ISSN: 2536-7153 SJMLS

Sokoto Journal of Medical Laboratory Science 2024; 9(2): 306 – 315

SJMLS - 9(2) - 036

The Epidemiology of Measles Virus Amongst Children Attending Specialist Hospital Sokoto, Nigeria.

Iduh M.U.[*1], Enitan, S.S.[2], Umar, A.I[1]., Bunza, N.M.[1], Usman, S.S.[3] and Nasiru, M.[4]
Department of Medical Microbiology, School of Medical Laboratory Science/College of Health Sciences, Usmanu Danfodiyo University, Sokoto Nigeria [1], Department of Medical Laboratory Science, School of Public and Allied Health, Babcock University, Ilishan-Remo, Ogun State, Nigeria [2], Department of Medical Microbiology and Parasitology, Sokoto State Specialist Hospital Sokoto, Nigeria [3], Federal University Teaching Hospital Birnin Kebbi, Nigeria [4].
Author for Correspondence: iduh.michael@udusok.edu.ng/+234-806-605-4527/+2203394436
https://dx.doi.org/10.4314/sokjmls.v9i2.36

Abstract
Measles remains the leading cause of vaccine-preventable childhood mortality in developing countries, with its greatest incidence in children younger than 5 years of age. The aim of this study was to determine the prevalence, gender and age most affected by measles, demographic and risk factors of measles virus amongst patients attending Specialist Hospital, Sokoto. A total of 90 blood samples comprising of children of different age groups from 0-7 years were collected and analyzed for measles virus IgM antibodies by enzyme-linked immunosorbent assay. An overall prevalence of 34.4% was obtained, with a prevalence of 17.8% in children aged 0-1 year and 12.2% in children aged 2-3 years. The prevalence of measles virus increased with age in children 0-1 years and decreased with age in older children (>5 years). A higher prevalence was found in females (18.9%) than in males (15.6%). There was a statistically significant association between the location and vaccination status among participants that shows positive for measles with p-value of 0.010 and 0.001 respectively. There was no significant difference in the tribe and vitamin A status among participants that show positive for measles with p-value of 0.631 and 0.359 respectively. The findings of this study confirm the presence of measles virus infection in children < 1 year, mostly from rural areas who do not comply with the vaccination schedule. An improvement on enhanced measles surveillance and routine immunization especially in the northern regions of Nigeria is recommended. There is a need to work out alternate strategies for the control of measles such as introducing a two-dose schedule to halt the endemic transmission.

Keywords: Measles, hospital, antibodies, vaccine, Sokoto

Introduction

Measles Virus is an enveloped virus, containing non segmented negative sense Ribonucleic acid (RNA). The virion has spherical to pleomorphic shape, they range in size of 120 nm to 300 nm in diameter and are composed of six structural proteins and two non-structural proteins C and V. Measles Virus RNA genome consists of approximately16,000 nucleotides and is enclosed in a lipid containing envelope derived from the host cell. Two envelope glycoproteins are important in the pathogens is transmembrane haemagglutinin (H), which is responsible for binding of the virion to cells and fusion (F) glycoprotein, responsible for fusion of virus and host cell membranes, viral penetration, and hemolysis. The matrix (M) protein lies in the interiors of the virion envelope, which strengthens the structure of the virion (Gans & Maldonado, 2022; Shobayo *et al.,* 2024;).

Measles is a disease of global significance and remains a leading cause of mortality, especially among children under 5 years of age. The Precise global incidence estimates are difficult to obtain because of different surveillance systems and they are under-reporting. Before the introduction of the idea of measles vaccine, more than two million deaths occurred every year. Measles occurs predominantly in areas without or with vaccination rates, particularly resource-limited settings like Africa, Nigeria in particular. Despite the fact that measles is a vaccine preventable disease (Shorunke *et al*., 2019; Dhalaria *et al*.,

2024), it is endemic in Nigeria, and it exhibits a seasonal pattern with high incidence during the dry season (Fatiregun *et al*., 2014). Outbreak is recorded mostly between February and April of every year, which corelates with the dry season time. In 2016, about 39.9 million cases of measles were recorded together with 777,000 deaths, globally (WHO, UNICEF, 2021). Africa and Southeast Asia give an account for 70% and 84% of cases of measles and measles related mortality reported, respectively, globally. The burden cases of measles infection remain high in Nigeria, which happen to be the most populated country in Africa. Measles viruses are endemic in most states in the northern Nigeria, including Sokoto State (Shorunke *et al*., 2019; Lawal *et al*., 2023).

