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ENVIRONMENTAL PREDICTORS OF UNDER-FIVE IMMUNIZATION UTILIZATION AMONG WOMEN OF CHILDBEARING AGE IN PLATEAU NORTH SENATORIAL DISTRICT OF PLATEAU STATE, NIGERIA

***Abiodun Joel Oladejo, Rhoda Mundi and Adewuyi Oluwatoyin Akanbi**

Department of Geography and Environmental Management, University of Abuja, Nigeria.

*Corresponding authors' email: abiodunpopulation28@gmail.com Phone: 08036093486

ABSTRACT

Immunization remains a cornerstone of child survival strategies globally. Environmental barriers often limit mothers' access to vaccination services such as poor road infrastructure continue to hinder the accessibility of immunization services in many low-resource settings. In the study area, there are still gaps for under-five immunization service. Despite studies to attain full immunization and enhance the immunization programmes. It is important to understand the underlying environmental predictors to fill the exi69sting gaps using the following objective: to investigate the environmental predictors affecting under-five immunization utilization among women of childbearing age and to assess the association between environmental predictors and childhood immunization status.in study area. A cross-sectional study was conducted among 400 women of childbearing age (15-49 years) selected using a multistage random sampling technique. Data were collected through structured questionnaires and in-depth interview (IDI). The data collected were analyzed descriptively, while inferential employed multiple linear regression analysis to examine relationships between independent and dependent variables of under-five immunization utilization among women of childbearing age in the study area. Broken structure statistically significant ($p = 0.008$); descriptively, with 66.5% "deteriorated road" and 37.50% having the highest number of respondents and non-immunized respectively, of under-five more likely affecting utilization of childhood immunization in the study area. Also, raining season effects is significant ($p = 0.005$), and descriptively, having highest (82%) number of respondents "not attempting" to immunized their children during raining season" with 43.00% immunized against 39.00% of non-immunized under-five in the study area. Environmental predictors remain critical in shaping childhood immunization utilization in Plateau North. Policymakers should prioritize road rehabilitation, drainage maintenance, and targeted health outreach to enhance under-five immunization utilization.

Keywords: Environmental Factors, Immunization, Wo/Men Of Childbearing Age, Under-Five, Utilization

INTRODUCTION

Under-five immunization is one of the most effective and economical means of illness prevention. Under-five immunization is a crucial component of child healthcare, and it has been universally recognized as a public health success story, saving an estimated 3 million lives per year (WHO, 2022). It protects against severe childhood infections such as measles, diphtheria, TB, hepatitis B, and polio. According to studies, immunization not only protects individual children but also helps to build herd immunity, lowering the overall illness burden in the community (Gavi, 2024). Despite global gains in immunization coverage, substantial gaps still exist, especially in low- and middle-income nations. However, global progress in regular immunization (RI) has stagnated in recent years. Vaccine-preventable diseases (VPDs) such as measles, polio, and diphtheria are resurgent, even in high-income nations. Studies suggest that global coverage of essential vaccines, such as the measles vaccine and DTP3, has decreased since 2019 (WHO & UNICEF, 2024). According to WHO/UNICEF projections, global DTP3 coverage peaked at around 84% in 2023, leaving roughly 14.5 million children without full protection, up from pre-pandemic levels (WHO & UNICEF, 2024). There are major hazards associated with under-immunization. In 2023, only 83% of children worldwide received the first measles-containing vaccine (MCV1), significantly below than the 95% threshold required to prevent outbreaks (WHO & UNICEF, 2024). As a result, more than 35 million children are still susceptible to measles and other VPDs.

Furthermore, a projected 6.7 million African children were "zero-dose," which means they had not received any routine vaccines at all (WHO Africa, 2024). This disparity was exacerbated by the COVID-19 pandemic, as well as causes such as violence, vaccine hesitancy, misinformation, limited access to health care, and inadequate health infrastructure (Reuters, 2024).

Given the continent's demographic variety and healthcare problems, targeted initiatives are required to increase routine childhood vaccination coverage. This involves enhancing health communication, strengthening cold chain systems, training front-line health workers, and involving local communities (Ekezie *et al.*, 2024).

Nigeria, Africa's most populous country, plays an important role in meeting global immunization targets. Despite the availability of free vaccines under the Expanded Programme on Immunization (EPI), many children are still unvaccinated or under-vaccinated (Dougherty *et al.*, 2024). According to the current National Programme on Immunization (NPI) schedule in Nigeria, children should have completed their routine vaccines by the age of 15 months (WHO, 2022).

