Spatial Analysis of Under-five Mortality Clustering in Northern Nigeria: Findings from Nahuche Health and Demographic Surveillance System, Zamfara State

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Introduction

Undoubtedly, under-five mortality remains generally high worldwide. For example in 2013, over 6 million under-five deaths were recorded globally (UNICEF, 2014). There is a wide variation between the developed and the developing countries in terms of their contribution to the global under-five mortality burden. Under-five mortality rates are generally worse for the sub-Saharan African countries compared to other parts of the world. Under-five mortality rate in Nigeria is among the world's highest with northern Nigeria having the most appalling under-five health indicators. Despite the streams of publications and knowledge on determinants of under-five mortality in Nigeria, the current trend in under-five mortality in Nigeria does not justify the much available knowledge on the topic. One area that has often been neglected in the study on under-five mortality in Nigeria in particular is related to under-five mortality clustering.

Under-five mortality clustering is simply defined as the variability in the spread of under-five mortality in a population. It explores why under-five mortality is clustered within certain individuals, families or communities. Worldwide, child deaths are unevenly distributed among women (Vandezande, Moreels and Matthijs, 2010). Child deaths tend to concentrate in some families and among few women with certain characteristics. This aspect of under-five mortality study is relatively new in Nigeria hence, under-researched. The first of such study in Nigeria was carried out almost two decades ago in Kano State and just recently, in three northern Nigeria States of Yobe, Katsina and Zamfara (Klouda and Adamu, 2013). Generally, there is dearth of literature on under-five mortality clustering in Nigeria and application of spatial analysis in understanding the under-five mortality clustering is non-existence to the best of our knowledge.

In all the settings where clustering of child mortality is evident, it is usually a case of a few women/families/households responsible for most deaths (Brandstrom, 1988; Das Gupta, 1990). The intriguing findings of most of the studies (Sastry, 1997; Vandezande et al., 2010) is the fact that while few families and women are responsible for the most deaths occurring, a large proportion of women and families do not experience a single under-five death in the same setting. For instance, 65 percent of women in three northern States of Yobe, Jigawa, and Zamfara never experienced infant death while 20 percent of the women had 80 percent of all child deaths (Klouda and Adamu, 2013). Further, under-five mortality clustering as observed in most of the studies (Sastry, 1997; Vandezande et al. 2010) occurred where there is high under-five mortality rate. Also, clustering of under-five mortality is common in settings where there is male dominance and observance of gender separation, especially of women of child bearing age.

Northern Nigeria generally, and north-west geo-political zone of Nigeria provides a good study setting to understand the concept of mortality clustering and findings from the study may be used to explain the high under-five mortality regime in northern States in particular and Nigeria as a whole. Northern Nigeria is a region with most worrisome health indicators especially child health indicators. For instance, only 21% of pregnant women in north-west Nigeria received antenatal care during their last pregnancy and the child mortality rate was estimated at 246 per 1,000 live births in 2008 (Alabi, et al 2014). The educational attainments in the Northern States of Nigeria are among the lowest in the country with Zamfara State having 86.3% of women and 51.9% of men with no education and average household size generally larger, ranging from seven and above (NPC and ICF International, 2014).

The use of geographic information systems to support public health systems is already spreading across the world, Nigeria inclusive. This is because the importance of spatial assessment and map view to health analysis and planning cannot be over emphasized. Maps give better interpretation to health phenomenon and presents to health officers' alternatives through which proper intervention activities can be carried out. Simply by seeing the location of health incidence, facilities and infrastructure that are located around it and the location of households that are affected, more insight can be gained into the magnitude of the effect of the incidence. However, studies on spatial analysis of under-five mortality clustering are limited in resource

constrained countries thereby limiting opportunities for deploying effective and appropriate health interventions.

This aspect of under-five mortality study is relatively new in Nigeria hence, under-researched. As the deadline to the Millennium Development Goals approaches and within the context of global interest in reducing under-five mortality and huge efforts at achieving this, this study intended to examine spatial analysis of under-five mortality clustering in northern Nigeria State of Zamfara.

Data and Research Methods

Study Area

Located in Zamfara State of northwest Nigeria, the Nahuche Health and Demographic Surveillance System (Nahuche HDSS) tracks longitudinal health and demographic changes to geographically defined community with a surveillance population of 142,127 as of December 2013. The surveillance area is made up of six districts of Bella, Gada, Karakai, Nahuche Keku, Nahuche Ubandawaki, and Rawayya. Nahuche HDSS was implemented in 2009 by the PRRINN-MNCH[1] Programme and Zamfara State Ministry of Health with funding from UKaid (Department for International Development) and the Norwegian Government. Nahuche HDSS was set up in order to support studies aimed at assessing the wider progress and impact of strengthening health systems (Doctor et al. 2012). Nahuche area has substandard infrastructure, non-existent power supply, and poor road network. Further, economic and health indicators are poor, with birth deliveries often occurring at home without a skilled birth attendant (Doctor, et al. 2011).