Individuals at risk for measles include infants who are too young to be vaccinated, those who have not been vaccinated due to medical or other reasons, those who have not received a second dose of the measles vaccine, and those for whom the vaccine fail or refuse to elicit a protective immune response (Gans & Maldonado, 2022; Adunga *et al.,* 2024).

Although vaccination has significantly led to reduction of 73% of worldwide deaths as result of measles between 2000 and 2018, the burden and percentage of measles virus remains high in Nigeria. More than three fourths of measles-related deaths are recorded in countries with poor development, low earnings per capital, and the weak health system recorded as result of poor health management. Malnutrition, poor management, lack of immunization and overcrowding are common factors associated with measles mortality. These factors are common in a low-income country like Nigeria (Shorunke *et al*., 2019; Melis *et al*., 2024).

However, in 2019 there were still over 870,000 measles cases and over 200,000 measles deaths worldwide (Tanne, 2020; Sinumvayo *et al*., 2024). Despite early progress and impact, recent misunderstandings about the measles vaccine have led to vaccine hesitancy and refusal, resulting in an increase in measles incidence from 2016 to 2019, 50% worldwide (Tanne, 2020; *Alemu et al*., 2024). Meanwhile, global measles vaccination coverage has stagnated at about 85% for 5 years.

Nigeria has one of the highest measles incidence rates in the world. In 2021, Nigeria had the highest number of measles cases of any country in the world, with over 10,000 cases recorded based on Integrated Disease Surveillance and Response (IDSR) data. However, measles vaccination coverage has been suboptimal and stagnant since 1990, from 53% in 1990 to 54% in 2018 (ICF, 2022; Ayodele *et al*., 2024).

Ibrahim *et al.* (2019) examined trends in measles incidence and mortality in Nigeria from 2012 to 2016 and found high measles incidence, especially in the northern regions of the country. They emphasized on the importance of routine immunization but did not provide empirical evidence on the relationship between measles incidence and vaccination coverage. Baptiste *et al.* (2021) investigated trends in measles incidence and measles vaccination coverage from 2008 to 2018. Baptiste *et al.* (2021) also noted the prevalence of measles in northern Nigeria. Additionally, an examination of trends in measles vaccination coverage over the years found that it was suboptimal. However, they did not investigate the relationship between measles incidence and vaccination coverage.

Measles is a systemic infection. The primary site of infection is alveolar macrophages or dendritic cells. Two to three days after replication in the lung, measles virus spreads to regional lymphoid tissues followed by a systemic infection. Following further viral replication in regional and distal reticuloendothelial system (Sulaiman *et al*., 2024).

Measles virus invades the cells lining the upper respiratory tracts i.e. respiratory epithelium of the nasopharynx and spreads to the regional lymph nodes.

Primary viremia occurs after 2 to 3 days of replication in these sites, it widens the infection to the reticuloendothelial system where further replication takes place (Gans & Maldonado, 2022; Branda *et al*., 2024).

Secondary viremia occurs 5 to 7 days after exposure, the virus enters the skin, conjunctivae, respiratory tract and other organs, including the

spleen, thymus, lung, liver, and kidney and further replication occurs (Anguinze *et al*., 2024).

A previous report (Shorunke *et al*., 2019) confirms the presence of measles virus infection in children < 1 year, mostly from rural areas who does not comply with the vaccination schedule. An improvement in enhanced measles surveillance and routine immunization especially in the northern regions of Nigeria is recommended. The study recommended the need to work out alternate strategies for control of measles such as introducing a two-dose schedule to halt endemic transmission.

Materials and Methods

Study Area

This study was conducted in the Specialist Hospital Sokoto, and Medical Microbiology Department of School of Medical Laboratory Sciences, Usmanu Danfodiyo University (UDUS), Sokoto, North-Western Nigeria. Specialist Hospital is located within the Sokoto Metropolis. It serves as referral health center for more than 10 million people of Nigerian States like Sokoto, Kebbi, Zamfara and some other neighboring countries like Niger and Benin Republic in the West African Sub-region. The state is located in the extreme Northwest of Nigeria, near to the confluence of the Sokoto River and the Rima River. The State is in the dry Sahel, surrounded by sandy savannah and isolated hills, with an annual average temperature of 28.3°C (82.9°F). Sokoto is, on the whole, a very hot area. However, maximum daytime temperatures are for most of the year generally under 40^{0}C (104.0^{0}F) and the dryness makes the heat bearable. The warmest months are February to April when daytime temperature can exceed 45°C (113.0^{0}F). The rainy season is from June to October during which showers are a daily occurrence. Sokoto city is a major commerce center in leather, crafts and agricultural products. As of 2022, the state has a projected population of 6.1 million (NPC/FGN, 2006). Report from the national population commission indicates that the state had a population of 3.6 million.

