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Outbreak of measles in Sokoto State North-Western Nigeria, three months after a supplementary immunization campaign: An investigation report 2016

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RESEARCH

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ABSTRACT

Background
Worldwide, measles infects about 20 million people with about 200,000 deaths annually. On February 12, 2016 an outbreak of measles was reported from Sokoto state, Nigeria.

Aims
A team of Nigeria Field Epidemiology and Laboratory Training Program (NFELTP) Residents was sent to confirm the existence of the outbreak, describe the socio-demographic characteristics and identify risk factors for the outbreak.

Methods
We defined cases according to the World Health Organization (WHO) criteria. We conducted an unmatched case-control study and descriptive study. We actively searched for cases across local government areas (LGAs) of the state, and administered questionnaires to parents of affected children. We analyzed the data using Epi-Info 7 and Microsoft Excel 2013.

Results
A total of 979 cases were recorded. Median age was 36 months with age range of 3–168 months. Ten deaths were recorded with a Case Fatality Rate (CFR) of 1.02 per cent. About 76.51 per cent of cases were under-five years of age. The outbreak spanned over a period of 10 weeks. Twenty-two out of 23 LGAs were affected. Eighty-nine cases (9.1 per cent) had their blood sample taken for laboratory confirmation, where 21 (23.6 per cent) tested positive for measles.

A total of 238 respondents were interviewed; 128 cases and 110 controls. Mothers' education (OR: 2.9, 95 per cent CI: 1.4–5.9), immunization status of children (OR: 2.0, 95 per cent CI: 1.1–3.4), and fathers' occupation (OR: 0.2, 95 per cent CI: 0.1–0.5), are the factors that affect measles infection among children in the state.

Conclusion
Our investigation confirmed a measles outbreak in Sokoto state. Though with a low CFR, the majority of deaths occur in children <five years. Low level maternal education and low measles immunization of children are factors that adversely affect development of measles in Sokoto state.

Key Words
Measles, Sokoto State, North-Western Nigeria, outbreak, case fatality rate

What this study adds:

1. What is known about this subject?

Immunization campaign activities are known to reduce the risk for vaccine preventable diseases in susceptible children, thereby preventing outbreak of such diseases in communities.

2. What new information is offered in this study?

Despite a state-wide measles supplementary immunization campaign in Sokoto state three months earlier, a large measles outbreak occurred in the state.

3. What are the implications for research, policy, or practice?

Policies should be directed towards strengthening disease surveillance system and a more robust immunization campaign, especially to under-served and hard-to-reach settlements.

Background

Measles is an acute, highly infectious viral disease caused by the measles virus. The measles virus belongs to the family *Paramyxovirus* and genus *Morbillivirus*. It is 120–250nm in diameter, with a core of single-stranded RNA.[1] Measles is transmitted through aerosols and droplets and can spread easily through the coughs and sneezes of those infected. It may also spread through contact with saliva or nasal secretions. Measles has an attack rate of more than 90 per cent among non-immune individuals.[2] The incubation period of measles from exposure to rash onset averages 14 days (7–21 days). It is characterized by fever, followed by the onset of cough, coryza (runny nose), or conjunctivitis. Koplik spots, a rash present on mucous membranes, is considered to be pathognomonic for measles.[2] Koplik spots occur one–two days before to one–two days after the rash, and appear as punctate blue-white spots on the bright red background of the buccal mucosa. Infectiousness starts four days before to four days after the appearance of rash. Measles infection confers lifelong immunity to the disease.[1,3] The Case Fatality Rate (CFR) for measles in developed countries ranges between 0.1 per cent - 0.2 per cent. In developing nations with high levels of malnutrition and a lack of adequate healthcare, CFR can be as high as 10 per cent. In cases with complications, the CFR may rise to 20 per cent – 30 per cent.[1]

