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Article

Spatio-temporal patterns of under 5 mortality in Nigeria

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1. Introduction

In spite of remarkable reductions in under 5 mortality rates (U5MRs), 5.6 million children still die every year worldwide before their fifth birthday (i.e. about 15,000 under 5 deaths everyday). These deaths are largely concentrated in developing regions which have the highest under 5 mortality rates (45 deaths per 1000 live births respectively) compared to developed regions (6 deaths per 1000 live births respectively). Over the years, Sub Saharan Africa has consistently had the highest rate of under 5 deaths worldwide. In 2016, 2.8 million under 5 deaths (79 deaths per 1000 live births) occurred in this region alone. In addition, the proportion of global under 5 deaths occurring in this region increased from 30.1% in 1990 to almost half (49.2%) in 2016 (UN-IGME, 2017). Nigeria in particular, has the second highest absolute number of under 5 deaths (733,000) after India (1.1 million) and one of the highest U5MRs (104 deaths per 1000 live births) after Mali (111), Sierra Leone (114), Central African Republic (124), Chad (127) and Somalia (137) (UN-IGME, 2017).

A significant number of studies have been carried out on under 5 mortality in Nigeria such as studies by Caldwell and McDonald,1982; Ojikutu, 2008; Antai, 2011; Bamgboye, Clement, Adejuwolo, & Duro, 2012; Kayode, Adekanmbi, & Uthman, 2012; Akinyemi, Bamgboye, & Ayeni, 2013; Izugbara, 2014; Abu, Madu, & Ajaero, 2015; Chuckwu and Okonkwo, 2015; Ezeh, Agho, Dibley, Hall, & Page, 2015 Bako, Maiwada, Abubakar, & Akwo, 2016; Adebowale (2017); Adewemimo et al. (2017) among others. However, these studies are largely determinant studies focused on investigating differentials in and risk factors of under 5 mortality without statistically assessing spatial/geographical patterns of under 5 mortality while the few studies that have done so did not examine spatial clustering across states in Nigeria over time (Adebayo, Fahrmeir, & Klasen, 2004; Uthman, Aiyedun, & Yahaya, 2012). Nevertheless, spatial pattern analysis is fundamental to understanding and tackling the problem of under 5 mortality. The basis of spatial analysis is the theory that "everything is related to everything else but near things are more related than distant things" (Tobler, 1970). This phenomenon is referred to as spatial autocorrelation. U5MRs, like any other variable, vary over space. Hence, examining the distribution and extent to which mortality rates are spatially correlated helps to incorporate the impact of geographical/spatial effects into the assessment of under 5 mortality. Information that under 5 mortality may be concentrated in an area over time is crucial to evaluating the effectiveness/impact of child interventions/programs and in identifying high priority areas for future health planning. It can also help provide better insight into possible causes and processes linked to child mortality over space. The main aim of this study was therefore to examine the spatio-temporal patterns of under 5 mortality rates across states in Nigeria using statistical analysis and spatial autocorrelation measures. The objective was to answer a key question: what is the spatial pattern of under 5 mortality in Nigeria and has the pattern changed significantly over time.

2. Materials and methods

2.1. Study area

Nigeria lies between latitude 4° and 14° North of the Equator and longitude 3° and 15° East of the Greenwich Meridian and has a total land area of 923.768 km^2 (Fig. 1). Nigeria is the most populated country in Africa and 7th most populated country worldwide with an estimated population size of 190 million. Nigeria is a middle income country with more than 250 ethnic groups.

2.2. Study design

This study is both a descriptive and quantitative study based on secondary data from two sources: (1) The 2003, 2008 and 2013 Nigeria Demographic and Health Survey (NDHS) carried out by the National Population Commission (NPC) in collaboration with the United States Agency for International Development (USAID) and Macro International Calverton MD, USA. (2) The Institute of Health Metrics and Evaluation (IHME) open source database.

2.3. Sampling technique and data collection

Each Demographic and Health Survey adopted a two-stage stratified sampling technique based on the NPC sampling frame designed to collect data at the national, zonal, state and rural-urban levels during previous censuses. The first stage involved a stratification process