In Plateau State, under-five immunization services are not being used consistently notably in the Plateau North Senatorial District. While urban centers like Jos North and Jos South show relatively better uptake, semi-urban and rural areas within the district experience lower immunization rates due to a combination of socioeconomic, cultural, and logistical barriers (Muhammad *et al.*, 2025).

However, barriers such as vaccine hesitancy, long distances to clinics, stockouts, and negative health worker attitudes continue to hinder progress (Dougherty *et al.*, 2024). The COVID-19 pandemic further exacerbated these challenges, leading to disruptions in routine immunization services across Nigeria, with a notable drop in coverage in Plateau State (Galadima *et al.*, 2021).

Environmental factors such as road infrastructure, seasonal rainfall, and drainage conditions affect physical access to health facilities. Poor roads and broken culverts become impassable during the rainy season, restricting mothers from reaching vaccination points. Understanding how these factors influence utilization is essential for designing targeted interventions to improve immunization utilization with the objective; to investigate the environmental factors affecting utilization of under-five immunization among women of childbearing age in Plateau North Senatorial District, Nigeria.

Conceptual Framework and Literature Review

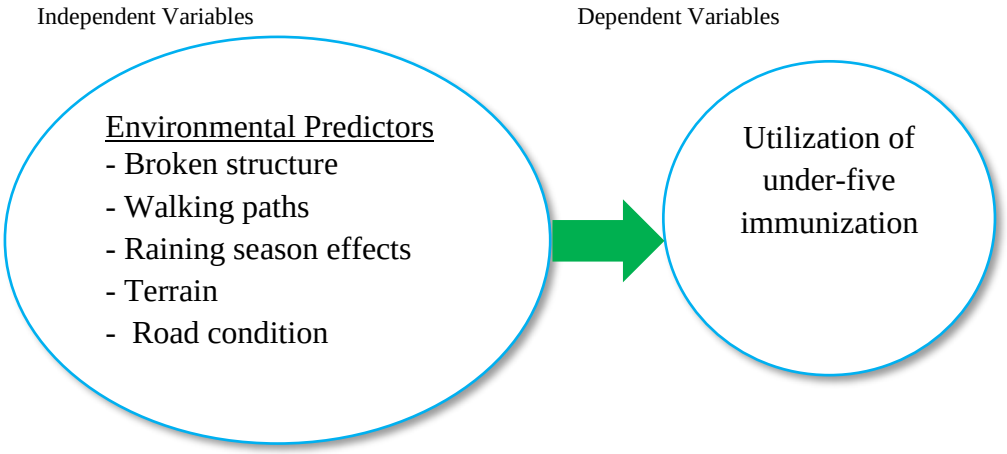

Figure 1: Conceptual Framework
Source: Fieldwork Research, 2025

Literature Review

Environmental Factors to Under-Five Immunization

Environmental factors refer to the physical and infrastructural factors that affects access to health services. These include road and path conditions, terrain type, walking trails, rainy season, and road conditions. Studies have indicated that during rainy seasons or in flood-prone zones, vaccination coverage decreases due to inaccessible health posts (Igbiri *et al.*, 2024).

Internationally, Lima *et al.*, (2025) undertook a case study in Careiro da Várzea, a municipality in the Brazilian Amazon, to assess the impact of flooding and geographic isolation on vaccine access. The study investigated the immunization process in floodplains and remote locations using qualitative methods such as participant observation and document analysis. The findings revealed that frequent flooding, high temperatures, and transportation constraints pose substantial challenges to vaccination delivery. However, the study also emphasized how local health professionals, sometimes known as "street-level bureaucrats," play an important role in overcoming these barriers by employing adaptive methods and social technology.

