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Research Article

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Engaging Communities in Anambra State in Improving Vaccination Outcome: A Participatory Research Approach to Enhancing Immunization Utilization

Helen Simon Nwafor*, Daprim Ogaji and Margaret Inemesit Akpan

Africa Centre of Excellence, Centre for Public Health and Toxicological Research (ACE-PUTOR), University of Port Harcourt, Rivers State, Nigeria

***Corresponding author**

Helen Simon Nwafor, Africa Centre of Excellence, Centre for Public Health and Toxicological Research (ACE-PUTOR), University of Port Harcourt, Rivers State, Nigeria.

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ABSTRACT

Background: Childhood immunization coverage in Nigeria remains below the 90% target despite free vaccines. Evidence on participatory community engagement for routine immunization in South-East Nigeria is limited.

Objectives: To (1) determine caregivers' knowledge of childhood immunization and baseline immunization utilization; (2) identify community-related factors influencing utilization; (3) implement community-based interventions developed with community stakeholders; and (4) determine changes in knowledge and utilization after the interventions.

Methods: A Participatory Action Research design with baseline assessment, participatory planning and implementation, and post-intervention evaluation was used in six communities across six Local Government Areas (two per senatorial zone) of Anambra State. Three hundred and sixty-one caregivers of children aged 0–12 months were sampled by multistage sampling at each assessment (sample size computed for a two-proportion comparison, 95% confidence, 80% power, inflated by 10% for attrition). Data were collected with a structured questionnaire (Cronbach's alpha 0.798 in pilot testing) and child immunization records. Interventions were health education, SMS reminders, telephone calls and supportive supervision. Data were analyzed with descriptive statistics and chi-square tests ($p < 0.05$).

Results: At baseline, 34.9% of caregivers had good knowledge and 30.5% had high utilization. Distance to facilities, mothers' time constraints, inconvenient session times and the lack of a reminder system were the community-related factors rated as significant barriers (item means ≥ 3.0). After the interventions, good knowledge rose to 63.2% (poor knowledge fell from 23.8% to 5.3%; $\chi^2 = 76.80$, df = 2, $p < 0.001$) and high utilization rose to 58.4% (low utilization fell from 15.2% to 0.6%; $\chi^2 = 87.76$, df = 2, $p < 0.001$). Timely completion of immunization rose from 45.4% to 66.8% ($p < 0.001$), and uptake improved significantly for 13 of 14 individual vaccine doses. Post-intervention utilization did not differ significantly by intervention type ($p = 0.41$).

Conclusion: Participatory community engagement combining health education, reminders and supportive supervision was associated with better caregiver knowledge and immunization utilization. The single-group design limits causal inference; controlled studies are needed.

Keywords: Community Engagement, Participatory Action Research, Childhood Immunization, Vaccination Uptake, Nigeria

Introduction

Immunization is among the most cost-effective public health interventions. Modelling of 50 years of the Expanded Programme on Immunization (EPI) estimates that vaccination has averted about 154 million deaths globally, and routine childhood vaccination also prevents illness, reduces household health spending and poverty, supports healthy childhood development and promotes equity [1,2]. Infants and young children benefit most because their immune systems are immature and they are at greatest risk from infectious diseases [3]. The World Health Organization (WHO) launched the EPI in 1974 to extend vaccination to children everywhere, and standardized schedules have since been developed and regularly updated. Even so, coverage and the quality of vaccination services remain important challenges [4].

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Nigeria offers routine immunization free of charge to children under two years of age at government hospitals, primary health centres (PHCs) and some private facilities. The current schedule comprises eight vaccines directed at ten vaccine-preventable diseases [2]. Despite this, coverage remains below the 90% level recommended by the WHO, and the country carries one of the world's largest burdens of zero-dose and under-immunized children [5-7]. In the 2021 Nigeria Multiple Indicator Cluster Survey/National Immunization Coverage Survey (MICS/NICS), only 36% of children aged 12–23 months were fully vaccinated [8]. Children who miss vaccines remain exposed to vaccine-preventable diseases and to the risk of dying before their fifth birthday [7].

