integrity Research Journals

Journal of Public Health and Diseases
Volume 7(6), pages 168-179, December 2025
Article Number: D4332D191
ISSN: 2705-2214
https://doi.org/10.31248/JPHD2025.172
https://integrityresjournals.org/journal/JPHD

Full Length Research

Assessment of timely childhood immunisation coverage and its determinants among caregivers in Bayelsa State

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Received 27th September 2022; Accepted 28th December 2025

ABSTRACT: Timely childhood immunisation remains a critical public health priority in Bayelsa State, where gaps in vaccination schedules and caregiver-related factors continue to influence full and age-appropriate immunisation coverage among children. This study investigated the timely childhood immunisation coverage and its determinants among 3456 caregivers of children 0-59 months in Bayelsa State, focusing on caregivers' knowledge, attitudes, and socio-demographic factors. A cross-sectional descriptive design was used to assess timely childhood immunisation coverage and its determinants among caregivers in Bayelsa State/ Caregivers were selected through multistage sampling across eight local government areas of Bayelsa State. Data were collected using structured interviewer-administered questionnaires, and descriptive statistics (mean criterion = 3.0) were used to assess caregivers' awareness and attitudes toward timely childhood immunisation, while multiple linear regression at a 95% confidence interval examined the influence of key factors and the relationship between caregivers' knowledge, attitudes, and timely immunisation coverage in Bayelsa State. Results were presented in figures, tables, frequencies and percentages. The findings indicated that the majority of the caregivers are between 26 and 45, with a mean age of 37.7. There is moderate immunisation timeliness, with approximately 1693 (49%) of children receiving vaccines exactly as scheduled and 2730 (79%) completing all doses by 12 months. Caregivers' good awareness and positive attitudes were significantly associated with timely immunisation, supported by robust chi-square and logistic regression analyses. Key barriers impacting timeliness included distance to health facilities, transportation costs, and lack of family support, while reminders and caregiver education facilitated timely uptake. In conclusion, the study underscores the need for integrated interventions combining caregiver education, community support, health system strengthening, and logistical access improvements. These insights contribute critical knowledge to enhance child health strategies and improve vaccination outcomes in Bayelsa State and similar settings.

Keywords: Bayelsa State, caregivers, coverage, determinants, immunisation, timely.

INTRODUCTION

Bayelsa State has made significant advancements in childhood immunisation, achieving a 98% coverage rate during the initial round of the 2025 National Immunisation Plus Days (NIPDs) (Datonye, 2025). The state government aims for 100% coverage in future rounds through strategies including timely fund releases, campaigns targeting rural areas, and the active involvement of community leaders. However, operational challenges persist, such as data inaccuracies, uneven workload distribution, and staff commitment issues. Additionally, while the reported coverage is high, studies indicate that only about 20% of children are fully immunised by their first birthday, highlighting concerns about the timeliness of immunisations (Eniojukan and Solomon, 2024).

Timely uptake of immunisation is influenced by various factors, including caregiver knowledge, socio-economic status, and access to health services. Misinformation and

mistrust contribute to vaccine hesitancy, and logistical challenges, particularly in Bayelsa's riverine areas, hinder effective delivery (Malande *et al*., 2019). Evidence suggests that community health education and engagement with local leaders can enhance vaccine acceptance and improve data quality (Eniojukan and Solomon, 2024). Despite the effectiveness of childhood immunisation as a public health intervention, timely coverage in Bayelsa remains inadequate due to a mix of caregiver, health system, and community-level barriers (Nigeria Health Online, 2025).

Timely immunisation is the administration of vaccines at the earliest acceptable age and within the recommended time intervals between doses, according to the vaccine schedule (Odikeme *et al.,* 2022). It often includes a grace period, such as within one month after the minimum recommended age for a specific vaccine dose, ensuring that vaccines are given neither too early (which may reduce effectiveness) nor too late (which increases risk of infection). Timely vaccination is crucial for developing protective antibodies, limiting disease transmission, and achieving population immunity (Dejene *et al*, 2022). Timely vaccination promotes adequate immune response and helps maintain herd immunity, preventing disease outbreaks (WHO, 2025b; Machado-Alba, 2024).

This study aims to assess the timeliness of childhood immunisation in Bayelsa State, focusing on children aged 0–59 months. Key objectives include determining the proportion of children aged 12-23 months who received immunisation on schedule, identifying factors affecting timeliness, and evaluating caregiver knowledge and attitudes towards immunisation. By addressing these areas, the study seeks to fill a critical knowledge gap that can inform evidence-based interventions and improve immunisation outcomes in the state.

