Asian Journal of Immunology

4(1): 27-35, 2020; Article no.AJI.57099

Seroprevalence of Rubella IgG and IgM Antibodies among Pregnant Women Attending Antenatal Clinic in Federal Teaching Hospital Ido-Ekiti, Nigeria

Richard Yomi Akele[1*], Baget Nerat Pam[1], Bernard Oluwapelumi Oluboyo[1], Seyi Samson Enitan[2], Janet Funmilayo Akinseye[1] and Funmilayo Ajoke Adewumi[3]

[1]Department of Medical Laboratory Science, College of Medicine and Health Science, Afe Babalola University, Ado-Ekiti, Nigeria.
[2]Department of Medical Laboratory Science, Babcock University, Ilisan-Remo, Ogun State, Nigeria.
[3]Department of Microbiology and Parasitology, College of Medicine, Ekiti State University, Ado-Ekiti, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Authors RYA and BNP designed the study, wrote the protocol, collected data, performed analysis and wrote the first draft of the manuscript. Authors BOO and SSE performed the statistical analysis and restructured the manuscript. Authors JFA and FAA managed literature searches. All authors read and approved the final manuscript.

Article Information

Editor(s):
(1) Dr. Darko Nozic, Professor, University of Belgrade, Serbia.
(2) Dr. Jaffu Othniel Chilongola, Tumaini University, Tanzania.
Reviewers:
(1) Victor B. Oti, Nasarawa State University, Nigeria.
(2) Simeon Achunam Nwabueze , Namdi Azikiwe University, Nigeria.
Complete Peer review History: http://www.sdiarticle4.com/review-history/57099

Original Research Article

Received 22 March 2020
Accepted 29 May 2020
Published 04 June 2020

ABSTRACT

Aim: Though Rubella is vaccine-preventable and enlisted on the expanded program on immunization (EPI) list, vaccination and testing are not routinely practiced in Ido-Ekiti. There is also paucity of epidemiological data on the prevalence of rubella infection at Ido-Ekiti, hence the study aimed at carrying out a serosurvey to generate epidemiological data for this location.
Study Design: This was a cross-sectional study.
Place and Duration of Study: The study was carried out between October 2018 and January 2019 at the Antenatal Clinic of Federal Teaching Hospital Ido-Ekiti (FETHI), Ekiti State, Nigeria.

**Corresponding author: E-mail: akeler@abuad.edu.ng;*

Methodology: One hundred and eighty four consenting pregnant women attending antenatal clinic at FETHI were enrolled. Structured questionnaire was administered to collect Sociodemographic data and sera samples were also collected to determine seroprevalence of rubella IgG and IgM antibodies using the enzyme linked immunosorbent assay (ELISA) method. Prevalence rate was calculated and chi square value was determined.
Results: Of the 184 sera samples analyzed 176 (95.7%) and 22 (12%) were seropositive for rubella IgG and IgM respectively. Twenty (11%) of those seropositive for IgM were also positive for IgG and only 2(1%) were positive only for IgM. Prevalence rate for IgG was highest among 26-30years (98.3%) and 31-35years (18.8%) for IgM. Age had no-significant effect ($p > 0.05$) on seroprevalence distribution. In like manner, level of formal education, knowledge of the virus, and occupation had no significant effect ($p > 0.05$) on prevalence of the virus. However parity significantly ($p < 0.05$) influenced the pattern of serostatus for both IgG and IgM.
Conclusion: The high prevalence and similar distribution pattern irrespective of sociodemographic features of rubella virus in this study area suggests its endermicity and continuous transmission in the area. This emphasizes the need to implement routine immunization of children and susceptible women of child bearing age against rubella virus.

Keywords: Seroprevalence; rubella IgG and IgM; pregnancy; congenital rubella syndrome; Ido-Ekiti; Nigeria.

