

## Introduction

Access to health care is affected by demand and supply side factors which need to be equally addressed in interventions or projects that seek to improve access to health care. Access to health care is also an important of mortality; both for children and adults. According to world health conventions, the first five years of life are very crucial and if one remains healthy or survives those periods, the risks of deaths are minimized. Investments in health through creating access is therefore crucial at this stage of life because of its spillover benefits to later periods in life. Various supply, demand, economic, social and cultural factors that impact under 5 mortality. To access health care, first, the hospital has to be available and also have health personnel, the hospital should have some facilities (supply side). Then individuals in the community must be able to afford the services and the facility should be accessible by some form of road network, so individuals do not find it costly in terms of transportation costs to visit the health facility (demand side).

Under 5 mortality measures the likelihood of a child dying between birth and their fifth birthday. The Demographic and Health Survey (DHS) estimated under 5 mortality to be 138 deaths/1,000 live births in 2007, in 2011, it rose to 158 deaths/1,000 live births before falling to 120/1,000 live births in 2016/17. Nigeria is not on pace to achieving the United Nations (UN) Sustainable Development Goals (SDG) target of 12 deaths/1,000 live births in 2030.

This research identifies using regression analysis factors that most influence under 5 mortality. Building on this, it using hotspot analysis and other GIS tools to understand some of these factors in detail and identify a recommended site for a new government health facility.

## Methods

GIS shapefiles and databases (see Appendix) were compiled using spatial and table joins. Ordinary Least Squares Regression, Geographically Weighted Regression, Hotspot Analysis were conducted. The unit of analysis for regression was the state – this was the level where disaggregated data was available for variables of interest. The dependent variables for both regressions was under 5 mortality (2013). The independent variables were road count, population density, health facilities count, index of quality of health facility. Health facilities (normalized by index of quality) and population density data were presented using graduated symbols. Buffer tool was used to identify proposed site for a new health care facility that was within 5 km of a road, but not within 7.5 km of any existing health care facility.

Quality of Health Facility Index was calculated as the sum of all facilities within a health facility. The average of this number was generated during the spatial join process and was the value used for further values. Some of the facilities included if the health facility has a maternal health delivery service, emergency transport, skilled birth attendant, electricity from the grid, facility for caesarian section, measles immunization, improved water supply, improved sanitation, vaccine fridge, antenatal care, family planning service, artemisinin for malaria. This data was qualitative. Therefore, Stata was used to recode before using in ArcGIS.

Hotspot analysis was conducted for health facilities and road networks at the state and LGA level. Maps showing hotspot analysis for health facilities also show symbols showing health facilities normalized by index of quality of health facility. Maps showing hotspot analysis for road networks also show graduated symbols showing population density.

## Results

### Ordinary Least Squares and Geographically Weighted Regression coordinates

Index of quality of facilities was the only predictor of under 5 mortality with a statistically significant coefficient (with 10 percent significance).

Independent variables	OLS
Road network	0.000040 (0.000171)
Population density	0.000460 (0.011802)
Number of Facilities	-0.016476 (0.021828)
Index of quality of Facilities	-20.211475 (-2.783559)*
R2	0.226039
Koener BP Statistic	1.379901 (0.847681)

Table 1 - OLS Regression estimates, Standard errors and Significance  
Dependent Variable: Under 5 Mortality

Figure 1 - Geographically Weighted Regression Coefficients for Number and Quality of Health Facilities in States