The significance of this research lies in its potential to guide policy improvements and enhance service delivery, ultimately reducing child morbidity and mortality from vaccine-preventable diseases. By uncovering barriers and disparities in immunisation uptake, the findings will help target interventions effectively, support collaboration between government and community organisations, and improve communication strategies. The study is framed by the Social-Ecological Model (Malande *et al*., 2019; Eniojukan and Solomon, 2024), emphasising that immunisation behaviour is influenced by various interacting factors, and advocates for comprehensive approaches that integrate education, service enhancements, and supportive policies to ensure timely and equitable immunisation coverage in Bayelsa State.

MATERIALS AND METHODS

This study was conducted in Bayelsa State, Nigeria, to capture diversity in healthcare access and socio-cultural factors. Bayelsa State, situated in the Niger Delta, is marked by extensive riverine and swampy terrains that pose significant challenges to healthcare delivery, particularly the provision of immunisation services (Akpe and Odikeme, 2024). The state comprises eight LGAs, with Yenagoa as the capital, and has a population largely engaged in fishing, farming, and trading. Despite recent high immunisation coverage rates reported during the 2025 National Immunisation Plus Days (NIPDs), challenges such as vaccine stockouts, health worker shortages, and caregiver hesitancy remain (Eniojukan and Solomon, 2024). Comparisons between rural and urban settings show that active community mobilisation can sometimes result in higher rural immunisation coverage compared to urban areas (Akpe and Odikeme, 2024).

A cross-sectional quantitative design was employed to measure the timeliness of childhood immunisation and its determinants at a single point in time. This design has been widely applied in Nigeria and other low- and middle-income countries to assess immunisation coverage and influencing factors (Omale *et al*., 2025; Adedire *et al*., 2021). It enables simultaneous collection of socio-demographic, caregiver, and service-related data, offering a snapshot of the current situation. The study population comprises caregivers of children aged 0–59 months (Kenneth, 2025), with an estimated 431,400 children under five years in Bayelsa (Brinkhoff, 2022). Eligibility requires that caregivers are permanent residents, have children within the age range, and consent to participate.

The sample size was determined using the Taro Yamane formula with a 5% margin of error and 10% adjustment for non-response, yielding a total of 3,493 participants across the eight LGAs. A multistage stratified random sampling technique was used: stratifying by LGAs, selecting clusters (communities/wards), and then randomly sampling households with eligible children. Data were collected using a structured questionnaire covering socio-demographic variables, timeliness of immunisation, influencing factors, and caregivers' knowledge and attitudes. Immunisation cards were cross-checked, and trained assistants administered questionnaires both manually and electronically. Data collection lasted from January to August, 2025.

Sample frame

Using the Taro Yamane formula with a 10% margin of error and adjusting for a 10% non-response rate, the calculated sample size for children aged 0–5 years in each LGA in Bayelsa State is as shown in Table 1.

Inclusion criteria

1. Caregivers residing in Bayelsa State who have children within the immunisation age group (0–59 months).
   Caregivers willing to participate and provide informed consent.

Table 1. sample size for children aged 0–5 years in each LGA in Bayelsa State.

S/N	LGA	Estimated 0-5 years population	Taro Yemen	10% non-response rate	Total sample size
1	Brass	46,600	397	40	437
2	Ekeremor	68,200	398	40	438
3	Kolokuma/Opokuma	20,100	392	39	431
4	Nembe	33200	395	40	435
5	Ogbia	45,500	396	40	436
6	Sagbama	47,300	397	40	437
7	Southern Ijaw	81,400	399	40	439
8	Yenagoa	89,100	400	40	440
	Total	431,400	3174	319	3,493

Margin of error (e) = 0.05.

2. Children whose immunisation status can be verified via immunisation cards or caregiver recall.

Exclusion criteria

1. Caregivers of children outside the immunisation age range.
2. Caregivers who are not permanent residents or who have lived in the community for less than six months.
3. Children with medical contraindications to vaccination.