Study Site

This study was conducted in Specialist hospital, in collaboration with Medical Microbiology Department of school of medical laboratory Science of Usmanu Danfodiyo University, Sokoto. Specialist Hospital is located within the Sokoto Metropolis.

Study Design

This study is a Prevalence study by which random samples are analyzed.

Study Subjects Selection Criteria

Inclusion Criteria

Children within the age range of 0-7 years whose record shows suspected signs and symptoms of measles.

Exclusion Criteria

Children reported to have measles-like symptoms but above the age of 7 years.

Study Instrument

Ethical Consideration

Appropriate Ethical approval for this study was obtained from the Public Health Department of Sokoto State Ministry of Health and also the ethical committee of the state Ministry of Health. For confidentiality, personal information was concealed. Data was protected by ensuring that only the research team had access to the dataset during extraction and analysis.

Sampling

Sample Collection and Processing

Using a sterile disposable syringe, a 2mL blood sample was collected from each patient aseptically by venipuncture and dispensed into sterile, labelled, anticoagulant containers containing ethylenediaminetetraacetic acid. The blood samples were transported in an ice box to the laboratory. The blood samples were centrifuged at 3000rpm for 5 minutes, the plasma was separated using clean Pasteur pipettes into sterile plain sample containers. The samples were stored at refrigeration temperature (4°C) until required for analysis.

Reagents and Chemicals

Enzyme linked immunosorbent assay (ELISA) kit for Immunoglobulin M antibody for Measles
Methylated spirit.

Equipment and Glassware
The following equipment and glassware were used for the study:
Syringes and Needles, Cotton wool, Hand Gloves, Ethylenediaminetetraacetic acid (EDTA) container, Sample bottles (plain), Pasteur pipette, Centrifuge (Universal 320), Microplate washer, ELISA microplate reader.

Method of Analysis
Detection of measles immunoglobulin M (IgM) by ELISA

Assay (ELISA) Procedure:
Measles specific IgM antibodies in serum was detected by enzyme immunoassay (Diagnostics Automation, U.S.A) in accordance with the manufacturer's instruction. The samples were analyzed using immunoglobulin M measles enzyme-linked immunosorbent assay reagent. All the samples and reagents were removed from the refrigerator and allowed to come to room temperature (25°C). The coated strips were placed in a holder and labeled (one blank well, one negative control, two calibrators, one positive control, and 91 wells for sample specimens). Exactly 3µL of the test samples, negative control, positive control, and calibrators, were added to 240µL of the serum diluent and mixed well to make 1:80 dilutions. Exactly100µL each of the diluted samples were dispensed into appropriate wells, ensuring that there were no air bubbles. Air bubbles present in the liquid were removed by tapping the holder. Exactly 100µL of the serum diluent were then added into the reagent blank well. The wells were incubated at room temperature (i.e. 25°C) for 30 minutes. After incubation, the liquid from all wells were removed by washing three times with 300µL of wash buffer. Exactly100µL of enzyme conjugate were added into each well and incubated at room temperature for 30 minutes. Excess enzyme conjugate was removed by washing three times with the buffer. Exactly 100µL of chromogen/substrate solution was then dispensed into each well. The wells were incubated at room temperature for 15 minutes. The reaction was stopped by addition of 100µL of stop solution (1 M H_2SO_4). The plate was tapped gently to mix the contents of the wells. The reading was done using an enzyme-linked immunosorbent assay microplate reader at 450 nm.

Statistical Analysis
The data generated from the results of the laboratory analysis and data obtained from the questionnaires were recorded and analyzed using Microsoft Excel 2016 and Statistical Package for the Social Sciences (SPSS) version 20.0 software (IBM Corporation, Armonk, NY, USA) to obtain the prevalence. The Pearson's Chi-square test was used to determine the significance of variables at a 95% confidence interval, and a *P*-value <0.05 was considered to be statistically significant.

Result
The result of this study showed the prevalence of measles virus cases among the study participants as well as the frequency distributions of Measles Cases by Age, gender, Tribe, Location, Vitamin A and Vaccination status of the subjects.

The study revealed a total prevalence of 31(34.4%) measles cases among the 90 subjects (Table 1). The frequency distribution of measles cases by aged 0-1 year, 2-3 years, 4-5 years and 6-7 years indicated prevalence of 17.8%, 12.2%, 3.3% and 1.1% respectively. The distribution was not statistically significant (P = 0.054) (Table 2).

Frequency distribution of measles cases by gender revealed that females had a higher prevalence of 18.9% than their male counterparts (15.6%). It was not statistically significant (P = 0.168). This showed that both sexes can be equally affected (Table 3).

