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Geographical distribution of health resources in Sudan: Is it Equitable?

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Introduction: The aim of this study is to evaluate the inequality of geographical distribution of health centers, hospitals, hospital-beds and physicians among the thirteen administrative areas that comprises the map of Sudan. It uses the Lorenz curves and the Gini coefficient. A data matrix of the thirteen administrative areas by four health resources was constructed based on the available government data of the Central Department of Statistics and Information (CDSI). This data matrix is for 22years starting from 1992 to 2013 for the health resources with the exception of the data for physicians, which is available up to 2007. To obtain the relative share of an area of each health resource, the total number of it is divided by the corresponding total population of the area. Total populations, of administrative areas, were projected using the between censuses declared growth rates. Human population calculator was used to run the projection at this website. Thus, relative shares are used instead of numbers because they provide a more realistic picture. Lorenz curves were constructed depending on excel, while Gini coefficients were calculated using an online Gini calculator. The results of this study have demonstrated that health services are geographically distributed in an equitable manner between administrative areas. Among the studied health resources, hospital-beds ranks first as the most equitably distributed resource followed by physicians. Health centers and hospitals came on the third and fourth ranks. The average Gin coefficients calculated for the period (1997 –2013) revealed values of 0.1508 for physicians;0.1854 for hospital-beds; 0.2231 for health centers and 0.2245 for Hospitals. The study showed that, according to the Lorenz curves and Gini coefficients, the four health resources are equitably distributed among the areas. This tells us that geographic distribution of health services does not stop health authorities from reaching populations wherever they are in Sudan.

Keywords: Health care resources, Inequality, Lorenz curve, Gini coefficient, health services

INTRODUCTION

Inequality in health services distribution has become a worldwide challenge among different countries where health inequality has a progressive trend. This fact has been repeated in different studies. Ameryoun, A et al. (2011) stated that inequality in distribution of health services and accessibility to such services has become a major issue in most health systems, therefore, it is vital to develop a good method of detecting inequalities in the distribution of health resources. According to him, different countries utilize different methods for such a purpose. These methods include the customer reports or policy makers' views and in some countries they use scientific and clear-cut measures to quantify health care equality. According to Horev T et al. (2004), the U.S. health sector is mostly concerned with racial or ethnical differences. Therefore, understanding the geographical distribution of health resources, patterns of accessibility to such resources, and improvement of these resources will lead to better planning to make health services accessible by all.

Objectives and Research Questions

The aim of this study is to evaluate the inequality of geographical distribution of health centers, hospitals, hospital-beds and physicians among the administrative areas that comprises the map of Sudan. It uses the Lorenz curves and the Gini coefficient.

Methods: A data matrix of the eighteen (States) administrative areas by four health resources was constructed based on the available governmental data of the Annual Health Statistical Reports, National Health Information Center, Federal Ministry of Health. This data matrix is for 18 years starting from 1994 to 2011 for the health resources. To obtain the relative share of an area of each health resource, the total number of it is divided by the corresponding total population of the area. Total populations, of administrative areas, were obtained from the same sources. Thus, relative shares are used instead of numbers because they provide a more realistic picture.

This part addresses the following research questions: First, do administrative areas receive equal relative shares

of each of the mentioned four variables? Second, are these increments result in an equitable distribution for all people in all areas? Finally, what method should be used to measure the inequality of health resources? It is worth mentioning that availability of health facilities in a geographical area implies some accession to these facilities by their population. Lorenz curve and the Gini Coefficient were used to measure health equality and resources. The Lorenz curves were constructed depending on excel, while Gini coefficients were calculated using an online Gini calculator.

MATERIALS AND METHODS

A data matrix of the eighteen states by the four health resources mentioned below was constructed based on the available governmental data of the Annual Health Statistical Reports, National Health Information Center, Federal Ministry of Health. This data matrix is for 18 years starting from 1994 to 2011 for the health resources. To obtain the relative share of an area of each health resource, the total number of, for example, health centers, is divided by the corresponding total population of the area and multiplied by k, which equals 100,000 (for all variables; health centers, hospitals, hospital beds and physicians). Looking at the absolute numbers of each area variable regardless of its corresponding population will lead to a faulty conclusion. Total populations, of administrative areas, were obtained from the same source. Thus, relative shares are used instead of numbers because they provide a more realistic picture.