Inequalities in vaccination are complex. Parents who delay or refuse some or all vaccines, a phenomenon that the WHO listed among the top ten threats to global health in 2019, weaken community protection against vaccine-preventable diseases [9]. In low- and middle-income countries, uptake is often low and inconsistent because many people lack sufficient knowledge of the benefits of immunization, face barriers in reaching services, or hesitate because of fear of side effects, religious opposition or general reluctance, which delays the vaccination of their children [10]. Misunderstanding of disease severity, mistrust of health professionals and governments, and limited access arising from the location and timing of services further widen the gaps [11].

The barriers to utilization operate at individual, interpersonal, community and health-system levels. They include limited knowledge, vaccine misconceptions, fear of adverse events, forgetfulness, vaccine stock-outs and health-worker attitudes [12,13]. They also differ from one setting to another because of social, economic, cultural, geographical, political and religious factors [3]. In rural India, for example, vaccine uptake was shaped by the attitude of community health workers and by caregivers' perceptions, which were in turn influenced by husbands, mothers-in-law and religious leaders [14]. In southern Nigeria, low coverage has been attributed to poor knowledge, poor compliance, limited accessibility and unfavorable attitudes towards vaccine uptake [15]. Because the barriers are context-specific, the interventions most likely to work are also context-specific, and interventions designed with the affected communities may be more acceptable and sustainable than top-down approaches [16].

Effective strategies are those that make people aware of the benefits of immunization, correct false beliefs and rumours, and tell caregivers where and when to be vaccinated [3]. Participatory action research (PAR) improved full immunization from 60.7% to 90.9% in Remo North, Ogun State, through dialogue among community members, frontline health workers and local government officials [17]. Engagement of traditional and religious leaders improved vaccination uptake in Cross River State, and a culturally tailored community theatre intervention raised the proportion of fully immunized children from 46% to 84% in 18 Niger Delta communities and reached children who had never received any vaccine. Reminder strategies have also performed well: in a randomized trial in Ilorin, vaccination completion at nine months was 99.2% with telephone reminders and 99.3% with SMS reminders, against 90.4% with usual care, and mobile reminders improved completeness and timeliness in Kano [18-21]. The evidence is not uniformly strong, however. A systematic review of mobile-phone interventions in 21 low- and middle-income countries concluded that their potential is clear but the evidence is not, and a recent meta-analysis found the evidence for community engagement in vaccination promotion to be fragmented and of uncertain quality [22,23]. Given the many factors behind low uptake, multifaceted interventions that combine information, reminders and service adjustments are likely to be more promising than single measures.

Immunization Situation in Anambra State

Anambra State has relatively favourable immunization indicators for Nigeria, but important gaps persist in completion and equity. Oli et al. (2021) reported that 87.5% of children aged 12–23 months in the state had received the third DPT-HepB-Hib dose and 75.8% had received all basic vaccines, whereas only 60.4% had received all age-appropriate vaccines [24]. High uptake of a single antigen therefore does not guarantee completion of the schedule. A geospatial analysis of the 2021 MICS/NICS estimated that 18.5% of children aged 12–23 months in Anambra State were zero-dose and 28.6% were under-immunized, compared with national estimates of 30.1% and 43.9%; the state-level confidence intervals were wide (3.9–55.9% and 10.3–58.1%, respectively), so these figures show continuing gaps rather than precise prevalence [25].

Caregiver knowledge presents a similar picture. In a cross-sectional study of 2,400 parents and guardians in Awka and Onitsha, 92.3% had heard of childhood immunization, but only 56.2% correctly identified disease prevention as its purpose, and 77.2% reported always ensuring that their children were fully immunized; correct knowledge of the purpose was significantly associated with higher education [24]. Between 17% and 34% of respondents disagreed with statements on the importance of immunization in and after the first year of life, of full immunization, of keeping immunization records and of supporting immunization in the neighbourhood. By contrast, 85.3% of caregivers in Ilorin, Kwara State, were classified as having good knowledge, and good knowledge was significantly associated with a child's full vaccination status [26]. Awareness in Anambra State is thus high, but specific knowledge of the purpose, timing and continued importance of vaccination is inadequate among a sizeable minority of caregivers.