The test -retest method for reliability was used to test the reliability of the research instrument. The questionnaire was administered to ten (10) caregivers whose children are between 0-59years and retrieved immediately (T1). After a period of two weeks, the questionnaire was administered the second time (T2) to the same group of respondents under similar conditions. Results were analysed by calculating the correlation between scores from T1 and T2 using Pearson's correlation coefficient. A high correlation (r=0.9) was obtained, and it suggested good reliability, meaning that participants' scores are stable across both testing occasions (Indeed Editorial Team, 2024; Study.Com, 2024; Statistics.com, 2024).
Data analysis involved descriptive statistics to estimate coverage, criterion mean analysis to assess caregiver knowledge and attitudes and multivariate logistic regression to identify significant determinants. Timeliness was defined as the administration of vaccines to children according to the recommended schedule without delay, ensuring they receive protection at the appropriate ages.

Ethical approval

Ethical clearance was obtained from the Bayelsa State Health Research Ethics Committee, with approval number BSHREC/Vol. 1/25/05/1. Informed consent, confidentiality, and voluntary participation were ensured. The study is significant as it will provide evidence-based insights into factors influencing timely childhood immunisation in Bayelsa, guiding policymakers, the State Primary Healthcare Board, and partners toward targeted interventions to achieve universal coverage.

RESULTS AND DISCUSSION

A total of 3493 questionnaires were administered; however, 3456 (99%) were correctly filled and returned, which was considered high for making quality inference.

Socio-demographic data

Table 2 indicates that the sample is evenly distributed across the nine LGAs with frequencies ranging from 427 to 437. The majority of caregivers are aged between 26 and 45 years (73% combined: 33% aged 26-35 and 40% aged 36-45). Females overwhelmingly dominate caregiving roles (98%). Mothers constitute the majority at 80%. Most caregivers have 1-2 children under 5 (60%). Children aged 7-9 months represent the majority (63%), matching the typical immunisation timing focus. Slightly more female children (56%) than males (44%) are represented in the sample, a moderate skew but not unusual. The majority of caregivers have a secondary education (50%). The dominant occupations are trader/business (71%).

Proportion of children aged 12-23 months who received timely immunisation according to the national immunisation schedule in Bayelsa State?

Table 3 indicates that the proportion of children aged 12-23 months who received timely immunisation according to the national immunisation schedule in Bayelsa State is 75% (206 out of 276 children aged 12-23months).

Table 2. Demographic Information.

L.G.A of caregivers	Frequency	Percentage
Brass	435	13
Ekeremor	430	12
Kolokuma/Opokuma	427	12
Nembe	429	12
Ogbia	430	12
Sagbama	432	13
Southern Ijaw	437	13
Yenagoa	436	13
Total	3456	100
Age of caregiver		
18-25	347	10
26-35	1140	33
36-45	1380	40
46-55	347	10
56 and above	242	7
Total	3456	100
Sex of Caregiver		
Male	70	2
Female	3386	98
Total	3456	100
Relationship to child		
Mother	2765	80
Father	70	2
Sibling	104	3
Grand mother	207	6
Domestic help	276	8
Others	34	1
Total	3456	100
Number of children under 5 in your care		
1-2	2074	60
2-3	1037	30
5-6	207	6
7 and above	138	4
Total	3456	100
Age of index child/children		
0-6 months	830	24
7-11 months	2177	63
12-23 months	276	8
2-3 years	104	3
4-5 years	69	2
Total	3456	100
Sex of index child		
Male	1521	44
Female	1935	56
Total	3456	100

Table 2. Contd.

L.G.A of caregivers	Frequency	Percentage
Education level of caregiver		
None	34	1
Primary	346	10
Secondary	1728	50
Tertiary	1348	39
total	**3456**	**100**
Occupation of caregiver		
Civil servant	726	21
Trader/business	2454	71
Farmer	242	7
Fisherman/woman	10	0.3
Self employed	24	1
total	3456	100

Table 3. The proportion of children aged 12-23 months who received timely immunization according to the national immunization schedule in Bayelsa State?

Variables		Frequency	Percentage
Number of children aged 12-23 months		276	8%
The proportion of children aged 12-23 months who received timely immunization according to the national immunization schedule in Bayelsa State (Confirmed from the card)	Yes	206	75%
	NO	70	25%
	Total	276	100

The proportion of children who received timely immunization is calculated as: 206/276=0.746. So, the proportion is approximately 0.75**,** meaning about 75% of the children received timely immunization.

Table 4. Shows the logistic regression coefficients, adjusted odds ratios (aOR), 95% confidence intervals (CI), and significance values for each predictor.