The frequency distribution of measles cases by tribe showed that the Hausa tribe had a higher prevalence of 16.7% compared to Yoruba (10.0%) and Igbo (3.3%) participants respectively, while other tribes had 4.4%. There is no significant difference statistically between the various tribes (P = 0.63) (Table 4).

Table 1: Prevalence of measles cases

Result	Frequency n	Percentage (%)
Negative	59	65.6
Positive	31	34.4
Total n (%)	90	100

Table 2: Frequency distribution of measles cases by age

Age (years)	Negative (%)	Positive (%)	Total (%)	X^2	P-Value
0-1	44(48.9)	16(17.8)	60(66.7)	9.299	0.054
2-3	12(13.3)	11(12.2)	23(25.6)		
4-5	1(1.1)	3(3.3)	4(4.4)		
6-7	2(2.2)	1(1.1)	3(3.3)		
Total n (%)	59(65.6)	31(34.4)	90 (100.0)		

Key: X^2= Chi-square, n=number.

Table 3: Frequency distribution of measles cases by sex

Gender	Negative (%)	Positive (%)	Total (%)	X^2	P-Value
Male	18(20.0)	14(15.6)	32(35.6)	1.904	0.168
Female	41(45.6)	17(18.9)	58(64.4)		
Total n (%)	59(65.6)	31(34.4)	90 (100.0)		

Key: X^2= Chi-square, n=number.

Table 4: Frequency distribution of measles cases by tribe

Tribe	Negative(%)	Positive (%)	Total (%)	X^2	P-Value
Hausa	30(33.3)	15(16.7)	45(50.0)	1.725	0.631
Yoruba	15(16.7)	9(10.0)	24(26.7)		
Igbo	10(11.1)	3(3.3)	13(14.4)		
Others	4(4.4)	4(4.4)	8(8.9)		
Total n (%)	59(65.6)	31(34.4)	90 (100.0)		

Key: X^2= Chi-square, n=number.

The rural area residents indicated a higher prevalence of 26.7% compared to urban area residents (7.8%) in the distribution of measles cases by location. The distribution of measles cases by location showed a statistically significant difference (P = 0.010) (Table 5).

The distribution of measles cases by vaccine status revealed that unvaccinated participants had a higher prevalence of 30.0% and the vaccinated 4.4%. It showed a statistically significant difference among the vaccinated and unvaccinated participants (P = 0.001) (Table 6).

The participants that received vitamin A supplement had a prevalence of 14.4% compared to those who did not receive (20.0%). The distribution of the measles cases by vitamin A status (intake), indicated no statistically significant difference among the participants (P = 0.359) (Table 7).

Table 5: Frequency distribution of measles cases by location

Location	Negative (%)	Positive (%)	Total(%)	X^2	P-Value
Urban	30(33.3)	7(7.8)	37(41.1)	6.707	0.010
Rural	29(32.2)	42(26.7)	53(58.9)		
Total (%)	59(65.6)	31(34.4)	90 (100.0)		

Key: X^2= Chi-square, n=number.

Table 6: Frequency distribution of measles cases by vaccine status

Vaccine Status	Negative (%)	Positive (%)	Total(%)	X^2	P-Value
Vaccinated	10(11.1)	4(4.4)	14(15.6)	17.560	0.001
First dose only	15(16.7)	0(0.0)	15(16.7)		
Unvaccinated	27(30.0)	27(30.0)	54(60.0)		
Unknown	7(7.8)	0(0.0)	7(7.8)		
Total n (%)	59(65.6)	31(34.4)	90 (100.0)		

Key: X^2= Chi-square, n=number.

Table 7: Frequency distribution of measles cases vitamin a status

Vit A Status	Negative(%)	Positive (%)	Total (%)	X^2	P-Value
Yes	19(21.1)	13(14.4)	32(35.6)	0.840	0.359
No	40(44.4)	18(20.0)	58(64.4)		
Total n (%)	59(65.6)	31(34.4)	90 (100.0)		

Key: X^2= Chi-square, n=number.