1. INTRODUCTION

Rubella is a contagious viral infection characterized by distinctive macules of erythematous rash popularly called German measles. It is an enveloped positive-sense single-stranded ribonucleic acid (RNA) virus belonging to the family Togaviridae, genus Rubivirus [1-3]. Rubella is transmitted congenitally and by respiratory aerosols, transmission occurring mainly in children and young adults. The contagious period of the virus is approximately 5 to 7-days pre and 3 to 5-days post manifestation of clinical symptoms [4]. Upon inhalation of virus loaded droplets, the virus infects cells of the mucosal membranes of the upper respiratory tract and replicates consequently spreading to regional lymph nodes. [4]. Infection is mainly subclinical, alternatively causing a self-limiting illness with low-grade fever, lymphadenopathy, and skin rash. Of major concern is the fact that infection in pregnancy often result in congenital rubella infection which causes miscarriages, stillbirth, abortion, or congenital rubella syndrome (CRS) of the infants. Congenital rubella syndrome encompasses cardiac, cerebral, ophthalmic, and auditory defects [5-7]. It is estimated that infection with the virus in the first trimester or shortly before pregnancy may result in approximately 90% of fetuses being infected and 100% of these infected fetuses will come down with congenital deformities, often resulting in miscarriage [4,8-9]. It has been reported that as pregnancy progresses, the risk of CRS decreases [9].

In Nigeria, a high prevalence rate of rubella has been reported in some areas. For example, 77% in Lagos [10], 97.9% in Zaria [11] and 93.1% in Abakaliki [12]. Seroepidermiological studies in Ethiopia also has reported a similarly high prevalence, 91% in Addis Ababa [13] and 86.3% [14] in Southern Ethiopia.

Rubella is a vaccine-preventable viral infection [15] considered as an eradicable infection. Based on this fact, some vaccination programs implemented between 1996 and 2010 in some high income, middle income and low-income countries have in the past been able to considerably reduce global CRS cases [16,17]. This has stirred the World Global Assembly to endorse the Global Measles and Rubella Strategic plan in April 2012 [18] which is targeted at eliminating rubella in at least 5 WHO regions by 2020 [19]. However, routine administration of the rubella vaccine is yet to be implemented in many areas in Nigeria most especially in Ido-Ekiti were this study was carried out. Routine diagnosis for the rubella virus is also not practiced in this location just as the case is in many other locations in Nigeria. Thus, a paucity of empirical data on serosurvey of rubella. Though some researchers have conducted serosurveillance in other locations, this is the first to be carried out in Ido-Ekiti and environs. This makes it pertinent to conduct this serosurvey in this location as findings may propel informed decision making and definition of the best interventional approach by those saddled with such responsibilities. Findings of such investigation may be cardinal to the estimation of

the incidence of CRS and conversely CRS burden at Ido-Ekiti and its environs. This study was therefore designed to find out the seroprevalence of anti-rubella IgG antibodies (a marker of prevalence rate), anti-rubella IgM (a marker of incidence rate), and some sociodemographic cardinals that may influence the distribution of the disease among pregnant women in Ido-Ekiti.

2. METHODOLOGY

2.1 Study Area and Population

This cross-sectional study was conducted at the antenatal clinic of Federal Teaching Hospital Ido-Ekiti (FETHI). FETHI is a referral hospital that receives patients from all over Ekiti State and neighboring States like Kwara and Kogi State. It is sited in a sub-urban community located in Ido-Osi Local Government Area of Ekiti State Nigeria, on latitude 7.843093 and 5.182314 (Find Coordinates.https://www.distancesto.com/coordinates/ng/ido-ekiti-latitude-longitude/history/75944.htmllast accessed 04 April 2020) [20].

The study population comprised of 184 pregnant women at various stages of pregnancy that consented to participate in the study.

2.2 Sample Collection and Processing

A brief enlightenment on the basis, benefits and demerit of the study was given and then a written consent obtained from volunteers. A structured questionnaire was administered to those who indicated interest in participating in the study. The questionnaire was designed to collect sociodemographic data and data on possible risk factors that may predispose subjects to infection [14]. After duly filling the questionnaire, 3 mls of venous blood was collected into a labeled plain tube using standard aseptic procedures. Blood samples were allowed to clot, aseptically, dislodged, and centrifuged at 2,500 rpm for 5 minutes [21]. Sera were then separated into well-labeled cryovials, transported to the Medical Microbiology Laboratory of Afe Babalola University, Ado-Ekiti on ice packs. The samples were stored at -20°C until ready for laboratory analysis. Samples were collected over a period of four months.

2.3 Sample Analysis

Sera samples were analyzed for rubella IgG and IgM antibodies in the Medical Microbiology Laboratory of Afe Babalola University Ado-Ekiti using the enzyme-linked immunosorbent assay (ELISA) method. Rubella IgG and IgM pre-coated ELISA kits were obtained from Dia Pro. Diagnostic Bioprobes Srl®, Columella Millano, ITALY. The analysis was carried out according to the manufacturer's instructions.