Problem Statement and Rationale

Vaccines are free in Nigeria, yet knowledge gaps, misconceptions, practical barriers and forgetfulness continue to keep children from being vaccinated fully and on time. On her visits to some primary health centres in Anambra State, the lead author observed poor turn-up for immunization services. It is not conclusively known why utilization is sub-optimal in communities in the state, nor which interventions would produce a positive response from caregivers. Participatory and community-engagement evidence from Nigeria comes from Ogun, Cross River and the Niger Delta, and the South-East is not represented. To our knowledge, no published study has used a participatory research approach to improve immunization utilization in Anambra State. This study addresses that gap by involving caregivers, community and religious leaders, women's groups and health workers in interpreting baseline findings, choosing interventions, implementing them and reflecting on the results.

Conceptual Framework

The study was guided by two complementary frameworks. The Social Ecological Model locates immunization behaviour at several nested levels: the individual caregiver (knowledge, beliefs), the interpersonal level (family members, neighbours), the community (leaders, religious and social groups) and the organisation or health system (session times, health-worker practice, vaccine supply). It suggests that interventions acting at more than one level are more likely to change behaviour than single-level approaches. The Health Belief Model explains how caregivers' perceptions of the susceptibility of their children to vaccine-preventable diseases, the severity of those diseases, the benefits of vaccination and the barriers to it, together with cues to action and self-efficacy, shape the decision to vaccinate. In this study, health education targeted perceived benefits and misconceptions; SMS and telephone reminders served as cues to action and addressed forgetfulness; and supportive supervision addressed organisational barriers such as inflexible session times.

Aim, Objectives, Research Questions and Hypotheses

The aim of the study was to assess the effectiveness of community engagement, through a participatory approach, in improving vaccination outcomes in selected communities in Anambra State. The objectives and research questions are shown in Table 1.

Table 1: Objectives and Research Questions

#	Objective	Research question
1	To determine caregivers' knowledge of childhood immunization and the baseline level of immunization utilization among eligible children in the selected communities	RQ1: What are the levels of caregivers' knowledge of childhood immunization and of baseline immunization utilization among eligible children?
2	To identify community-related factors influencing the utilization of immunization services	RQ2: What community-related factors influence the utilization of immunization services?
3	To implement community-based interventions, developed with community stakeholders, to improve immunization utilization	RQ3: What community-based interventions can be jointly developed and implemented with community stakeholders, and how were they delivered and received?
4	To determine changes in caregivers' knowledge and in childhood immunization utilization following the interventions	RQ4: Did caregivers' knowledge and childhood immunization utilization change significantly between baseline and post-intervention?

Hypotheses. H_o1: There is no significant relationship between knowledge of immunization at baseline and baseline immunization utilization. H_o2: There is no significant relationship between community-related factors and baseline immunization utilization. H_o3: There is no significant relationship between the type of community-based intervention and post-intervention immunization utilization. H_o4: There is no significant difference between baseline and post-intervention immunization utilization. H_o5: There is no significant difference between baseline and post-intervention knowledge of immunization.

Significance of the Study

The findings are relevant to families, communities, health workers, programme managers and researchers. For families, more complete and timely vaccination lowers the likelihood of illness, hospital admission and the costs of treating complications, so that household resources can be used for other needs such as food and education. For communities, higher coverage reduces outbreaks and, by building herd immunity, protects children who cannot be vaccinated for medical reasons; taking part in the research also builds knowledge, skills and a sense of ownership of local health initiatives. For primary health care workers, who are the main source of information on immunization and the first point of contact with caregivers, an understanding of local barriers supports more targeted interventions and gives them evidence with which to advocate for resources and policy support. For policy makers and programme managers, the study provides data on interventions that can be delivered with existing structures. For researchers, it adds to the limited literature on participatory approaches to improving vaccination outcomes and offers a model that can be tested, refined and adapted in other settings and for other health problems.

Methods

Study Design

A single-group pre-intervention and post-intervention Participatory Action Research (PAR) design was used. PAR is a collaborative approach in which researchers and community members jointly identify health problems, examine their underlying factors, plan and implement interventions, and evaluate the outcomes [27]. It emphasises active participation, shared decision-making, local ownership and practical solutions. The study had three sequential phases that corresponded to its objectives: (1) baseline assessment, including community-level feedback and diagnosis; (2) participatory planning and implementation of community-based interventions; and (3) post-intervention (endline) evaluation, with feedback of the findings to stakeholders. No separate control group was used, so the effect of the interventions was assessed by comparing outcomes before and after implementation in the same communities.