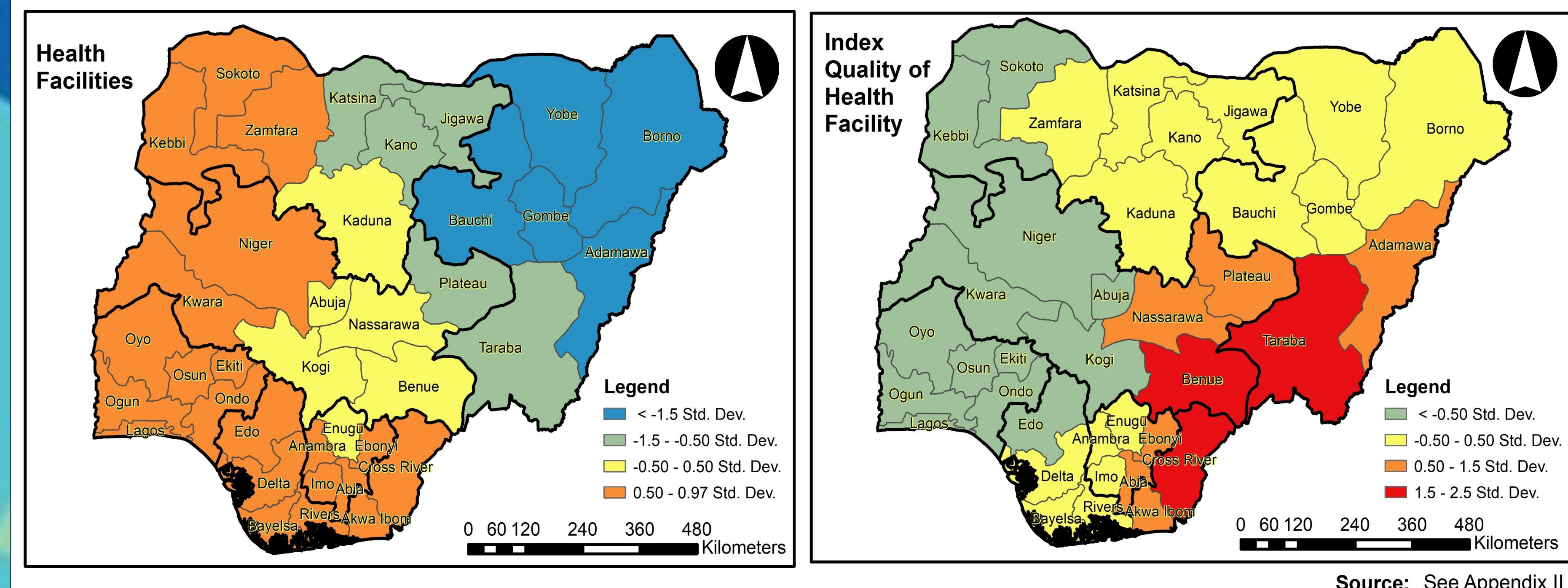
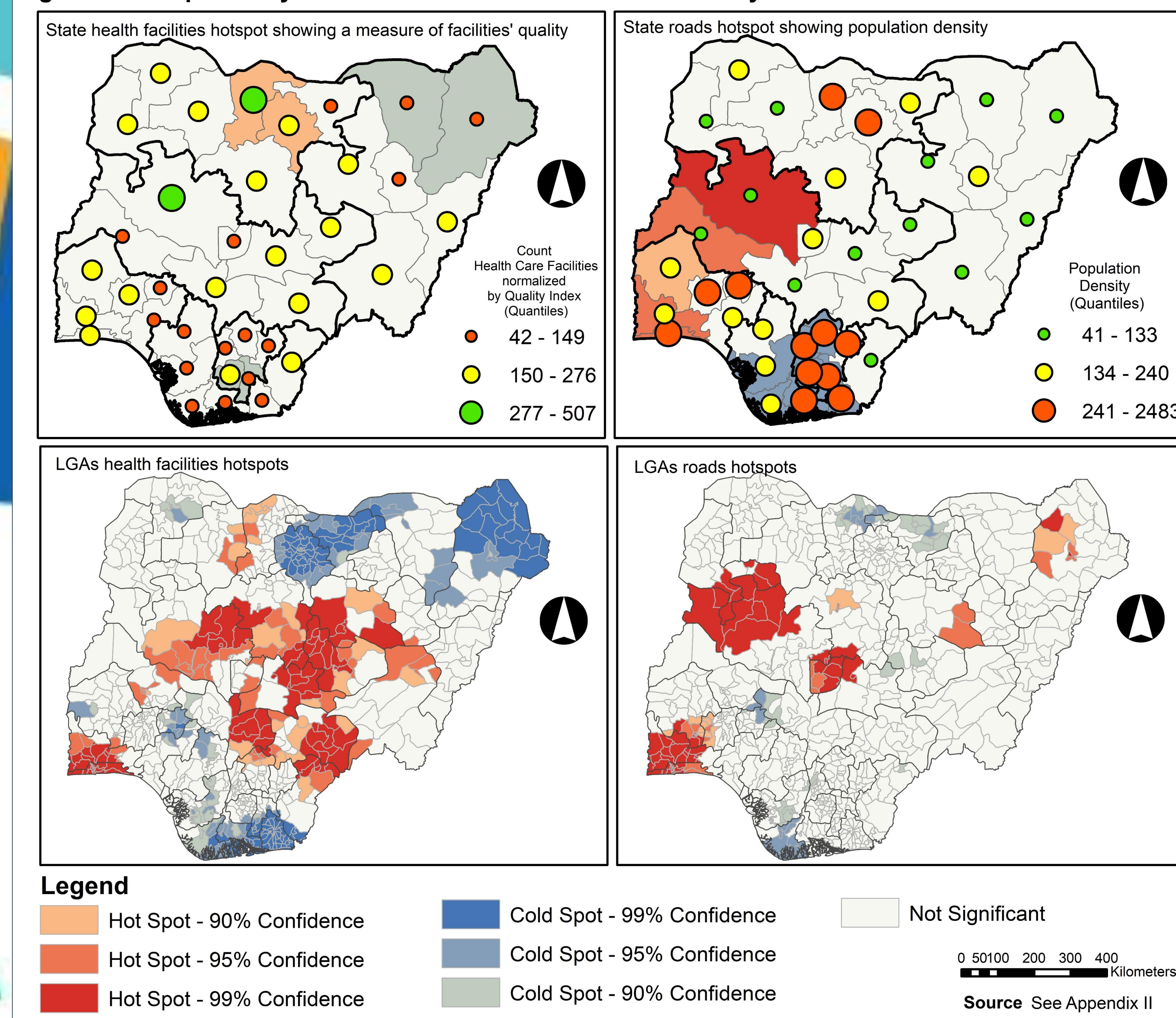