Worldwide, measles infects about 20 million people and causes about 200,000 deaths annually, primarily children.[4] These numbers can vary dramatically over a short period of time depending on the vaccination status of the population. Before measles vaccination became widely available, measles epidemics occurred every two or three years, particularly in preschool-aged and school-aged children.[4] Measles remains one of the leading causes of death among young children globally, despite the availability of a safe and effective vaccine. Approximately 114,900 people died from measles in 2014 – mostly children under the ages of five.[5] Measles vaccination resulted in a 79 per cent drop in measles deaths between 2000 and 2014 worldwide. In 2014, about 85 per cent of the world's children received one dose of measles vaccine by their first birthday through routine health services–up, as compared with 73 per cent in 2000.[5]

Measles remains a major childhood killer throughout most of Africa, responsible for an estimated 435,000 deaths or approximately 50 per cent of global measles deaths in 1995. Approximately 80 per cent of these deaths occurred in West and Central Africa. The West African sub region also reported the highest measles morbidity between 1992–1997 (121 measles cases per 100,000 inhabitants).[6]

Measles is an endemic disease in Nigeria, with recurrent outbreaks occurring at irregular intervals. Measles transmission in Nigeria occurs through all months of the year, but peaks in the dry season (February, March and April). Measles transmission also sometimes occurs immediately after the end of the rainy season and often reaches epidemic proportions in the dry season.[7] In Nigeria, measles is still a leading cause of under-five mortality and morbidity. The disease was said to be responsible for one per cent of deaths in under-fives in 2013 in Nigeria.[8] The failure to deliver at least one dose of measles vaccine to all infants remains the main reason for high measles morbidity and mortality, as 95 per cent coverage is required to interrupt measles transmission.[9] In line with the Global elimination plan, Nigeria's objective was to reduce measles mortality by 95 per cent in 2015 and achieve elimination by 2020. Nigeria conducted one catch up campaign in 2005 and three follow-up campaigns in subsequent years.[5,8,10] Despite these efforts, vaccination coverage, though increased from 35 per cent to 50 per cent, is still below the 95 per cent coverage needed to reach herds immunity for measles.[5,10]

Sokoto state remains one of Nigerian states with recurrent measles outbreak in the past decade. In an earlier report on infant mortality in Sokoto, it was established that measles is among the five leading causes of death in the state.[11] On December 26, 2015 a suspected case of measles was seen at a Primary Health Center (PHC) in Sokoto North local government area (LGA). Also in early January 2016,

increased cases of measles were reported in Sokoto North and Illela Local Government Areas of the state. This was after a Supplemental Immunization activity (SIA) for measles was held in the state (November 21–25, 2015). The state responded by organizing a state level clinical management response. However, the outbreak continued unabated and spreads to neighboring LGAs. On February 12, 2016, 18 out of the 23 LGAs of Sokoto State reported increased number of cases of measles compared to previous year. The magnitude, extent and source of the infection were unknown. An outbreak notification report was subsequently sent to the Nigerian field epidemiology and laboratory training program (NFELTP). A team of NFELTP residents was sent to Sokoto state on February 19, to confirm the existence of the measles outbreak, to describe the socio-demographic characteristics and management outcome of the cases, to identify risk factors for the outbreak, institute preventive and control measures, and to make recommendations where necessary. We subsequently reported on their investigation.

Method

Study setting: Sokoto state is in the northwestern part of Nigeria. The state has a population of 3,702,676 with an under-five population of 748,444.[12] Sokoto state has a total of 23 LGAs with a total land area of about 32,000 square kilometres. Sokoto state borders are Zamfara state to the southeast, Kebbi state to the southwest and Niger republic to the north. Rainy season starts in May and ends in September or October. The dry season starts in October and ends in April in some parts, and may extend to May or June in other areas.

Sokoto state is a cosmopolitan city. The Hausa-Fulani ethnic groups, who are predominantly of Islamic religion, constitute the most inhabitants of the city and the state in general. Although English is the official language, Hausa is the main spoken language in Sokoto state. The main economic activities in the area are farming, business and cattle rearing. Agriculture is the backbone of the economy and riverine flood plains provide cash crops for the farmers.