This design does not permit the causal inference of a randomized controlled trial. It was chosen because the main purpose was to engage communities in identifying immunization problems, developing context-specific solutions, implementing them together and observing changes in outcomes, in which interventions differ between communities according to local needs. The design and its limitations are discussed further in Section 4.

Working Definitions. Community engagement was defined as the collaborative process of actively involving community members in the activities that improve their vaccine uptake, including community meetings, health education and reminders [23]. A participatory research approach was defined as collaboration between the researcher and community members to implement interventions that enhance immunization uptake; it can help to identify local barriers to vaccination and may lead to

sustainable solutions in a way that a top-down approach cannot [16]. Immunization utilization referred to a child's receipt of the vaccines recommended in the national schedule for the first year of life, and timely immunization to receipt of those vaccines within the recommended timeline.

Study Area and Setting

The study was conducted in Anambra State, South-East Nigeria, which lies in a rainforest and humid climate zone and covers about 4,416 square kilometres. The state capital is Awka. Anambra is bounded by Kogi State to the north, Enugu to the east, Abia to the south-east, Imo and Rivers to the south, and Delta and Edo to the west. It has three senatorial zones (Anambra North, Anambra Central and Anambra South) containing 21 Local Government Areas (LGAs), seven in each zone. The state is the tenth most populous in Nigeria, with an estimated population of about 5,953,500 in 2022, projected from the 2006 census at an annual growth rate of 2.2%.

The population is predominantly Igbo, and Igbo and English are widely spoken. Literacy is comparatively high, and the people are mainly Christian, with few traditionalists and Muslims. Common occupations are trading and business, farming and the civil service. The state has large markets, many schools at all levels, primary health centres, general hospitals, one federal medical centre and two teaching hospitals. Communities in the state were chosen because of the sub-optimal level of vaccine uptake reported there, and because a participatory approach could help to uncover the cultural beliefs and norms that hinder vaccine acceptance and provide a platform for correcting misinformation and myths.

Study Population and Eligibility

The study population was approximately 1.66 million adults aged 18 years and above resident in the six selected LGAs (Table 2). This base included parents and caregivers of children aged 0–12 months, community and religious leaders, health workers, women's groups, community-based organizations and other stakeholders who could contribute to or influence childhood immunization. The quantitative component targeted parents and caregivers of children aged 0–12 months, who make the decisions about whether and when eligible children are vaccinated and are best placed to report on knowledge and uptake. The participatory component involved the wider group of stakeholders listed above, whose roles were to identify barriers and facilitators, interpret findings, prioritize needs, help to implement the interventions and evaluate the outcomes.

Communities were eligible if they had documented challenges with immunization uptake, were accessible to the researcher, and had functional community structures, such as recognized leaders, health workers, religious organizations, community-based organizations and women's groups, capable of facilitating participation. Individual participants were eligible if they were aged 18 years or above, were parents or caregivers of a child eligible for routine immunization (0–12 months), and had lived in the community for at least six months. Communities already involved in a similar immunization intervention or research programme during the study period were excluded. Individuals who had not lived in the community for six months, who were unavailable during data collection or participatory activities, or who were unwilling to take part were also excluded.

Sample Size Determination

Because the primary comparison was between two proportions (baseline and post-intervention), the sample size per assessment was calculated with the comparative-study formula of Cornfield, as refined by Cochran and Fleiss et al. [28-30]:

$$n_0 = 2\,(Z\alpha/2 + Z\beta)^2\,[p_1(1 - p_1) + p_2(1 - p_2)] \,/\, (p_1 - p_2)^2$$

where n_0 is the sample size per group, $Z\alpha/2 = 1.96$ for 95% confidence, $Z\beta = 0.84$ for 80% power, $p_1 = 53\%$ is the expected proportion before the intervention and $p_2 = 68\%$ is the expected proportion after it. These proportions, which imply an expected difference of 15 percentage points, were adapted from a community volunteer-driven immunization intervention in Rivers State [31]. Substituting the values gives $n_0 = 2 \times (2.80)^2 \times (0.53 \times 0.47 + 0.68 \times 0.32) \div (0.15)^2 = 325.2$ per assessment. A finite population correction for the study population of 1,663,800 left the figure unchanged (325.3). To allow for an expected attrition or non-response rate of 10%, the minimum size was divided by (1 − 0.10), giving 325.3 ÷ 0.9 = 361. A sample of 361 caregivers was therefore recruited at each assessment.