Data and Methods

The study uses health and demographic events data (i.e. births, deaths, migration, verbal autopsy on all deaths, pregnancy termination, and marriage) including geographic coordinates of all compounds within the surveillance area. Nahuche HDSS data are collected once in every six months to update the database. This process precedes a baseline census that was conducted in

[1]Partnership for Reviving Routine Immunization in Northern Nigeria; Maternal Newborn and Child Health Programme.

2010. For the purpose of this study, mortality and fertility data for all children aged 0-59 months were obtained from the Nahuche HDSS database. Compound level clustering was assessed by adopting Kuate-Defo and Dialo (2002) methodology of classifying compounds according to the number of under-five deaths reported per compound: (i) ‘‘no concentration’’ comprises the selected family in the sample whose children have all survived; (ii) ‘‘low concentration’’ includes families who have lost less than 20% of their children; (iii) ‘‘medium concentration’’ families have lost 20–59% of their children, and (iv) ‘‘high concentration’’ contains those families who have lost 60% or more of their children. This study thus measured the proportion of under-five deaths per compound and divided compounds according to Kuate-Defo and Diallo model. The justification for using compound as the unit of analysis was as a result of the living pattern in a typical rural northern Nigeria setting. Residents live together in a compound which consists of one or more households. Residents of a compound are blood relations and thus a household is not clearly defined in such setting.

Geographic coordinates of all the registered compounds within the HDSS were collected through the eTrex Garmin GIS machines by trained field workers at 3m degree of accuracy. Coordinates of compounds within each of the districts were processed using ArcGIS software. Compounds were grouped based on the proportion of under-five deaths reported during the survey year and maps generated to show areas within the DSA with high risk of under-five mortality clustering.

Results

A total of 4,153 under-five deaths were reported between 2011 and 2013 but 3,163 under-five deaths (about 76.2%) were used in plotting the map of high risk area. The difference was due to inability to collect GIS coordinates of some of the compounds due to insecurity in some of the areas under the surveillance. The insecurity was mostly cases of armed robbers and cattle rustlers. The distribution of deaths by district is presented in Table 1 with the lowest number of under-five deaths observed in Nahuche Keku (371) and the highest in Gada district (740).

Table 1: Percent distribution of under-five deaths by district, Nahuche HDSS 2011-2013

District	Number of under-five deaths	Percent
Bela	590	18.7
Gada	740	23.4
Karrakai	460	14.5
Nahuche Keku	371	11.7
Nahuche Ubandawaki	581	18.4
Rawayya	421	13.3
Total	**3,163**	**100.0**

Figure 1 shows the composite map of the surveillance area with boundaries of each of the districts from the geo-coordinate points collected. Nahuche-Keku and Bela were two districts with two different boundaries. These districts had villages that were far from the center of the main districts possibly due to a significant proportion of Fulani settlers and largely cattle herders. It should however be noted that the boundary depicted in Figure 1 is not administrative boundary. Figures 2 to 7 display the mapping of the six districts under the Demographic Surveillance Area (DSA) for under-five mortality clustering. Areas shaded "pink" were areas with "no concentration". That is, compounds within these areas did not experience under-five death clustering. "Green" shaded areas were compounds where less than 20% of their under-five children had died. Compounds in areas shaded with "blue" had lost between 20% and 59% of their under-five children. The compounds in regions shaded in "red" has lost at least 60% of their under-five children.