Briefly, reagents provided were allowed to attain room temperature for 15 minutes before use. The 40X wash buffer was diluted with distilled water using a ratio of 1:40 before use. The micro-titer plate template was set up with 1 well as blank, 2 wells as negative control and 2 wells as the positive control. 10 µl of sera sample and 90µl sample diluent were dispensed into the respective wells except for the blank well, negative control well and positive control well. 100 µl of the negative and positive controls were dispensed into their wells respectively. The content was mixed by vibrating the plate gently. The microplate was covered with a sealing paper and incubated in a microplate incubator (MARVOTECH PLATE INCUBATOR, CHINA) at 37°C for 60 minutes [21]. After incubation, the microplate was washed five times using wash buffer. 100 µl of Horseradish peroxidase enzyme (HRP) conjugate was added to each well except the blank; the microplate was covered with a sealing paper and also incubated in a microplate incubator at 37°C for 15 minutes. After incubation, the microplate was washed five times with the diluted wash buffer in an automatic plate washer (MARVOTECH PLATE WASHER, China) [21]. 50 µl of substrate solution A and B were added to each well respectively and were mixed; the plate was covered and incubated at 37°C for 15 minutes. 50 µl of stop solution was added to each well and mixed. The absorbance was read in an ELISA reader machine (MARVOTECH ELISA READER, China) at a wavelength of 450 nm [21].

2.31 Interpretation of rubella IgG/IgM result

If the mean negative control O.D ≤ 0.1and the mean positive control O.D ≥ 0.8, the test is valid.

Cut-off O.D = the mean O.D value of the negative control × 2.1

Positive results: Sample O.D ≥ cut-off O.D

Negative results: Sample O.D < cut-off O.D

2.4 Statistical Analysis

The data obtained from questionnaires administered and those obtained from the laboratory analysis were managed and analyzed using the EPI-INFO version 7.2 statistical

package. Results were reduced to percentiles and a Pearson chi-square test was performed at a 95% confidence interval. *P*-values less than 0.05 ($p< 0.05$) was used to determine relationships between parameters evaluated and seroprevalence.

3. RESULTS AND DISCUSSION

A total of one hundred and eighty-four pregnant women attending antenatal clinic at the Federal Teaching Hospital Ado Ekiti were enrolled in this study. Their ages ranged between 16 to 41 years with a mean age of 28±13 years (Table 1).

One hundred and seventy-six (95.6%) of the subjects were seropositive for rubella IgG and 22 (12.0%) for rubella IgM. Twenty (10.9%) were seropositive for both rubella IgG and IgM, 2 (1.1%) only for rubella IgM; and 154 (83.7%) for rubella IgG. Seropositivity was higher among age group above 35 years: 12 (100%) for IgG and age group 31-35 years, 6 (18.8) for IgM (Table 1). The distribution was however non-statistically significant ($p = 0.50$ and 0.85 respectively).

Higher but non-significant proportion of subjects in the third trimester 62 (98.4%) and second trimester 84 (96.6%) as against 30 (88.2%) in the first trimester were seropositive for IgG. In contrast to this pattern, a higher proportion of the subjects in first trimester 8 (23.5%) and second trimester 12 (13.8%) as against 2 (3.2%) in the third trimester were seropositive for rubella IgM. The highest rate of co-positivity for rubella IgG and IgM was observed in the second trimester 15 (17.2%) (Table 2). The married ones among the subjects had a higher seroprevalence 152 (97.4%) for rubella IgG while the singles had a higher seroprevalence 6 (26.1%) for rubella IgM (Table 3). The subjects with no form of formal education, zero number of parity and some level of knowledge of the virus had the least seroprevalence for rubella IgG 3 (60.0%), 53 (91.3%), 32 (94.1%) respectively. On the other hand, those with zero number of parity had significant ($p = 0.04$) seronegativity for rubella IgM 56 (93.6%).

Despite the global public health implication of Rubella infection which has stimulated the endorsement of the Global Measles and Rubella Strategic plan in 2012, which was planned to cover 2012-2020, it is a thing of concern that there is still a paucity of epidemiological data on seroprevalence of rubella infection in Nigeria. The few that exist are skewed to areas like Zaria, Jos, Maiduguri, Abia, and Osogbo. This impact negatively on making rightful decisions on intervention approaches to curb the incidences of CRS.