Figure 2 - Hotspot Analysis of Health Care Facilities and Roads by States and Local Government Areas



Although, the spatial autocorrelation report for this OLS shows that the regression was random. However, the Koener statistic was significant, indicating that some of the independent variables might be important predictors of Under 5 Mortality in some locations but weak predictors in other locations.

To address this concern, the Geographically Weighted Regression analysis was conducted. The geographically weighted coefficients of the number of facilities and average index of quality of health facilities within the state are shown in Figure 1. Red areas show where the coefficients are large; these are the locations where the independent variable (number of facilities or average index of quality of health facilities) is a strong predictor of Under 5 Mortality.

### Hotspot Analysis and Graduated symbols

Hotspots are areas with concentration of a variable of interest compared to other areas and are usually indicated in red, while, cold spots are the opposite and usually indicated in blue. Based on state level hotspot analysis of health facilities data, there are 4 cold spots and 2 hotspots (95% confidence). With respect to state health facilities performance, Kaduna comes top having significant hotspot for health facilities (90% significance) and only state with the highest facility indexed by quality value.

The hinterlands from Lagos are significant hotspots for road networks. While most states in the Niger Delta region are significant cold spots – this is likely due to the riverine nature of most of the area. Lagos, Osun, Ekiti, Kaduna, Kano and Eastern states the highest population densities.

### Location of new health facility to address under 5 mortality

The criteria for identifying recommended location for a new health care facility to address maternal concerns was determined by the researcher considering the size of the LGA and existing hospital and road infrastructure. The proposed site for health care facility was that it should be within 5 km of a road, but not within 7.5 km of any existing health care facility. The road network was chosen as one of the criteria because roads creates ease of access and proposed health facility needs to be situated where there are enabling conditions that make it amenable to usage and mobility of health care workers who would be recruited at the facility when is built.

Although Yobe and Borno state are cold spots for health facilities (95% confidence) and Borno state has more LGAs that are cold spots even at 99% confidence, Yobe was selected as the preferred location for a new health facility because of security situation in Borno state. Significant cold spots (90% confidence) for health facilities in the South East (Imo and Cross River state) were not selected because they are also cold spots for road networks (99% confidence). Yobe state was also in the lowest categorization for health care facilities normalized by quality index., along with 24 other states, including Lagos state and the Federal Capital Territory. However, the underlying reasons for this might vary and need to be investigated further.

Yobe state is a cold spot for road networks (not significant). LGA level analysis show that Karasuwa LGA in Yobe state is a cold spot for road networks (not significant) but a significant cold spot for health facilities (95% confidence). Karasuwa LGA has one of the highest patient to doctor ratio (1:118624) compared to the capital, Damaturu (1:3753) (Yobe State Socio-Economic Reform Agenda (YOSERA) III). It is also one of the LGAs where three cases of polio were discovered in 2010 (WHO, 2011).

## Conclusion and Recommendation

Policy interventions should focus on building more roads or improving mobility in the South South region, where the Niger Delta is located, so that enabling infrastructures are put in place to maximize new health care facilities. Quality of health care facilities in the North East should be improved. Regression analysis show that a one unit increase in the index of quality reduces under five mortality by 20 deaths per thousand (0.02). More investigation should be undertaken to identify the facilities that are the most important drivers for this decline.

## Appendix

### Appendix I - References

Yobe State Socio-Economic Reform Agenda (YOSERA) III (2012 – 2015)  
<http://budget.pfm.yb.gov.ng>

RMNCH in the news: 23-30 September 2011

[http://www.who.int/pmnch/media/mnchnews/2011/rmnch\\_inthenews\\_20110923-30.pdf](http://www.who.int/pmnch/media/mnchnews/2011/rmnch_inthenews_20110923-30.pdf)

### Appendix II - Data Sources and Shape files

- Health facilities data (2014) - Nigeria MDG (Millennium Development Goals) Information System (2014)
- Health statistics, population density and other statistics (2013) - Open data for Africa
- Nigeria shapefiles – Database of Global Administrative areas (gadm.org)
- Road shape file – Humanitarian Data Exchange (data.humdata.org)

Figure 3 - Karasuwa LGA, Yobe state, NE Nigeria recommended sites for new Primary Health Care Center