In an African cross-sectional mixed-methods study done in Hoima District, Uganda, Malande *et al.*, (2019) identified poor road terrain as a major impediment to effective vaccine distribution. The study discovered that limited access to immunization centers hampered outreach activities, delayed vaccine administration, and hindered health professional oversight and mentorship. These infrastructural issues resulted to poor completion uptakes for vaccines such as DPT3 (81%), and measles (65.5%), demonstrating that logistical barriers have a direct impact on vaccine coverage in remote areas. According to Joseph *et al.*, (2020), a nationally representative study from Kenya found that spatial availability to immunization services has a significant impact on vaccination usage. The researchers used GIS mapping, road network data, land cover, and topography to compute travel times to vaccine distribution sites. Under an optimistic combined walking and transportation scenario, 93% of the population might reach an immunization center within one hour, compared to 75% on foot alone. Children living more than 2 hours away were much less likely to receive full immunizations. This empirical evidence clearly shows that limited access due to poor roads or long travel durations lowers vaccine coverage, particularly in distant or poorly linked areas. The study stresses that, in addition to social and educational variables, spatial barriers are independently related with reduced vaccination uptake and hence must be addressed in immunization planning. Seasonal influences have been empirically demonstrated to influence children vaccine uptake. Other hurdles to full vaccination coverage, according to the study, include long lines, cultural attitudes, myths, and financial restraints (Zulu *et al.*, 2022). Vasilov (2025) provides strong empirical evidence in "Rain, Roads, and Health: A Spatial Investigation of How Accessibility Influences Health-Seeking Behavior in Rural Liberia" on how poor road infrastructure, specifically unpaved roads, affects access to healthcare in rural areas. Using a natural experiment approach, the study identifies rainfall as an exogenous factor influencing road accessibility. The majority of roads in rural Liberia are unpaved, leaving them especially vulnerable to weather-related delays. By combining household survey data on illness episodes with Open Street Map road surface quality data and rainfall data from the National Oceanic and Atmospheric Administration, the study shows that increased rainfall, particularly residual rain, has a significant negative impact on health-seeking behavior.

In Nigeria, Jimoh *et al.*, (2024) identified poor road networks in Ekiti State as a key logistical impediment to integrating COVID-19 vaccine into routine immunization regimens. According to the report, poor road conditions, particularly in rural and remote locations, inhibit timely vaccination supply, restrict outreach operations, and limit health officials' supervisory visits. These transportation-related issues not only cause delays in immunization sessions, but also limit community access to important health services, resulting to low vaccine coverage.

Figure 2: Plateau North Senatorial District, Road Conditions and Terrains
Source: Fieldwork Research, 2025

Climate Change and Under-Five Immunization

Nigeria is not immune to the growing threat that climate change poses to public health worldwide. Climate change has been established in Nigeria through studies such as rising temperatures, unpredictable rainfall, increased flooding, sea level rise, and drought (CCN, 2019). Climate change's consequences differ across the country, with the North and the Niger Delta Region in the south being the most vulnerable (Okon *et al.,* 2021). While the influence of climate change on health concerns in Nigeria has been investigated, its impact on immunization programs is unclear (Raimi *et al.,* 2021). However, climate change is known to influence the prevalence of vaccine-preventable diseases such as cholera, meningitis, pneumonia, and yellow fever (Oluwatimilehin *et al.,* 2022). The interplay of climate change, violence, and population displacement may aggravate existing gaps in vaccination coverage, with northern Nigeria bearing the brunt of these repercussions. In addition to insurgent violence, drought and desertification have caused forced migration and displacement, resulting in social conflict, notably between farming and pastoralist communities (Olagunju *et al.,* 2021). Targeted and tailored immunization service delivery will be critical in reaching the populations, for example Borno, where an emergency cholera vaccine campaign was launched following flooding in an area with a large number of camps for internally displaced people fleeing Boko Haram violence (Ngwa *et al.,* 2020).

MATERIALS AND METHODS

Study Design and Area

A cross-sectional design was adopted. The study was carried out in Plateau North Senatorial District comprising six Local Government Areas (LGAs): Bassa, Jos North, Jos East, Jos South, Riyom, and Barkin Ladi. The district experiences a tropical climate with distinct rainy and dry seasons and varied terrain that affects transport accessibility. The survey design used a structured questionnaires and in-depth interviews to obtain data from women of childbearing age (15-49) years as well as from key informants involved in immunization programs. The area lies between latitudes 8^0 24' and 10^0 30' North and longitudes 8^0 32' and 10^0 38' East. Plateau North Senatorial District and Jos have an elevation of 1,217m (3,993ft) above sea level, exhibits climatic conditions that are relatively moderate compared to many other regions in Nigeria. The climate considered in this context is of the wet and dry variety, falling under the category of tropical rainy weather. It is distinguished by an annual average of 1,250mm of precipitation, with the highest levels occurring during the months of July and August. The average temperature over the course of a year is approximately 22°C. Nevertheless, the average temperatures for each month show a range of inconsistency, with the coldest month of December recording an average of 19°C and the warmest month of April showing an average temperature of 25°C. (GVP, 2021)

Population and Sampling

Women of childbearing aged (15-49 years) who had at least one child under five were eligible. According to NPC (2024), Plateau North Senatorial District has an estimated 504,972 women of childbearing age (NPC, 2024). Yamene Taro formula was used to determine the sample size of 400 women of childbearing.