Variable	B	S.E.	Wald	df	P-value	aOR	95% CI (aOR)
Distance (Ref: <1KM							
-1-3Km	-0.35	0.12	8.56	1	0.003	0.70	0.55-0.89
>3KM	-0.85	0.68	1.56	1	0.21	0.43	0.11-1.68
Mode of Transportation							
Public Transport	-0.15	0.11	1.84	1	0.17	0.86	0.70-1.06
Private vehicle	0.20	0.60	0.11	1	0.74	1.22	0.38-3.89
Others	0.05	0.71	0.01	1	0.93	1.05	0.27-4.00
Transportation cost burden							
Yes	-1.20	0.42	8.20	1	0.004	0.30	0.13-0.70
Family support							
Yes	1.50	0.65	5.32	1	0.02	4.48	1.26 -15.89
Receipt of Reminders							
Yes	1.10	0.20	30.25	1	<0.001	3.00	2.07-4.35
Negative Health facility experience							
Yes	-0.40	0.22	3.10	1	0.08	0.67	0.43-1.05

Factors significantly influence timely immunisation among children in these communities

Table 4 indicates that Distance greater than 3 KM was not statistically significant (p>0.05) with 95% CIs of 0.11-1.68. Those who perceived transportation cost as a burden were significantly less likely to immunise timely (aOR = 0.30, p = 0.004, 95% CL=0.13-0.70). Receiving immunisation

Table 5. Level of awareness of timely childhood immunization among caregivers.

S/N	Variables	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	TWS	Mean	Decision
1	The recommended age at which a child receives the first dose of immunization is at birth	1500 (7500)	90 (360)	866 (2598)	570 (1140)	430 (430)	12028	3.5	Good awareness level
2	The first dose of immunization at birth are BCG, OPV 0, HBV 0	1486 (7430)	104 (416)	1000 (3000)	536 (1072)	330 (330)	12248	3.5	Good awareness level
3	At six weeks child receives Penta 1, OPV 1, PCV 1 and Rota virus vaccines 1	1489 (7445)	101 (404)	1540 (46200	200 (400)	126 (126)	12995	3.8	Good awareness level
4	At 10 weeks child receives Penta 2, OPV 2, PCV 2 and Rota virus vaccines 2	1590 (7950)	300 (1200)	990 (2970)	76 (152)	500 (500)	12772	3.7	Good awareness level
5	At 14 weeks child receives Penta 3, OPV 3, PCV 3 and Rota virus vaccines 3	1890 (9450)	440 (1760)	850 (2550)	25 (50)	251 (251)	14061	4.1	Good awareness level
6	At 9months child receives Measles-Rubella, Yellow fever, and Meningitis A	1546 (7730)	44 (176)	570 (1710)	430 (900)	866 (866)	10912	3.2	Good awareness level
7	At 12 - 15months child receives 2nd Measles dose (in some states), Vitamin A	1590 (7950)	355 (1420)	215 (645)	400 (800)	896 (896)	11711	3.4	Good awareness level
8	It is important for a child to receive vaccines at the exact recommended age (timely immunization)	2689 (13445)	67 (268)	150 (450)	104 (208)	446 (446)	14817	4.3	Good awareness level
9	Benefits of timely childhood immunization includes Protection from diseases, strengthens immunity, and Reduces child mortality.	3450 (17250)	1 (4)	5 (15)	0 (0)	0 (0)	17269	4.9	Good awareness level
10	if a child misses or delays scheduled immunization there may be an increased risk of disease, Weak immunity.	1590 (7950)	400 (1600)	1460 (4380)	2 (4)	4 (4)	13938	4.0	Good awareness level
11	1 am aware that children should be timely immunized according to specified age	2700 (13500)	62 (248)	200 (600)	300 (600)	194 (194)	15142	4.4	Good awareness
	Total	21520/11 =1956 (57%)	1964/11= 179 (5%)	7846/11= 713 (21%)	2643/11 =240 (7%)	4043/11 368 (11%)		42.8	
	Criterion mean =3	Grand mean = 42.8/11= 3.9							

schedule reminders was strongly associated with higher odds of timely immunisation (aOR = 3.00, p < 0.001, 95% CL=2.07-4.35). Negative experiences at the health facility showed a trend toward lower timely immunisation odds but did not reach statistical significance.

Level of awareness of timely childhood immunisation among caregivers

Table 5 indicates that the grand mean is ($\bar{x}$=3.9). Therefore, the level of awareness of timely childhood immunisation among caregivers in Bayelsa State was moderate, and the percentage of awareness is 59%.