Discussion

This study was conducted to assess the epidemiology of measles infection amongst patients attending Specialist Hospital, Sokoto. Among the 90 participants that were investigated during this study period, accumulative prevalence of 34.4% measles cases was recorded which does not correlate with comparative seroprevalence of measles virus immunoglobulin M that was carried out in some selected hospitals in Kaduna State, that indicated a prevalence of 21% (Olaitan, *et al*., 2015) and in Jigawa State which recorded a 17.6% prevalence (Faruk *et al.,* 2020). The difference in prevalence might be due to differences in the targeted population included in the researches. Another study shows a prevalence of 30.2% among children aged 0-23 months reported in Akwa Ibom State (Bassey, *et al*., 2010) and 32.2% among older children in Giwa (Chechet, *et al*., 2014) which are all higher than that of Omilabo *et al*. (1999) that shows a prevalence of 15.6% from Southwestern Nigeria. The reason for the observed differences may be attributed to the seriousness and dedication of relevant authorities in ensuring better measles vaccine coverage in their region, which may be as a result of accelerated measles control activities. This includes improved routine immunization coverage, provision of a second dose of measles vaccine as part of a supplementary vaccination activities in certain countries of the world. It could also be due to differences in their geographical locations and case-based surveillance with laboratory confirmation may have reduced measles-associated morbidity and mortality (Manirakiza, *et al*., 2011; Manda *et al*., 2024).

Findings from this study revealed a high prevalence of measles of 17.8% among children aged 0-1years, 12.2% in age group 2-3years and 3.3% in age group 4-5years respectively. The greater burden observed in the under-five years age group is similarly to findings in some previous studies conducted in Nigeria and some developing countries (Saleh, *et*

al., 2016; Faruk, *et al*., 2020). This is unexpected considering the measles control measures established within the country through the availability of free and effective measles vaccine administered during routine immunization targeted at the under-five age group, yet the high prevalence may be due to vaccination failure (Madubu, 2021; Ayodele *et al*., 2024). The lower incidence observed among the age groups of five years and above could be attributed to lifelong immunity acquired through measles infection and/or possible exposure to the antigen through vaccination. It has also been indicated that determinants of the average age of acquiring measles are mainly population immunity and birth rate, low population immunity, high birth rates, and high population density all lead to increase transmission in younger age groups commonly seen in developing countries (Kabami *et al*., 2020; WHO, 2022). An increase in the vaccination coverage can influence the average age of acquiring measles infection from the younger age group to adolescents and young adults (WHO, 2022).

This study also revealed higher susceptibility to measles infection in females than their male counterparts with a prevalence of 18.9% and 15.6% respectively. This result agrees with previous studies in other parts of Nigeria (Bassey *et al*., 2010) and Bolivia, (Masuet-Aumatell *et al*., 2013) which documented that measles antibody is marginally higher in females than in males, but disagrees with the work of (Chechet *et al*., 2014) who reported the contrary. A study revealed that females become infected earlier than males because they may lose maternal antibodies earlier than boys (Aaby *et al*., 2012; Maliki *et al.,* 2021).

There was no statistically significant association between measles virus and tribe. Although there was variation in the different tribe frequencies where the Hausa tribe appears to have a prevalence of 16.7% which is higher than other tribes. This may be primarily due to the higher number of Hausa that participated in this research, and also the fact that, the study was carried out among Hausa dominated residents. The study also, recorded a prevalence of 26.7% from the rural area, which might be related to the high prevalence among the Hausa tribe because most of the positive cases were from the Hausa that resides in the rural area and also may be due to illiteracy and lack of awareness on the availability of effective measles vaccine and also lack of completing the measles vaccine dose.

The vaccination status was significantly associated with high prevalence of 30% observed among the unvaccinated participant with p-value of 0.001 than that observed among vaccinated children (4.4%). The low level recorded for vaccinated children may reflect vaccine failure as well as effectiveness of vaccination. This study conforms to an acceptable measles vaccination threshold of >9% (Chectet *et al.*, 2014) as well as in early indication of failure stipulated in the range of 2%-10% reported by (Wilkins, *et al*., 1978). Problems with storage, transport, and maintenance of a cold chain system can easily affect the potency of vaccines in developing nations (Adu *et al.*, 1996; Omilabo *et al*., 1999). Diversifications in measles strains has also been reported to account for the early presentation of measles and occurrence of measles in vaccinated children (Kouomou *et al.*, 2002; Ayodele *et al*., 2024).

There is no association between positive participants and vitamin A intake in this study. But vitamin A status can be a guardian in analyzing the risk factors associated with measles virus infection.

This study established that all symptoms (fever, cough, coryza, diarrhea, rash, conjunctiva, and kolpik spots) had a significant association with the measles virus. This means that a child with measles virus must present with some of the above-mentioned signs and symptoms, and this agrees with the work Chechet *et al*. (2014), it also agreed with the WHO clinical case definition, that is, any person presenting with a history of fever (39-40^{O}C) lasting 3 days or more and generalized maculopapular rash with one of the following: coryza, cough, or conjunctivitis (Wharton, *et al*., 1990; Majekodunmi *et al*., 2022).