Data Collection and Analysis

Structured questionnaires captured environmental data. while Linear Multiple regression tested the association between environmental factors and immunization utilization at $p < 0.05$. Analyses were performed using SPSS version 26.

Sample Size

In determining the sample size for this study, Yamane Taro formula for determining sample size was used to calculate the aggregate sample size of 400 respondents. The sample size was 400, additional 10% questionnaires totaled 420 were administered to allow for potential non-responses. Out of

these 400 valid and fully completed questionnaires were returned.

RESULTS AND DISCUSSIONS

Condition of Broken Structure Barrier of Respondents in the Study Area

The figure 3 shows that more than half of the respondents constitutes 66.5% indicated that there is deteriorated roads barriers hindering their under-five immunization, 26.8% said that Yes, collapsed culverts barrier to access their under-five immunization, 5.5% there are broken bridges barrier to access their under-five immunization and only 1.3% that constituted small portion of the respondents said they don't know if there are any physical structures standing as a barrier to access their under-five immunization. In an interview conducted to respondents who yes, to broken bridges as a barrier to their children immunization participated, it was asserted that:

"Yes, there is a broken bridge on the route from my house to the health center. Because of that, it is difficult and sometimes impossible to cross, especially with children. This has made it hard for me to complete my children immunizations.". (IDI, Danto, Riyom LGC, 2024).

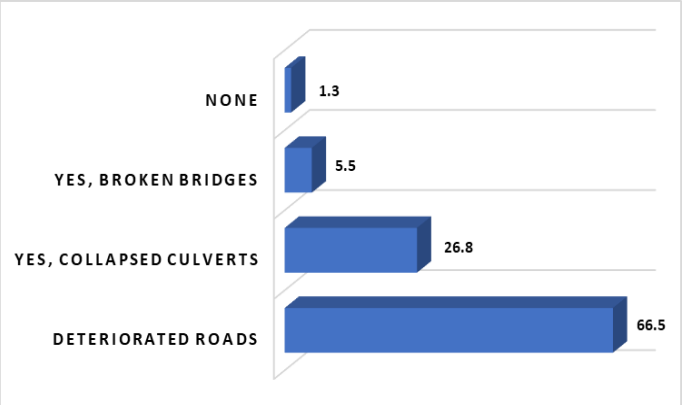

Figure 3: Broken Structure Distribution in the Study Area
Source: Author's Field Survey, 2024

Walking Paths of Respondents in the Study Area

Figure 4 shows that 26% of the respondents indicated unsafe path, 2% stated clear and wide, 27% (more than quarter) stated muddy and 45% stated narrow but passable to walking path to immunization centers.

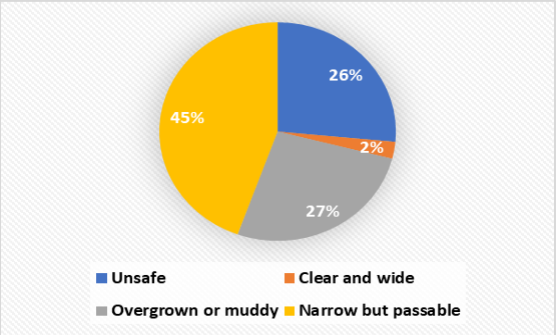

Figure 4: Walking Paths Distribution to Immunization Centers in the Study Area
Source: Author's Field Survey, 2024

Raining Season Effects of Respondents

Table 1 reveals that, 6% of the respondents Yes, without problem to raining season effect to immunization site, 5% said they don't know, 82% said I don't attempt during raining season and 11.5% said Yes, they attempt with difficulties. This shows that the majority of the respondents hardly attempt immunization of their children due to rains. In an interview conducted to respondents who said Yes, with difficulty accessing immunization center during raining season 11.5% participated, it was asserted that:

"It is difficult to access the immunization center during raining season. I can't enter the rain and the road is always muddy". (IDI, Rafan, Barkin ladi LGC, 2024).