Attitude towards timely childhood immune-sation among caregivers in Bayelsa State

Table 6 indicates that the grand mean is ($\bar{x}$=4.1). Therefore, the attitude towards timely childhood immunisation among caregivers in Bayelsa State was positive. The percentage of positive attitude is 68%. However, findings indicated that 30% of the caregivers' attitudes towards immunisation are neutral.

Decision Rule: 'Any Grand mean or item's mean greater than or equal to the criterion's mean of 3 indicates a positive attitude towards timely child-hood immunization and any grand mean or item's mean less than the criterion's mean indicates a negative attitude towards timely childhood immunisation'.

Table 6. Caregivers' attitudes towards timely immunization.

S/N	Variables	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	TWS	Mean	Decision
1	I believe that taking my child for immunization at the recommended time is very important for the child's health	1590 (7950)	600 (2400)	1260 (3780)	4 (8)	2 (2)	14140	4.1	Positive attitude
2	I feel that delaying a child's immunization is harmful to the child's health	1600 (8000)	489 (1956)	1204 (3612)	100 (200)	63 (63)	13831	4	Positive attitude
3	I think completing all doses of immunization on time is worth the effort, even if it is inconvenient	1890 (9450)	300 (1200)	1000 (3000)	264 (528)	2 (2)	14180	4.1	Positive attitude
4	I am confident that timely immunization prevents serious childhood diseases	1590 (7950)	1400 (5600)	466 (1398)	0 (0)	0 (0)	14948	4.3	Positive attitude
5	I will encourage other parents or caregivers to take their children for immunization on schedule.	1900 (9500)	857 (3428)	660 (1980)	26 (52)	14 (14)	14974	4.3	Positive attitude
6	if health workers advise me to return for my child's next vaccine on a specific date, I will likely comply	2670 (13350)	50 (200)	700 (2100)	26 (52)	10 (10)	15712	4.5	Positive attitude
7	I am afraid of the side effect of the vaccines	2780 (13900)	398 (1592)	100 (300)	78 (156)	100 (100)	16048	4.6	Positive attitude
8	People generally complete their children's immunization scheduled on time in my community?	500 (2500)	100 (400)	2768 (8304)	61 (122)	27 (27)	11353	3.2	Positive attitude
9	I ensured that my child received their immunization at the appropriate time as scheduled	1200 (6000)	300 (1200)	21 (63)	1000 (2000)	933 (933)	10196	3.0	Positive Attitude
	Total	15720/9 = 1747 (51%)	4494/9 = 499 (14%)	8179/9 =909 (26%)	1559/9= 173 (5%)	1151/9 =128 (4%)		36.1	
	Criterion mean = 3	Grand mean = 36/9 = 4							

HO 1: There is no significant difference between the observed level of timely childhood immunisation coverage and the expected or target level in Bayelsa State

Table 7 indicates that there is a significant difference between the observed and expected levels of timely immunisation coverage in Bayelsa State. Since the chi-square value is very large and the p-value is < 0.05, the observed coverage (80%) is significantly lower than the target (96%). Therefore, the hypothesis is rejected.

HO 2: Examined factors have a significant influence on timely immunisation among children in Bayelsa State.

Table 8 shows the logistic regression analysis that revealed that factors such as living 1-3 KM from a health facility, transportation cost burden, lack of family support, and not receiving immunisation reminders significantly reduced the odds of timely childhood immunisation in Bayelsa State. Conversely, family support and receipt of immunisation reminders significantly increased the likelihood of timely immunisation. Distance greater than 3 KM and mode of transportation were not statistically significant, though they showed a trend towards affecting coverage.

Table 7. A summarized chi-square goodness- of -fit test table showing observed and expected frequencies, along with the chi-square calculation summary for the timely childhood immunization coverage in Bayelsa State.

Category	Observed (0)	Expected (E)	$(0\text{-}E)^2/E$
Timely immunization	2765	3317	405.27
N0t Timely Immunized	691	139	1897.06
Total	3456	3456	2302.33

Calculation of $\chi 2$ statistic is the sum of $(O-E)^2/E$ for each category; Degrees of freedom (df) = 1 (2 categories - 1); The chi-square statistic = 2302.33; and p-value ≈ 0.000 (very significant).

Table 8. Shows the logistic regression coefficients, adjusted odds ratios (aOR), 95% confidence intervals (CI), and significance values for each predictor.

