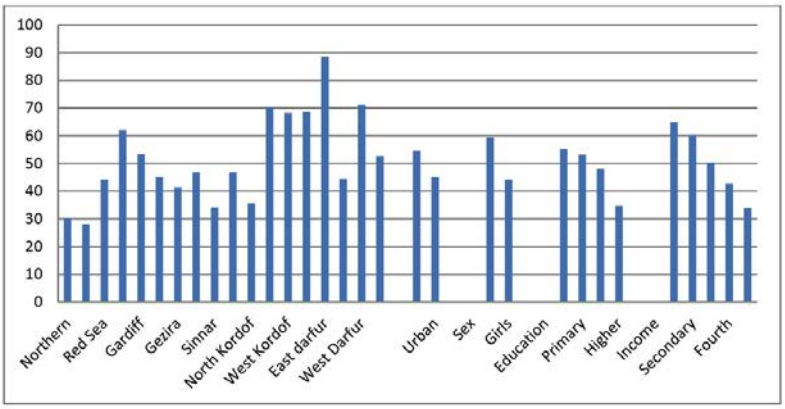


Figure 1. IMR by SDH (rounded data worked out from MICS 2014 Sudan with kind permission of UNICEF).

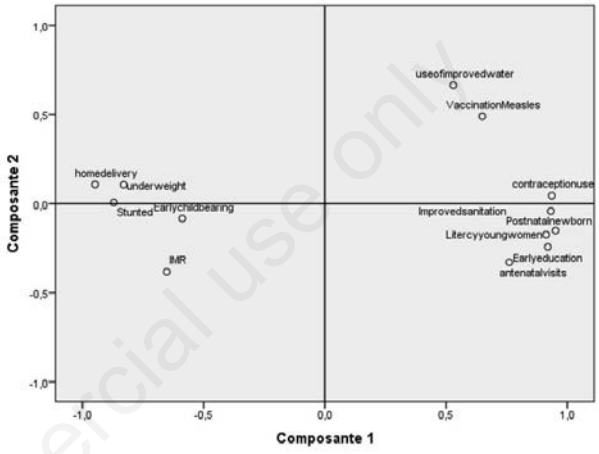


Figure 2. Projection of variables on the circle of correlations.

Table 1. Values of 13 variables observed on the 18 states of Sudan.

State	IMR	Stunted	Under weigh	Vaccination Measles	Contraception use	Early child bearing	Antenatal visits	Home delivery	Postnatal newborn	Early education	Litercy young women	Use of improved water	Improved sanitation
Northern	30	22,6	21,9	97,1	22,9	8,6	66,5	27,1	48,2	47,3	91,5	93,8	95
River Nile	28,1	29,5	32,2	95,5	21,3	15,1	52,9	43,6	45,7	36,1	79,8	88,3	61,9
Red Sea	44,2	45,4	33,6	67,3	9,6	15,5	53,4	51,5	32,4	37,6	71,9	33,2	56
Kassala	62,1	48,8	42	73	7,9	22,6	54	71,5	27,2	12,2	48,4	57,2	34,1
Gadarif	53,4	46	37,7	86,4	9,5	18,8	44,8	79,5	20,8	16,2	42,8	27,7	12,6
Khartoum	45,1	21,9	23,2	89,7	26,5	9,4	81,9	35,7	57,4	56,2	82,6	86,9	85,4
Gezira	41,4	41,6	32,4	96,7	12,2	13,5	50,5	62,5	28,5	21	66,4	88,9	49,9
White Nile	46,8	36,6	29,8	89,1	15,6	14,5	45,5	63,4	32,7	26,2	67,5	32,7	38,8
Sinnar	34,1	38,1	36,4	87,4	13,5	13,1	43,5	73,7	24,5	24,8	54	88,7	28,9
Blue Nile	46,8	46,7	35,3	90,6	7,1	23,4	42,7	86,1	15,8	13,3	36,1	71,3	42,8
North Kordofan	35,6	40,8	32,4	74,5	14,7	20,9	57,7	76,1	31,3	9,4	58,8	69,8	30
South Kordofan	70,2	40,6	34,8	75,2	9	15,9	59,3	85	16,2	21,9	49,2	60,1	20,9
West Kordofan	68,2	42,5	38,7	67,5	6,1	14	28,1	91,4	12,4	4,3	32,9	86	11,6
North Darfur	68,5	45,9	44,9	67,5	3,7	11,8	36,9	88,9	15,8	13,7	56	50,6	13,8
East Darfur	88,5	46,6	40,2	72,1	6,2	19,8	46,8	84,2	17,6	11,8	40	45,1	17
Central Darfur	44,5	47,2	41	77,8	2,9	14,4	47,1	88,1	12,2	9,1	27,4	50,6	19,1
West Darfur	71,2	35,2	29,4	83,4	4,1	14,6	56,1	82,5	27,1	13,5	50,1	67,5	18,3
South Darfur	52,6	34,2	29,4	58,9	5,4	19,1	40,9	88,6	19	17,3	49,3	46,6	29

(Data extracted with kind permission of UNICEF from MICS 2014 Sudan, Final Report). U5MR is expressed in deaths per 1000 live births while all the other variables are expressed as %.

