

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

## **ABSTRACT**

**Aims:** The persistent high rate of under-five (age 0-59 months) mortality in Nigeria and northern Nigeria in particular, remains one of the most discussed topics in all population-development spheres. The importance of spatial assessment and mapping of health data cannot be over emphasized. The objective of the study was to identify high risk areas of under-five mortality clustering in selected communities of Zamfara State in northern Nigeria.

**Study design:** Longitudinal study of demographic data collected at the household level.

**Place and Duration of Study:** Nahuche Health and Demographic Surveillance System, Zamfara State, Nigeria, between January 2011 and December 2013.

**Methodology:** The study identified high risk areas of under-five mortality clustering in the study area through collection and processing of health and demographic data (mortality and fertility) and geographic coordinates of all compounds within a demographic surveillance system area in northern Nigeria. The surveillance area had a population of 142,129 as of December 2013.

**Results:** Under-five mortality clustering was observed in all the six districts of the surveillance area. Two of the six districts with significant under-five mortality clustering were characterized by poor access to health care facilities, poor sanitation and living conditions which are typical of rural and disadvantaged northern Nigeria settings.

**Conclusion:** The findings call for effective health interventions to reduce the high burden of under-five mortality in the study communities and other communities in northern Nigeria with similar characteristics.

**Keywords:** Under-five mortality; Clustering; Demographic surveillance; Health systems; INDEPTH Network; Nigeria.

## **1. INTRODUCTION**

Undoubtedly, under-five mortality remains generally high worldwide. For example in 2013, over 6 million under-five deaths were recorded globally [1]. Childhood malnutrition, poor immunization coverage, poor health seeking behaviour are some of the factors responsible for the poor child health outcomes. For example, Nigeria accounted for 11 million out of the 60 million stunted children worldwide in 2012 [2]. The National Immunization Coverage Survey in Nigeria, which was conducted in 2010, showed that the national coverage is below the average rate for Africa with significant heterogeneity in States' coverage. There is a wide variation between the developed and the developing countries in terms of their contribution to the global under-five mortality burden [1]. Under-five mortality rates (U5MRs) are generally high for sub-Saharan African countries compared with other parts of the world.

Under-five mortality rate in Nigeria is among the world's highest [1] with northern Nigeria having the most appalling under-five health indicators. The doctor–patient ratio in Nigeria was estimated at 1:2560 in 2010 [3]; and in 2012, Nigeria's doctor-patient ratio stood at 1:3500 compared with 1:600 World Health Organization standard [4]. The case is more worrisome in northern Nigeria where health system infrastructural development is deficient.

Despite the plethora of publications and knowledge on the 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 [5] and tend to concentrate in some families and among few women with certain characteristics. The first child mortality clustering study in Nigeria was carried out in the 1990s in Kano State and just recently, in three northern Nigeria States of Yobe, Katsina and Zamfara<sup>1</sup>. 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 virtually non-existent.

The determinants of mortality clustering within families and communities and the mechanisms which initiates or perpetuates it have been of interest to researchers and policymakers for a considerable time. In some European countries, child mortality was found to concentrate in few families, communities or localities [5]. However, since the 1990s, child mortality clustering has been documented in a number of developing countries. For example, in Burundi, mothers reporting multiple deaths were only 20% but were having 70% burden of all child deaths [6]. In rural Punjab in India, a small proportion of families (12.6%) accounted for the majority (62.2%) of child deaths in the community [7]. Das Gupta [7] argued that mortality clustering within small families can be explained by the differentials in mother's innate ability rather than mother's educational level [see also 8-10].

Under-five mortality clustering in other studies [5, 11] was observed in areas or communities with high U5MRs. Further, clustering of under-five mortality is common in settings characterized by male dominance and observance of gender separation, especially of women of child bearing age. Northern Nigeria generally, and the North West geo-political zone in particular is an ideal setting to study mortality clustering since findings from such a study may help to explain the reported high under-five mortality and be used as a basis to deploy effective interventions to reduce child mortality. 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 deaths per 1,000 children in 2008 [12]. Educational attainment in northern Nigeria is 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, at least seven members per household [13].

The use of geographic information systems to support public health systems is gaining momentum across the world, Nigeria inclusive. This momentum is due to the critical role of spatial assessment and mapping of health data in health policy and planning. Spatial presentation of data enables health officials and other stakeholders to contextualize existing health challenges and successes. Understanding of the context further enables deployment of interventions to address any health challenges. Simply by seeing the location of health

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<sup>1</sup> This was a study conducted as part of the Partnership for Reviving Routine Immunization in Northern Nigeria; Maternal Newborn and Child Health (PRINN-MNCH) Programme activities.

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 targeted at specific communities or areas in need.

Against this background, we take advantage of longitudinal data from a health and demographic surveillance system, (HDSS) area in Zamfara State in northern Nigeria to examine under-five mortality clustering within the context of the Sustainable Development Goal 3 of ensuring good health for all by 2030.