Table 1: Raining Season Effects Distribution in the Study Area

Raining Season Effect	Frequency	Percentage (%)
Yes, without problem	24	6.0
I don't know	2	.5
I don't attempt during raining season	328	82.0
Yes, with difficulty	46	11.5
Total	400	100.0

Source: Author's Field Survey, 2024

Nature of Terrain of Respondents in the Study Area

Figure 5 indicates that among the respondents 51.3% (half) were of the opinion that hilly or uneven terrain is the barrier to their under-five immunization, 45.5% stated swampy of flooded area, 0.8% stated forested/bushes and 2.5% stated flat/accessible as a barrier to immunization center.

In an interview conducted confirmed that the respondents 51.3% who were of the opinion of hilly or uneven as a terrain barrier participated, it was asserted that:

"I have to climb up and down with my children is tiring and sometimes risky. Because of this, it is not easy to reach the immunization center, and I sometime miss my children's under-five immunizations". (IDI, Gyel B, Jos South LGC, 2024).

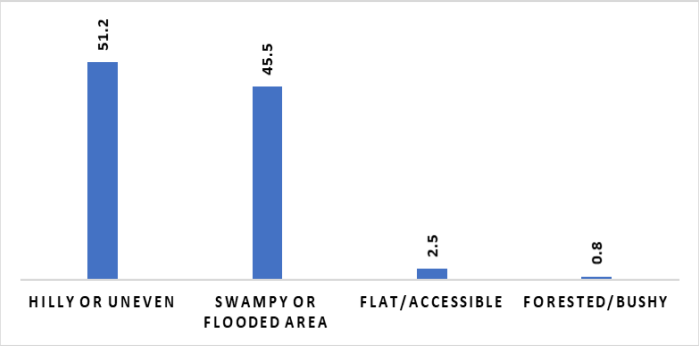

Figure 5: Terrain Barriers Distribution in the Study Area
Source: Author's Field Survey, 2024

Condition of Road of Respondents

Table 2 shows that 22.5% of the respondents uses untarred road but motorable, 33.3% tarred road, easy to pass, 41.3% untarred road, not motorable and 3% indicated rough part, difficult to pass as obstacles to immunization centers.

Table 2: Condition of Road Distribution in the Study Area

Road condition	Frequency	Percentage (%)
Untarred road but motorable	90	22.5
Tarred road, easy to pass	133	33.3
Untarred road, not motorable	165	41.3
Rough part, difficult to pass	12	3.0
Total	400	100.0

Source: Author's Field Survey, 2024

Cross-tabulation of Environmental Factors with Child Immunization Status

Condition of Broken Structure Barrier; The most prevalent infrastructural barrier was deteriorated roads, affecting 66.5% of the total sample. A clear pattern emerges with a higher proportion of non-immunized children (37.50%) lived in areas with deteriorated roads compared to immunized children (29.00%). This table agrees with the study of Vasilov (2025), in a spatial investigation titled, Rain, roads and Health: A spatial investigation of how accessibility Influences Health-seeking Behaviour in Rural Liberia", the outcome of the result shows that rural Liberia are unpaved, making them particularly vulnerable to weather-related disruptions. The study further revealed that women are disproportionately affected by poor road conditions. This suggests that poor road conditions may be a significant barrier to accessing immunization services while the broken bridges show higher immunized of 3.75% against 1.75% of non-immunized children. The most common type of walking path in the study area was narrow but passable (44.5%) number of respondents. Within this category, a larger percentage of non-immunized children (25.25%) is found compared to immunized children (19.25%) lived in areas with overgrown/muddy paths than immunized children (12.25%). This pattern indicates that difficult walking conditions, even if technically "passable," they are associated with non-immunization. The distributions for "unsafe" and "clear and wide" paths were relatively balanced between the other two groups. Raining Season Effect; this factor reveals one of the most striking patterns. The vast majority of respondents 82.0% reported that they do not attempt to travel during the rainy season. This behavior is similarly high in both groups Immunized: 39.00%, compared to non-immunized: 43.00% highlighting the rainy season as a universal access barrier. However, among those who do attempt travel, a higher proportion of non-immunized children 7.50% faced difficulty during the rain compared to immunized children 4.00%. This suggests that for the subset of the population that must travel in the rain, the experience of difficulty is more common among those who are not immunized. This agrees with the work of Zulu *et al.,* (2022) in a study in Nangoma Constituency that revealed that plating season typically during the rains significantly reduce the likelihood of women taking their children for immunization with P=0.021 observed that women are heavily engaged in farming activities and road conditions caused by rainfall hinders access to immunization sites.