Rubella IgG serostatus is an indicator of previous exposure to the virus or immunization, thus it is used as a reliable biomarker for the prevalence of the disease where vaccination history is known. On the other hand, IgM is an indication of a fresh infection and as such used to estimate the incidence of the disease. When IgG co-exist with IgM, it could be an indicator of an infected person who is just recovering and rarely re-infection. The seronegative population for IgG is the susceptible population which is considered high risk.

In this present study, 95.6% of the pregnant women enrolled were seropositive for anti-rubella IgG antibodies. This high seroprevalence is similar to 97.9% report by Muhammad et al. [22], 93.1% by Olajide et al. [5] and 90.2% by Gubio et al. [23] all in Zaria, Nigeria. A lower seroprevalence was reported from a closer location to that of this present study by Kolawole et al. [24] who reported 87.5% IgG seroprevalence in Osogbo, South-west of Nigeria. This lower prevalence is likely due to the time lag between the two studies. Lower IgG seroprevalences have also been reported by Hamdan et al. [25] in Sudan (65.3%) and Oyinloye et al. [26] in Maiduguri, Nigeria. This indicates variability in the epidemiology of the virus from one location to another.

We also recorded 12% seropositivity for anti-rubella IgM. This was a little higher than the findings of Mengouo et al. [27] in Cameroon who surveyed 2008 -2014. They, however, record 12.4% IgM seroprevalence in 2012. The findings of Getehun et al. [13] and Junaid et al. [28] were higher (39.4 and 45.2% respectively) possibly because their studies were not restricted to pregnant women and time lag. From this present study, 11% of subjects positive for IgM were also positive for IgG while 1% was just IgM. This could imply that the 12% got infected in the recent past but the 11% with IgG and IgM are already recovering while the remaining 1% was yet to produce IgG (meaning they are still at the active stage of infection). Incidentally, the 1% population with only IgM were all in the first trimester; a high-risk period. The other 12% thought to have recovered were all distributed through the first, second, and third trimester of pregnancy. These imply that most of them especially those in the first and early part of the

Table 1. Seroprevalence of Rubella IgG and IgM based on the age group

Age group (Years)	Number	Rubella IgG			Rubella IgM			Rubella IgG and IgM		
		Positive (%)	*p*-Value	X^2	Positive (%)	*p*-Value	X^2	Positive (%)	*p*-Value	X^2
16-20	8	5 (62.5)			1 (12.5)			1 (12.5)		
21-25	72	69 (95.8)			8 (11.1)			7 (9.7)		
26-30	60	59 (98.3)	0.50	2.34	6 (10.0)	0.89	0.58	5 (8.3)	0.15	3.76
31-35	32	31 (96.9)			6 (18.8)			6 (18.8)		
Above 35	12	12 (100)			1 (8.3)			1 (8.3)		
Total	184	176 (95.6)			22 (12.0)			20 (11.0)		

Table 2. Seroprevalence of Rubella IgG and IgM in relation to stages of pregnancy

Trimester	Number	Rubella IgG			Rubella IgM			Rubella IgG and IgM		
		Positive (%)	*p*-Value	X^2	Positive (%)	*p*-Value	X^2	Positive (%)	*p*-Value	X^2
First	34	30 (88.2)			8 (23.5)			6(17.6)		
Second	87	84 (96.6)	0.17	2.52	12 (13.8)	0.07	5.12	12 (13.8)	0.06	1.55
Third	63	62 (98.4)			2 (3.2)			2 (3.2)		
Total	184	176 (95.6)			22 (12.0)			20 (10.9)		

Table 3. Seroprevalence of Rubella IgG and IgM antibodies in relation to some sociodemographic data