## **2. MATERIALS AND METHODS**

### **2.1 Study Area**

Located in Zamfara State of northwest Nigeria, the 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 consists of six districts of Bella, Gada, Karakai, Nahuche Keku, Nahuche Ubandawaki, and Rawayya. Nahuche HDSS was implemented in 2009 by the PRRINN-MNCH Programme and Zamfara State Ministry of Health with funding from UKaid (United Kingdom 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 [14]. Nahuche area has substandard infrastructure, non-existent power supply, and poor road network. Further, economic and health indicators are poor, with the majority of women delivering at home without a skilled birth attendant [15].

### **2.2 Data and Methods**

The study used 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 biannually to update the database. This process precedes a baseline census that was conducted in 2010. For this study, mortality and fertility data for all children aged 0-59 months collected prospectively from 2011 to 2013, were obtained from the Nahuche HDSS database. Compound level clustering was assessed by adopting Kuate-Defo and Diallo 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 [16]. 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 the compound as a unit of analysis was an artefact of the living pattern in rural northern Nigeria where residents live in a compound consisting of one or more households. Residents of a compound are blood relations and thus a household is not clearly defined in such a setting.

Geographic coordinates of all the registered compounds within the HDSS were collected using 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 were generated to show areas within the DSA with high risk of under-five mortality clustering.

### 3. 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 district (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<br>under-five deaths | Percent |
|--------------------|--------------------------------|---------|
| Bella              | 590                            | 18.7    |
| Gada               | 740                            | 23.4    |
| Karakai            | 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 Bella 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. Worth noting is the fact that the boundary depicted in Figure 1 is not an administrative boundary. Figures 2 to 7 display the mapping of the six districts under the surveillance for under-five mortality clustering. Areas shaded pink were areas with "no concentration". That is, compounds within these areas had no 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 with red had lost at least 60% of their under-five children.