Sampling Procedure

A multistage sampling technique was used, which is suited to populations spread over wide geographical areas [32]. In stage one, two LGAs were selected by simple random sampling from each of the three senatorial zones, giving six LGAs: Onitsha North, Oyi, Awka South, Njikoka, Nnewi South and Ihiala. In stage two, one community with a functional primary health centre that met the eligibility criteria was purposively selected in each LGA, because participatory strategies were most needed there and outcomes could be meaningfully assessed. Within each community, households with a caregiver of a child aged 0–12 months were recruited by convenience sampling among those who were available and willing, with one respondent per household. In stage three, the 361 respondents were allocated to the six LGAs in proportion to their adult populations (Table 2), using n = (LGA population ÷ total population) × 361.

Table 2: Selected LGAS and Communities and Proportionate Allocation of the Sample

Senatorial zone	LGA	Community	Adult population	Sample allocated
Anambra North	Onitsha North	Omagba Phase II	179,400	39
Anambra North	Oyi	Awkuzu	239,300	52
Anambra Central	Awka South	Amawbia	270,300	59
Anambra Central	Njikoka	Abagana	211,500	46
Anambra South	Nnewi South	Amichi	332,500	72
Anambra South	Ihiala	Ihiala	430,800	93
Total			**1,663,800**	**361**

The same sampling frame and allocation were used for the post-intervention assessment. Because respondents were recruited afresh by convenience within each community, they were not strictly followed up as the same individuals at both time points, and the two assessments were treated as independent samples.

Participatory Process and Interventions

Baseline and Community Diagnosis. After the baseline data had been collected and analyzed, the findings were presented to community stakeholders in each community, including community leaders, representatives of community groups, caregivers and health workers. Stakeholders jointly interpreted the findings, identified priority problems and selected feasible strategies. Written approvals from the state and community authorities had been obtained beforehand.

Interventions. A multifaceted package was agreed, and the components were implemented in each community according to its needs (Table 3). Health education aimed to raise awareness of routine immunization, its schedule, importance and safety, and to dispel common misconceptions among caregivers and community influencers. It was delivered through several channels to maximize reach: house-to-house visits, which educated caregivers and other family members and made it possible to involve men; person-to-person contact; group meetings; and community and religious gatherings organized with local leaders and other stakeholders. Reminders by telephone call or SMS were sent, in collaboration with health workers, to caregivers who failed to bring a child for a scheduled vaccination appointment. Supportive supervision was provided to health workers and volunteers involved in immunization delivery, and included discussion of ways of making session times more flexible for caregivers who complained of time constraints.

Table 3: Components of the Community-Based Intervention Package

Component	How it was delivered	Target	Frequency
Health education	House-to-house visits; person-to-person contact; group meetings; community and religious gatherings organized with local leaders	Caregivers, family members (including men) and community influencers; content on benefits, schedule, safety and misconceptions	Fixed times during community or religious meetings, within a one-month intervention period
Telephone and SMS reminders	Telephone calls or text messages, in collaboration with health workers	Caregivers who failed to attend a scheduled vaccination appointment	Sent whenever a scheduled appointment was missed
Supportive supervision	Visits to health facilities; discussion with health workers and volunteers on flexible immunization session times	Health workers and volunteers delivering immunization	Monthly

Timing and Feedback. The intensive intervention period lasted about one month, to allow sustained engagement and reinforcement of key messages. A six-month interval was then allowed for change to take place before the post-intervention data were collected. Community members and stakeholders took part in implementation, monitoring and feedback to promote ownership and sustainability, and the post-intervention findings were shared with stakeholders so that they could reflect on what had worked and what needed to be improved. Possible confounders were acknowledged and, as far as possible, documented: caregivers' socioeconomic status and education, cultural and religious beliefs, health-system limitations such as vaccine stock-outs or negative provider attitudes, prior exposure to similar campaigns, and environmental factors such as weather that could affect attendance.