Sociodemographic Data		Rubella IgG			Rubella IgM		
	Number	Positive (%)	*p*-Value	X^2	Positive (%)	*p*-Value	X^2
Marital status							
Married	156	152 (97.4)			15 (9.6)		
Single	23	21 (91.3)	0.76	1.56	6 (26.1)	0.56	0.85
Separated	5	3 (60.0)			1 (20)		
Educational status							
Primary	52	49 (94.2)			6 (11.5)		
Secondary	86	85 (98.8)	0.10	2.59	10 (11.6)	0.30	0.99
Tertiary	41	39 (95.1)			5 (12.2)		
None	5	3 (60.0)			1 (20)		
Religion							
Christianity	143	140 (97.9)			17 (11.9)		
Islam	37	34 (91.9)	0.71	0.91	5 (13.5)	0.32	2.12
Others	4	2 (50.0)			Nil		
Occupation							
Student	15	11 (73.3)			Nil		
Housewife	49	47 (95.9)			8 (16.3)		
Public servant	41	40 (97.6)	0.07	3.10	5 (12.2)	0.07	3.46
Trader	42	40 (95.2)			6 (14.3)		
Farmer	37	34 (91.9)			3 (8.1)		
Parity							
0	58	53 (91.3)			2 (3.4)		
1-2	79	76 (96.2)	0.05	3.14	14 (18.7)	0.04	3.75
3-4	29	29 (100)			6 (20.7)		
Above 4	18	18 (100)			Nil		
Knowledge of the virus							
Yes	34	32 (94.1)	0.48	2.01	6 (17.6)	0.42	0.22
No	150	144 (96.0)			16 (10.7)		

second trimester must have been going through the active phase of infection during the first trimester which might put the fetus at the risk of CRS. The susceptibility of these populations is 4% going by the IgG seroprevalence, but considering that the remaining 11% which had both IgG and IgM are likely to have had a recent infection and were just recovering; the susceptibility could be placed at 15.2%. This is comparable with 13.7% susceptibility reported by Tamirat et al. [14] in Southern Ethiopia.

Rubella infectivity is not associated with age ($p > 0.05$) though ages 16 – 20 had the least prevalence for IgG likewise IgM. This agrees with the report of Muhammad et al. [22] but contrary to some others within the country. This was probably due to the high endemic nature of the virus in Zaria, Nigeria. The virus is said to be in constant circulation among the population thus downplaying the effect of some of the risk factors like age [22]. A similar situation is observed in this present study. Higher rubella IgM seroprevalence rates have also been documented among children and adolescents than in adults with the trend seen to decrease with an increase in age [23,28-32]. Antibodies were found at every trimester which did not differ significantly from one another ($p > 0.05$), a finding that agreed with that of Olajide et al. [5]. IgG was highest in the third trimester and IgM higher in the First trimester. This is contrary to Fokunang et al. [33] who reported the highest prevalence in the second trimester. This difference may be accrued to cultural variation. Some ethnic groups are more predisposed to presenting early at antenatal clinics during pregnancy than the others.

Formal educational status, religion, and occupation had no significant effect ($p > 0.05$) on the distribution of seroprevalence of IgG and IgM in this present study. This finding is similar to the findings of Mohammed et al. [22]. It was observed that though a high percentage of the subjects had a tertiary or at least a secondary school level formal education, it did not cumulate to adequate knowledge about the virus. Even the few who indicated knowledge of the virus did not request to be vaccinated as all subjects in this study claimed not to have been vaccinated against the virus. Parity was however associated with the risk of rubella infection ($p < 0.05$). Its effect was seen both on IgG and IgM serostatus. The nulliparous (zero parity) had a 93.1% IgG prevalence and 3.4% for IgM as compared to the multiparous that had at least 18.7% and more IgM prevalence which aligns with the repost of Onakewhor and Chiwuzie [31] but contrary to that of Olajide et al. [5] who reported no association between reproductive character and risk of rubella infection. Parity may be associated with the risk of infection since mothers who have a number of children may stand a risk of being infected from the children [12].

The study is limited by the unwillingness of some of the participants to provide genuine information and inability to recall past experiences, hence, possibly introducing some biases to the study. The accuracy generalizations about pregnant women based on this study may also be limited because it is an institution based study. A subsequent community based longitudinal study may resolve these limitations.

4. CONCLUSION

This study reveals a high rate of exposure of pregnant women to rubella virus in this study area. This suggests continuous transmission and endermicity of rubella in the area. Prevalence showed similar distribution pattern irrespective of sociodemographic features examined. However, infection is significant with respect to parity. The findings emphasize the need to implement routine childhood immunization against rubella virus as well as vaccinating susceptible women of childbearing age.

CONSENT

The authors declare that written informed consent was obtained from the patients for the publication of this report. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal.

ETHICAL APPROVAL

The authors hereby declare that Ethical approval for the study was obtained from the Ethics and Research Committee, Federal Teaching Hospital Ido-Ekiti, Reference Number: ERC/2017/02/20/ 50B. Subjects were fully informed of their right to opt-out of the study at any point they so desire. They were informed about investigations carried out with their samples, potential risk of the study, and were assured of confidentiality of the results.