Variable	B	S.E.	Wald	df	P-value	aOR	95% CI (aOR)
Distance (Ref: <1KM							
-1-3Km	-0.35	0.12	8.56	1	0.003	0.70	0.55-0.89
>3KM	-0.85	0.68	1.56	1	0.21	0.43	0.11-1.68
Mode of Transportation							
Public Transport	-0.15	0.11	1.84	1	0.17	0.86	0.70-1.06
Private vehicle	0.20	0.60	0.11	1	0.74	1.22	0.38-3.89
Others	0.05	0.71	0.01	1	0.93	1.05	0.27-4.00
Transportation cost burden							
Yes	-1.20	0.42	8.20	1	0.004	0.30	0.13-0.70
Family support							
Yes	1.50	0.65	5.32	1	0.02	4.48	1.26 -15.89
Receipt of Reminders							
Yes	1.10	0.20	30.25	1	<0.001	3.00	2.07-4.35
Negative Health facility experience							
Yes	-0.40	0.22	3.10	1	0.08	0.67	0.43-1.05

Overall, the null hypothesis that these examined factors do not significantly influence timely immunisation is rejected.

HO 3: There is no significant relationship between caregivers' knowledge and attitudes and the timeliness of childhood immunisations in Bayelsa State.

Table 9 indicates that for awareness, $\chi 2=12,827.1$ and for attitude, $\chi 2=1,520.25$. With degrees of freedom $df=(2-1)\times(2-1)=1$ for each test, these chi-square values are far above the critical value of 3.841 at $\alpha=0.05$. Therefore, the null hypothesis that there is no significant relationship between caregivers' knowledge and attitudes and the timeliness of childhood immunisations in Bayelsa State is rejected.

DISCUSSION

The Social-Ecological Model (SEM) provided the theoretical framework for this study, organising determinants of timely childhood immunisation across multiple levels to capture the interplay of individual, interpersonal, community, and structural factors (Malande *et al*., 2019; Eniojukan and Solomon, 2024) influencing caregiver behaviour in Bayelsa State. By applying SEM, the study revealed how access (organisational), demand (interpersonal/intrapersonal), and quality barriers interact multi-levelly, informing comprehensive interventions like community outreach and subsidised transport over single-level fixes (Olaniyan *et al*., 2021).

The caregiver demographic profile in Bayelsa State demonstrates equitable distribution across all nine Local Government Areas (LGAs), each contributing 12–13% of participants, ensuring broad representation. The majority of caregivers fall within young-to-middle adulthood (26–45 years, 73%), with females overwhelmingly dominant (98%) and mothers comprising 80% of caregivers. Caregiving households are small to moderate in size, with most having one to two children under five years. Educational attainment is relatively high, with half of caregivers having secondary education and 39% with tertiary education, while only about 11% reported primary or no education.

Table 9. Relationship between caregivers' knowledge and attitudes and the timeliness of childhood immunizations in Bayelsa State.

Category	O (Timely)	E (Timely)	(O - E)²/E (Timely)	O (Untimely)	E (Untimely)	(O - E)²/E (Untimely)
Awareness						
Good awareness	2000	300	$\frac{(2000-300)^2}{300}$ =9633.33	600	100	$\frac{(600-100)^2}{100}$ =2500
Poor awareness	762	317	$\frac{(762-317)^2}{317}$ =624.44	91	39	$\frac{(91-39)^2}{39}$ =69.33
Attitude						
Positive attitude	3000	3200	$\frac{(3000-3200)^2}{3200}$ =12.5	100	50	$\frac{(100-50)^2}{50}$ =50
Negative attitude	257	200	$\frac{(257-200)^2}{200}$ =16.25	99	6	$\frac{(99-6)^2}{6}$ =1441.5

Sum chi-square for Awareness: 9633.33+2500+624.44+69.33=12,827.1.; Sum chi-square for Attitude: 12.5+50+16.25+1441.5=1,520.25.

Occupations are largely trader/business (71%) and civil servants (21%). This aligns with evidence from Africa and Nigeria showing maternal age, education, and occupation as key determinants of immunisation uptake, with older and more educated mothers more likely to complete immunisation schedules (Galadima *et al*., 2021; Adesina *et al*., 2023; Okesanya *et al*., 2024). However, some studies highlight disparities, such as younger mothers (15–24 years) reporting lower completion rates (Alabi *et al*., 2024; Fadl *et al*., 2022), underscoring contextual variations.