To measure the inequalities of health resources, we utilize the Lorenz curve. The Lorenz curve compares the distribution of a given variable with the uniform distribution (of same variable) that represents equality. This uniform distribution is shown by a diagonal line, the perfect equality line (Thomas V et al. (2011). The farther the Lorenz curve lies from this line, the higher the inequality. In this curve, the horizontal axis (X) represents the cumulative percentage of population and the vertical axis (Y) illustrates the percentage of some value of a variable (e.g. health centers) held by the corresponding cumulative proportion of the population. In this study, the X axis demonstrates the cumulative percentage of population of Sudan states while the Y axis illustrates the cumulative percentage of a corresponding type of health resources under study (health center, hospital, hospital beds or physicians). The common usage of the Lorenz curve in the literature seems to be that for magnitudes other than income or wealth, Lorenz curves are called “Concentration Curves.” One should be mindful of it when reading that literature and not be confused by it. The Gini measure is a method used for the evaluation of the equality of distribution of health care services. This coefficient (or index) compares the cumulative frequency curve of distribution of a variable with the equal distribution of it (Le Grand J. (1985), and Wan GH (2001). This index has been used in many medical studies such as survival studies, prediction of improvement rate, the number of Primary Care Physicians, and the number of hospital beds (Horev T et al., 2004). In Lorenz curve cumulative percent of population is illustrated on horizontal axis while cumulative percent of other variable is figurate on vertical axis. The Gini coefficient is calculated as a proportion of two areas, the area of the egalitarian triangle as the denominator and the area between the Lorenz curve and the egalitarian line as the numerator (Feldstein MS. (1964)). Its mathematical formula is as follows:

$$Gini=\Sigma i=1XiYi+1-\Sigma i=1Xi+1Yi$$

In this study, X represents the cumulative percentage of the population and Y represents the cumulative percentage of health resource ratios. The Gini coefficient ranges between 0 and 1, where theoretically, zero corresponds to a perfect equality and 1 corresponds to a perfect inequality. According to Miao CX, et al. (2007), the Gini coefficient takes the following values and interpretations:

- Gini coefficient smaller than 0.2 means an absolute equality
- Values between 0.2 and 0.3 indicate a high equality
- Between 0.3 and 0.4, an inequality
- Between 0.4 and 0.6, a high inequality
- Greater than 0.6, an absolute inequality

Populations and their corresponding health facilities ratio data of all states were entered into Excel software and manipulated to generate the Lorene curve for each of the four variables. In this part of the study the researcher computed the Gini coefficient for each resource type using the online GINI calculator (http://www.peterrosenmai.com/). The focus of this part will be on assessment of the inequality of the geographical distribution of health resources in Sudan, namely ratios of health centers, hospitals, hospital-beds, and number of physicians in the eighteen states. The data of the year 2011 is used to draw the Lorenz curves and to calculate the Gini coefficients for the variables of health center, hospital, hospital-beds and physicians.

RESULTS AND DISCUSSION

Health Facilities Relative Shares by states Table (1) shows the ratios calculated for the eighteen states of Sudan.

These figures reveal the distribution of relative shares of each of the four variables (health facilities) of each of state in the year 2011. Health center shares range between 0.3 in Bahr Elghazal&19.2 in River Nileper 100,000 populations. This result portrays the persistent variations among the state. Hospital shares are has small variation it ranged between 0.38 in S. Darfur to 3.92 in Northern.

Table 1: Populations & Ratios of Health Services by Administrative Area

State	Ratios of health services				
	population	Health Centers	Hospital	Hospital Bed	Physicians
Khartoum	006,885	2.7	0.82	108.59	54.62
El Gezira	988,735	7.8	1.93	94.52	18.53
White Nile	936,609	6.3	1.55	73.01	14.20
Blue Nile	910,546	4.9	1.87	98.18	10.65
Sinnar	454,155	5.1	1.79	96.96	12.79
River Nile	229,916	19.2	2.60	157.25	26.18
Northern	764,451	13.9	3.92	236.77	24.59
Kassala	987,572	6.1	0.81	56.90	10.52
El Gadarif	573,070	3.9	1.78	98.53	11.63
Red Sea	328,446	3.2	1.20	87.02	9.79
N. Kordofan	017,033	3.0	1.03	73.62	9.21
S. Kordofan	,702,177	4.6	1.00	65.45	4.17
N. Darfur	,188,028	3.7	0.91	54.16	8.46
S. Darfur	,450,803	0.8	0.38	24.65	3.03
W. Darfur	,437,168	0.9	0.70	44.95	3.41
Greater . Equatoria	,779,942	1.3	0.58	42.81	1.65
Bahr Elghazal	,143,857	0.3	0.42	44.50	1.31
Upper Nile	,076,055	1.1	0.55	31.08	1.69
	,975,448	4.9	1.3	82.7	12.6

Disparities also exist in the number of hospital beds per 100000 populations. The relative shares range between 24.65 in S. Darfur&236.77 in Northern. The number of physicians per 100,000 populations ineach state. The shares range between 1.31 in Bahr Elghazal&54.62 in Khartoum.