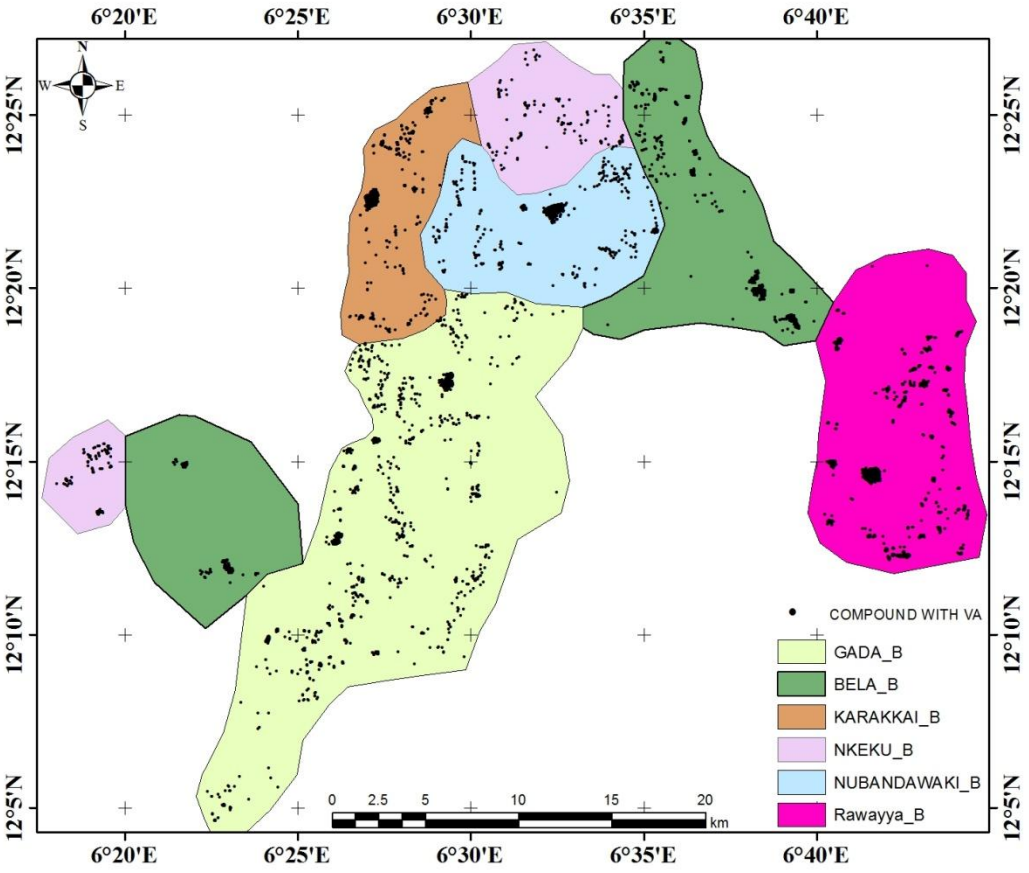

Figure 1: Composite map of Nahuche HDSS. **Note**: Boundaries shown are not administrative boundaries