Data Sources and Instrument

Primary data were collected from caregivers using a structured questionnaire titled "Engaging communities in Anambra State in improving vaccination outcome questionnaire". For caregivers who could not recall the immunization status of their child, the information was taken from the child's immunization record booklet. The questionnaire had seven sections. Section A collected socio-demographic characteristics (age, marital status, education, occupation, household size and religion). The remaining sections covered knowledge of immunization, utilization of immunization services, community-related factors influencing utilization, the community-based interventions received, knowledge after the intervention and utilization after the intervention.

Knowledge was measured with eight five-point Likert items (strongly agree to strongly disagree), five of them positively worded and three negatively worded (for example, "vaccines can potentially cause sudden infant death"). Item means were compared with a criterion mean of 3.0, and a knowledge score of 0–8 was derived and classified as poor, moderate or good [cut-off points to be stated]. Utilization was measured with 15 yes/no items covering birth doses (BCG, hepatitis B and oral polio vaccine), the pentavalent, pneumococcal conjugate (PCV) and oral polio vaccines at six, ten and 14 weeks, measles and yellow fever vaccines at nine months, and whether the child's vaccinations were taken within the recommended timeline. The utilization score (0–15) was classified as low, moderate or high [cut-off points to be stated]. Community-related factors were measured with ten five-point Likert items (lack of awareness, cultural beliefs and practices, distance to the health facility, financial constraints, fear of side effects, vaccine unavailability, poor attitude of health workers, mothers' time constraints, lack of a reminder system and inconvenient session times). Further items recorded exposure to the programme, the mode of delivery and type of intervention received, and whether respondents found the interventions appropriate and would recommend them.

Validity and Reliability

The items were derived from the study objectives. The draft questionnaire was given to the project supervisors and to experts in measurement and evaluation, who judged its face and content validity for clarity, congruence with the objectives and appropriateness of language; their comments were incorporated

before the instrument was used. Internal consistency was assessed in a pilot test with 36 caregivers from six communities in Enugu State, a state with characteristics similar to those of Anambra State, outside the study area. The pilot also checked whether respondents had difficulty understanding the questions. Cronbach's alpha was 0.798, above the 0.70 threshold and indicating acceptable to good reliability.

Data Collection Procedure

Five research assistants were briefed on the selection of participants and on the meaning of the questions. They administered the questionnaires by direct delivery and retrieval to increase the return rate, over a period of five days in the six communities [data collection dates to be inserted]. Three hundred and seventy copies of the questionnaire were printed; completing one took about 6–12 minutes, and the completed questionnaires were collected immediately, giving a return rate of 100% for the 361 respondents analyzed. Completed questionnaires were stored out of reach of unauthorized persons and will be disposed of according to institutional directions when no longer needed.

Data Analysis

Data were coded, entered and analyzed in IBM SPSS Statistics version 25. Frequencies, percentages, means and standard deviations described the socio-demographic characteristics, knowledge, community-related factors, intervention exposure and utilization. For Likert items, a mean of 3.0 or above was taken as agreement (accepted) and below 3.0 as disagreement (rejected). Because respondents at the two time points were not the same individuals, baseline and post-intervention data were treated as independent categorical data and compared with Pearson chi-square tests of association (without continuity correction) at $\alpha = 0.05$; paired tests such as the paired t-test and McNemar's test, which require matched observations, were not appropriate. The same approach was used to test the five hypotheses. To help readers judge the size of the changes, differences in proportions are also reported with Wald 95% confidence intervals, and changes in mean scores with standardized mean differences (Cohen's d) calculated from the reported means and standard deviations. These two measures were added during manuscript preparation and were not part of the original analysis plan. Fifteen comparisons were made (14 vaccine doses and timeliness); because of the number of tests, we also note which results would survive a Bonferroni-adjusted threshold ($p < 0.0033$).

Ethical Considerations

A letter of introduction from the Coordinator of the Postgraduate Programme of ACE-PUTOR, University of Port Harcourt, and abridged copies of the proposal and instrument were submitted to the University of Port Harcourt Research Ethics Committee. Ethical approval was granted on 31 March 2026 (ref. UPH/R&D/REC/EXEC/003/018). The approval and introduction letters were then submitted to the Planning, Research and Statistics Department of the Anambra State Ministry, and the written approvals were presented to the leaders of each community, whose support was obtained before data collection and before the interventions began. Participants were told the purpose and nature of the study, gave informed consent and were assured that participation was voluntary, that they could withdraw at any time without any negative consequence, and that their identity and responses would remain confidential. Respondents did not write their names or any identifying mark on the questionnaires, and they were not exposed to any hazard during the study.