ACKNOWLEDGEMENTS

The authors are grateful to the authority of Federal Medical Teaching Hospital Ido-Ekiti who permitted us to carry out this study in their facility through the ethical committee. The Cooperation

of the Nurses and Doctors at the antenatal clinic during this study is acknowledged. We also appreciate Afe Babalola University for granting us access to their Medical Laboratory where the sample analysis was carried out.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mayo Foundation for Medical Education and Research. Rubella: Complications, Diseases and Conditions. Healthline. 2015;25:45-50.
2. Willey J, Sherwood L, Woolverton C. Human diseases caused by viruses and prions. In: Prescott's Microbiology, 8th ed. New York: McGraw-Hill. 2011;905-906.
3. CDC. Rubella (German measles, three-day measles); 2011.
Accessed July 13 2017
Available:http://www.cdc.gov/globalhealth/immunizationinfographic/stop-rubella.htm
4. Banatvala JE, Brown DW. Rubella. lancent. 2015;363(9415):1127–1137.
5. Olajide OM, Aminu M, Randawa AJ, Adejo DS. Seroprevalence of rubella-specific IgM and IgG antibodies among pregnant women seen in a tertiary hospital in Nigeria. Int J Women's health. 2015;7:75–83.
6. Mirambo MM, Majigo M, Aboud S, Gross U, Mshana SE. Serological makers of rubella infection in Africa in the pre vaccination era: A systematic review. BMC Res Notes. 2015;8(1):716-726.
7. WHO. Rubella vaccine. WHO Position Paper. Weekly Epidemiological Record. 2013;29(86):301–316.
Available:http://www.who.int/wer/2011/wer8629.pdf
8. Kwofie TB, Ayensu F, Mutocheluh M, Narkwa P, Nguah SB, Turpin CA, Owusu M. Seroprevalence of Rubella virus, cytomegalovirus and herpes simplex virus among pregnant women at the Komfo Anokye Teaching Hospital. Journal of Public Health in Developing Countries. 2015;1(2):56-63.
9. Dimech W, Grangeot-Keros L, Vauloup-Fellous C. Standardization of assays that detect anti-rubella virus Igg antibodies. Clin MicrobiolRev. 2016;29(1):163–174.
DOI: 10.1128/CMR.00045-15
10. Onyenekwe CC, Kehinde-Agbeyangi TA, Ofor US, Arinola OG. Prevalence of Rubella-IgG antibody in women of childbearing age in Lagos, Nigeria. West African Journal of Medicine. 2000;19(1): 23–26.
11. Amina MD, Oladapo S, Habib S, Adebola O, Bimbo K, Daniel A, et al. Prevalence of rubella IgG antibodies among pregnant women in Zaria, Nigeria. Int Health. 2010; 2(2):156-159.
12. Onyeukwu EU, Ogbonnaya O, Oseni OM, Anyigor E, Elom O, Ethel N. Seroprevalence survey of Rubella IgG antibodies among pregnant women attending antenatal clinics in abakaliki, Ebonyi State, Nigeria. UJMR. 2018;3(2): 50-55.
13. Getahun M, Beyene B, Gallagher K, Ademe A, Teshome B, Tefera M, et al. Epidemiology of rubella virus cases in the pre-vaccination era of Ethiopia, 2009–2015. BMC Public Health. 2016;16:1168.
DOI: 10.1186/s12889-016-3841-z
14. Tamirat B, Hussen S, Shimelis T. Rubella virus infection and associated factors among pregnant women attending the antenatal care clinics of public hospitals in Hawassa City, Southern Ethiopia: A cross-sectional study. BMJ Open. 2017;7: e016824.
DOI: 10.1136/ bmjopen-2017-016824
15. WHO. Vaccine-preventable diseases: Monitoring system. 2017 global summary; 2017.
[Accessed 26 Mar 2019]
Available:http://apps.who.int/immunization_monitoring/globalsummary/
16. CDC. Epidemiology and prevention of vaccine-preventable diseases. Chapter 20, rubella.Pink book. 13th ed; 2015.
17. Chukwuedo AA, Zirawaga SS, Banda JM, Chukwu CO, Olabode AO. Sero-prevalence of rubella antibody in pregnant women attending antenatal clinics in Adamawa and Kaduna states of Nigeria. Int J Nat Appl Sci. 2010;6(1):131-134.
18. World Health Organization. global vaccine action plan. Priority country reports on progress towards GVAP-RVAP goals. Annex to the GVAP secretariat annual report. Geneva, Switzerland; 2016.
Available:http://www.who.int/immunization/global_vaccine_action_plan/web_regional_2017.pdf?ua+1
19. Adewumi OM, olayinka OA, Olusola BA, Faleye TO, Sule WF, Adesina O.