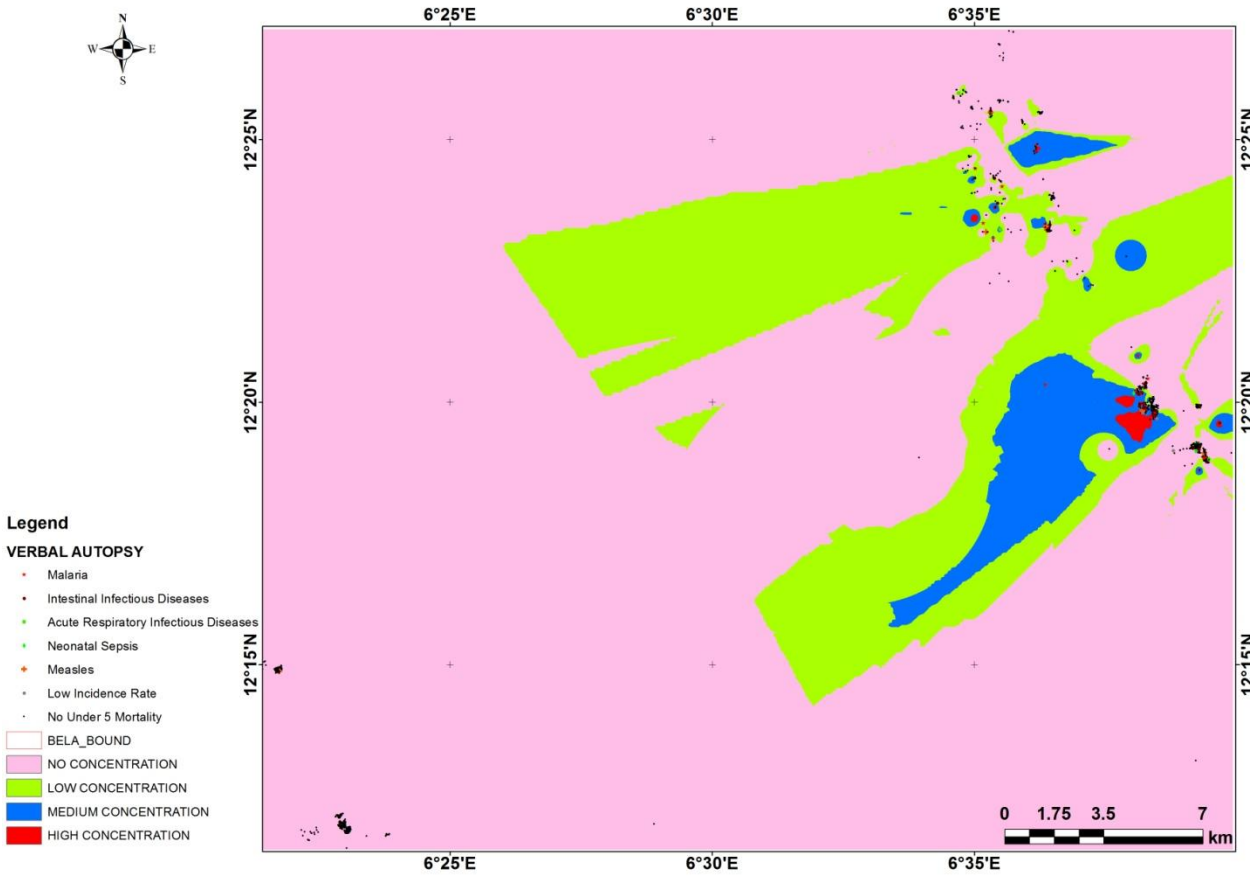

Figure 2: Map of compounds in Bela District showing areas of under-five mortality clustering, Nahuche HDSS