Nature of Terrain; the terrain is predominantly hilly/uneven 51.25% or swampy/flooded 45.50%. The distributions between immunized and non-immunized children in the two major categories are remarkably similar. From the study, 25.50% of immunized and 25.75% of non-immunized children live in hilly areas. This indicates that the general nature of the terrain (hilly or swampy) is a common challenge for the entire study area and does not, by itself, show a strong discriminatory pattern between the immunization groups. The "flat/accessible" terrain, while rare, had a notably higher percentage of non-immunized children (2.25% vs. 0.25%), which is an unexpected finding that may warrant further

investigation. The result of this table agrees with the finding of Lima *et al.,* (2025), they conducted a study in Careiro da V'arzea, a municipality in the Brazilian Amazon, to examine how flooding and geographic isolation affect access to vaccine. Their findings revealed that regular flooding barrier pose significant challenges to vaccine delivery. Road Condition; the most challenging road type, untarred and not motorable, was the most common 41.25% and showed a distinct pattern: a higher percentage of non-immunized children 23.75% lived in these areas compared to immunized children (17.50%). This reinforces the finding from the "deteriorated roads" category, underscoring that non-motorable roads are a significant environmental barrier to immunization. In contrast, the distributions for "tarred road, easy to pass" and "untarred but motorable" were relatively balanced between the two groups.

Table 3: Cross Tabulation of Environmental Factors with Child Immunization Status showing its Patterns and Distributions in the Study Area

Condition of Broken	**Immunized**		**Non-Immunized**		**Total**	
Structure Barrier	**No.**	**%**	**No.**	**%**	**F**	**%**
Deteriorated roads	116	29.00	150	37.50	266	66.50
Collapsed culverts	53	13.25	54	13.50	107	26.75
Broken bridges	15	3.75	7	1.75	22	5.50
None	4	1.00	1	0.25	5	1.25
Total	**188**	**47.00**	**212**	**53.00**	**400**	**100.00**
Nature of Walking Paths						
Unsafe	55	13.75	51	12.75	106	26.50
Clear and wide	7	1.75	3	0.75	10	2.50
Overgrown/muddy	49	12.25	57	14.25	106	26.50
Narrow but passable	77	19.25	101	25.25	178	44.50
Total	**188**	**47.00**	**212**	**53.00**	**400**	**100.00**
Raining Season Effect						
Yes, without problem	16	4.0	8	2.00	24	6.00
I don't know	0	0.00	2	0.50	2	0.50
I don't attempt in rainy season	156	39.00	172	43.00	328	82.00
Yes, with difficulty	16	4.00	30	7.50	46	11.50
Total	**188**	**47.00**	**212**	**53.00**	**400**	**100.00**
Nature of Terrain						
Hilly/Uneven	102	25.50	103	25.75	205	51.25
Swampy/Flooded area	84	21.00	98	24.50	182	45.50
Flat/Accessible	1	0.25	9	2.25	10	2.50
Forested/Bushy	1	0.25	2	0.50	3	0.75
Total	**188**	**47.00**	**212**	**53.00**	**400**	**100.00**
Road Condition						
Untarred but motorable	47	11.75	43	10.75	90	22.50
Tarred road, easy to pass	64	16.00	69	17.25	133	33.25
Untarred, not motorable	70	17.50	95	23.75	165	41.25
Rough, difficult to pass	7	1.75	5	1.25	12	3.00
Total	**188**	**47.00**	**212**	**53.00**	**400**	**100.00**

Source: Author's Field Survey, 2024

Hypothesis

There is no significant relationship between environmental factors and utilization of under-five immunization in study area.

The result shows a level of significant for broken structure, p = 0.008 (p<.05). The influenced under-five immunization in the study area. The null hypothesis is thereby rejected and the alternative hypothesis accepted. Therefore, from the study area broken structure is significant. This result of analysis agrees with the study of Vasilov (2025), in a spatial investigation titled, Rain, roads and Health: A spatial investigation of how accessibility Influences Health-seeking Behaviour in Rural Liberia", the outcome of the result shows that rural Liberia are unpaved, making them particularly vulnerable to weather-related disruptions. The study further revealed that women are disproportionately affected by poor road conditions.

