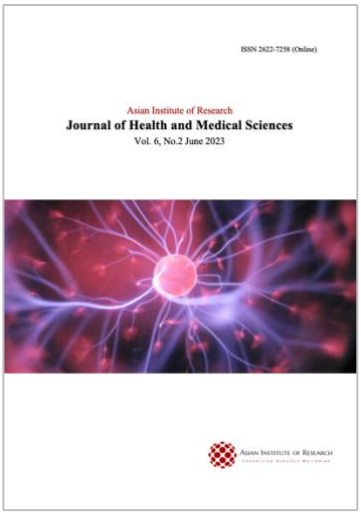

Journal of Health and Medical Sciences

Chukwurah, S. N., Jisieike-Onuigbo, N. N., Onubogu, C. U., Kalu, S. O., Ufoaroh, C. U., Onah, S. K., Eleje, G. U., Mbanuzuru, V. A., Ezejiofor, O. I., Ezeude, C. M., Okpala C.I., Onah, C. E., Nweje, I. S., Ekwebene, O. C., Eze, K. C., Ugochukwu, E. F., & Ibe, C. C. (2023), Assessment of Immunity against Hepatitis B Virus among Children Aged 2-17 Years in Nnewi, Anambra State, South-East Nigeria: A Pilot Study. *Journal of Health and Medical Sciences*, 6(2), 63-71.

ISSN 2622-7258

DOI: 10.31014/aior.1994.06.02.269

The online version of this article can be found at:
https://www.asianinstituteofresearch.org/

Published by:
The Asian Institute of Research

The Asian Institute of Research *Journal of Health and Medical Sciences* is a peer-reviewed International Journal. The journal covers scholarly articles in the fields of Medicine and Public Health, including medicine, surgery, ophthalmology, gynecology and obstetrics, psychiatry, anesthesia, pediatrics, orthopedics, microbiology, pathology and laboratory medicine, medical education, research methodology, forensic medicine, medical ethics, community medicine, public health, community health, behavioral health, health policy, health service, health education, health economics, medical ethics, health protection, environmental health, and equity in health. As the journal is Open Access, it ensures high visibility and the increase of citations for all research articles published. The *Journal of Health and Medical Sciences* aims to facilitate scholarly work on recent theoretical and practical aspects of Health and Medical Sciences.

ASIAN INSTITUTE OF RESEARCH
Connecting Scholars Worldwide

The Asian Institute of Research
Journal of Health and Medical Sciences
Vol.6, No.2, 2023: 63-71
ISSN 2622-7258

DOI: 10.31014/aior.1994.06.02.269

Assessment of Immunity against Hepatitis B Virus among Children Aged 2-17 Years in Nnewi, Anambra State, South-East Nigeria: A Pilot Study

Shirley Nneka Chukwurah[1], Nonyelum Nnenna Jisieike-Onuigbo[1], Chinyere Ukamaka Onubogu[2], Stephen Okorafor Kalu[3], Chinyelu Uchenna Ufoaroh[1], Stanley Kenechukwu Onah[2], George Uchenna Eleje[4], Victor Ahoma Mbanuzuru[5], Ogochukwu Ifeanyi Ezejiofor[1], Chidiebele Malachy Ezeude[1], Chibuzor Ifeanyi Okpala[1], Christian Ejike Onah[6], Ifeyinwa Sussan Nweje[7], Onyeka Chukwudalu Ekwebene[8], Kenneth Chukwudi Eze[9], Ebele Francesca Ugochukwu[2], Christian Chibuzo Ibe[5]

[1] Department of Medicine, NAUTH, Nnewi
[2] Department of Paediatrics, NAUTH, Nnewi
[3] HIV Care unit, NAUTH, Nnewi
[4] Department of Obstetrics and Gynecology, NAUTH, Nnewi
[5] Department of Community Medicine, NAUTH, Nnewi
[6] Department of Chemical Pathology, NAUTH, Nnewi
[7] Nursing Department, NAUTH, Nnewi
[8] Department of Biostatistics and Epidemiology, East Tennessee State University, Johnson city, Tennessee, United States
[9] Department of Radiology, NAUTH, Nnewi

Correspondence: Shirley Nneka Chukwurah. Department of Internal Medicine, Nnamdi Azikiwe University, Awka. Email: sn.chukwurah@unizik.edu.ng