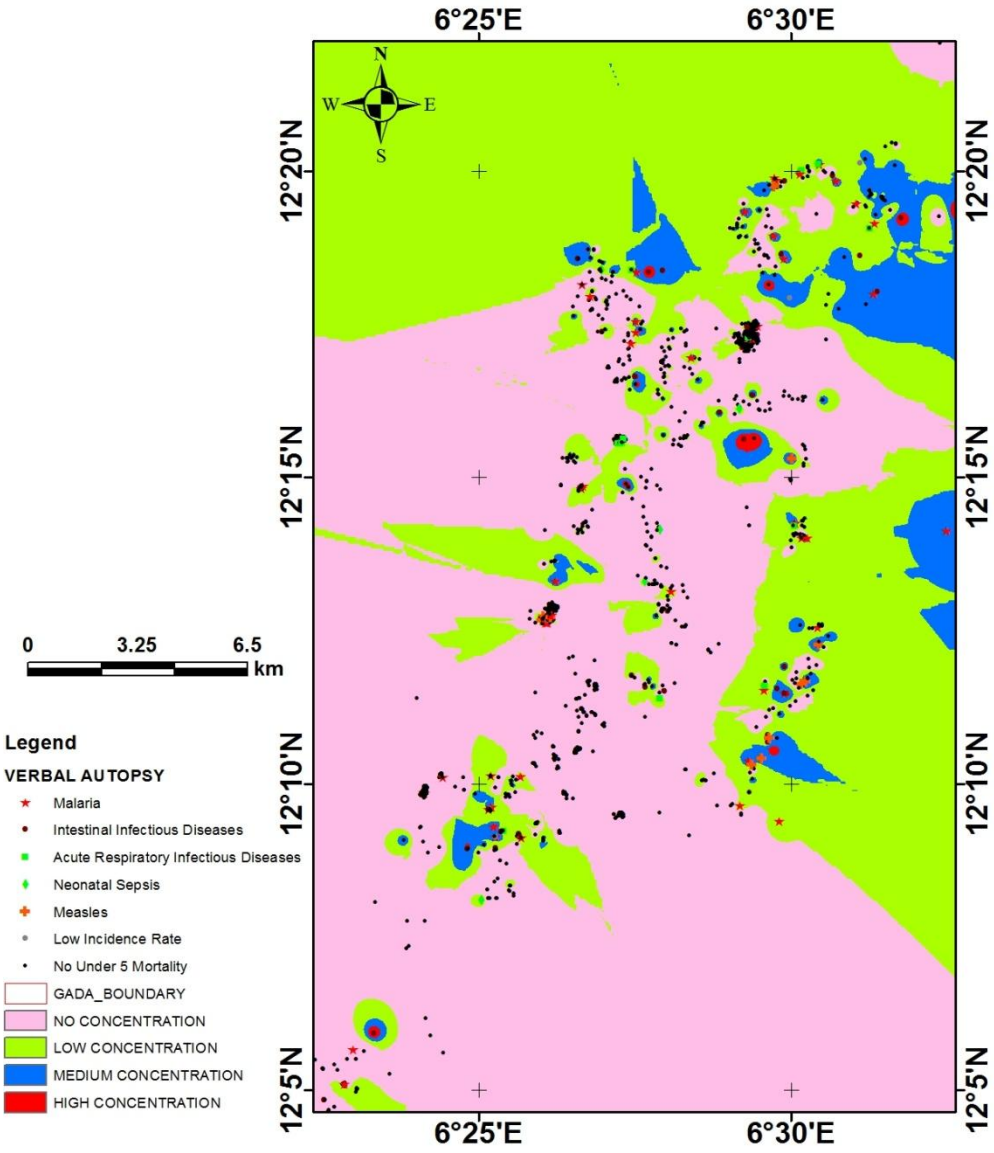

Figure3: Map of compounds in Gada District showing areas of under-five mortality clustering, Nahuche HDSS

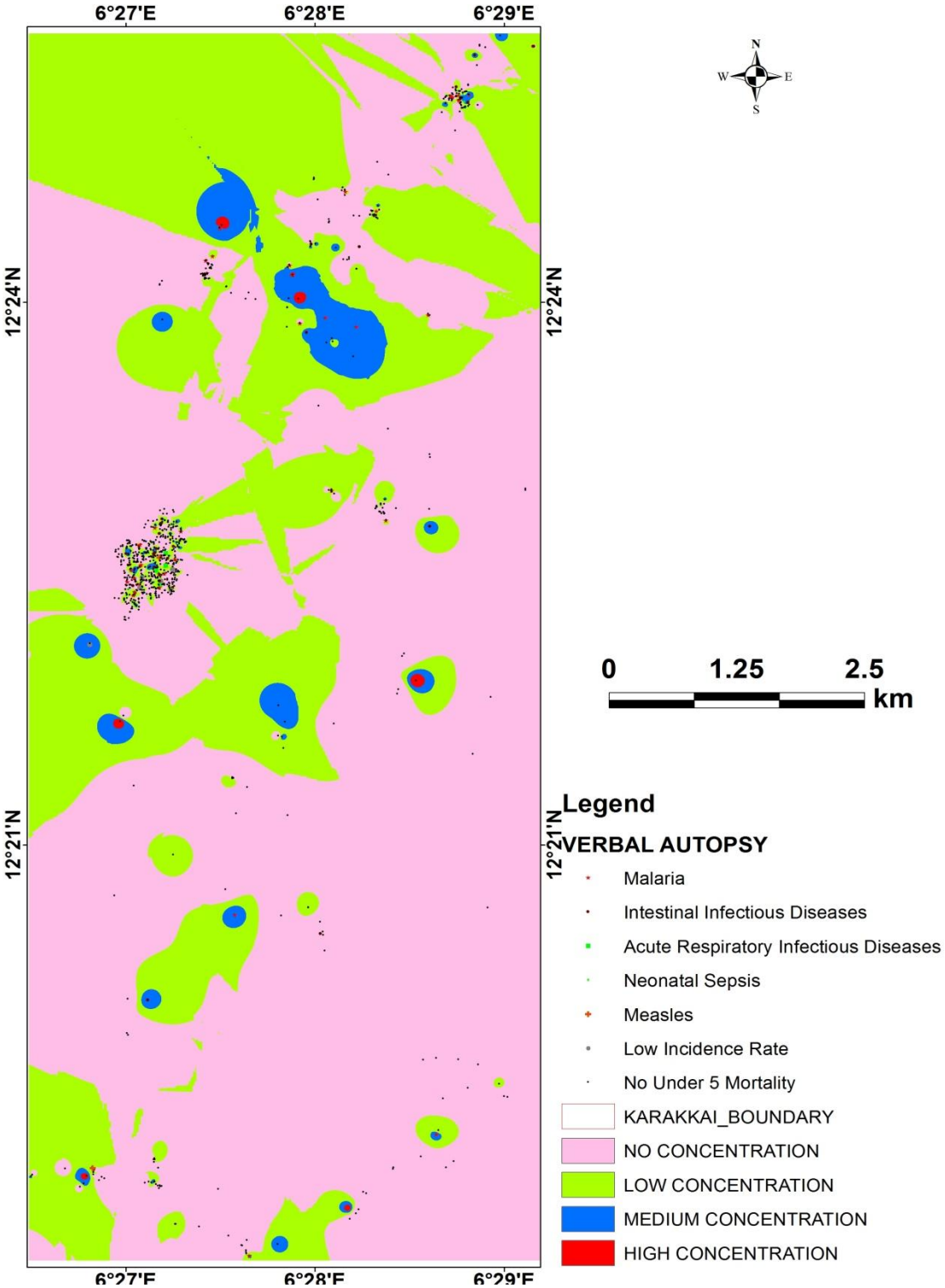

Figure 4: Map of compounds in Karrakai District showing areas of under-five mortality clustering, Nahuche HDSS