The Lorenz Curves

Figure 4 depicts the Lorenz curve of health centers derived for the thirteen areas in 2011. The figures that appear on the curve points represent the corresponding cumulative percentage shares of health centers (vertical axis) that consumed by the corresponding cumulative percentage populations (horizontal axis). The first bottom right point on the curve reveals that (40.7%) of the population enjoys only (26.7%) of health centers. The second point on the row shows a much better share where (65.8%) of the population consumes only (45.9%) of the service. The gap declines as one goes up to the upper left curve points. The inequality of the distribution is exemplified by the gap between the curve and the perfect equality line.

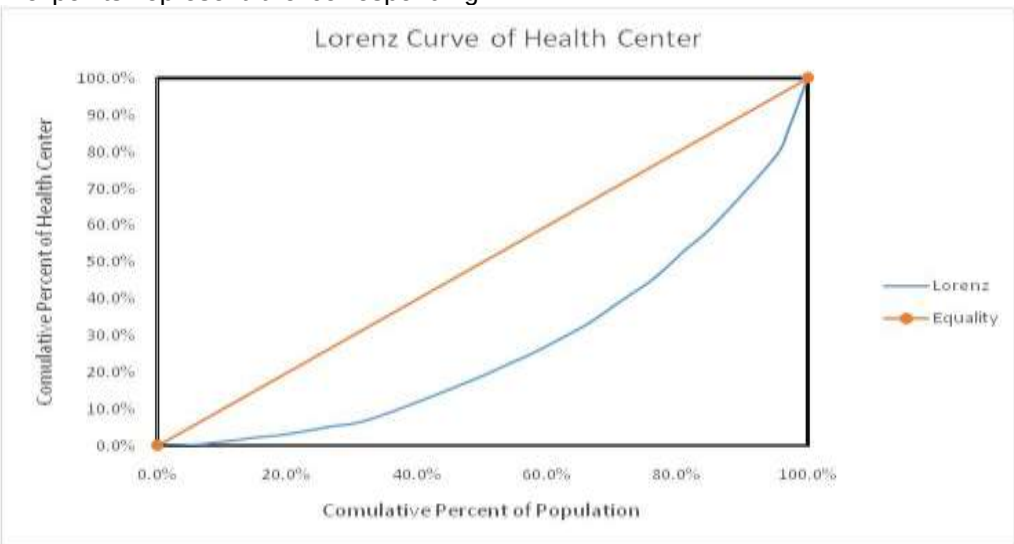

Figure 1: Lorenz curve of health center

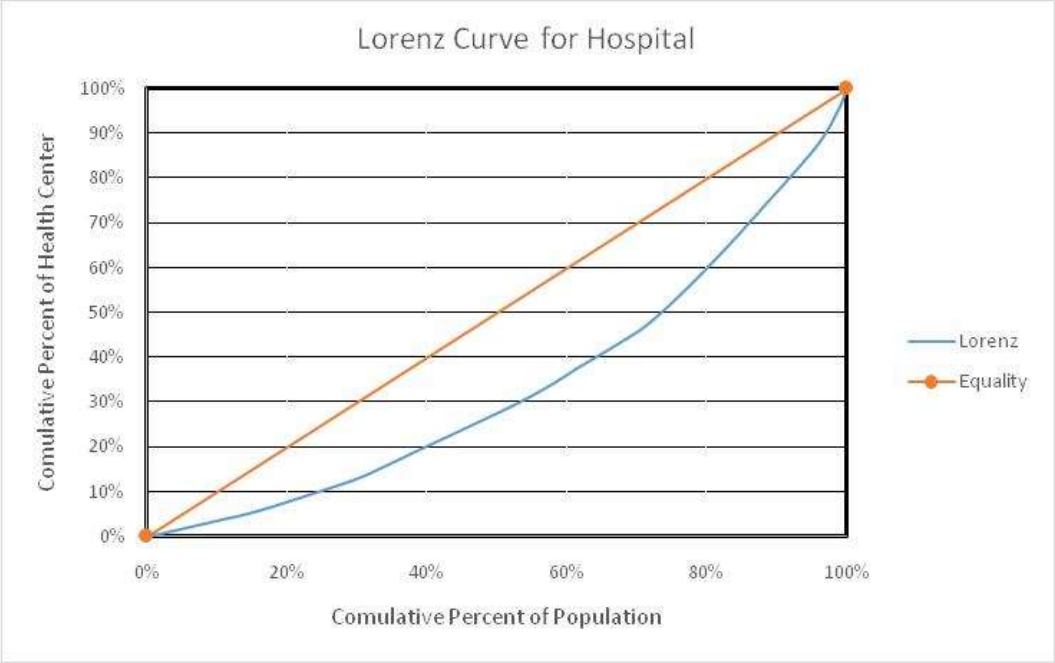

Figure 2: Lorenz curve of hospital

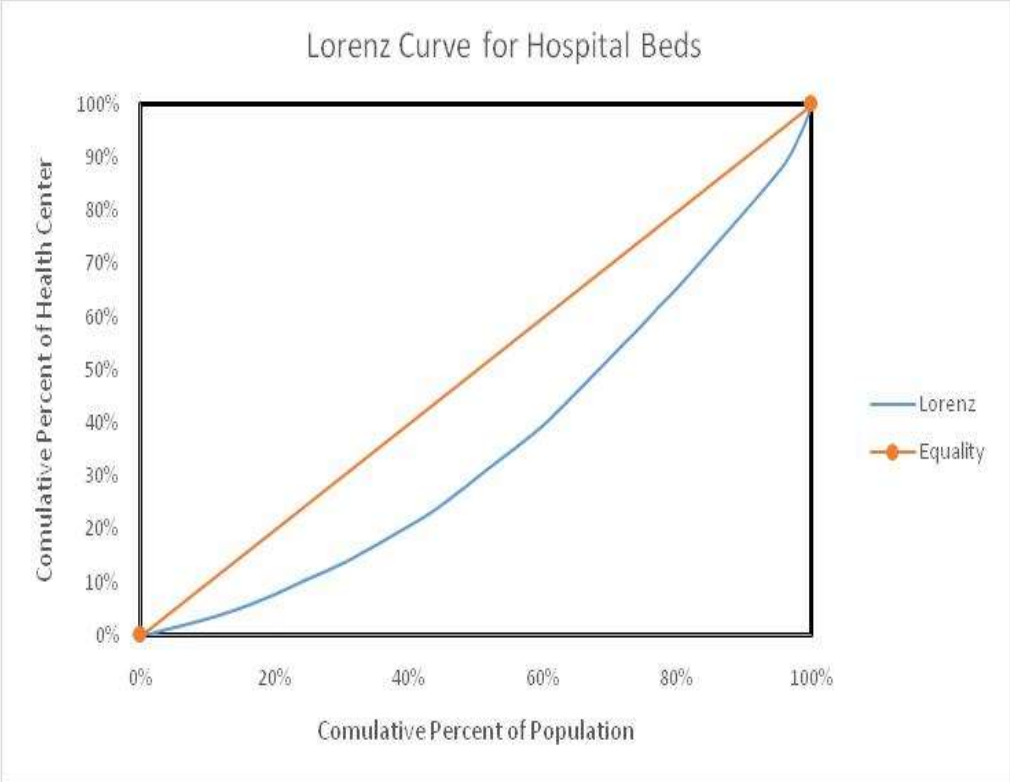

Figure 3: Lorenz curve of hospital beds

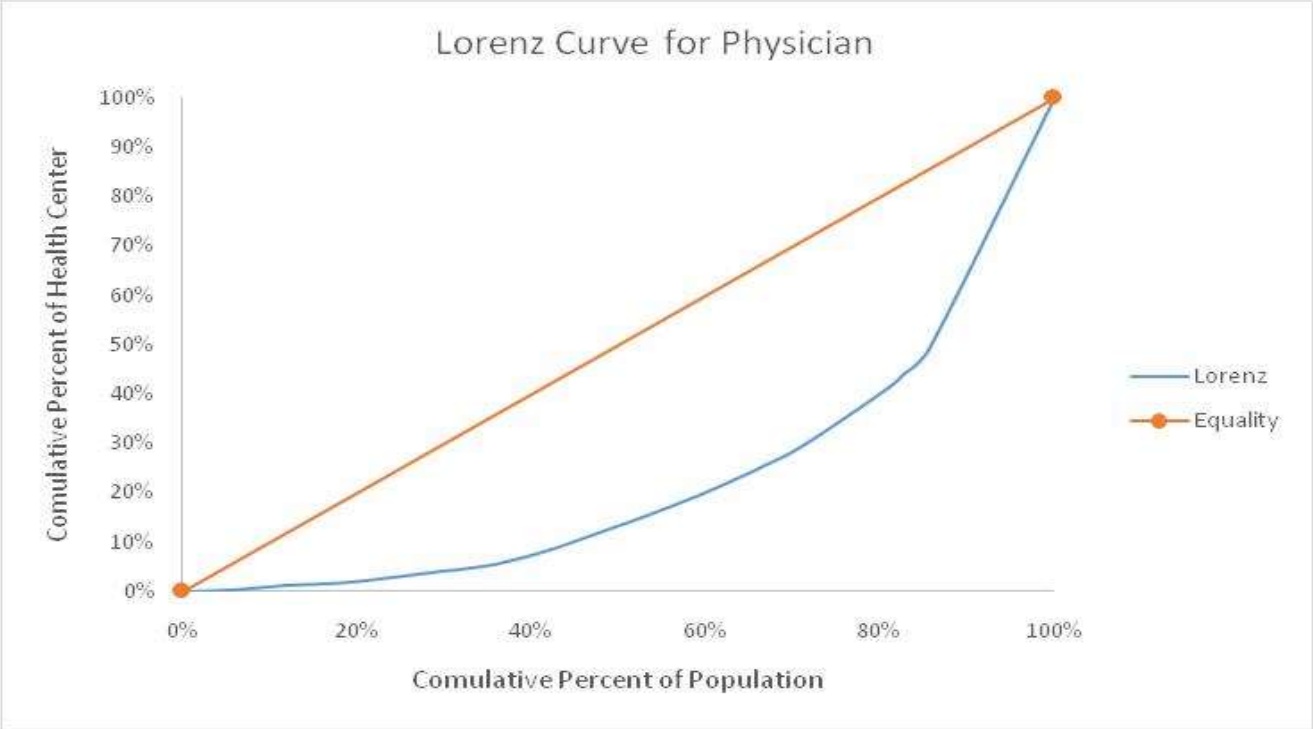

Figure 4: Lorenz curve for physician

The above interpretation applies for the remaining 4 Lorenz curves. Hospital beds and physician curves have the least and lowest gaps, respectively, between the perfect line and the Lorenz curve.

Gini Coefficient Analysis

Coefficients in Table 2 below are calculated for each health facility to explain the degree of inequality of the resource spatial distribution amongst the thirteen administrative areas in Sudan. These coefficients are calculated for each resource to check for performance over time. The time span is five years. Because data was not available, the coefficient is calculated only four times for the physicians.