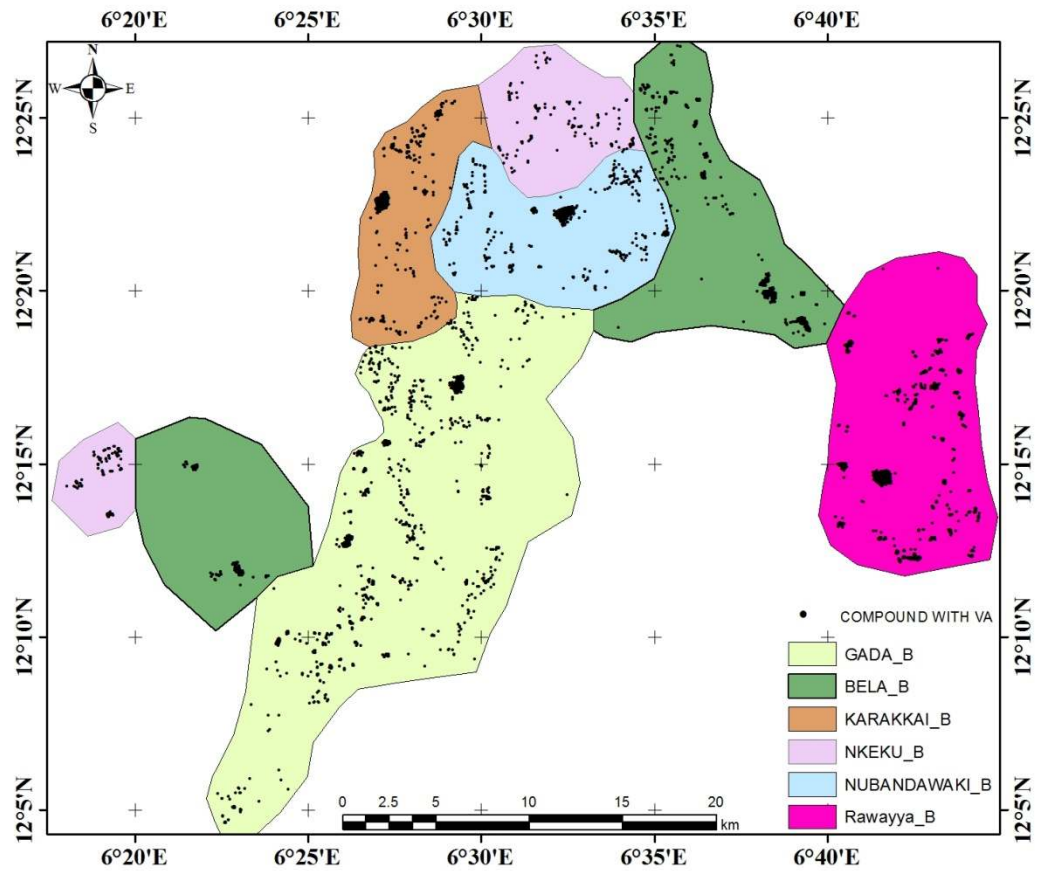


**Figure 1:** Composite map of Nahuche HDSS. **Note:** Boundaries shown are not administrative boundaries

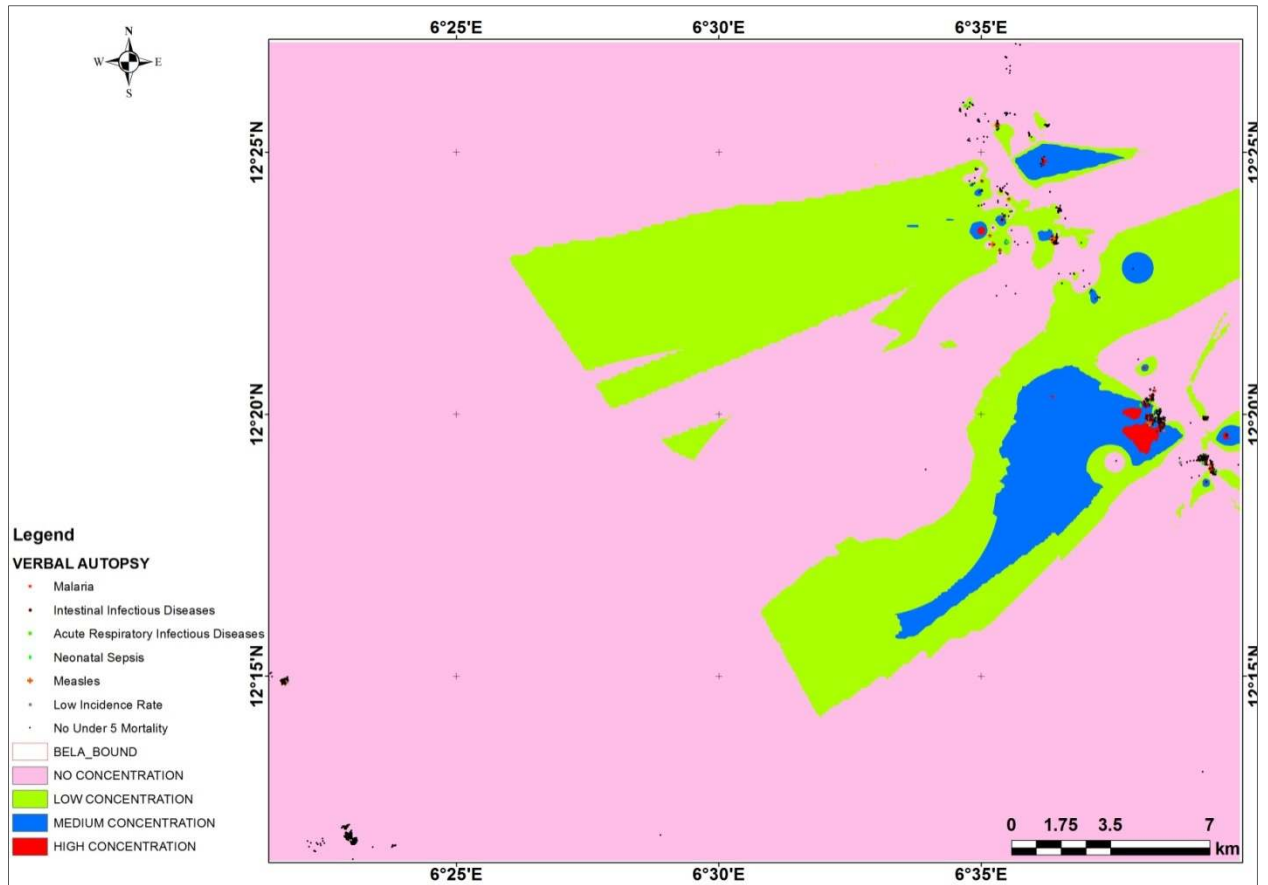