Abstract
Background: Nigeria is one of the hyper-endemic countries for hepatitis B with national prevalence rate of 11%. No study has been done in Nigeria to the best of authors' knowledge to assess the level of immunity among children vaccinated against HBV. Objective: To assess prevalence of Hepatitis B surface antigen, determine the presence of antibodies to hepatitis B surface antigen (anti-HBs) and determine the titre levels of anti-HBs among those who have anti-HBs. Design: This was a pilot and a cross-sectional study. Methods: Consecutive children aged between 2 and 17 years seen at the outpatient clinic of NAUTH, Nnewi, Nigeria were recruited. Questionnaire was interviewer-administered. Venous blood was collected from each participant, analyzed for HBV serological markers and anti-HBs titre. Results: A total of sixty children were recruited. There was equal male and female distribution. 36.7% were aged 10-14 years. One child did not receive HBV vaccine. There was no incidental finding of HbsAg positivity. 15% of respondents had their immunity assessed after completing vaccination. There was presence of antibodies to HBsAg in19 children, and the anti-HBs titre was protective in 78.9% of those who had antibodies. Conclusion: After 18 years of introduction of the HBV vaccine into the NPI and routine infant immunization against hepatitis B virus in Nigeria, this pilot study has shown immunity against hepatitis B is not usually assessed after immunization and a significant proportion of children who were adequately immunized are not adequately protected against HBV. A large-scale study would be desirable for confirmation.

Keywords: HBV Immunity, Children, Nigeria

1. Background

Hepatitis B virus (HBV) is a preventable cause of liver diseases including liver cancer worldwide. It is a serious public health problem. Globally, about a billion individuals have been infected with HBV at some point in their lifetime and almost 296 million people are chronically infected with HBV. More than a million die annually from HBV related causes. In 2015, HBV resulted in an estimated 887 000 deaths, mostly from cirrhosis and hepatocellular carcinoma (Chang, 2007).

Nigeria is ranked as one of the hyper-endemic countries with a national prevalence rate of 11%. (Federal Ministry of Health. National strategic plan for the control of viral Hepatitis in Nigeria, 2016). In Nigeria, the prevalence rates vary from region to region; 7.6% in the East (Chukwuka et al., 2003) and 9.7 in the North (Ndako et al, 2010). The vaccine against HBV was introduced into the National Programme on immunization (NPI) in 2004 in a bid to reduce the prevalence of HBV infection (Thomas et al, 2021). However, there was a 1.3% prevalence of HBsAg among vaccinated children in a rural community in Edo State, Nigeria (Odunsaya eet al. 2005). In Yemen, 27.8% of the children had non-protective anti- HBs levels despite a good HBV vaccine coverage rate of 87.3% (Alssamei eet al. 2017). Hepatitis B vaccine coverage rate in Nigeria has ranged from 41% to 58% (Odunsaya, 2008). While the hepatitis B birth dose vaccine coverage is about 53% (Olakunde eet al. 2022).

The possible limitation in the level of vaccine coverage may include the place of birth as those delivered at home or in private health centres are likely not to be immunized unlike those delivered in the government hospitals (Olakunde et al., 2022). In Senegal, children aged between 6 months and 16 years who were vaccinated against HBV to access infection and level of immunity were studied. They found that 1.1% of the children had the infection while only 65.0% had sero-protective levels (Lô et al., 2019). In a study in Italy, titres of antibodies to hepatitis B surface antigen (Anti- HBs) of <10 IU/L (unprotective levels) were seen in 50.4% of the students (mean age was 25.4 years) studied who had received vaccine for HBV (Sernia et al, 2020).

The monovalent vaccine is used in Nigeria and the routine HBV immunization schedule for children is at birth, 6 weeks and 10 weeks. Several factors may affect the efficacy of the HBV vaccine such as the characteristics of the infectious agent (genetic variation), vaccine factors (type of vaccine, adjuvant, dose, and administration route and schedule), and the host factors (age, sex, genetics, nutritional status, gut microbiota, obesity, and immune history). Persons in whom the vaccine is not effective are referred to as 'non-responders.' They lack immunogenic memory and will require a repeat vaccination series to develop immunity (Zimmermann & Curtis, 2019) (Dhakal& Klein, 2019). Therefore, suggesting the need to access the immunity of HBV after vaccination.