Given the classification provided by Miao CX,et al. (2007), Table 2 suggests an optimistic conclusion that all distributions could be classifieds highly equal between 2000& 2004. The highest average registered for a health resource is that of hospitals (0.2245), followed by health centers(0.2231), hospital-beds (0.1854) and physicians, the lowest, (0.1508).Distributions of physicians and hospital beds, however, are clearly classified as indicative of absolute equality with their Gini coefficients smaller than 0.20. This fact could be regarded an applausive result of health policy makers and planners in Sudan. With such massive area of the Sudan (2,150,000 km2 (830,000 sq. miles)), Maintenance of such equitable distribution overtime demonstrates a high potential watchful planning that cares for equitability and accessibility of health resources.

Table 2: Gini Coefficients of Health Facilities in KSA (1992 – 2013)

Ratios	Years					Average
	2000	2001	2002	2003	2004	
Health centers	0.21855	0.222125	0.21001	0.23144	0.2335	0.2231
Hospitals	0.21220	0.20964	0.20702	0.24822	0.24532	0.22450
Hospital beds	0.17788	0.17639	0.17685	0.19925	0.19643	0.18540
Physicians	0.15869	0.17951	0.12247	0.14244	0.15080	0.15080

Figure 8 below depicts the values of the above coefficients. The objective is to compare

the trend of inequality over time. It is clear that physician health services show the least equitable distribution.

In addition, there is a trend indicative of increasing equality now and perhaps in the near

Future. The remaining three resources (hospital beds, health centers and hospitals), have upward trend lines with hospitals having the most steep trend implying a regressive future equality.

Comparing these findings with that of Hover T et al. (2004), the Gini coefficient was used in a study in the U.S. in 1998 to measure the distribution of hospital beds. The findings showed coefficients of 0.0571–0.4303 in different states. The 1970–1997 trend indicated progressive equality in the distribution

This study is significant in the sense that it assesses inequality of geographical distribution of individual in Sudan. However, it must be noted that, this study is based on cross-sectional data and conducted with data spanning from the year 1992 to 2013. Furthermore, the distribution of the selected four health facilities is evaluated to measure inequality between administrative areas in certain years with a gap of five years. Of hospital beds. The northern states have been reported to enjoy an equal distribution of hospital beds.

Although the obtained Gini coefficients in our study are representative of equality distribution of these resources throughout the country, the equitability of geographical distribution of each resource may be different within various administrative areas if these coefficients are calculated for provinces (lower administrative areas) within each administrative area.