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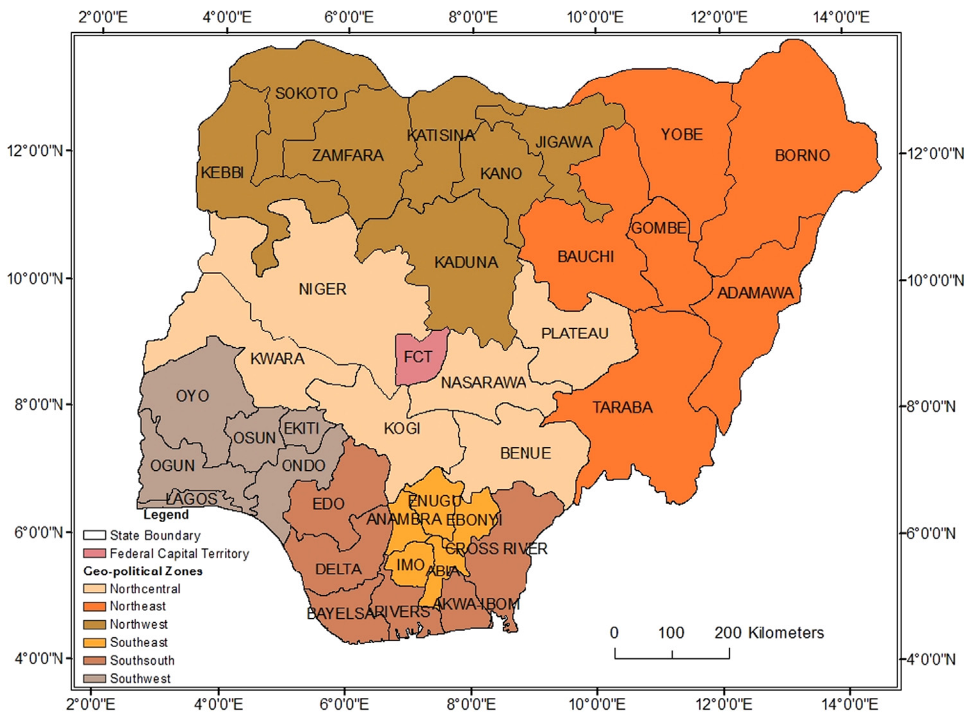

Fig. 1. Map of study area.

whereby clusters or Enumeration Areas (EAs) were selected with probability proportional to population size. The second stage involved the systematic sampling of households in each selected cluster. Representative samples of 7864 households, 36,800 households and 40,680 households were selected in the 2003, 2008 and 2013 surveys respectively. In each survey, data was collected on the sex, month and year of birth, number of births, survival status of all births, current age (if the child is alive) and age at death (if the child is dead) from women aged 15–49 for the five years prior to the survey. Data was also collected on anthropometric indicators, fertility, health care, household assets among others. Further details about the sampling technique can be obtained from individual NDHS reports available on www.measuredhs.com. State U5MRs (defined as the number of deaths before the age of 5 reported by women aged 15–49 years divided by the total number of births) was directly derived from data on birth histories for the 5 years preceding the 2003 NDHS (1999–2003), 2008 NDHS (2004–2008) and 2013 NDHS (2009–2013) covering a 15 year period. NDHS sample weights were applied.

Data was also obtained from the Institute for Health Metrics and Evaluation (IHME) launched in June, 2007 at the University of Washington, Seattle. The research institute runs the well known Global Health Data Exchange (GHDx) catalog which provides free access to health related and demographic datasets. State level U5MRs for Nigeria were derived by IHME researchers for each year from 2000–2013 by synthesizing data from multiple sources. First of all, one-year summary and complete birth history data were extracted from multiple surveys and sources such as the Demographic and Health Survey (DHS), Multiple Indicator Cluster Survey (MICS) and Malaria Indicator Survey (MIS) to estimate source year specific probabilities of death before the age of 5 years. Under 5 mortality for each year was then modeled by applying a one-knot natural spline model. Further details are available on www.healthdata.org.

Both data sources rely on complete birth histories. However, they still differ with regards to how they were collected and processed. The rationale for the choice of both data sources in this study was therefore not to evaluate and compare their data collection and processing/estimation methods but to see the differences and similarities in the spatial patterns of under 5 mortality generated by the two types of data - one at 5 year intervals and the other annual. This could help identify which dataset might be more useful for decision making purposes as Nigeria plans towards achieving the Sustainable Development Goal (SDG) 3.2 target of 25 or fewer under 5 deaths per 1,000 live births by 2030.

2.4. Ethical consideration

Ethical approval and permission to use the 2003, 2008 and 2013 NDHS datasets was obtained from the ethics committee of the USAID/ICF Macro international at Calverton, Maryland USA in conjunction with the ethics committee of the Federal Ministry of Health, Nigeria. Both oral and written informed consent was obtained from each respondent before the questionnaire was administered and all information was collected confidentially.

2.5. Techniques of analysis

1) Statistical analysis and mapping
Descriptive statistics and choropleth maps were used to summarise and examine variations in under 5 mortality nationally and across states.
2) Spatial Pattern Analysis

a) Global Moran's Index
The Global Moran's Index was used to investigate whether or not there was a pattern of overall clustering in U5MRs over space. Moran's I varies from -1 through 0 to +1 such that a Moran's I of +1 indicates a high positive spatial autocorrelation (clustering), 0 indicates no spatial autocorrelation (random pattern) and -1 indicates a high negative spatial autocorrelation (dispersion). When z scores are between -1.96 and +1.96 then a p value larger than 0.05 means the pattern is random. On the other hand, a p value less than the confidence level indicates a statistically significant spatial autocorrelation. Global Moran's I is expressed as:

$$I = \frac{N\sum_{i=1}^{n}\sum_{j=1}^{n} wij(Xi-\bar{X})(Xj-\bar{X})}{(\sum_{i=1}^{n}\sum_{j=1}^{n} wij)\sum_{i=1}^{n}(Xi-\bar{X})^2}$$