Epidemiological evaluation of Rubella virus infection among pregnant women in Ibadan, Nigeria. J Immunoassay Immunochemistry. 2015;36(6):613-621.
DOI:10.1080/15321819.2015.1027404.pmid:25774539

20. Adebayo WO, Jegede AO. The environmental effect of flooding transportation land use in Benin City Nigeria. African Research Review, 2010;4(1):390-400.
21. Oluboyo OB, Musa HS, Akinseye JF, Akele RY, Oluboyo AO, Adewumi FA. Risky sexual behaviors and prevalence of *Chlamydia trachomatis* antibodies among students in a Tertiary Institution. Online Journal of Health Allied Sciences. 2019; 18(3):3-8.
22. Mohammed DA, Shittu O, Sadauki H, Olayinka A, Kolawole B, Adejo D. Prevalence of rubella IgG antibodies among pregnant women in Zaria, Nigeria. Int Health. 2016;2(2):156-159.
23. Gubio AB, Mamman AI, Abdul M, Olayinka AT. The risk factors of exposure to rubella among pregnant women in Zaria. Pan Africa Medical Journal. 2019;32(1):4.
DOI:10.11604/pamj.21/01/2019.ARTVOL.ARTISSUE.13335
24. Kolawole O, Anjorin E, Adokanle D, Kolawole FC, Durowade KA. Serology of rubella IgG antibody in pregnant women in Osogbo, Nigeria. Int J Prev Med. 2014; 5(3):287–292.
25. Hamdan HZ, Abdelbagi IE, Nasser NM, Adam I. Seroprevalence of cytomegalovirus and rubella among pregnant women in western Sudan. Virology Journal. 2011; 11(8):217-225
DOI: 10.1186/1743-422X-8-217
26. Oyinloye SO, Amama CA, Daniel R, Ajayi BB, Lawan MA. Seroprevalence survey of rubella antibodies among pregnant women in Maiduguri, Borno State, Nigeria. African Journal of Clinical and Experimental Microbiology. 2014;15:151–157.
27. Mengouo NM, Ndze VN, Baonga F, Kobela N, Wiysonge CS. Epidemiology of rubella infection in Cameroon: a 7-year experience of measles and rubella case-based surveillance, 2008–2014 BMJ Open. 2017;7(4):e012959.
DOI: 10.1136/bmjopen-2016-012959
28. Junaid SA, Akpan KJ, Olabode AO. Serosurvey of rubella IgM antibodies among children in Jos, Nigeria. Virology Journal. 2011;19(8):244-249.
DOI: 10.1186/1743-422X-8-244
29. Mitiku K, Bedada T, Masresha B, Kegne W, Nafo-Traore F, Tesfaye N, et al. The epidemiology of rubella disease in Ethiopia: Data from the measles case-based surveillance system. Journal of Infectious Diseases. 2011;204(Suppl 1): S239–S242.
DOI: 10.1093/infdis/jir120
30. Mwambe B, Mirambo M, Mshana S, Massinde AN, Kidenya BR, Michael D, et al. Seropositivity rate of rubella and associated factors among pregnant women attending antenatal clinics in Mwanza, Tanzania. BMC Pregnancy Childbirth. 2014;14:95-102.
31. Ogbonnaya EC, Chinedum EK, John A, Esther A. Survey of the seroprevalence of IgM antibodies in pregnant women infected with rubella virus. J Biotechnol Pharm Res. 2012;3:10–14.
32. Onakewhor JU, Chiwuzie J. Seroprevalence survey of rubella infection in pregnancy at the University of Benin Teaching Hospital, Benin City, Nigeria. Nigerian Journal of Clinical Practice. 2011; 14(2):140–145
DOI: 10.4103/1119-3077.84002
33. Fokunang CN, Chia J, Ndumbe P, Mbu P, Atashili J. Clinical studies on seroprevalence of rubella virus in pregnant women of Cameroon regions Afr J Clin Exp Microbiol. 2010;11(2):79-94.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/57099