Study population: All settlements and health facilities within the 23 local government areas are within the scope of this outbreak investigation. The outbreak investigation includes all persons less than 15 years, living in affected communities with symptoms suggestive of measles (cases) or without symptoms (controls).

Study design: We conducted a cross-sectional descriptive study and an Unmatched Case-Control Analytical study.

We defined cases according to the World Health Organization (WHO) criteria as follows;

Suspected measles case: Any person, who resided in any of the LGAs in Sokoto state and developed fever and maculopapular (non-vesicular) rash and any of the following: cough, coryza (runny nose) or conjunctivitis or any person in whom a physician suspects measles.[5]

Confirmed measles case: Any suspected case with laboratory confirmation of measles-specific IgM antibodies, who had not received measles vaccination within 30 days before the specimen was collected.[5]

We actively searched for cases across affected LGAs of the state. We retrieved all line-listed measles cases from the states Disease Surveillance and Notification Officer (DSNO) starting from December, 2015. All the state's surveillance system apparatus were directed to report any case that fits into the case definitions to the state epidemiologist or local government DSNOs immediately.

For each suspected case, we collected information on age, sex, vaccination status, residence and time of onset of illness. For each suspected case, we selected one unmatched control from the same settlement, who fits into our inclusion criteria for analysis. We administered a semi-structured questionnaire to parents or care-givers of suspected cases and controls in all affected settlements. The questionnaire was designed to collect information on basic biodata, vaccination status and other factors associated with contracting measles for both cases and controls. We analyzed data for the outbreak using Microsoft Excel 2013, Epi-info version 7, and Health Mapper.

Inclusion criteria

Cases

Any resident of affected communities who tested positive for IgM or had symptoms of measles from January 1 to March 1, 2016 are agreed to participate in the study.

Controls

Any resident of the affected communities who was a neighbor to a case, who did not develop signs and symptoms of measles during the period and with no past history of measles, who agreed to participate in the study.

Exclusion criteria

Cases: any asymptomatic person with or without a past history of measles.

Controls: Any patient who is above 15 years of age.

Sample size estimation: The sample size for the case-control study was calculated using Epi-Info version 7 for Two-by-two software, with; 95 per cent Confident Interval (CI), Power of 80 per cent and Odds Ratio (OR) of 3. Frequency of exposure among controls of 20 per cent and case to control ratio of 1:1. A total sample size of 226 was calculated (113 cases and 113 controls). To cover for attrition, we added 10 per cent of the calculated sample size (226+23=249). We thus approximated our sample size to 250 (125 cases and 125 controls).

Ethical consideration and informed consent

We got the permission of the State Ministry of Health to conduct the study after the review and adaptation of the study instrument (questionnaires). The communities were informed of the study by the State Epidemiologist prior to our arrival. We used staff of the health facilities as guides into affected communities. We obtained informed verbal consent from all study participants before we administered questionnaires to subjects. Confidentiality was assured throughout the study. We did not use names or address of participants in our study. We treated participants with respect and all participants willingly participated in the study without being paid money or coerced.

Data management

All the line listed data we collected from the states DSNO were entered into excel sheet, cleaned and used for descriptive analysis. We entered questionnaire data into Epi-info version 7 software for analysis. We conducted univariate and bivariate analysis using Epi-info version 7 and Microsoft Excel 2013.

Laboratory investigations

Venous blood samples were collected from first to fifth suspected cases seen at all health facilities in all affected LGAs. These samples if collected, are sent for measles confirmation, while subsequent cases from these areas are epi-linked to confirmed cases or diagnosed using clinical signs and symptoms only. All collected samples were sent to the Measles Reference Laboratory in Kaduna state for laboratory confirmation. Measles confirmation in the laboratory was done using serological test for serum immunoglobulin M (IgM) antibodies specific for measles.

Results

Descriptive

The first case was a 19-month-old boy who resides in Gidan harshi in Sokoto North LGA with his parents. He developed symptoms on December 26, 2015 and presented at the health facility on December 31, 2015. A second child who developed symptoms two days later (December 28, 2015) also presented on December 31, 2015 at the same health facility.