**Figure 2:** Map of compounds in Bella District showing areas of under-five mortality clustering, Nahuche HDSS

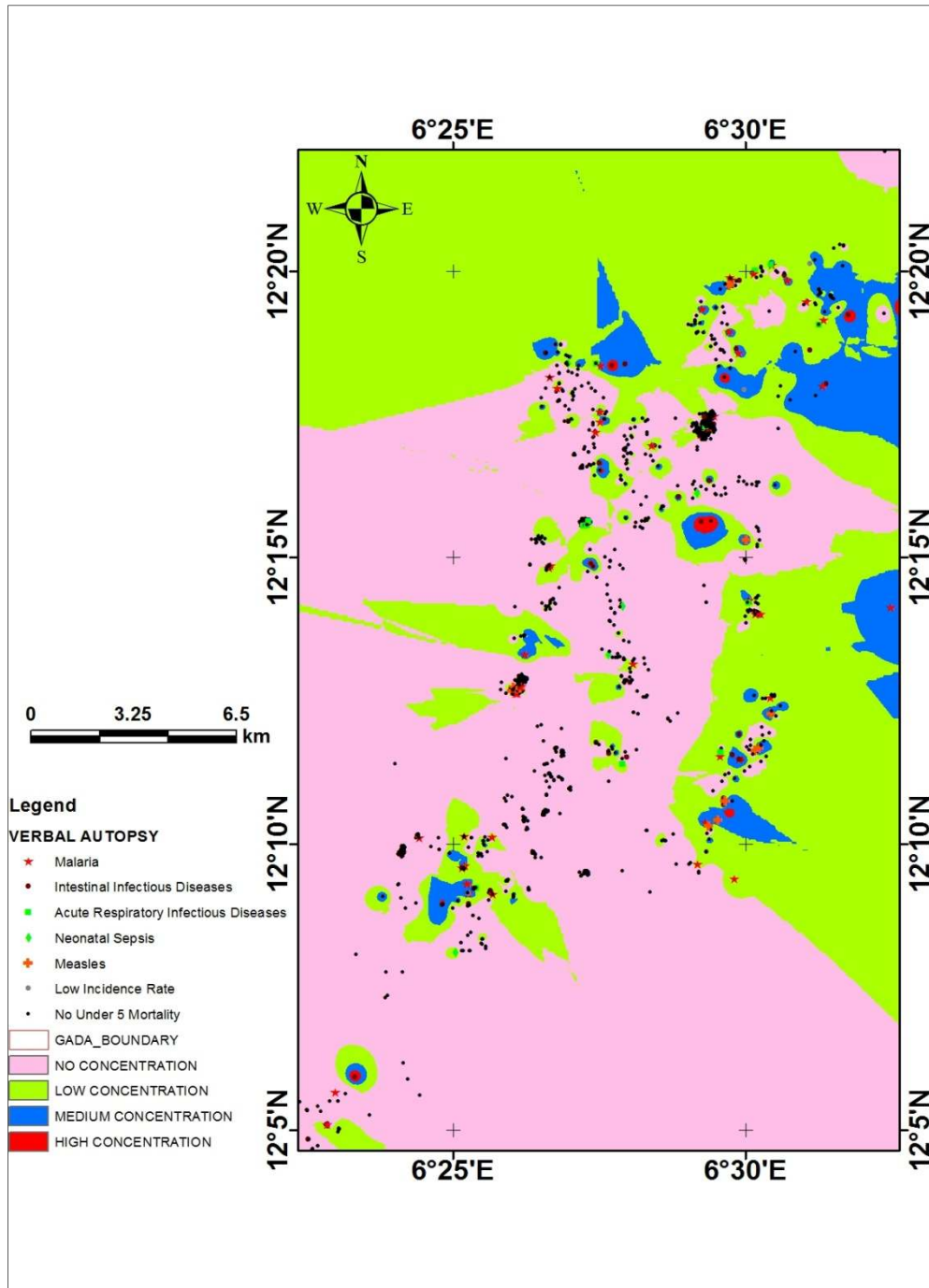
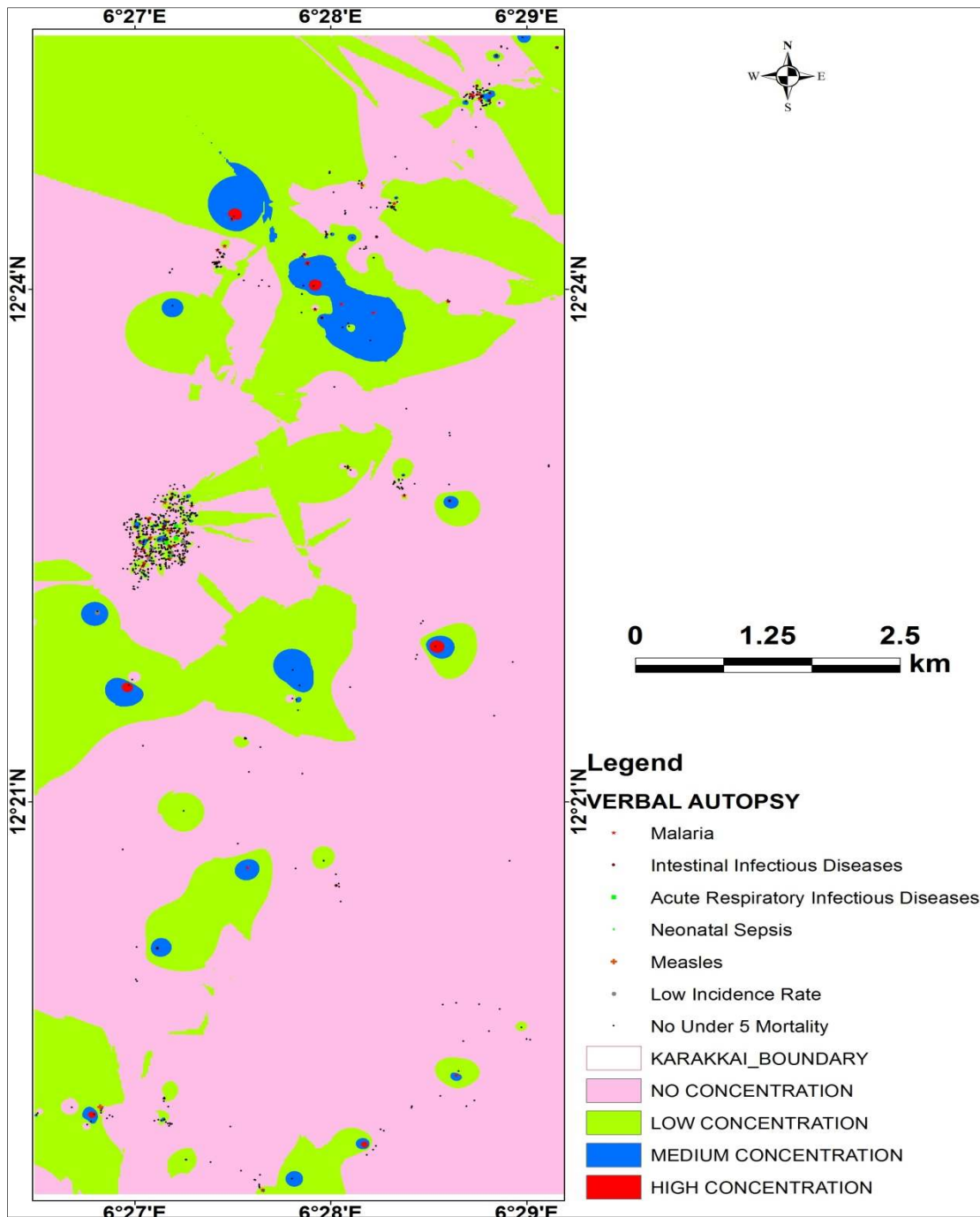