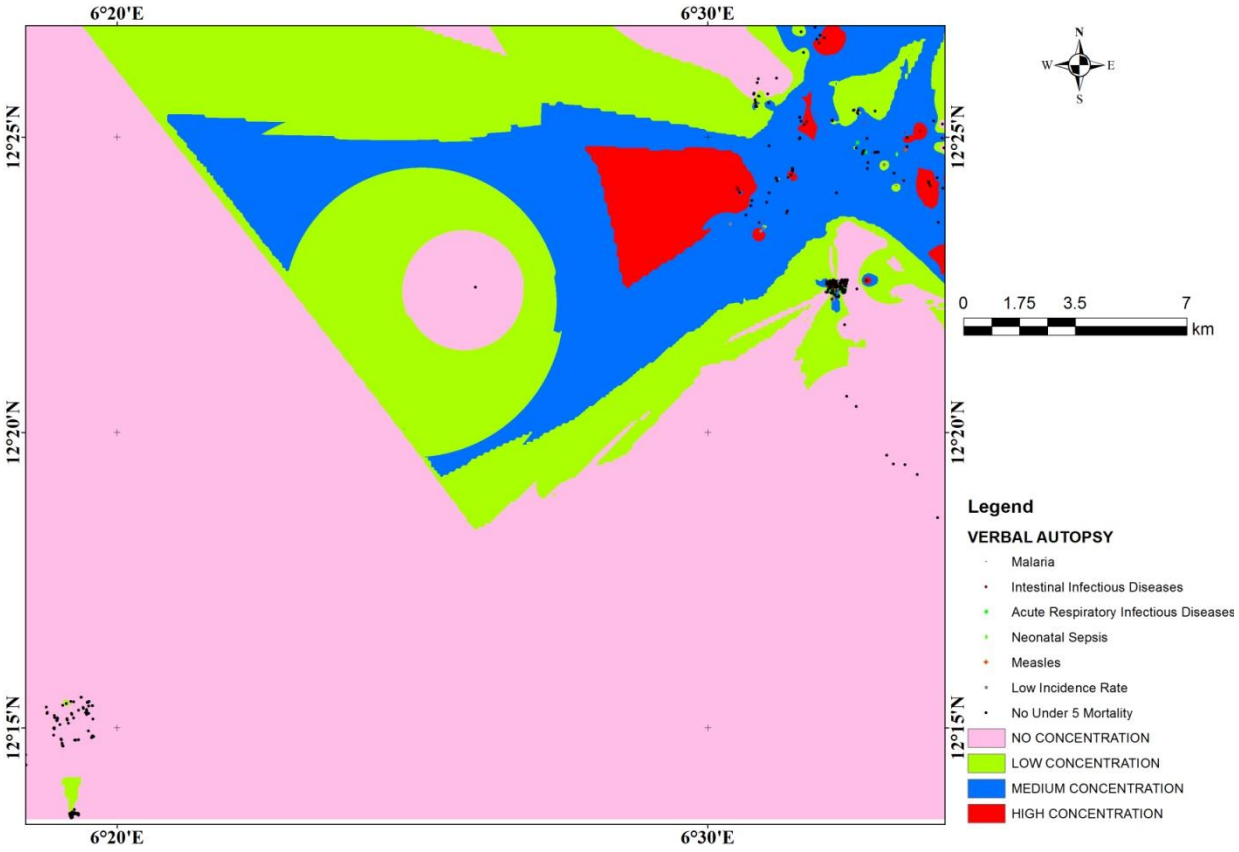

Figure 5: Map of compounds in Nahuche-keku District showing areas of under-five mortality clustering, Nahuche HDSS