A total of 979 cases were recorded between December 26, 2015 and March 1, 2016. Median age was 36 months with age range of 3 months to 168 months. A total of 10 deaths were recorded, giving a case fatality rate (CFR) of 1.02 per cent. The majority of cases (76.51 per cent) are under five years of age, followed by the five–nine years age group with 21 per cent of cases. All deaths that were recorded are under 10 years of age, with 80 per cent of the deaths among those under five years of age. Attack Rate (AR) and Age Specific Case Fatality Rate (ASCFR) follow a similar pattern, with under five years having an AR of 98.34 per hundred thousand and ASCFR of 1.09 per cent. While the five–nine years age group had AR of 33.26 per hundred thousand and ASCFR of 0.99 per cent (Table 1). Of the 979 cases recorded, there were slightly more male cases (51.6 per cent) than female cases (48.4 per cent), but CFR is higher in males (1.39 per cent) than in females (0.63 per cent) (Table 1).

Cases were recorded from the last week of 2015, and the outbreak spanned over a period of about 10 weeks, up to February 29, 2016, with multiple peaks during this period. Notification for the outbreak was sent on February 12, 2016. First death case was recorded on January 3, 2016, while the last recorded death was on February 15, 2016 (Figure 1).

Twenty-two out of the 23 LGAs were affected during this measles outbreak. Wurno LGA recorded the highest number of cases (154), while Yabo had the least case. Rabah LGA did not report any measles case during the period. Five (5) of the 22 affected LGAs (Wurno, Sokoto south, Sokoto north, Illela and Goronyo) accounted for more than half (57 per cent) of the cases recorded (Figure 2). Cases were scattered across the whole state, affecting both rural and urban LGAs. There seem to be clustering of cases within the central area of the state (Figure 3).

Laboratory investigation

Out of the 979 recorded cases, 89 (9.1 per cent) had their blood sample taken for laboratory confirmation of measles, where 21 (23.6 per cent) of the 89 tested positive for measles.

Analytical (Case-Control)

A total of 238 respondents were recorded for the case-control study, 128 cases (53.8 per cent) and 110 controls (46.2 per cent). Children less than 5 years made up 80.5 per cent of cases and 75.5 per cent of controls, followed by the five–nine years age group with 17.2 per cent of cases and 22.7 per cent of controls. In total, there were more males (54.2 per cent) than females (45.8 per cent) respondent. The majority of respondents are Hausas (78.8 per cent), followed by Fulanis (19.9 per cent). Also, Islam constitutes the major religion of respondents with 98.7 per cent. The majority (96.6 per cent) of the parents of respondents are married. Only 28.9 per cent of the cases and 46.4 per cent of the controls had received measles vaccination. Vaccination coverage for both cases and control was 37 per cent, whereas 60.9 per cent had never received measles vaccination (Table 2).

Children whose mothers have no formal education were more likely to develop measles compared with children whose mothers had formal education (Primary, Secondary or Post-secondary) (OR: 2.9, 95 per cent CI: 1.4–5.9). Also, children who had not been immunized for measles were more likely to be measles cases than children who had at least one measles immunization (OR: 2.0, 95 per cent CI: 1.1–3.4). Children whose parents were civil servant were less likely to develop measles compared to those children whose parents' were farmers or traders (OR: 0.2, 95 per cent CI: 0.1–0.5). Mother's age, distance to nearest health facilities and amount of money spent on immunization had to effect on the disease status of the children (Table 3).

Discussion

Our investigation found a massive measles outbreak in Sokoto state that had spread and involved almost all of the local government areas of the state. The majority of the affected children are less than five years of age, while almost all affected children are less than 10 years of age. Though the measles outbreak had a low Case Fatality Rate, the majority of the deaths occur in children less than five years. The CFR found in this study is below the national average of 11 per cent.[13] Most studies however alludes to the highest prevalence of measles in under-five year children.[13,14] There was delay in reporting and notification of the outbreak, which eventually lead to delay in response to the outbreak. Both sexes are almost equally affected. Very few cases had their blood samples collected for laboratory confirmation. There was generally low vaccination coverage in all affected communities in the LGAs of Sokoto state.