**Figure 3:** Map of compounds in Gada District showing areas of under-five mortality clustering, Nahuche HDSS

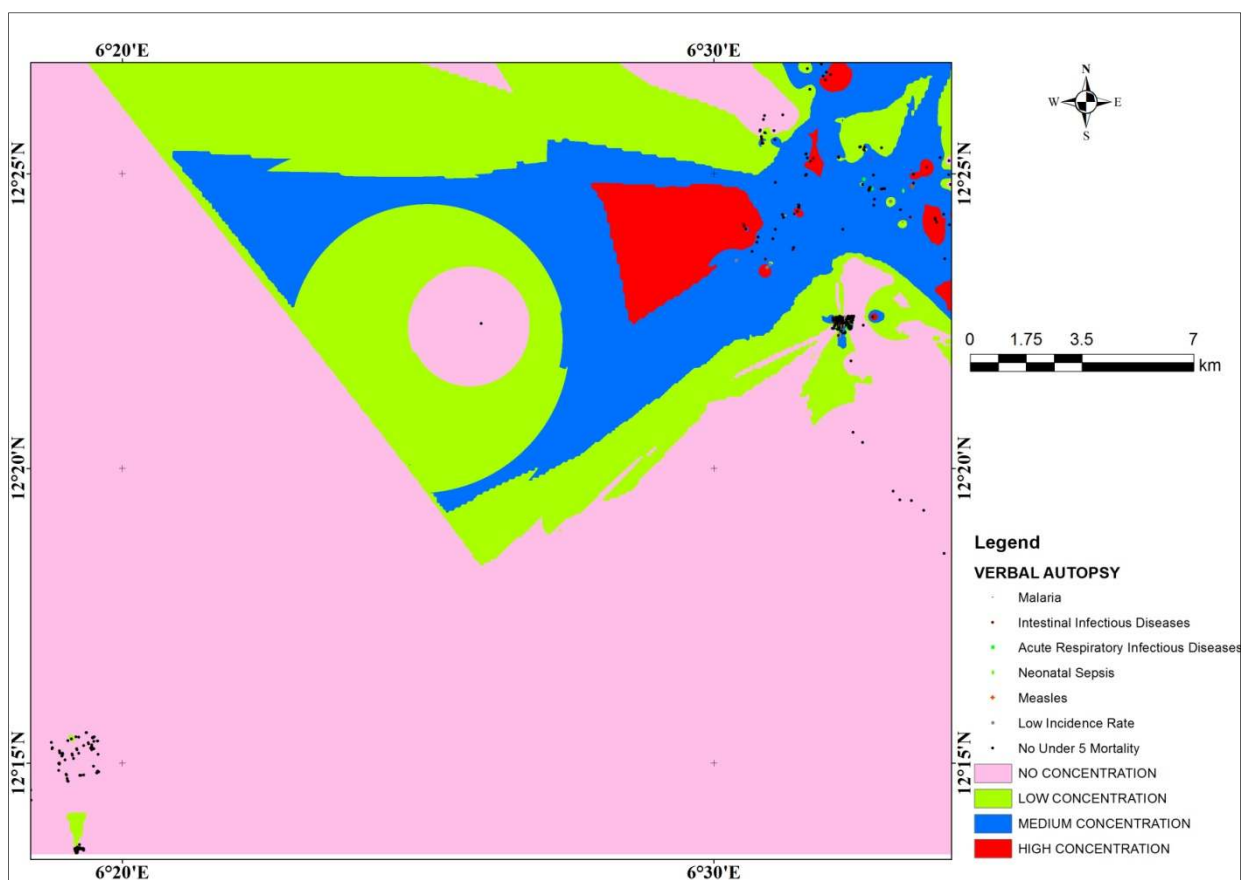


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**Figure 4:** Map of compounds in Karrakai District showing areas of under-five mortality clustering, Nahuche HDSS



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169 **Figure 5:** Map of compounds in Nahuche-Keku District showing areas of under-five mortality  
 170 clustering, Nahuche HDSS