In Nigeria, it is not a usual practice to access the achievement of immunity following vaccination. No study has been carried out in Nigeria to the best of authors' knowledge to assess the level of immunity among children vaccinated against HBV since its inclusion in the National program on immunization. Thus, this study has become necessary to ensure that even while treating already infected persons, the children growing up are adequately protected from this preventable carcinogen in order to achieve the WHO goal of eradicating the virus by 2030.

Anecdotal report has shown that there are some children as well as adults who have received the complete dose of the HBV vaccine and have shown no evidence of immunity against the virus and some others have reported completion of the vaccination schedule among individuals with HBV infection. This study was aimed at assessing the prevalence of HBsAg and the presence of anti-HBs among vaccinated children aged 2-17 years; in addition to assessing the titre levels of anti-HBS among those who have anti-HBS.

2. Method

2.1. Study Site/area

The study was conducted in the children outpatient of Nnamdi Azikiwe University Teaching Hospital, Nnewi, Nnewi North Local Government Area (LGA), Anambra State, in Nigeria. The LGA had a population of 155,443

in 2006 according to the National Population Census of 2006 and an extrapolated population of 193,987 in2020 (World population review, 2022).

The town is made up of four component parts namely Otolo, Nnewchi, Uruagu, andUmudim. The LGA is an emerging commercial and industrial city with a large proportion of the population engaged in trading, industrial work and civil service. The College of Health Sciences of the Nnamdi Azikiwe University Nnewi Campus and the Nnamdi Azikiwe University Teaching Hospital Nnewi are located within the town. The HBV vaccine is stored in standard conditions in the hospital and is always available to clients.

2.2. Study population

Children between the ages of 2 and 17 years constituted the study population. The age group 2 years was chosen to ensure complete waning of maternal antibody while 17 years was chosen to avoid using those born before the introduction of the HBV vaccine into the NPI program.
Inclusion criteria

- Children 2-17 years who were apparently healthy and with a parent to give required information

Exclusion criteria:

- Children with chronic illnesses eg HIV, Bone marrow disorders/ blood cancers
- Children who are known to have chronic HBV infection

2.3. Study design

This was a pilot study as well as a cross-sectional and descriptive study.

2.4. Sample size determination

This was a pilot study and the number of children obtained during 6 months duration was used

2.5. Sampling technique

Consecutive children aged between 2 and 17 years seen at the outpatient clinic of NAUTH, Nnewi were recruited over a period of 6 months.

2.6. Outcome measures

The outcome measures include panel test parameters and anti-HBS titre. The panel test includes qualitative (positive or negative) results of the following tests; HBsAg, (anti- HBs, HBeAg, HBeAb, HBcAb.

2.7. Sample collection and laboratory analysis

After administering the questionnaire to the parent(s) to obtain information concerning the child's immunization, five milliliters of venous blood was collected from each of the study participants into plain vacutainer tubes and transported to the NAUTH, Nnewi laboratory for processing. The samples were allowed to clot and retract before centrifugation at 1600 rpm for five minutes. The supernatant was separated into two cryovials and stored at -20°C if testing was not performed immediately.

The samples were analyzed by a medical laboratory scientist for HBV serological markers by a colloidal gold and membrane chromatography technology. HBsAg, anti-HBs, and HBeAg were measured in serum with the dual-antibody sandwich method, while HBeAb and HBcAb were measured by the competitive neutralization method (Biosino Biotech Company, China). The second sample aliquots were used to estimate Anti-HBs titer among those who were positive by Enzyme-Linked Immunosorbent Assay (ELISA) (Guangzhou Wondfo Biotech Co., Ltd., China).

2.8. Definition of hepatitis B seroprotection

Children with anti-HBs levels ≥ 10 international units per liter (IU/L) were considered as sero-protected against HBV while those with anti- HBs levels < 10 IU/L were non-sero-protected (unprotected) (Schillie et al., 2013).

2.9. Ethical consideration

Ethical approval for the study was obtained from Nnamdi Azikiwe University Teaching Hospital Ethics Committee (NAUTH/CS/66/Vol. 13/VER III/80/2020/023). Informed consent was also obtained from the parents and accenting children.