Low level maternal education and lack of measles immunization of children are factors that we found to adversely affect development of measles in children, while fathers' regular and constant income (civil servants) tends to positively affect measles infection in children of Sokoto state. Studies done in Nigeria had shown maternal knowledge and education to be major determinants of immunization coverage in children, hence factors that prevent measles in childhood.[15]

We recognized the following limitations to our study; that many cases were concealed and under reported, which had drastically reduced the number of cases in the line-list submitted to the States' DSNO. We hence visited and actively searched for cases in the most hard-to-reach and most affected areas of the state. We also made hands-on assessments of these areas. Also, transportation of samples to measles reference laboratory at Kaduna state (which is about 500 kilometers away from Sokoto state) may have affected the laboratory outcome of the samples. We ensure that most samples we collected are well stored and transported in standard conditions.

Conclusion

Based on our investigation, we recommended a robust public health enlightenment on girl-child education across Sokoto state, strengthening of the Sokoto state Disease Surveillance and Notification system, planning and execution of more outreach sessions for routine immunization activities at the ward level in each LGA, and improving infrastructure for routine immunization activities and surveillance.

We took the following public health actions during the course of our investigation; immediate administration of Vitamin A to active cases and encouraging parents of susceptible children to have them vaccinated henceforth, health education talks to parents/guardians of affected and susceptible children (at all settlements we visited) on the importance of routine immunization, incorporation of routine immunization into the February 2016 immunization plus days (IPDS). This was achieved by ensuring that two fixed posts in each ward of every LGA in the state had health workers who administered the routine antigens.

References

1. Centers for Disease Control and Prevention. Immunology and Vaccine-Preventable Diseases – Pink Book. Hamborsky J, Kroger A, Wolfe S, eds. 13th ed. Washington D.C. Public Health Foundation, 2015.
2. Ryan KJ and Ray CG. Sherris Medical Microbiology. 4th ed. 513–524. The McGraw-Hill companies Inc., 2004.
3. Weldegebriel GG, Gasasira A, Harvey P, et al. Measles resurgence following a nationwide measles vaccination

campaign in Nigeria, 2005–2008. Journal of Infectious Diseases. 2011 Jul 1;204(suppl 1):S226-31.
4. Mary T. Caserta MD. Measles (Rubeola; Morbilli; 9-Day Measles. Merck Manuals. 2014). Available at: http://www.merckmanuals.com/professional/pediatrics/miscellaneous-viral-infections-in-infants-and-children/measles.
5. WHO | Measles. WHO (2016).
6. International Federation of Red Cross and Red Crescent Societies. Measles in Africa: Burden of Disease. Vaccination News (2010). Available at: http://www.vaccinationnews.org/DailyNews/April2002/MeaslesAfricaBurdenDisease.htm. (Accessed: 7th May 2016)
7. Grigsby ME, Adetosoye JI. Measles epidemiology and control in Western Nigeria. Journal of the National Medical Association. 1973 Sep;65(5):378.
8. WHO|World Health Organization. WHO (2016).
9. Nigeria Center for Disease & Control, Weekly Epidemiological report. Vol. 6 No. 18. 13th May, 2016. Available at: http://nigeriacdc.org/genre/weekly-epidemiologial-reports. (Accessed: 7th June 2016).
10. Truelove SA, Moss WJ, Lessler J. Mitigating measles outbreaks in West Africa post-Ebola. Expert review of anti-infective therapy. 2015 Nov 2;13(11):1299–301.
11. Jiya NM. Clinical presentation and outcome of measles in Sokoto, Nigeria. Sahel Medical Journal. 1999 Apr 1;2(2):104.
12. Nation Population Commission of Nigeria. National Census Data. (2015). Available at: http://www.population.gov.ng/index.php/censuses. (Accessed: 28th April 2016)
13. Grais RF, Dubray C, Gerstl S, et al. Unacceptably high mortality related to measles epidemics in Niger, Nigeria, and Chad. PLoS Med. 2007 Jan 2;4(1):e16.
14. Weldegebriel GG, Gasasira A, Harvey P, et al. Measles resurgence following a nationwide measles vaccination campaign in Nigeria, 2005–2008. Journal of Infectious Diseases. 2011 Jul 1;204(suppl 1):S226–31.
15. Gidado S, Nguku P, Biya O, et al. Determinants of routine immunization coverage in Bungudu, Zamfara State, Northern Nigeria, May 2010. The Pan African medical journal. 2014;18(Suppl 1).