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education (p-value <0.005). The 18 states can be classified in four groups according to the level of IMR in each state. A first group including four states having an IMR less than 40; a second group comprising six states with IMR greater than 40 and less than 50; a third group of five states having IMR between 50 and 70; finally, a fourth group of three states To illustrate the simultaneous variations of the 13 health indicators by state, Principal Component Analysis (PCA) was carried out using the 18 states for individuals and 13 variables (IMR, stunting, under-weight, vaccination, contraceptive use, early child bearing, antenatal access, home delivery, postnatal access, early education, literacy of young women, use of improved drinking water and use of improved sanitation). Table 1 shows values of the 13 variables as collected by UNICEF through the Multiple Indicator Cluster Survey (MICS) carried out in 2014 in the 18 states of Sudan.[11]

The PCA allows to deal with all the 13 variables simultaneously. It starts giving the correlation between all the variables as indicated in Table 3. In particular, infant mortality rate is seen to have a correlation greater than 0.5 or less than -0.5 with 7 out of 12 variables and it is especially negatively highly correlated with contraception use (r=-0.64) and positively highly correlated with home delivery (r=0.62). Table 3 also shows the correlation of each variable with the other 12 variables.

Then projecting variables on the circle of correlation (Figure 2) and states on the first plan (axis F1 × axis F2) (Figure 3) allows interesting illustration (1) explicitly between variables, (2) explicitly between states and (3) implicitly between variables and states.

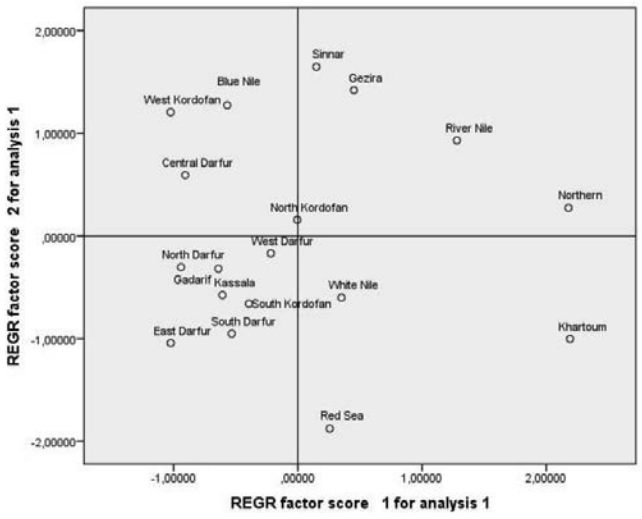


Figure 3. Projection of states on the first plan (F1xF2).

Table 2. Mean and standard deviation of 13 health indicators.

	Mean	Standard deviation
IMR	51,7389	16,53097
Stunted	39,4556	8,16969
Underweight	34,1833	6,15986
Vaccination Measles	80,5389	11,60984
contraception use	11,0111	6,89603
Early childbearing	15,8333	4,17401
Antenatal visits	50,4778	11,88294
Home delivery	71,0778	19,71749
Postnatal new born	26,9333	12,83932
Early education	21,7722	14,11832
Litercy young women	55,8167	17,82303
Use of improved water	63,6111	21,88211
Improved sanitation	36,95	24,47797

Table 3. Correlation between the 13 variables considered in PCA.

State	IMR	Stunted	Under weigh	Vaccination Measles	Contraception use	Early child bearing	Antenatal visits	Home delivery	Postnatal newborn	Early education	Litercy young women	Use of improved water	Improved sanitation
IMR	1,000	,452	,487	-,555	-,643	,250	-,294	,617	-,565	-,513	-,562	-,394	-,637
Stunted	,452	1,000	,875	-,461	-,796	,622	-,622	,720	-,806	-,776	-,754	-,542	-,732
Underweight	,487	,875	1,000	-,473	-,719	,414	-,662	,696	-,759	-,726	-,713	-,379	-,753
Vaccination Measles	-,555	-,461	-,473	1,000	,643	-,326	,411	-,591	,554	,482	,475	,497	,565
contraception use	-,643	-,796	-,719	,643	1,000	-,457	,692	-,889	,919	,841	,844	,503	,840
Early childbearing	,250	,622	,414	-,326	-,457	1,000	-,311	,518	-,461	-,603	-,559	-,404	-,442
antenatal visits	-,294	-,622	-,662	,411	,692	-,311	1,000	-,711	,788	,730	,648	,288	,706
home delivery	,617	,720	,696	-,591	-,889	,518	-,711	1,000	-,941	-,913	-,920	-,389	-,938
Postnatal new born	-,565	-,806	-,759	,554	,919	-,461	,788	-,941	1,000	,874	,908	,412	,879
Early education	-,513	-,776	-,726	,482	,841	-,603	,730	-,913	,874	1,000	,873	,303	,889
Literacy young women	-,562	-,754	-,713	,475	,844	-,559	,648	-,920	,908	,873	1,000	,348	,851
use of improved water	-,394	-,542	-,379	,497	,503	-,404	,288	-,389	,412	,303	,348	1,000	,476
Improved sanitation	-,637	-,732	-,753	,565	,840	-,442	,706	-,938	,879	,889	,851	,476	1,000