2.10. Data Management

The variables from the study consisted of the independent variables (socio-demographic, HBV vaccination status of subjects, and exposure to risk factors of HBV infection). The descriptive statistics of the subjects (mean, standard deviations and proportions of the variables were determined. The analysis for the outcome measures of the study (panel test and anti-HBS titre) qualitative (positive or negative), HBsAg, anti HBs, HBeAg, HBeAb, HBcAb were done. The proportions (percentage %) of subjects positive to the tests were determined. The quantitative results of HBs titre (for subjects with positive anti-HBs) were determined. The titre was further classified as sub-optimal and normal and the proportions of sub-optimal and normal were determined.

3. Results

Table 1 shows the socio-demographic characteristics of respondents. A total of 60 children were used for the study. There was equal male and female distribution (1:1). About one-third (36.7%) of the participants were between 10-14 years. There mean age was 8.7 ±4.3 years. About half of the participants (51.7%) were in secondary school. Approximately half of the fathers (46.7%) and mothers (51.7%) had tertiary education.

Table 1: Socio-demographic characteristics of respondents

Variables		Frequency (N=60)	Percentage (%)
Gender	Female	30	50.0
	Male	30	50.0
Age Category	0-4 years	13	21.7
	5-9 years	20	33.3
	10-14 years	22	36.7
	15-17 years	5	8.3
Age (Mean ± SD):	8.7 ± 4.3 years	Median age: 8.5 years	
Educational level of children	None	1	1.7
	Nursery	1	1.7
	Primary	5	8.3
	Secondary	31	51.7
	Tertiary	22	36.7
Educational level of fathers	None	5	8.3
	Primary	9	15.0
	Secondary	18	30.0
	Tertiary	28	46.7
Educational level of mothers			
	None	2	3.3
	Primary	4	6.7
	Secondary	23	38.3
	Tertiary	31	51.7

Table 2 shows the vaccination parameters of the respondents. They were 59 out of the 60 respondents (98.3%) that received at least one dose of the vaccine while only 1 respondent (1.7%) did not receive vaccine at all. Confirmation of vaccination status and number of doses received was mainly based on verbal reports from parents (78.3%). 57 of the 60 respondents received the complete 3 doses of the vaccine. Vaccination took place more in the public health institutions (37/60) than in the private health institutions (33/60)

Table 2: Vaccination parameter of the respondents

Variables		Frequency (N=60)	Percentage (%)
Received vaccine	No	1	1.7
	Yes	59	98.3
Verbal/Card	Card	13	21.7
	Verbal	47	78.3
Number of doses	Zero	1	1.7
	Two	2	3.3
	Three	57	95.0
Where did vaccination take place?	None	1	1.7
	Local Government	2	3.3
	Primary Centre	13	21.7
	Private Centre	22	36.7
	Tertiary Centre	22	36.7

Table 3 shows the distribution of the panel test results. Only 15% of the respondents had their immunity assessed following immunization using panel test. All the respondents were negative to HBsAg. Only 19 of the 60 (31.7%) children were positive to HBsAb. None of the children was positive to HBeAg, HBeAbor HBcAb.Anti-HBs titre was <10 IU/L in 56.7% of the children and ≥10IU/L in 43.3% of the respondents.

Table 3: Distribution of the panel tests

Variables		Frequency (N=60)	Percentage (%)
Was a panel test done after vaccination?	No	51	85.0
	Yes	9	15.0
HBsAg	Negative	60	100.0
	Positive	-	-
HBsAb	Negative	41	68.3
	Positive	19	31.7
HBeAg	Negative	60	100.0
	Positive	-	-
HBeAb	Negative	60	100.0
	Positive	-	-
HBcAb	Negative	60	100.0
	Positive	-	-

**Abrreviations- HBsAg= Hepatitis B surface antigen, HBSAb= Hepatitis B surface antibody, HBeAg= Hepatitis B envelope antigen, HBeAb= Hepatitis B envelope antibody, HBcAb= Hepatitis Bcore antibody, anti- HBs titre= antibody to Hepatitis B surface antibody titre*

Table 4 shows that out of the 19 children that had HBsAb, 15 (78.9%) had adequate antibody titre of ≥10IU/L.