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PEER REVIEW

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CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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Table 1: Distribution of Cases, Deaths, Attack Rate, and Age Specific Case Fatality Rate by Age group and Gender, Sokoto state measles outbreak 2016

Age grp	Cases	Percentage	Deaths (%)	Census pop	Attack Rate per 100,000 pop	ASCFR %
0 - 4	736	76.51	8 (80)	748,444	98.34	1.09
5 - 9	202	21.00	2 (20)	607,377	33.26	0.99
10 - 14	24	2.49	0	403,496	5.95	0.00
>14	0	0	0	1,943,359	0	0.00
Total	**962**	**100.00**	**10**	**3,702,676**	**25.98**	**1.04**
Gender	**Cases**	**Percentage**	**Deaths**	**CFR %**		
Male	505	51.6	7	1.39		
Female	474	48.4	3	0.63		
Total	979	100	10	1.02		

Table 2: Socio-demographic characteristics of cases and controls in Sokoto state measles outbreak, 2016

Characteristics	Cases (%)	Controls (%)	Total (%)
Total	128 (53.8)	110 (46.2)	238
Age Group (Yrs)			
0 - 4	103 (80.5)	83 (75.5)	186 (78.2)
5 - 9	22 (17.2)	25 (22.7)	47 (19.7)
10 - 14	3 (2.3)	2 (1.8)	5 (2.1)
15 & above	0 (0.0)	0 (0.0)	0 (0.0)
Total	128	110	238
Sex			
Male	63 (49.2)	66 (60.0)	129 (54.2)
Female	65 (50.8)	44 (40.0)	109 (45.8)
Total	128	110	238
Ethnicity			
Hausa	99 (79.2)	83 (78.3)	182 (78.8)
Fulani	24 (19.2)	22 (20.8)	46 (19.9)
Igbo	1 (0.8)	0 (0.0)	1 (0.4)
Others	1 (0.8)	1 (0.9)	2 (0.9)
Total	125	106	231
Religion			
Islam	124 (98.4)	105 ((99.1)	229 (98.7)
Christianity	2 (1.6)	1 (0.9)	3 (1.3)
Others	0 (0.0)	0 (0.0)	0 (0.0)
Total	126	106	232
Marital status of parents			
Married	124 (96.9)	106 (96.4)	230 (96.6)
Divorce	4 (3.1)	4 (3.6)	8 (3.4)
Total	128	110	238
Measles Immunization Status			
Received Vaccination	37 (28.9)	51 (46.4)	88 (37.0)
Not Vaccinated	86 (67.2)	59 (53.6)	145 (60.9)
Don’t Know	5 (3.9)	0 (0.0)	5 (2.1)
Total	128	110	238

Table 3: Factors associated with measles infection among cases and controls, Sokoto Measles outbreak, 2016