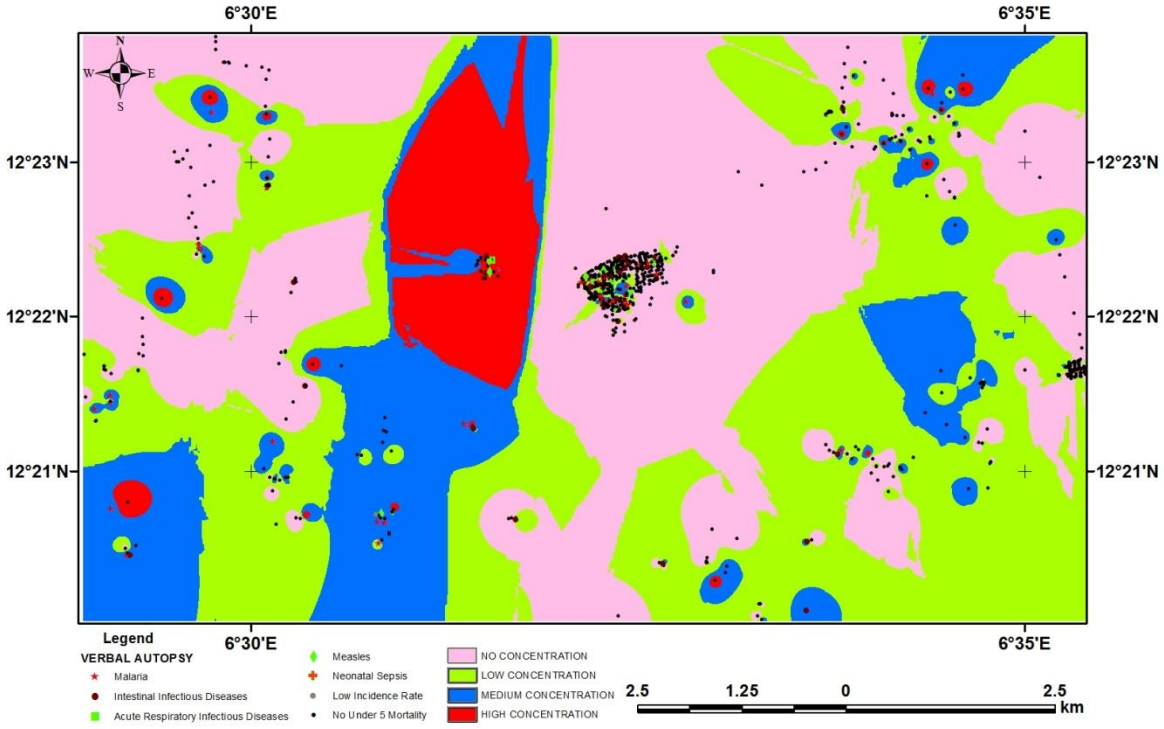

Figure 6: Map of compounds in Nahuche-Ubandawaki District showing areas of under-five mortality clustering, Nahuche HDSS