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The quality of representation depends on the percentage of information explained by each axis and is mathematically given by eigenvalues. In our case, the first plan summarizes more than 75% of information (first axis F1: 67.12% and second axis F2: 8.32%). Figure 3 shows a net opposition between a set of five variables well represented on the left-hand side and another set of eight variables also well represented on the right-hand side.

Combining the graphic illustration with data in Table 1, we can see, for example that IMR is positively correlated with stunting, under-weight, home delivery and early childbearing and negatively correlated with the remaining eight variables. This classification indicates obviously, that a strategy to reduce IMR should aim to decrease stunting, under-weight, home delivery and early childbearing and/or to enhance access to vaccination, antenatal visits, postnatal care, contraception, early education, literacy of young women, improved drinking water and sanitation.

Now, coming to the sketch of states on the first (horizontal) axis provided by PCA, we see again a display of the 18 states, with three states (Northern, Khartoum and River Nile) isolated on the right-hand side opposed to a set of four states on the left-hand side (West Kordofan, Central Darfur, North Darfur, East Darfur) while the remaining states are projected between the two previous sets. Again, combining the graphic illustration with data in Table 2, we can see that IMR has a value less than or equal to 30 in River Nile (28.1) and Northern (30) whereas its value is greater than 70 in South Kordofan (70.2), West Darfur (71.2) and East Darfur (88.5). Similar comparisons can be made for stunting, under-weight, home delivery and early childbearing as well as for the 13 remaining variables.

Additional information can be obtained by the second axis F2 but the interpretation is then conditional to the information provided by the first factor F1. For instance, we see that Sinnar and Red sea have nearly the same projection on the horizontal axis F1 but they appear opposed on the vertical axis F2 mainly due to the opposition of the two variables: use of improved water (Sinnar 88.7% vs Red sea 33.2%) and antenatal visits (at least 4 visits) (Sinnar 73.7% vs Red sea 53.4%). A similar opposition is seen on the left-hand side between Blue Nile (antenatal visits 42% and improved water 71.9%) and South Darfur (antenatal visits 40.9% and improved water 46.6%).

More importantly, the PCA offers also the opportunity for a critical analysis. For instance, Table 1 indicates that North Kordofan (35.6) has the fourth smallest IMR which is less than IMR in Khartoum (45.1) while this state is projected near zero on the first axis, far away from the group of River Nile, Northern and Khartoum. In fact, the four variables positively correlated with IMR (stunting, under-weight, home delivery and early child-bearing) all have values in North Kordofan (40.8, 32.4, 76.1 and 20.9) greater than in Khartoum (21.9, 23.2, 35.7 and 9.4) and on the other side, the remaining 13 variables negatively correlated with IMR all have values in North Kordofan (74.5, 14.7, 57.7, 31.3, 9.4, 58.8, 69.8 and 30) smaller than in Khartoum (89.7, 26.5, 81.9, 57.4, 56.2, 82.6, 86.9 and 85.4). Consequently, we can conclude that the IMR given for North Kordofan may be under estimated.

Conclusions

Using descriptive statistics, statistics for decision (Pearson's chi-squared test) and multivariate analysis (Principal Component Analysis), we have graphically illustrated and pragmatically proved that IMR in Sudan is influenced by social determinants of health like milieu (rural-urban), gender (boys-girls), education level, income (as approximated by household assets) and territorial disparity between states. In particular, our study has shown that a large gap is found between states according to the 13 variables in general and especially in term of infant mortality. As we indicated in the introduction section, if Sudan is to be really considered as a pioneer in terms of Health in All Policies, serious efforts must be devoted to reducing huge territorial disparities and unacceptable heath inequalities by acting on social determinants of health. The next Multiple Indicator Cluster Survey planned for 2020 (Sudan MICS6) could be a first test.

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