Associated Factors	Cases n=128 (%)	Controls n=110 (%)	OR (P-value)	95% CI
Mothers Education				
Non-formal	115 (89.8)	83 (75.5)	**2.9 (0.005)**	**1.4 - 5.9**
Formal Education	13 (10.2)	27 (24.5)	-	-
Immunization Status				
Not Immunized	86 (67.2)	59 (53.6)	**2.0 (0.01)**	**1.1 - 3.4**
Immunized	37 (28.9)	51 (46.4)	-	-
Mothers Age				
Less than 20 Years	16 (12.5)	9 (8.2)	1.6 (0.28)	0.7 - 3.8
20 Years and above	112 (87.5)	101 (91.8)	-	-
Fathers Occupation				
Civil Servant	6 (4.7)	23 (20.9)	**0.2 (0.00009)**	**0.1 - 0.5**
Others	120 (93.6)	82 (74.5)	-	-
Distance to Nearest Health Facility				
Less than 5 Km	97 (75.8)	78 (70.9)	1.2 (0.59)	0.6 - 2.3
5 Km and above	24 (18.8)	23 (20.9)	-	-
Amount Spent on Immunization				
Less than 200 Naira	94 (73.4)	76 (69.1)	1.2 (0.6)	0.6 - 2.2
200 Naira and above	25 (19.5)	24 (21.8)	-	-

Figure 1: Epidemic curve showing the distribution of measles cases and deaths over time, Sokoto state, 2016

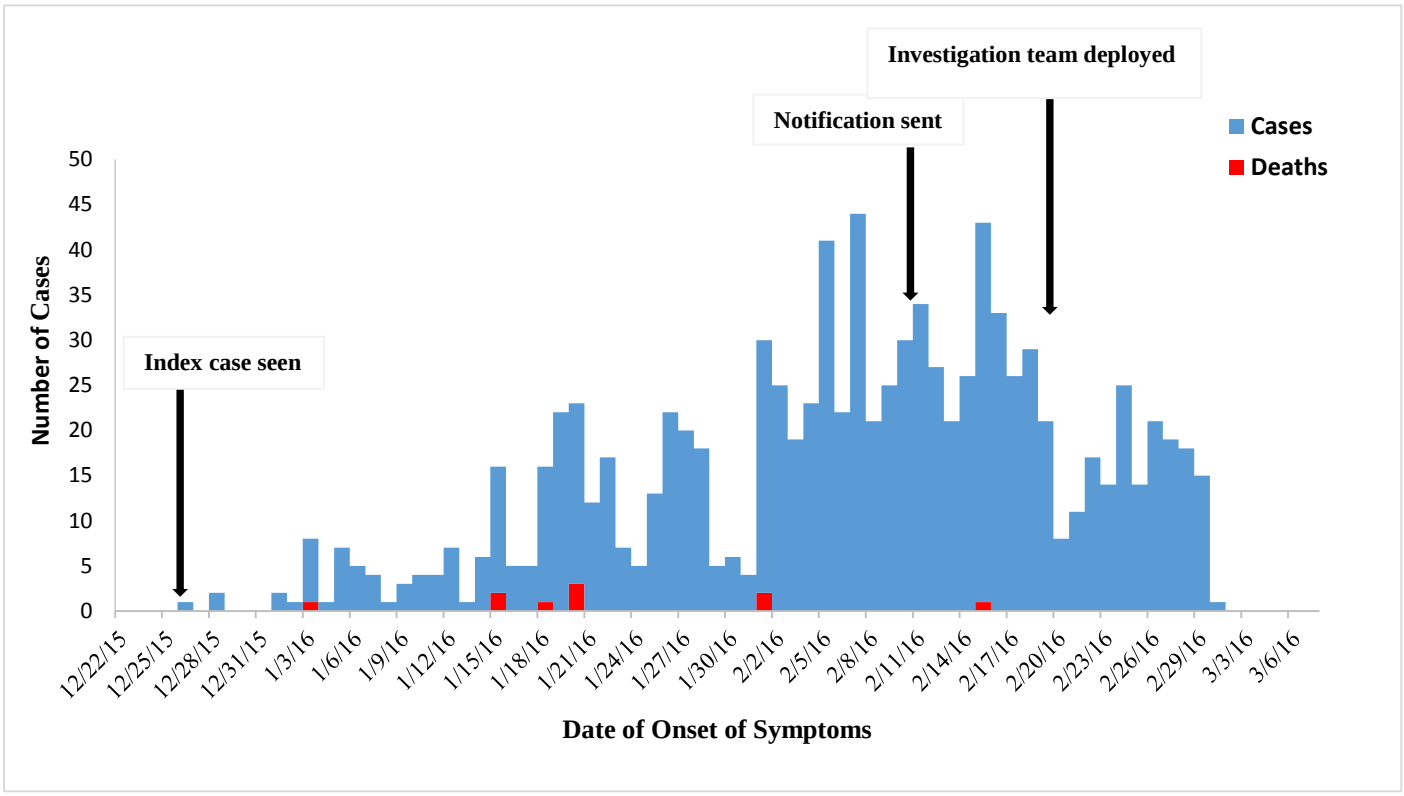

Figure 2: Distribution of Measles cases across LGAs in Sokoto state, Nigeria 2016