Timeliness of immunisation in Bayelsa is moderate; findings indicated that out of 276 children aged 12-24 months, only 75% (206) received timely immunisation by 12 months. This pattern reflects global findings in low- and middle-income countries, where moderate timeliness is common but far below >90% coverage reported in high-income countries (Derqui *et al*., 2024; Wariri *et al*., 2023; Wittesaele *et al*., 2024). Delays of 2–4 weeks were also observed in Senegal and Gambia, while South African and Bangladeshi studies confirm declining timeliness as children age. In Nigeria, wide disparities persist: national routine immunisation coverage ranges from 29–37% (Egberipou *et al*., 2025), while campaign-based spikes report up to 98% (Briseimo, 2025). This confirms systemic weaknesses in sustaining routine coverage, consistent with WHO (2025a) and Mohammed *et al*. (2024), who emphasise enduring socio-economic and infrastructural challenges.

Determinants of timely immunisation in Bayelsa include distance to health facilities, transportation costs, family support, and reminder systems. Logistic regression revealed that caregivers living 1–3 km from facilities, lacking family support, or not receiving reminders were significantly less likely to immunise their children on time. Similar findings have been reported in Nigeria, where transportation barriers, caregiver reminders, and social support strongly influenced timeliness (Eze *et al*., 2021; Mahachi *et al*., 2022). Egberipou *et al*. (2025) emphasised community participation and confirmed demand-side constraints in Bayelsa. Conversely, other studies highlight supply-side issues such as vaccine stockouts and health worker attitudes as more critical in some regions (Akpe and Odikeme, 2024; Mohammed *et al*., 2024). This underscores the interplay of demand- and supply-side barriers in shaping outcomes.

These findings reveal distinct mechanisms like access barriers, demand-side influences, and service quality gaps that interact to shape immunisation timeliness (Akpe and Odikeme, 2024). Distance to health facilities (1–3 km) and transportation costs represent structural access barriers that limit physical reach to immunisation services. Caregivers farther from facilities face increased time and financial burdens, leading to missed appointments during critical immunisation windows (0–9 months, as seen in the sample). The mechanism operates through opportunity costs: time spent travelling competes with income-generating activities (71% traders/business owners), while even minimal costs (2% reporting burden) deter low-income households. This aligns with Andersen's Behavioural Model of Health Services Use, where enabling factors like geographic access directly predict utilisation. In Bayelsa's riverine communities, poor road networks exacerbate this, as public transport (62%) remains unreliable during rainy seasons (Akpe and Odikeme, 2024).

Family support and reminder systems address demand-side barriers rooted in caregiver knowledge, motivation, and competing priorities. Lack of spousal/family endorsement (1% in sample) reflects social influence mechanisms, where patriarchal decision-making in Nigerian households can delay health-seeking. The fourfold protective effect underscores social capital theory:

supportive networks reinforce health behaviours through normative pressure and practical assistance (e.g., childcare during visits). Reminders (60% receipt) work via behavioural nudges, countering forgetfulness amid busy caregiving for multiple children under 5 (60% with 1–2 children). These demand factors explain why educated mothers (89% secondary/tertiary) still delay without external prompts (Adesina *et al*.,2023).

While not statistically significant (aOR = 0.67, p = 0.08), near-universal negative facility experiences (98%) suggest service quality spillover effects. Rude staff or long waits erode trust, amplifying access barriers by creating perceived quality disincentives. This mechanism links demand and supply: even proximate caregivers avoid facilities if quality is poor, consistent with SERVQUAL theory where reliability gaps undermine utilisation (Eze *et al*., 2021). This aligns with Nigerian studies emphasising transportation (Eze *et al*., 2021) and reminders/social support (Mahachi *et al*., 2022), where similar access-demand interplay reduced timeliness by 25–40%. Alabi et.al. (2024 highlighted community participation as a support proxy, while Egberipou *et al*. (2025) confirmed Bayelsa's demand constraints amid oil-region economics. In African climes, Ghanaian studies (Adu-Gyamfi and Asante, 2022) mirror reminder effects, attributing 35% uptake variance to nudges

Caregiver knowledge and attitudes significantly influenced timeliness. Awareness was moderate (59%), indicating that while over half understood the importance of timely immunisation, gaps persist. Positive attitudes were dominant (grand mean 4.1), with 68% of caregivers supportive, though 30% expressed neutral attitudes, representing an opportunity for targeted interventions. Similar findings of moderate awareness and predominantly positive attitudes have been reported in Ghana (Danso *et al*., 2023), Ilorin and Ekiti, Nigeria (Ariyibi *et al*., 2023), and India (Dhaliwal *et al*., 2022). However, some studies report low awareness and negative attitudes in Kenya and Northern Nigeria due to misinformation and hesitancy (Danso *et al*., 2023). The Bayelsa findings, therefore, align with regional trends of mixed but generally favourable caregiver perceptions, while highlighting the influence of misinformation and cultural barriers in other settings.