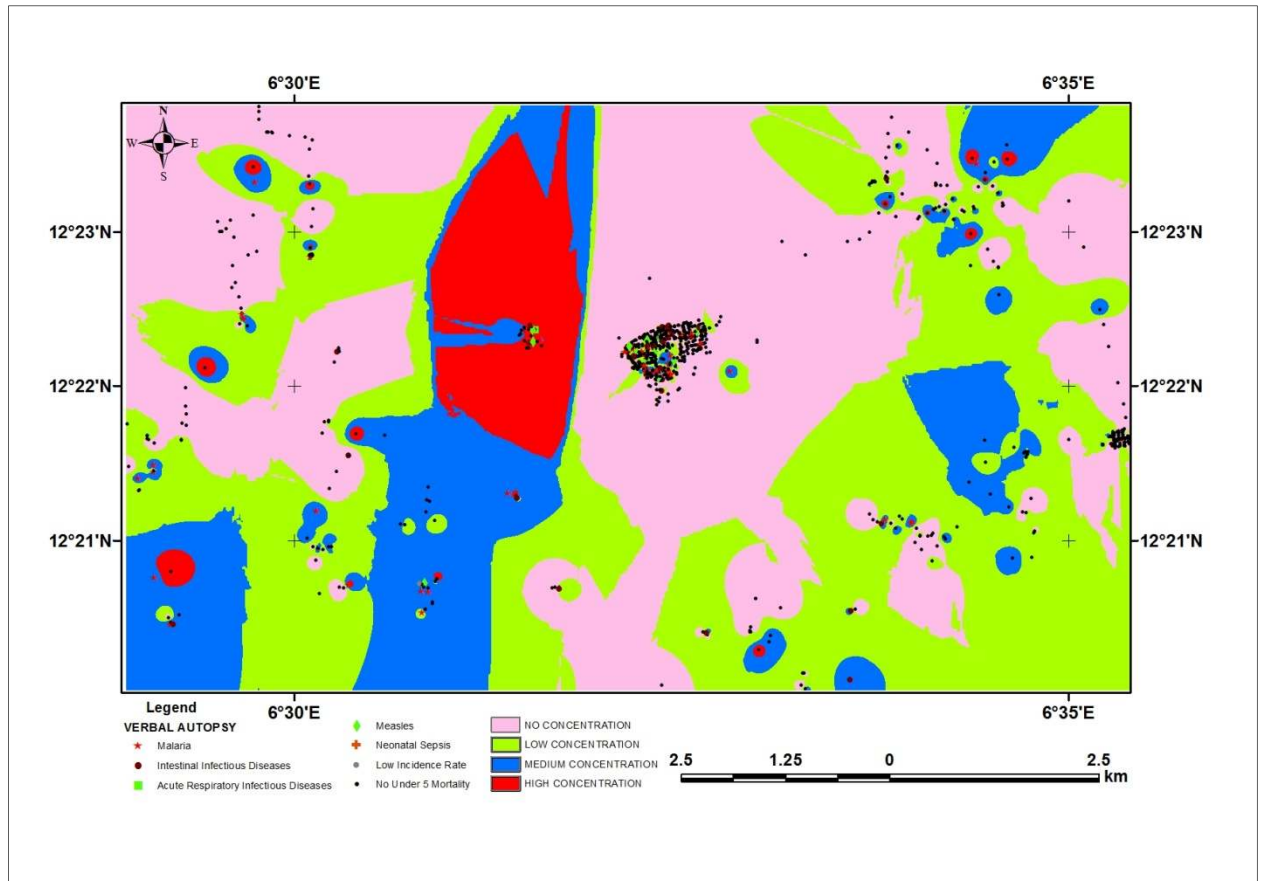
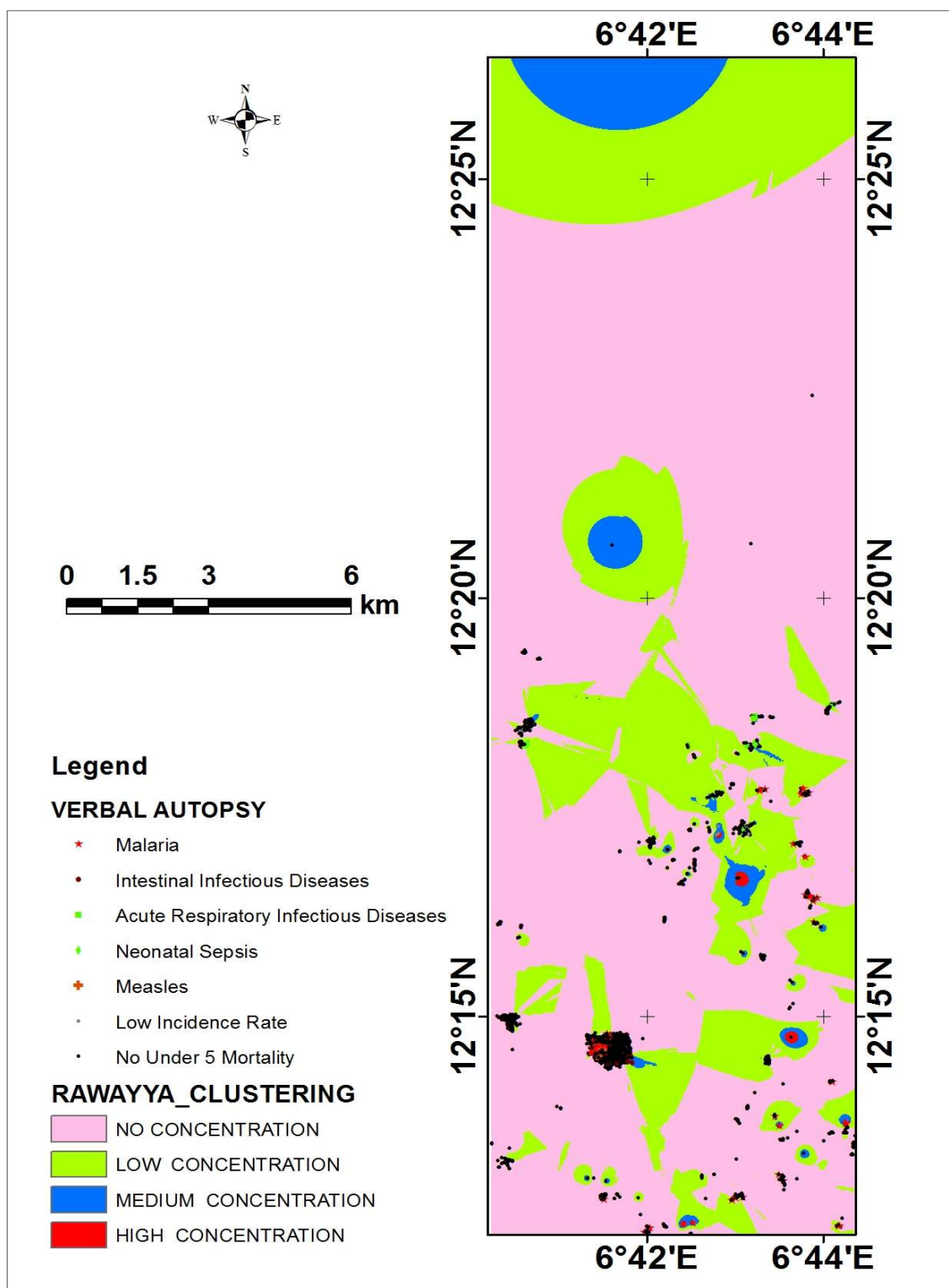