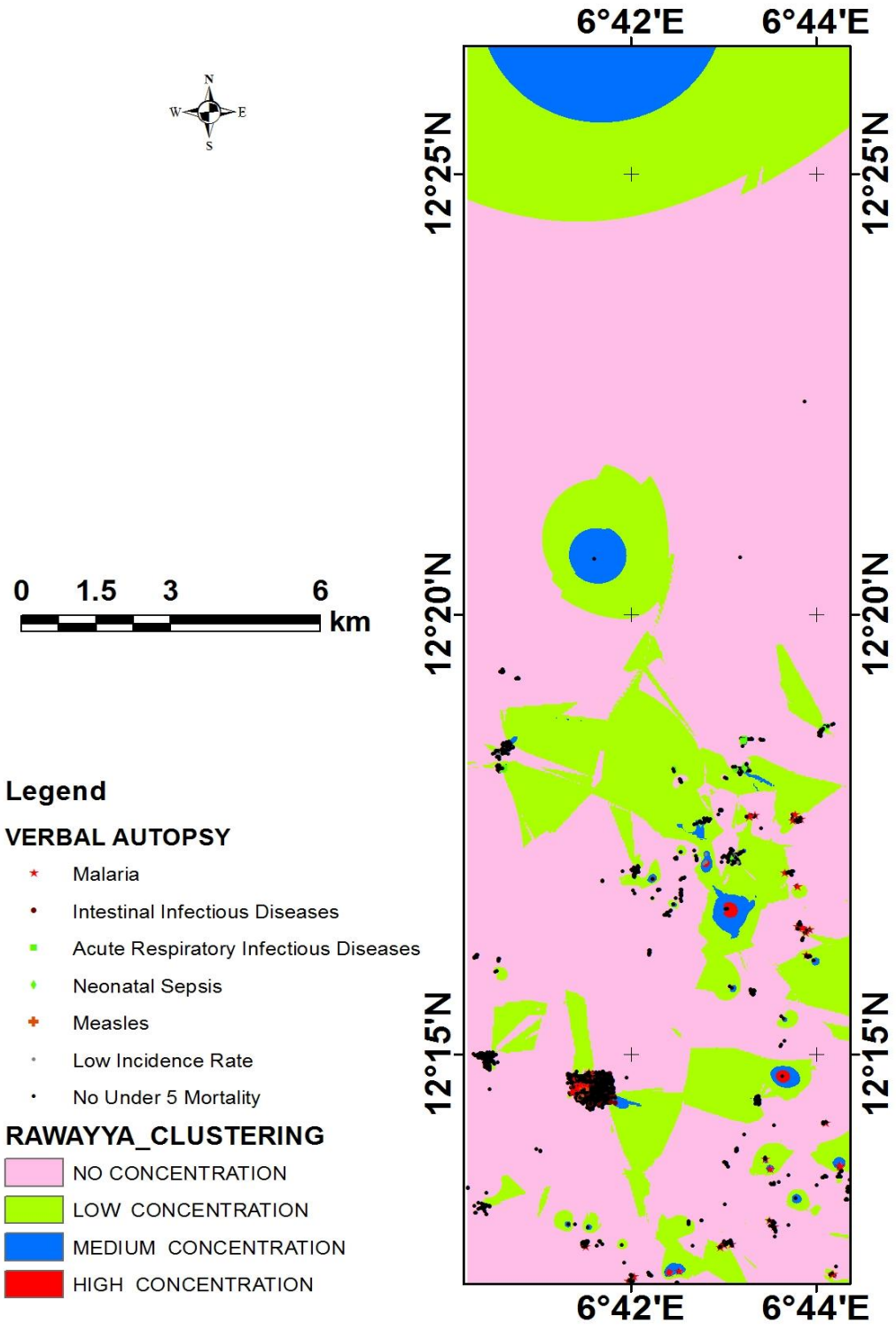

Figure 7: Map of compounds in Rawaya District showing areas of under-five mortality clustering, Nahuche HDSS

Discussion

The objective of the study was to identify the high risk area of under-five mortality clustering in the study area. This was achieved by collecting the births and deaths data and disaggregating the compounds by the proportion of under-five deaths reported per compound and geographic coordinates of all compounds within the DSA and processing the coordinates with ArcGIS software.

The GIS coordinates of these compounds were mapped to show high risk areas of under-five mortality clustering. Figures 2 to 7 showed high risk areas in each of the six districts under the DSA. Areas shaded with red on each of the map were areas with compounds that have lost at 60% and above of their children before attaining their fifth birthday and are termed "high risk areas of under-five mortality clustering". One striking revelation from the maps was the fact that most of the areas that fell within the high risk areas were villages that were located far from the main town within the districts. Most of these areas lack the basic social amenities like good road network and health facilities and are generally "hard to reach" during the raining season.

Furthermore, because of the living pattern in a typical rural northern Nigeria, it was observed that the most of the compounds were scattered and far from each other. This factor may contribute to high mortality clustering due to lack of social support from neighbouring compounds coupled by long distances to the nearest health centre in almost all the districts. Unlike the southern part of the country where people leave closer to each other, the social context in Nahuche area is different and thus, there is absence of "comparative advantage" due to the living pattern. The high risk areas are much pronounced in Nahuche-Keku and Nahuche-Ubandawaki districts. This may be due to the distance between the two districts and their surrounding villages and hamlets. For instance, Gada, Bela, and Rawayya districts were located close to the state capital, Gusau. Thus, easy access to the state capital, where there is access to health care services, from these districts may be related to the low incidence of high risk areas of under-five mortality clustering within these districts. This finding is consistent with other studies on the effect of various types of barriers to accessing health care on under-five mortality. Adedini et al (2014) found that risk of dying during the first five years of life was higher for children whose mothers reported physical or geographical barrier to accessing health care.

Summarily, under-developed amenities and general living patterns in the study area were identified as likely factor for the pattern of high risk areas of under-five mortality clustering. Poor sanitation system and source of drinking water may also be a contributing factor to child mortality clustering. Most households within the high risk areas of under-five mortality clustering source drinking water from open well and uncovered well. It is a common scene to see households sourcing their drinking and cooking water from the same source where livestock like cattle, camels, goats also drink.

Conclusion

Analysis of under-five mortality clustering in Nahuche HDSS area showed that within each district, under-five mortality tends to be clustered. General living patterns and poor sanitation system as well as under-developed social amenities were identified as likely factors for the under-five mortality clustering in the study area. Results of under-five mortality clustering from this study call for effective health intervention to reduce the high burden of under-five mortality. Provision of adequately equipped health facilities in terms of personnel and consumables should be made available in communities with less access to adequate health services. Further, development of social network system within the communities to assist in under-five care should be encouraged.

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