Table 4: Antibody titre of the respondents

Variables	Titre level	Frequency (N=19)	Percentage (%)
Anti- HBs titre	<10	4	21.1
	≥10	15	78.9

4. Discussion

HBV infection has remained a global health challenge. The World Health Organization aims to eliminate the virus by 2030. This is probably the first study to determine the post vaccine immunity status among children following the inclusion of the HBV vaccine into the National Program of Immunization (NPI) in Nigeria. The study showed no incidental HBV infection among the respondents who were completely immunized. This may be an encouraging finding considering the 1.3% prevalence reported among vaccinated children (Odunsaya et al., 2005). It is also an encouraging finding considering the goal of WHO concerning HBV by 2030. There was no case suggestive of a previous infection among the study respondents as they all tested negative for HBeAg, HBeAb and HBcAb. The HBeAg test indicates infectivity. HBeAb reactive indicates that the body has a high level of antibodies against the hepatitis B virus. A "positive" or "reactive" anti-HBc (or HBcAb) test result indicates a past or current hepatitis B infection. (Hepatitis B Foundation: Hepatitis B Blood Tests (hepb.org).

Very few children (15%) had their immunity accessed using a panel test. This is quite poor. Assessment of HBV immunity is usually done with a panel test or an anti-HBs titre (Post-Vaccination Testing for Hepatitis B - Viral Hepatitis and Liver Disease) (Jack et al., 1999). These tests are not known to members of the public and even among health practitioners and are not usually available in most laboratories. The panel test is more affordable compared to the anti HBs titre which is not as common and which is more expensive in our environment. Studies are scarce in literature where panel test was used to access immunity post vaccination of HBV vaccine. However, anti-HBs titre was used in some studies in China to assess immunity in children (Jiang et al., 2021) (Li et al., 2018) (He et al., 2016). It is however not routinely done for all children in China. Data on its use to access immunity in Nigeria is not available.

Despite the fact that 78.9% (N= 15/19) of those who had anti-HBs (N=19/41) had protective antibody levels, it is interesting to note that 21.1% (N= 4/19) did not develop anti-HBs (N= 32/60). This figure of 21.1% is higher than the global rate of non-responsiveness of 5-15% (Wiedermann et al., 2016). It is similar to what was done in northern Nigeria where they had a non- response rate of 17.9% but it involved both children and adults. (Thomas et al, 2021). Higher non-response rates of 30% and 20% were seen in Rajasthan and Bulgaria respectively (Welker & Zeuzem, 2016). Also, among students in Italy, a non –response rate of 50.4% was seen (Sernia et al, 2015). These findings may suggest that age may play a role in the anti- HBs titre following complete immunization Therefore with increasing age, antibody titres fall and this is the reason for booster doses being recommended by certain groups every 10 years (Adults need booster vaccines every ten years - NIPH (fhi.no).

The sero-protective levels in this study of 78.9% differ from the study done in Iran among similar populations as employed in this study which showed a sero- protective level of 44% (Wiedermann et al, 2016). The reason for the difference could be because of the small sample size. Additionally, studies done in Yemen and Senegal showed sero-protective levels of 72.2% and 65%, respectively (Alssamei et al, 2017) (Odunsaya, 2008). These were also lower than the sero-protective levels in this study. This could be because both studies were nationwide studies or may be related to the immunogenetics of the population. In Poland, among paediatrics patients with inflammatory bowel disease, nearly half had protective antibody levels (53.2%) (Huang et al., 2013). A booster dose with one or three doses of vaccine increased the protective level to 92% and 100% respectively (Baranowska-Nowak et al., 2020). A study to assess post-vaccination immunity in Burkina Faso showed a high sero-protective level of 76.3%, however there was a significant reduction in anti HBs titre levels after three years (Kissou et al., 2018). This may

also be accounted for by differences in the genetics of the population or vaccine properties or the large size of the population used.

This study has some strengths. To the best of authors' knowledge, this study was the first study in Nigeria to assess the level of immunity among children vaccinated against HBV since HBV vaccine inclusion in the National Program on immunization in Nigeria. However, this study could be limited because of the small sample size which prevented us from carrying out further analysis such as relationship of anti HBs titre with increasing age and gender and therefore need for a large- scale study

5. Conclusion

After 18 years of introduction of the HBV vaccine into the National program of immunization, and subsequent routine infant immunization against hepatitis B virus in Nigeria, it has been found that it is not a usual practice to assess immunity of children. It has also been found that some children are not protected against HBV after completing three doses of the HBV vaccine though this is a pilot study. Hence, a larger scale multicentre study would be desirable to confirm this finding.

6. Contribution to knowledge

This study revealed that assessment of immunity following immunization is not usually done and should be done to check for non-responders. A significant proportion of those immunized who develop HBsAb also develop adequate anti HBs titre.