**Figure 6:** Map of compounds in Nahuche-Ubandawaki District showing areas of under-five mortality clustering, Nahuche HDSS



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175 **Figure 7:** Map of compounds in Rawayya District showing areas of under-five mortality  
 176 clustering, Nahuche HDSS

#### 4. DISCUSSION

The study aimed at identifying high risk areas of under-five mortality clustering in the Nahuche HDSS area. This was achieved by collecting births and deaths data and disaggregating the compounds by the proportion of under-five deaths reported per compound. Geo-referenced data enabled mapping of mortality clustering.

The geo-referenced data were mapped to show high risk areas of under-five mortality clustering. One important finding from the maps (Figure 2 through 7) was that the high risk areas were villages that were located far from the main town within the districts. Most of these areas lack basic social amenities such as good road network and health facilities and are generally hard to reach during the raining season.

Furthermore, due to the living patterns in rural northern Nigeria 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 facilities in almost all the districts. Unlike the southern part of Nigeria where people live in close proximity, the social context in Nahuche area is different, that is, the absence of "comparative advantage". The high risk areas were more pronounced in Nahuche-Keku and Nahuche-Ubandawaki districts. This may be influenced by the distance between the two districts and their surrounding villages and hamlets. For instance, Gada, Bella, and Rawayya districts were located close to the Zamfara 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 that documented a high risk of dying during the first five years of life for children whose mothers reported physical or geographical barrier to accessing health care [17].

Under-developed amenities and general living patterns in the study area were identified as potential factors associated with under-five mortality clustering in the high risk areas. 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 fetch drinking water from open and uncovered wells. It is common to see households



fetching drinking and cooking water from the same sources used by livestock (see Figure 8).

Figure 8: Source of drinking water in Nahuche HDSS area  
Photo credit: Nahuche HDSS

At the end of 2015, the international community embraced the new set of Sustainable Development Goals (SDG) calling for countries to ensure that no one is left behind by 2030. Specifically, SDG 3 calls for efforts to ensure good health for everyone. Achieving this Goal in settings such as Nahuche area and similar settings in northern Nigeria requires a package of health interventions that takes into account the peculiarities and perpetual challenges

experienced by poor and disadvantaged people on a daily basis. Where opportunities to deploy interventions occur, they should be designed comprehensively and scaled up accordingly to minimize the limited improvement in child health that was observed in a systematic review of maternal and child health interventions in Nigeria from 1990 to 2014 [18]. A number of health intervention programmes have been implemented in selected states and communities of northern Nigeria for a considerable time. The challenge with most of these interventions is that not only were they donor-funded with modest state government (counterpart) funding in selected cases but they were also implemented with a limited duration. The PRRINN-MNCH is an example of a programme that deployed a package of interventions to address the health system challenges in selected states of northern Nigeria from early 2007 to 2013. While tremendous achievements were recorded [19], the health challenges in northern Nigeria are protracted. Continued multi-stakeholder partnerships with the government in Nigeria and availability of geo-referenced data such as those reported in this paper are inevitable as Nigeria follows the path to the SDG deadline of 2030.

## 5. 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 in order to ensure that Nigeria documents good health for everyone by 2030.

## ETHICAL APPROVAL (WHERE EVER APPLICABLE)

Ethical clearance and informed consent was obtained for the demographic surveillance activities prior to the commencement of routine data collection activities from all the stakeholders involved and from the Zamfara State Ministry of Health Research Ethics Committee.