Conclusion

The prevalence of measles virus among participating children attending Specialist Hospital Sokoto was 34.4%. The prevalence of 17.8% obtained in children aged 0-1 years was an indication that measles is endemic in Sokoto state and still poses a public health problem,

despite the availability of safe and effective vaccine program. Findings from this study revealed a high prevalence of 17.8% measles cases in children with age group 0-1years, 12.2% in age group 2-3years and 3.3% in age group 4-5years.This study also indicated higher susceptibility to measles infection in females than their male counterparts with a prevalence of 18.9% and 15.6% respectively. The Hausa tribe had a prevalence of 16.7% which is higher than the other tribe. The study also recorded a prevalence of 26.7% from the rural area, which might be related to the high prevalence among the Hausa tribe because most of the positive cases were from the Hausa ethnic group that resides in the rural area and also may be due to illiteracy and lack of awareness on the availability of effective measles vaccine and also lack of completing the measles vaccine dose. The unvaccinated participants had 30% prevalence compared to vaccinated children (4.4%). The low level recorded for vaccinated children may reflect vaccine failure as well as effectiveness of vaccination.

Recommendations

1. We recommended improvement on enhanced measles surveillance and routine immunization especially in the northern regions of Nigeria.
2. There should be improved measles cases management across all regions.
3. There is a need to work out alternate strategies for control of measles such as introducing a two-dose schedule to halt the endemic transmission (which has been adopted in some developing countries).
4. There is a need to conduct research to assess the prevalence of measles in Sokoto state as a whole.
4. Blood samples collection and testing, strengthening and upgrading of states and regional laboratories to be able to perform confirmatory testing for measles, if the goal towards measles elimination is to be achieved should be encouraged.
5. It is important for health providers and policy makers to recognize the health implications of this virus, review the vaccination age of infants, and intensify vaccination campaign programs.

References

Adu, F.D., Adedeji, A.A., Esan, J.S. and Odusanya, O.G. (1996). Live viral vaccine potency: an index for assessing the cold chain system. *Public Health;* **110**: 325–330**.** https://doi.org/10.1016/S0033-3506(96)80003-5

Aaby, P., Schenck-Gustafsson, K., DeCola, P.R., Pfaff, D.W. and Pisetsky, D.S. (eds). (2012). Handbook of Clinical Gender Medicine. Basel: 405-413. https://doi.org/10. 1159 /isbn.978-3-8055-9930-6

Adugna, B., Tola, A., Fite, M. B. and Motuma, A. (2024). Determinants of Second-Dose Measles Vaccination Dropout in Ethiopia: A Community-Based Matched Case-Control Study. *Heliyon;* **10(9)**: E30764. https://doi.org/10.1016 /j.heliyon. 2024. e30764

Anguinze, R. S., Touré, A., Cissé, F., Grayo, S., Troupin, C. et al. (2024). Viral etiology of measles-like rash in Guinean children during the COVID epidemic in 2022. *Journal of Medical Virology;* ***96*(2)**: e29437. https://doi.org/10.1002/jmv.29437

Alemu, T. G., Tamir, T. T., Workneh, B. S., Mekonen, E. G., Ali, M. S., Zegeye, A. F., ... & Gonete, A. T. (2024). Coverage and determinants of second-dose measles vaccination among under-five children in East Africa countries: a systematic review and meta-analysis. *Frontiers in Public Health*; **12**:1359572. https://doi. org/10. 3389/ fpubh.2024.1359572

Ayodele, A.M., Fasasi, M.I., Uche, O.R., Ikemdinachi, N.G., and Ugochukwu, U.H. (2024). Factors associated with full childhood vaccination coverage among young mothers in Northern Nigeria. *The Pan African Medical Journal*, *47*. https://doi.org/ 10.11604/pamj.2024.47.4.37517

Branda, F., Giovanetti, M., Romano, C., Benvenuto, D., Ciccozzi, A. *et al.* (2024). Global Measles Surveillance: Trends, Challenges, and Implications for Public Health Interventions. *Infectious Disease Reports;* ***16*(2)**:367-379. https://doi.org /10.3390 /idr16020028

Bassey EB, Moses AE, Udo SU, and Umo AN. (2010). The impact of immunization control activities on measles in Akwa Ibom State;

Online Journal of Health and Allied Sciences, **9(1)**: 1-5.

Chechet, J., Ella, E.E. and Ige, S.O. (2014). Seroprevalence of measles IgM in children 5–12 years from selected primary schools in Giwa Local Government Area, Zaria, Kaduna State. *Scientific Journal of Microbiology;* **3(2)**: 19–24.