Results

Results are presented in the order of the research questions: respondent characteristics, baseline knowledge and utilization, community-related factors, the interventions implemented, and changes in knowledge and utilization after the interventions, followed by the tests of the hypotheses.

Respondent Characteristics

Three hundred and sixty-one caregivers were included at each assessment (return rate 100%). Table 4 describes the 361 respondents, who were mostly young adults, with a mean age of 30.19 ± 6.49 years; 52.1% were aged 30–39 years and 44.3% were aged 19–29 years. Most were married (83.1%), and only 2.5% had no formal education, while half (49.6%) had completed secondary education and over one-third (34.6%) tertiary education. Trading was the commonest occupation (36.3%), followed by the civil service (21.3%), studentship (17.7%) and unemployment (16.9%). Most households were small, with 1–3 members in 70.9%, and the sample was overwhelmingly Christian (93.4%).

Table 4: Socio-Demographic Characteristics of Respondents (n = 361)

Variable	n	%
Age group (years)		
19–29	160	44.3
30–39	188	52.1
40–49	13	3.6
Mean ± SD	30.19 ± 6.49	
Marital status		
Married	300	83.1
Divorced	31	8.6
Widowed	17	4.7
Single	13	3.6
Educational level		
No formal education	9	2.5
Primary	48	13.3
Secondary	179	49.6
Tertiary	125	34.6
Occupation		
Trader	131	36.3
Civil servant	77	21.3
Student	64	17.7
Unemployed	61	16.9
Farmer	28	7.8
Household size		
1–3 members	256	70.9
4–6 members	84	23.3
7 or more members	21	5.8
Religion		

Christianity	337	93.4
Traditional religion	20	5.5
Islam	4	1.1

Baseline Knowledge and Utilization (RQ1)

At baseline, 41.3% of caregivers had moderate knowledge of childhood immunization, 34.9% had good knowledge and 23.8% had poor knowledge (mean score 4.73 ± 1.50 of 8). Item-level results (Table 5) show that most respondents accepted that immunization protects children from serious diseases (mean 3.87; 72.1% agreed or strongly agreed), that vaccinating children protects others in the community (3.67), that vaccines strengthen the immune system (3.41) and that all vaccines should be taken within the recommended timeline (3.90). Three misconceptions were rejected on average (item means below 3.0): that vaccines can cause sudden infant death (2.86), that the harm of immunization outweighs its benefits (2.43) and that a healthy child does not need vaccination (2.90). Nevertheless, sizeable minorities endorsed each of them: 36.9% agreed or strongly agreed that vaccines can cause sudden infant death, 39.9% that a healthy child does not need vaccination and 20.8% that the harm of immunization outweighs its benefits. The grand mean of 3.28 indicates relatively good knowledge with persistent misconceptions.

Table 5: Knowledge of Immunization at Baseline and After the Interventions: Item Means (SD)

Knowledge item	Baseline mean (SD)	Post-intervention mean (SD)	Change
Childhood immunization protects children from serious diseases	3.87 (1.13)	3.90 (1.00)	+0.03
Vaccinating children is important for the health of others in the community	3.67 (1.16)	3.63 (1.29)	−0.04
Vaccines can potentially cause sudden infant death†	2.86 (1.35)	2.66 (1.48)	−0.20
Vaccines are used for all age groups, not just for children	3.20 (1.45)	3.71 (1.33)	+0.51
The harm of immunization outweighs its benefits†	2.43 (1.28)	2.21 (1.14)	−0.22
Vaccines make the immune system stronger against diseases	3.41 (1.49)	3.94 (1.14)	+0.53
A child who is in good health does not need vaccination†	2.90 (1.47)	2.23 (1.19)	−0.67
All vaccines should be taken within the timeline	3.90 (1.24)	4.03 (1.22)	+0.13
Grand mean	3.28	3.29	

Criterion mean = 3.0. † Misconception: a lower mean indicates better knowledge.