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## REFERENCES

1. UNICEF. Levels and trends in child mortality: Report 2014. [http://www.unicef.org/media/files/Levels and Trends in Child Mortality 2014.pdf](http://www.unicef.org/media/files/Levels_and_Trends_in_Child_Mortality_2014.pdf) (Accessed 28/1/2016).
2. Ehikoya, A., And Adanikin, O. The report, '11 million Nigerian children are malnourished' 2012. Retrieved from [http://www.A life free from hungerinternational.org/url.cfm](http://www.A_life_free_from_hungerinternational.org/url.cfm) (Accessed 18/02/2016)

- 281 3. Population Reference Bureau. Nigeria Health facts. 2010.  
282 <http://nigeriahealthjournal.com/?p=182> (Accessed 23/2/2016)
- 283 4. Daily Trust. Nigeria:2,701 Medical Doctors left Nigeria in four years-Minister (4  
284 October, 2012).<http://allfrica.com/storiea/201210050044.html> (Accessed 23/2/2016).
- 285 5. Vandezande M, Moreels S, Matthijs, K. Explaining death clustering:  
286 Intergenerational patterns in infant mortality Antwerp 1846-1905, Working paper of  
287 the Scientific Research Community Historical Demography, Centre for Sociological  
288 Research, Leuven. 2010.  
289 <https://lirias.kuleuven.be/bitstream/123456789/269130/1/WOG+working+paper13.pdf>  
290 f (Accessed 28/1/2016).
- 291 6. Edvinsson, S., and Janssens, A. Clustering of deaths in families: Infant and Child  
292 mortality in Historical Perspective. *Biodemography and Social Biology* 2012, 58:75-  
293 86. Doi:10.1080/19485565.2012.738575 (Accessed 21/2/2016)
- 294 7. Das Gupta, M. Death clustering, mothers' education and determinants of child  
295 mortality in rural Punjab, India. *Popul Studies*.1990; 44, 489–505.
- 296 8. Omariba DWR, Beaujot R, Rajulton F. Correlated mortality of sibling in Kenya: the  
297 role of State dependence. *Demographic Research*. 2008.18, 311-336.
- 298 9. Monden, C. WS., and Smits, J. Maternal education is associated with reduced  
299 female disadvantages in under-five mortality in sub-Saharan Africa and southern  
300 Asia. *International Journal of Epidemiology*. 2012, 1-8. doi:10.1093/ije/dys201.
- 301 10. Adjuik, M., Kanyomse, E., Kondayire, F., Wak, G., and Hodgson, A. Clustering of  
302 under-five mortality in Navrongo HDSS in the Kassena-Nankana District of northern  
303 Ghana. *Global Health Action* 2010; doi: 10.3402/gha.v3i0.5233.
- 304 11. Sastry N. Family-level clustering of childhood mortality risk in Northeast Brazil. *Popul*  
305 *Studies*. 1997; 51: 245-26.
- 306 12. Alabi O, Doctor HV, Afenyadu GY, Findley SE. Lessons learned from setting up the  
307 Nahuche Health and Demographic Surveillance System in the resource-constrained  
308 context of Northern Nigeria. *Global Health Action*. 2014; 7: 23368;  
309 doi.org/10.3402/gha.v7.23368.
- 310 13. National Population Commission (NPC) [Nigeria], ICF International. *Nigeria*  
311 *Demographic and Health Survey 2013*. Abuja, Nigeria, and Rockville, Maryland,  
312 USA: NPC and ICF International. 2014
- 313 14. Doctor HV, Alabi O, Findley SE, Afenyadu GY, Abdulwahab A, Jumare A. Maternal  
314 mortality in northern Nigeria: findings of a health and demographic surveillance  
315 system in Zamfara State, Nigeria. *Tropical Doctor*. 2012; 42: 140-143.
- 316 15. Doctor HV, Bairagi R, Findley SE, Helleringer S, Dahiru T. Northern Nigeria  
317 Maternal, Newborn and Child Health Programme: Selected analyses from  
318 population-based baseline survey. *Open journal of Demography*. 2011; 4:11-21.
- 319 16. Kuate-Defo B, Diallo K. Geography of child mortality clustering within African  
320 families. *Health and Place*. 2002; 8(2): 93-117.
- 321 17. Adedini SA, Odimegwu C, Bamiwuye O, Fadeyibi O, De-Wet N. Barriers to  
322 accessing health care in Nigeria: implications for child survival. *Global Health Action*.  
323 2014; 7: 23499 doi.org/10.3402/gha.v7.23499
- 324 18. Kana MA, Doctor HV, Peleteiro B, Lunet N, and Barros H. 2015. Maternal and child  
325 health interventions in Nigeria: a systematic review of published studies from 1990  
326 to 2014. *BMC Public Health* 15: 334; doi: 10.1186/s12889-015-1688-3.
- 327 19. PRRINN-MNCH Programme. 2013. Final Report 2013 - Stronger Systems: Healthy  
328 Women and Children. Kano, Nigeria: PRRINN-MNCH Programme.  
329 <http://www.prrinn-mnch.org/documents/PRRINN-MNCHFinalReport2013.pdf>; Last  
330 accessed 28 January 2016.
- 331