Secondly, it also shows that there is a highly level of significant of Raining season effects, p = 0.005 (p<.05). The null hypothesis is thereby rejected and the alternative hypothesis accepted. Therefore, from the study area, raining season effects influenced the utilization of under-five immunization in the study area. The result is in line with the work of Igbiri *et al.,* (2024) that said during the raining season and flood prone zone have shown a decline in vaccine coverage due to inaccessibility of health posts.

Table 4: Result of Multiple Regression Analysis of Environmental Factors Affecting Utilization of Under-five Immunization in Plateau North Senatorial District

Model		**Unstandardized Coefficients**		**StandardizedCoefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	.710	.300		2.369	.018

Broken Structure	.182	.069	.132	2.650	.008
Walking paths	.045	.037	.061	1.219	.224
Raining season effects	.216	.077	.144	2.824	.005
Terrain Type	.030	.076	.020	.393	.694
Road condition	.004	.054	.004	.072	.942

Dependent Variable: Utilization of under-five immunization

CONCLUSION

The result shows a level of significant for broken structure, p = 0.008 (p<.05); with the highest number of respondents having "deteriorated roads" 66.5% influenced children immunization in the study area. The null hypothesis is thereby rejected and the alternative hypothesis accepted. Therefore, from the study area broken structure is significant.

This result of analysis agrees with the study of Vasilov (2025), in a spatial investigation titled, Rain, roads and Health: A spatial investigation of how accessibility Influences Health-seeking Behaviour in Rural Liberia", the outcome of the result shows that rural Liberia are unpaved, making them particularly vulnerable to weather-related disruptions. The study further revealed that women are disproportionately affected by poor road conditions.

Secondly, it also shows that there is a highly level of significant of Raining season effects, p = 0.005 (p<.05); with the respondents of "I don't attempt during raining season" having the highest number 82%. The null hypothesis is thereby rejected and the alternative hypothesis accepted. Therefore, from the study area, raining season effects influenced the utilization of under-five immunization in the study area.

The result is in line with the work of Igbiri *et al.,* (2024) that said during the raining season and flood prone zone have shown a decline in vaccine coverage due to inaccessibility of health posts.

The is intended to aid policymakers, health planners, and stakeholders in creating and implementing interventions to increase vaccination coverage and eliminate inequities in access. Road infrastructure and seasonal impediments, such as floods during the rainy season, have a substantial impact on immunization service access. To ensure continuous service delivery throughout the rainy season, the Ministry of Health and the Ministry of Works and Transport should work together to build durable roads and provide alternative routes or mobile clinics.

ETHICAL CONSIDERATIONS

Ethical approval was obtained from the Ministry of Health, Plateau state, Nigeria. Informed consent was obtained from all participants, and confidentiality was maintained. Informed consent was secured from all respondents, and confidentiality and anonymity were strictly maintained. Participation were strictly maintained. Participation was voluntary and data collected were used solely for academic purposes.

REFERENCES

Climate Change in Nigeria: Impacts and Responses PreventionWeb," (2019). https://www.preventionweb.net/publication/climate-change-nigeria-impacts-and-responses

Dougherty, L., Adediran, M., Akinola, A., Usman, A., & Balogun, M. (2024). *An evaluation of a multi-partner approach to increase routine immunization coverage in six northern Nigerian states.* BMC Health Services Research.

Ekezie, W., Igein, B., Varughese, J., Butt, A., Ukoha-Kalu, B. O., Ikhile, I., & Bosah, G. (2024). *Vaccination communication strategies and uptake in Africa: A systematic review.* Vaccines, 12(12), 1333.

Galadima, A. N., Zulkefli, N. A. M., Md Said, S., & Ahmad, N. (2021). *Factors influencing childhood immunisation uptake in Africa: A systematic review*. BMC Public Health

Gavi. (2024). Global immunization in 2023: *7 things you need to know*. Gavi: The Vaccine Alliance.