Dhalaria, P., Kumar, P., Verma, A., Priyadarshini, P., Singh, A.K. *et al*. (2024). Exploring landscape of measles vaccination coverage: A step towards measles elimination goal in India. Vaccine. 2024 May 3. https://doi.org/10.1016/j.vaccine.2024.04.075

Fatiregun, A.A., Adebowale, A.S., and Fagbamigbe, A.F. (2014). Epidemiology of measles in Southwest Nigeria: An analysis of measles case-based surveillance data from 2007 to 2012. *Transactions of The Royal Society of Tropical Medicine and Hygiene;* ***108*****(3)**: 133–140. https://doi.org/10.1093/trstmh/tru004

Faruk, A.S., Adebowale, A.S., Balogun, M.S., Taiwo, L., Adeoye, O., Mamuda, S., and Waziri, N.E. (2020). Temporal trend of measles cases and impact of vaccination on mortality in Jigawa State, Nigeria, 2013-2017: a secondary data analysis. *International Journal of Infectious Diseases*; **35(1)**:13. https://doi.org/10.1016/j.ijid.2020.09.919

Gans, H., and Maldonado, Y.A. (2022). *Measles: Epidemiology and transmission*. https://medilib.ir/uptodate/show/3019.

Ibrahim, B.S., Usman, R., Mohammed, Y., Datti, Z., Okunromade, O. *et al.* (2019). Burden of measles in Nigeria: a five-year review of casebased surveillance data, 2012-2016. *Pan African Medical Journal*; **32(1)**: 5. doi:10.11604/pamj. supp.2019. 32.1. 13564.

ICF International, Maryland USA. (2022). STATcompiler. [Internet]. [accessed 2022 Aug 15]. https://www.statcompiler.com/en/ Google Scholar

Jean Baptiste, A.E., Masresha, B., Wagai, J., Luce, R. and Oteri, J. *et al*. (2021). Trends in measles incidence and measles vaccination coverage in Nigeria, 2008–2018. Vaccine;**39**:C89–C95. doi: 10.1016/j.vaccine.2021.03.095.

Kabami, Z., Simbwa, B. N., Kizito, S. N., Agaba, B., Kayiwa, J., Kadobera, D., Migisha, R. Epidemiological characteristics and trends of measles cases reported through the case-based surveillance system, Uganda, 2016–2020. https://uniph.go.ug/epidemiological- characteristics-and-trends-of-measles-cases-reported-through-the-case-based-surveillance-system-uganda-2016-2020/

Kouomou, D.W., Nerrienet, E., Mfoupouendoun, J., Tene, G., Whittle, H. and Wild, T.F. (2002). Measles virus strains circulating in Central and West Africa: geographical distribution of two B3 genotypes. *Journal of Medical Virology; **68(3)**: 433-440.* https://doi. org/10.1002/jmv.10222

Lawal, T. V., Atoloye, K. A., Adebowale, A. S., and Fagbamigbe, A. F. (2023). Spatio-temporal analysis of childhood vaccine uptake in Nigeria: a hierarchical Bayesian Zero-inflated Poisson approach. *BMC Pediatrics; **23*****(1)**: 493. https://doi.org/10.1186/s12887-023-04300-x+*8-

Maliki, I., Njoh, A.A. and Castetbon, K. (2024). Factors Associated with Antenatal Care Visit and Measles Immunization of Children in Nigeria: A Cross-Sectional Study. https://doi.org/10.21203/rs.3.rs-3891607/v1

Majekodunmi, O. B., Oladele, E. A., & Greenwood, B. (2022). Factors affecting poor measles vaccination coverage in sub-Saharan Africa with a special focus on Nigeria: a narrative review. *Transactions of The Royal Society of Tropical Medicine and Hygiene*; ***116*****(8)**: 686-693. https://doi.org/10.1093/trstmh/trac013

Manda, J.A., Tuli, L.L., Mbuya, H.K., and Ramazani, R.A. (2024). Epidemiological study of the occurrence of measles in children aged 0-15 years in the Banalia Health Zone (DR Congo) during 2022. *World Journal of Advanced Research and Reviews; **22*****(1)**: 1266-1275.