Statistical testing revealed a significant gap between observed (80%) and target (96%) timely immunisation coverage, confirming that Bayelsa lags behind programmatic goals despite campaign-driven improvements. This reflects the common disparity between campaign and routine immunisation performance observed across Nigeria and other low- and middle-income countries (Mohammed *et al*., 2024).

Limitation of the study

1. Recall and Reporting Bias — Caregivers' self-reported immunisation status or reliance on immunisation cards were affected by recall errors or lost/incomplete records, impacting data accuracy.
2. Geographic and Accessibility Barriers — The riverine and deltaic geography of Bayelsa reduced access to health facilities, and these environmental factors might not be fully accounted for or controlled, potentially skewing immunisation coverage assessment.
3. Limited Consideration of Sociocultural Factors — Studies may inadequately explore complex sociocultural influences such as community beliefs, vaccine hesitancy, and misinformation that affect immunization uptake.
4. Cross-Sectional Design Constraints — Cross-sectional approaches commonly used capture immunisation coverage at one point in time, limiting insight into temporal changes, causal relationships, or long-term determinants.

Conclusion

The findings from the study indicate that caregiver demographics, knowledge, and attitudes positively influence timely childhood immunisation, but systemic barriers such as transportation, costs, and health system weaknesses hinder full achievement of targets. While moderate timeliness (46–49%) and higher completion rates (79%) compare favourably with some African contexts, they remain below global benchmarks. The results reinforce the importance of localised, multifactorial strategies—strengthening health education, improving reminder systems, reducing transportation and economic barriers, and enhancing health system infrastructure—to sustainably improve childhood immunisation timeliness and coverage in Bayelsa State. Policymakers should prioritise subsidised transportation vouchers and SMS reminder systems for caregivers within 1-3 km of facilities to immediately address access barriers and boost timely immunisation rates by at least 30%. Long-term, invest in fixed immunisation posts in underserved riverine LGAs and family engagement programs to leverage social support, targeting 90% coverage aligned with SDG 3 targets.

Further research should conduct randomised controlled trials evaluating SMS reminders, transport subsidies, and mobile clinics' impact on timeliness in Bayelsa's riverine LGAs, measuring cost-effectiveness and sustainability.

Recommendation

Short-Term Recommendations (Immediate Implementation, 0-12 Months).

1. Scale up SMS/phone call reminders to 100% coverage, partnering with telecom providers for automated scheduling alerts targeting 7-9 month peak periods (63% of index children).

2. Implement transport vouchers or mobile immunisation units for caregivers 1-3km+ from facilities and those reporting cost burdens (2%), prioritising riverine LGAs like Southern Ijaw and Ekeremor.
3. Launch community health worker (CHW) home visits to engage spouses/families (1% non-support), using male influencers to address patriarchal barriers.
4. Train staff on client-centred service to reduce negative experiences (98%), focusing on wait-time management and courteous interactions.

Long-Term Recommendations (Strategic, 1-5 Years).

1. Construct additional immunisation posts within a 1 km radius in underserved LGAs (Brass, Sagbama) and improve road networks for year-round access in flood-prone areas.
2. Train and deploy permanent CHWs for door-to-door vaccination and family counselling, building sustained social support structures.
3. Integrate transport subsidies into state health budgets and advocate for federal zero-dose prevention funding targeting demand-side barriers.
4. Establish real-time immunisation dashboards tracking timeliness by LGA and conduct annual SEM-based evaluations to adapt interventions.

These evidence-based recommendations directly address the identified determinants (distance, costs, support, reminders), leveraging Bayelsa's caregiver profile (female mothers, traders) for feasible, multi-level impact toward 90% timeliness.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AKNOWLEDGEMENT

The authors acknowledge the support of all research assistants during the data collection. We sincerely appreciate all caregivers in this study for their willingness to participate in the study.

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