Funding
No special funding

Conflict of interest
None

Acknowledgement
We acknowledge the NAUTH, Nnewi management and the research assistants for their support in the study. We also appreciate the parents who volunteered to participate.

Author contributions:
SNC, NNJ, GUE, SOK, CUO and CCI conceptualized and designed the study.
All authors contributed to implementation of the project and revision of the manuscript.
All authors were involved in the writing and revision of the manuscript.
The authors read, approved the final manuscript and agreed to be accountable for all aspects of the work.

Data availability
The data used to support the findings of this study are available from the corresponding author upon reasonable request.

References

Adults need booster vaccines every ten years - NIPH (fhi.no)

Alssamei, F. A., Al-Sonboli, N. A., Alkumaim, F. A., Alsayaad, N. S., Al-Ahdal, M. S., Higazi, T. B., &Elagib, A. A. (2017). Assessment of Immunization to Hepatitis B Vaccine among Children under Five Years in Rural Areas of Taiz, Yemen. *Hepatitis research and treatment*, 2131627. https://doi.org/10.1155/2017/2131627

Baranowska-Nowak, M., IwaŃczak, B., Szczepanik, M., Banasiuk, M., DembiŃski, Ł., Karolewska-Bochenek, K., Dziekiewicz, M., Radzikowski, A., & Banaszkiewicz, A. (2020). Immune response to hepatitis B vaccination in pediatric patients with inflammatory bowel disease. *Central-European journal of immunology*, *45*(2), 144–150. https://doi.org/10.5114/ceji.2020.97902.

Chang M. H. (2007). Hepatitis B virus infection. *Seminars in fetal & neonatal medicine*, *12*(3), 160–167. https://doi.org/10.1016/j.siny.2007.01.013

Chukwuka, J.O., Ezechukwu, C. C. & Egbuonu, I. (2003). Cultural Influences on Hepatitis B Surface Antigen Seropositivity in Primary School in Nnewi. Nigeria Journal of Paediatrics, 30 :140-2.

Dhakal, S., & Klein, S. L. (2019). Host Factors Impact Vaccine Efficacy: Implications for Seasonal and Universal Influenza Vaccine Programs. *Journal of virology*, *93*(21), e00797-19. https://doi.org/10.1128/JVI.00797-19

Federal Ministry of Health. National strategic plan for the control of viral Hepatitis in Nigeria. (2016-2020). Pg 10-11.

He, F., Ma, Y. J., Zhou, T. Y., Duan, J. C., Wang, J.F, Ji, Y.L., Li, H., Zhang, J. Y& Tang, H. (2016). The Serum Anti-HBs Level Among Children Who Received Routine Hepatitis B Vaccination During Infancy in Mianyang City, China: A Cross-Sectional Study. Viral Immunol. Jan-Feb;29(1),40-8. doi: 10.1089/vim.2015.0073. Epub 2015 Nov 13. PMID: 26565951.

Hepatitis B Foundation: Hepatitis B Blood Tests (hepb.org)

Huang, Y. H., Hsiao, L. T.& Hong, Y.C. (2013). Randomized controlled trial of entecavir prophylaxis for rituximab associated hepatitis B virus reactivation in patients with lymphoma and resolved hepatitis B. J Clin Oncology, 31(22),2765–72.

Jack, A. D., Hall, A. J., Maine, N., Mendy, M., & Whittle, H. C. (1999). What level of hepatitis B antibody is protective? *The Journal of infectious diseases*, *179*(2), 489–492. https://doi.org/10.1086/314578

Jiang, M., Zhu, B., Yao, Q., Lou, H., & Zhang, X. (2021). Anti-HBs levels in children under the age of two years born to HBV carrier mothers after immunoprophylaxis: a multicenter cross-sectional study. *BMC pediatrics*, *21*(1), 492. https://doi.org/10.1186/s12887-021-02967-8

Kissou, S.A., Sidibé, K., Sourabié, Y., Cessouma, K.R., Ouedraogo, A.S., Sawadogo, A., Nacro, B. &Bazie, W. W. (2018). Post-Vaccine Immunity against Hepatitis B in Burkina Faso children. *Journal of Gastroenterology, Pancreatology & Liver Disorders. 6(1),*1-4.