Madubu, D. M. (2021). Sociodemographic Factors Associated with Childhood Vaccination Status in Sokoto State, Nigeria (Doctoral dissertation, Walden University).https://www.proquest.com/openview/9888fe02cb688a56a148f88 da85f05d1/1?pq-origsite=gscholar&cbl=18750&diss=y

Masuet-Aumatell, C., Ramon-Torrell. J.M., Casanova-Rituerto, A., Banqué Navarro, M., Dávalos Gamboa Model, R. and Montaño Rodríguez, S.L. (2013). Measles in Bolivia: a honeymoon period. *Vaccine;* **31(16)**: 2097–2102. https://doi.org/10.1016/j.vaccine .2012.12.037

Manirakiza, A., Kipel, M.J., Sosler. S., Daba, M.R. and Vasilache, G.I. (2011). Seroprevalence of measles and natural rubella antibodies among children in Bangui, Central African Republic. *BMC Public Health*; **11**:327. http://www.biomedcentral.com/1471-2458/11/327

Melis, T., Mose, A., Fikadu, Y., Haile, K., Habte, A., & Jofiro, G. (2024). Predictors for low coverage of uptake of second dose of measles vaccine among children in sub-Saharan Africa, 2023: a systematic review and meta-analysis. *Journal of Pharmaceutical Policy and Practice;* **17(1)**: 2285507. https://doi.org/10.1080/20523211.2023.2285507.

National Population Commission, NPC (2006). https://nationalpopulation.gov.ng/

Olaitan, A.E., Ella, E.E. and Ameh J.B. (2015). Comparative seroprevalence of measles virus immunoglobulin M antibodies in children aged 0-8 months and a control population aged 9-23 months presenting with measles-like symptoms in selected hospitals in Kaduna State. *International Journal of General Medicine;* **10(8)**: 101-108. https://doi.org/10.2147/IJGM.S79423

Omilabu SA, Oyefolu A.O, Ojo O.O, and Audu R.A. (1999). Potency status and efficacy of the measles vaccine administered in Nigeria: a case study of three EPI centers in Lagos, Nigeria. *African Journal of Medicine and Medical Sciences;* **28(3-4)**: 209-212. *https://europepmc.org/article/med/11205835*

Saleh, J.E. (2016). Trends of measles in Nigeria: A systematic review. *Sahel Medical Journal;* **19(1)**: 5-11. https://doi.org/10.4103/1118-8561.181887.

Shorunke, F.O., Adeola-Musa, O., Usman, A., Ameh, C., Waziri, E., & Adebowale, S.A. (2019). Descriptive epidemiology of measles surveillance data, Osun state, Nigeria, 2016–2018. *BMC Public Health*; **19**: 1-8. https://doi.org/10.1186/s12889-019-8012-6

Shobayo, B., Umeokonkwo, C.D., Jetoh, R.W., Gilayeneh Sr, J.S. and Akpan, G. *et al.* (2024). Descriptive Analysis of Measles Outbreak in Liberia, 2022. *IJID Regions;* **10**: 200-206. https://doi.org/10.1016/j.ijregi.2024.01.008

Sinumvayo, J.P., Munezero, P.C., Tope, A.T., Adeyemo, R.O. and Bale, M.I. *et al*. (2024). Vaccination and vaccine-preventable diseases in Africa. *Scientific African*: e02199. https://doi.org/10.1016/j.sciaf.2024.e02199

Sulaiman, S.A., Vora, N.M., Chhabra, K., Bashir, M.A. and Awan, Z. (2024). Pediatric subacute sclerosing panencephalitis: A narrative review on measles and the future of vaccination. *Journal of Child Neurology:* 08830738241238860. https://doi.org/10.1177/08830738241238860

Tanne, J.H. (2020). Measles cases and deaths are increasing worldwide, warn health agencies. BMJ Journals; 371:m4450. doi:10.1136/bmj.m4450.

Wharton, M., Chorba, T.L., Vogt, R.L., Morse, D.L. and Buehler, J.W. (1990). Case definitions for public health surveillance. *MMWR Recommendations and Reports;* **39**: 1–43. https://pubmed.ncbi.nlm.nih.gov/2122225/

Wilkins, J. and Wehle, P.F. (1978). Evidence for reinstatement of infants 12 to 14 months of age into routine measles immunization programs. American Journal of Disease in Children; **(132)**:164–166. https://doi.org/10.1001/archpedi.1978.02120270062013

WHO, UNICEF (2021). Immunization, measles (% of children ages 12-23 months). Data [Internet]. [accessed 2022 Aug 15].

World Health Organization (2017). Measles vaccines: WHO position paper – April 2017. *Weekly Epidemiological Record*; **92**(17):205–228. https://www.who.int/ publications-detail-redirect/who-wer9217-205-227

Citation: Iduh M.U., Enitan, S. S., Umar A.I., Bunza N.M., Usman S.S and Nasiru, M. The Epidemiology of Measles Virus Amongst Children Attending Specialist Hospital Sokoto, Nigeria. ***Sokoto Journal of Medical Laboratory Science*; 9(2): 306 – 315**
https://dx.doi.org/10.4314/sokjmls.v9i2.36