Global Volcanism Program. (2021). Smithsonian Institution. Jos Plateau Retrieved 2021-06-24

Igbiri, S. (2024). *Impact of climate-induced flooding on childhood vaccination in two Nigerian states: A retrospective analysis of DHIS2 data.* [Link] immunizationagenda2030.org

Jimoh, A. U., Filani, O., & Omoya, S. (2024). *Enablers and barriers to integrating COVID-19 vaccination into routine immunization in Ekiti State, Nigeria. Human Resources for Health*, 22, Article 217. https://doi.org/10.1186/s12982-024-00217-7

Joseph, N. K., Macharia, P. M., Ouma, P. O., Mumo, E., Jalang'o, R., Wagacha, P. W., & Okiro, E. A. (2020). *Spatial access inequities and childhood immunisation uptake in Kenya.* BMC Public Health, 20, 1407. https://doi.org/10.1186/s12889-020-09486-8 *journal article*

Lima, J. A. de., Neta, A. A., Assis, S. M. C., Rodrigues, B. de O., & Ribeiro, H. (2025). Access to Vaccines in Floodplains and Hard-to-Reach Areas of the Brazilian Amazon: The Contribution of Street-Level Bureaucrats and the Use of Social Technologies. *International Journal of Environmental Research and Public Health*, 22(5), 680.

Malande, O. O., Munube, D., Afaayo, R. N., Annet, K., Bodo, B., Bakainaga, A., Ayebare, E., Njunwamukama, S., Mworozi, E. A., & Musyoki, A. M. (2019). *Barriers to effective uptake and provision of immunization in a rural district in Uganda.* PLoS ONE, 14(2), e0212270. https://doi.org/10.1371/journal.pone.0212270

Muhammad, L. G., Maigoro, A. M., & Usman, U. S. (2025). *Determinants of completion of routine immunization among children in rural areas of Jigawa State, Nigeria.* Magna Scientia Advanced Research and Reviews, 13(2), 37–46.

Ngwa, Moise Chi, Wondimagegnehu Alemu, Ifeanyi Okudo, Collins Owili, Uzoma Ugochukwu, Peter Clement, Isabelle Devaux, et al., (2020). "The Reactive Vaccination Campaign against Cholera Emergency in Camps for Internally Displaced Persons, Borno, Nigeria, 2017: A Two-Stage Cluster Survey." *BMJ Global Health* 5, no. 6: e002431.

Okon, E.M., B.M. Falana, S.O. Solaja, S.O. Yakubu, O.O. Alabi, B.T. Okikiola, T.E. Awe, et al., (2021). "Systematic

Review of Climate Change Impact Research in Nigeria: Implication for Sustainable Development." *Heliyon* 7,

Olagunju, T. E., S. O. Adewoye, A. O. Adewoye, and O. A. Opasola (2021):. "Climate Change Impacts on Environment: Human Displacement and Social Conflicts in Nigeria." *IOP Conference Series: Earth and Environmental Science* 655, no. 1012072.

Oluwatimilehin, I. A., Joseph O. A., Tolulope A. O., Mojisola H. O., and Godwin A.. (2022). "Assessment of the Impact of Climate Change on the Occurrences of Malaria, Pneumonia, Meningitis, and Cholera in Lokoja City, Nigeria." *Regional Sustainability* 3.

Raimi, M. O., Odubo T. V., and Omidiji A. O. (2021). *"Creating the Healthiest Nation: Climate Change and Environmental Health Impacts in Nigeria:* A Narrative Review." SSRN Scholarly Paper.

Reuters. (2024). *Rising conflicts globally slowed childhood vaccination rate in 2023, UN says. Reuters News*. https://www.reuters.com/world/rising-conflicts-globally-slowed-childhood-vaccination-rate-2023-un-says-2024-07-15/

Vasilov, C. (2025). *Rain, Roads and Health: A Spatial Investigation of How Accessibility Influences Health-Seeking Behavior in Rural Liberia*. Lund University, Department of Human Geography.

WHO Africa. (2024, April). *Regional immunization update: Zero-dose and under-vaccinated children remain a challenge*. Retrieved from https://www.afro.who.int

World Health Organization (WHO). (2024). *Immunization coverage.* https://www.who.int/news-room/fact-sheets/detail/immunization-coverage

World Health Organization. (2022). "*Child Mortality (under 5 Years) Fact Sheet,"* https://www.who.int/news-room/fact-sheets/detail/levels-and-trends-in-child-under-5-mortality.

World Health Organization. (WHO) (2022). Vaccines and Immunization. Available from: https://www.who.int/ health-topics/vaccines-and-immunization#tab=tab_1.Gavi, the Vaccine Alliance. (2024).

World Health Organization/UNICEF. (2022). Estimates of National Immunization Coverage (WUENIC). WHO Immunization Data Portal. https://immunizationdata.-

Zulu, M., Banda, T., & Mwale, C. (2022). Determinants of Childhood Immunisation in Nangoma Constituency. *International Journal of Health Systems and Policy, 8(1), 45–53.*