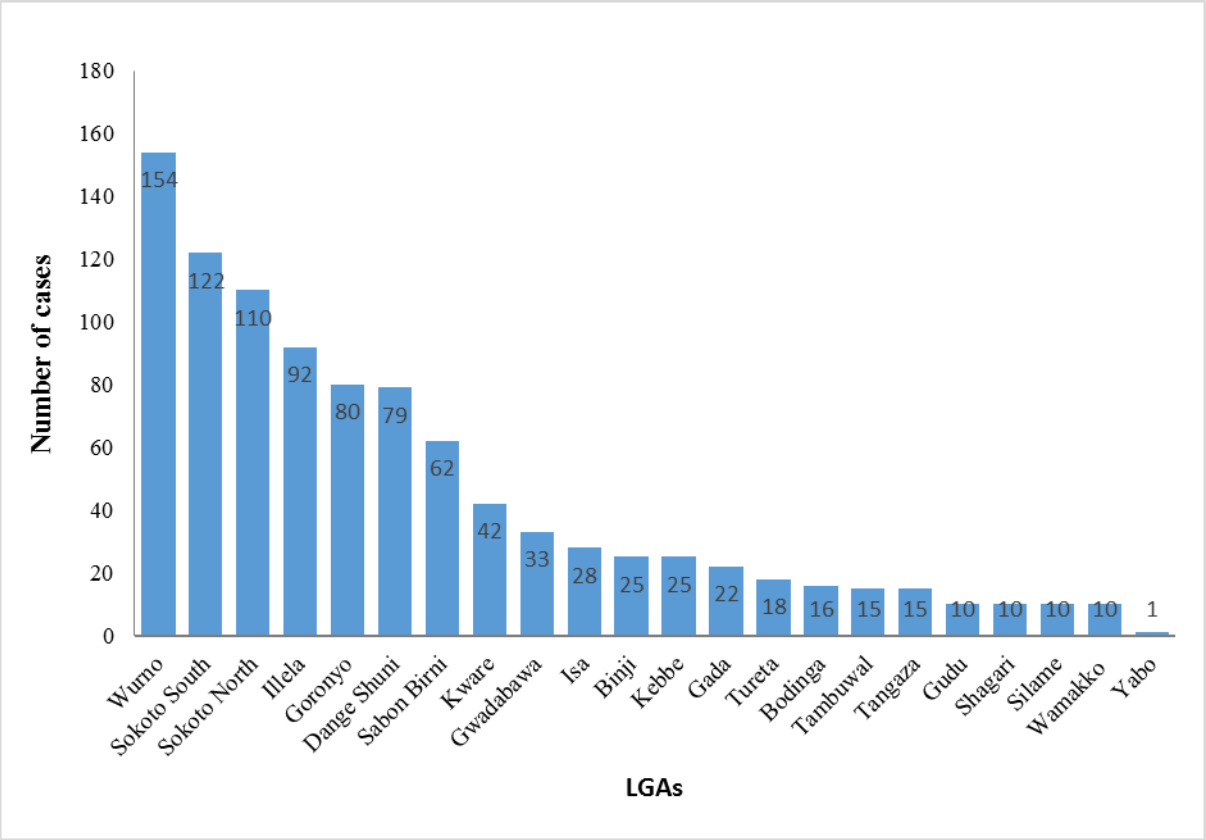

Figure 3: Spot map showing the distribution of measles cases across LGAs in Sokoto state, Nigeria 2016