DOI: 10.15226/2374-815X/6/1/0011120

Li, X., Xu, Y., Dong, Y., Yang, X., Ye, B., Wang, Y., & Chen, Y. (2018). Monitoring the efficacy of infant hepatitis B vaccination and revaccination in 0- to 8-year-old children: Protective anti-HBs levels and cellular immune responses. *Vaccine*, *36*(18), 2442–2449. https://doi.org/10.1016/j.vaccine.2018.03.044

Lô, G., Sow-Sall, A., Diop-Ndiaye, H., Babacar, N., Diouf, N. N., Daffé, S. M., Ndao, B., Thiam, M., Mbow, M., Soumboundou, M. B., Lemoine, M., Sylla-Niang, M., Ndiaye, O., Boye, C. S., Mboup, S., & Touré-Kane, N. C. (2019). Hepatitis B virus (HBV) infection amongst children in Senegal: current prevalence and seroprotection level. *The Pan African medical journal*, *32*, 140. https://doi.org/10.11604/pamj.2019.32.140.14485

Musa, B. M., Bussell, S., Borodo, M. M., Samaila, A. A., & Femi, O. L. (2015). Prevalence of hepatitis B virus infection in Nigeria, 2000-2013: a systematic review and meta-analysis. *Nigerian journal of clinical practice*, *18*(2), 163–172. https://doi.org/10.4103/1119-3077.151035

Ndako, J.A., Echeonwu, G.O., Olabode, A.O., Nwankiti, O.O., Aimakhu, S.O., Onovoh, E., Chukwuekezie, J., Banda, J.M., & Paul, G. (2010). Seroprevalence of Hepatitis B Surface Antigen (HBsAg) among Children of Primary School Age in a Community, North-Central, Nigeria.Sierra Leone journal of biomedical researchhttps://doi.org/10.4314/SLJBR.V2I1.56600

Odusanya, O.O. (2008). Hepatitis B Virus Vaccine: The Nigerian Story. Journal of the Obafemi Awolowo University Medical Student's Association (IFEMED). 14. 10.4314/ifemed.v14i1.41725.

Olakunde, B. O., Adeyinka, D. A., Olakunde, O. A., Ogundipe, T., Oladunni, F., & Ezeanolue, E. E. (2022). The coverage of hepatitis B birth dose vaccination in Nigeria: Does the place of delivery matter? *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *116*(4), 359–368. https://doi.org/10.1093/trstmh/trab129

Post-Vaccination Testing for Hepatitis B - Viral Hepatitis and Liver Disease

Schillie, S., Murphy, T. V., Sawyer, M., Ly, K., Hughes, E., Jiles, R., de Perio, M. A., Reilly, M., Byrd, K., Ward, J. W., & Centers for Disease Control and Prevention (CDC) (2013). CDC guidance for evaluating health-care personnel for hepatitis B virus protection and for administering postexposure management. *MMWR. Recommendations and reports: Morbidity and mortality weekly report. Recommendations and reports*, *62*(RR-10), 1–19.

Sernia, S., Ortis, M., Antoniozzi, T., Maffongelli, E., & La Torre, G. (2015). Levels of anti-HBs antibody in HBV-vaccinated students enrolled in the faculty of medicine, dentistry and health professions of a large Italian University. *BioMed research international*, *2015*, 712020. https://doi.org/10.1155/2015/712020

Thomas, K. M., Zakari, H., Lar, P. M.& Em, T. S. (2021). Evaluation of Hepatitis B vaccine Immunogenicity in Relation to ABO and Rhesus Blood Group in vaccinated subjects in Bauchi State, Nigeria.*Umyu journal of microbiology research, Volume 6 Number 2, December, pp 142 - 148*

Welker, M.W&Zeuzem S. (2016). Pre- and post-transplant antiviral therapy (HBV, HCV). Visc Med. 32(2), 105-109.

Wiedermann, U., Garner-Spitzer, E and Wagner, A. (2016). Primary Vaccine Failure to Routine Vaccines: Why and what to do? Human Vaccine and Immunotherapeutic, 12(1), 239-243

World Population Review, http://worldpopulationreview.com/countries/nigeria-population/cities/ Accessed on 19/02/2022.

Zimmermann, P., & Curtis, N. (2019). Factors That Influence the Immune Response to Vaccination. *Clinical microbiology reviews*, *32*(2), e00084-18. https://doi.org/10.1128/CMR.00084-18