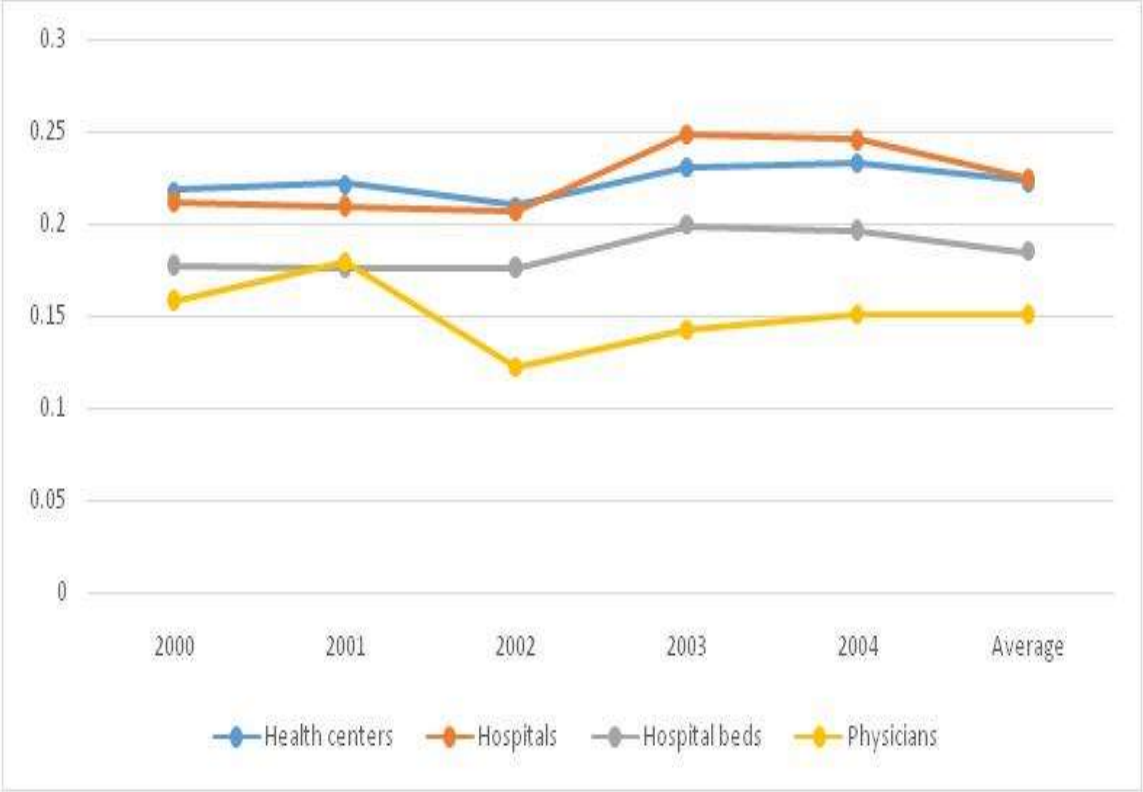

Figure5:Trend of Inequality (2000-2004)

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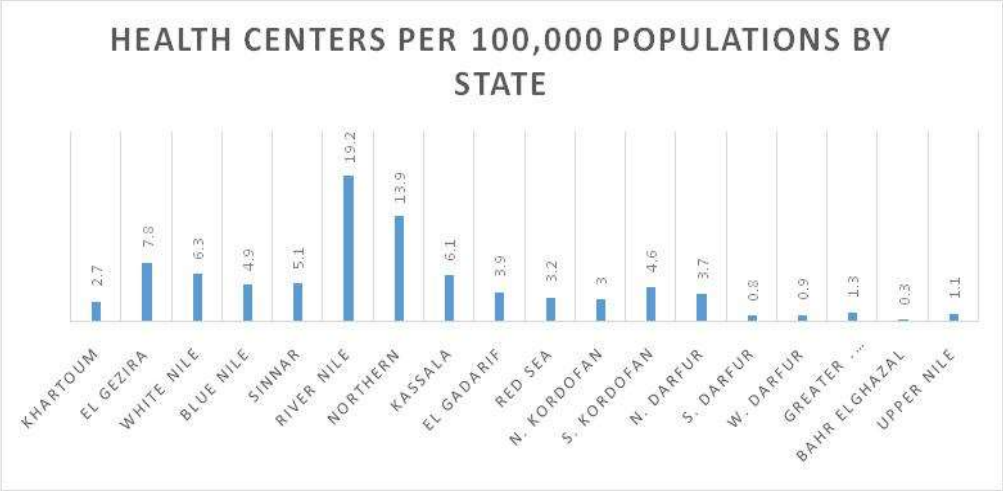

Figure 6:health centre per 1000,000 population by state.

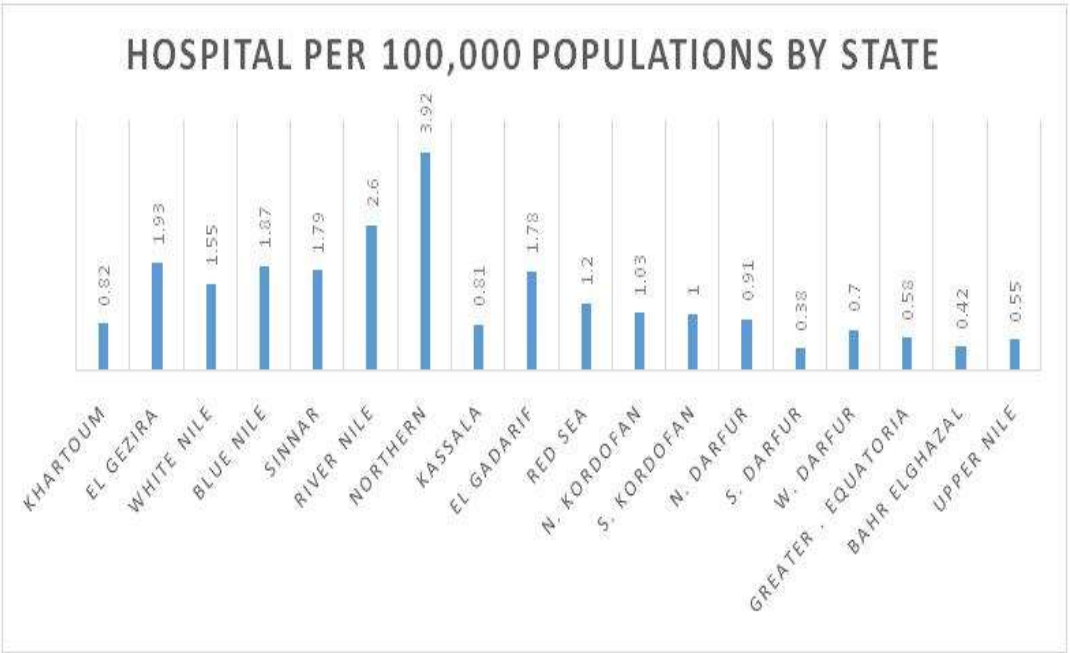

Figure 7:hospital per 1000,000 population by state.

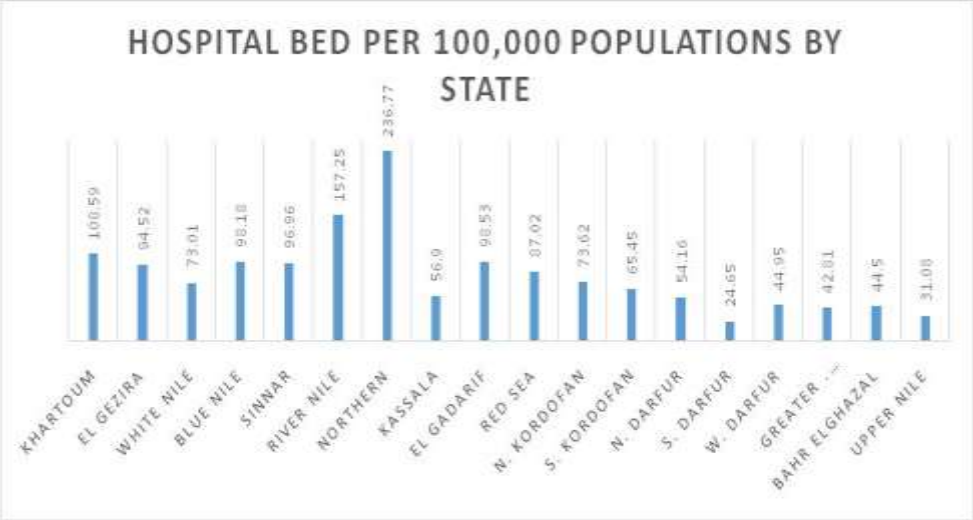

Figure 8:hospital beds per 1000,000 population by state.

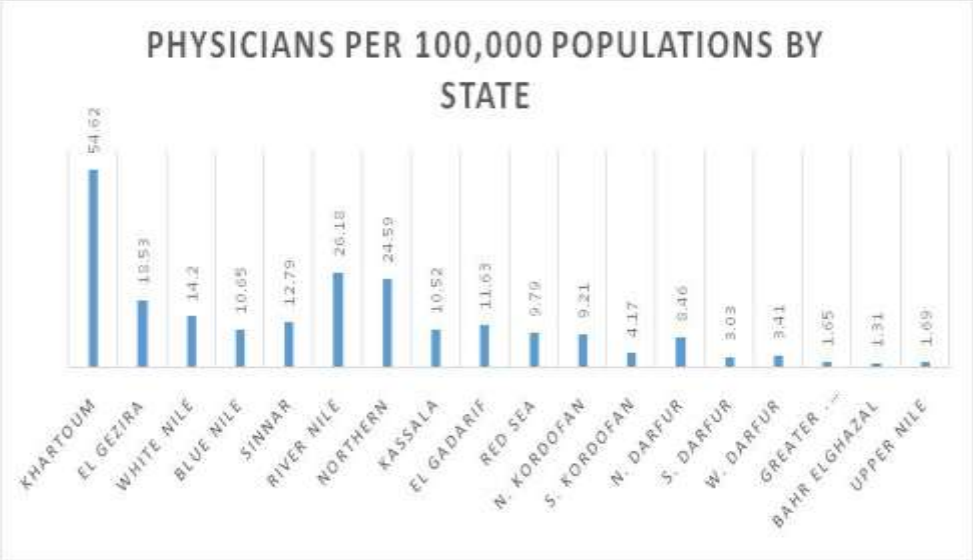

Figure 9: physician per 1000,000 population by state.

CONCLUSION

The findings of this study can be used by managers and policy makers of healthcare system in Sudan for planning to reduce inequality in distribution of health care services. It helps in enhancing of allocation of health facilities across areas. Such studies should be conducted on a regular basis to assess progress in equality of distribution of health facilities. The use of the Lorenz curve and the Gini coefficient will lead to a better understanding of current health resources and thus, improvement of the quality of health services. The measure of inequality in the distribution of the health facilities and or resources may depend strongly on the underlying measure of health care needs. In cases of anon-uniform distribution of health care needs across geographical areas, measures other than population levels may have to be developed in order to ensure a more meaningful measurement of distributional inequalities of health services.

The results of this study have demonstrated that health services are geographically distributed inan equitable manner. However, it is important to monitor these trends in the future. Use of other health resources such as total health workforce and the use of smaller geographic areas in future studies may lead to more accurate indicators of health resource distributions that help planners and policy makers allocated these services more

Optimally. Also, demographic characteristics can distribution. In their conclusive statement of their research, JIN, Jian et al. (2015) mentioned that equality of China's

demographically assessed distribution of health care resources is greater than that of its geographically measured distribution. Coefficients expressed by population imply there

is ready access to healthcare in all regions, whilst the Coefficients by geographical area apparently indicate inequality. This evidence should motivate researchers not to confine their studies on geographical areas but to look for other attributes such as ethnicities, nationalities, population densities and other grouping attributes.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

AUTHOR CONTRIBUTIONS

All authors contributed equally in this research

REFERENCES

Barros, Pedro (1998) "The Black Box of Health Care Expenditure Growth Determinants." Health Economics 7, 533 – 544. 1998.

Central Bureau of Statistics (CBS) (2009), 5th Sudan Population and Housing Census (2008), 26th April 2009

Elias Mossialos and Julian Le Grand "Health Care and Cost Containment in the European Union (European Political Economy)". Ashgate Pub Ltd; 1 edition (February 1999)

Hansen, Paul and King, Alan (1996) "The determinants of health care expenditure: A co integration approach." Journal of Health Economics 15 127 – 137. 1996.

Herwartz, Helmut and Theilen, Bernd (2003) "The determinants of health care expenditure: testing pooling restrictions in small samples." Health Economics 12, 113 – 124. 2003.

Matteo, Livio Di (2003) "The macro determinants of health expenditures in the United States and Canada: assessing the impact of income, age distribution and time." Health Policy 71 23 – 42. 2003.

Newhouse, Joseph (1977) "Medical-Care Expenditure: A Cross-National Survey." The Journal of Human Resources, Vol. 12, No. 1 pp. 115 – 125. Winter, 1977.

Sen, & Anindya (2005) "Is Health Care a Luxury? New Evidence from OECD Data." International Journal of Health Care Finance and Economics, Vol. 5 No. 2 pp. 147 - 164. June 2005.

World Health Organization (WHO), Countries, Sudan www.who.int/countries/sd/en/

World Health Organization (WHO), National Health Account database, http://apps.who.int/nha/database/DataExplorerRegime.aspx