Baseline utilization was moderate in 54.3% of children, high in 30.5% and low in 15.2% (mean score 8.53 ± 2.70 of 15). Only 45.4% of children had received their vaccines within the recommended timeline. Uptake of birth doses was low, at 52.1% for BCG, 53.2% for hepatitis B and 48.5% for oral polio vaccine, and the uptake of the pentavalent, PCV and oral polio vaccines ranged from 52.9% to 69.8% at six, ten and 14 weeks, with OPV 1 the highest (69.8%). Uptake of the third doses was lower than that of the second doses (57.3% against 61.2% for the pentavalent vaccine, 55.1% against 58.7% for PCV and 52.9% against 63.7% for oral polio vaccine), and only 56.0% and 59.8% had received measles and yellow fever vaccines at nine months. Uptake therefore declined as children advanced through the schedule (Table 10).

Knowledge was strongly associated with utilization at baseline (Table 6). High utilization was found in 53.2% of caregivers with good knowledge, 22.1% of those with moderate knowledge and only 11.6% of those with poor knowledge, whereas low utilization was found in 32.6%, 14.1% and 4.8%, respectively ($\chi^2 = 66.83$, df = 4, $p < 0.001$). Hypothesis $H_0 1$ was therefore rejected.

Table 6: Baseline Knowledge and Baseline Immunization Utilization, n (row %)

Knowledge level	Low utilization	Moderate utilization	High utilization	Total
Poor	28 (32.6)	48 (55.8)	10 (11.6)	86 (100)
Moderate	21 (14.1)	95 (63.8)	33 (22.1)	149 (100)
Good	6 (4.8)	53 (42.1)	67 (53.2)	126 (100)
Total	55 (15.2)	196 (54.3)	110 (30.5)	361 (100)

Pearson $\chi^2 = 66.83$, df = 4, $p < 0.001$ (recalculated from the cell counts shown).

Community-Related Factors Influencing Utilization (RQ2)

Four of the ten community-related factors were accepted as significant barriers on the criterion mean (Table 7): inconvenient session times (mean 3.36; 58.5% agreed or strongly agreed), distance to the health facility (3.32; 55.7%), lack of a reminder system (3.20; 51.8%) and mothers' time constraints (3.16; 51.0%). Six factors were rejected on average: vaccine unavailability at health centres (2.99), fear of side effects (2.76), cultural beliefs and practices (2.39), financial constraints (2.31), lack of awareness (2.22) and poor attitude of health workers (2.09). The grand mean across the ten items was 2.78, which means that, taken together, respondents did

not regard community-related factors as a major barrier; the four accepted factors were mainly practical and service-related rather than attitudinal. Even among the rejected items, minorities endorsed the barrier, including 47.1% for vaccine unavailability (which fell just below the criterion mean) and 36.6% for fear of side effects.

When each factor was cross-tabulated with baseline utilization (Table 7), eight of the ten were significantly associated with it: lack of awareness ($\chi^2 = 11.90$, $p = 0.003$), cultural beliefs (15.79, $p < 0.001$), financial constraints (10.99, $p = 0.004$), fear of side effects (28.25, $p < 0.001$), vaccine unavailability (49.12, $p < 0.001$), poor attitude of health workers (8.05, $p = 0.018$), time constraints (10.72, $p = 0.005$) and the lack of a reminder system (15.67, $p < 0.001$). Distance to the facility ($p = 0.49$) and inconvenient session times ($p = 0.74$) were not. H_o2 was therefore rejected for eight factors and retained for two. The barriers that respondents rated most highly were thus not always those that discriminated best between high and low utilizers, which suggests that caregivers' general perceptions of barriers and their own vaccination behaviour are only partly aligned.

Table 7: Community-Related Factors Influencing Immunization Utilization (n = 361)

Factor	Mean	SD	Decision	χ^2 (df = 2)	p-value
Inconvenient time schedule for immunization	3.36	1.45	Accepted	0.59	0.743
Distance to the health facility	3.32	1.46	Accepted	1.43	0.490
Lack of a reminder system	3.20	1.48	Accepted	15.67	<0.001
Time constraint (mothers' busy schedule)	3.16	1.42	Accepted	10.72	0.005
Unavailability of vaccine in health centres	2.99	1.50	Rejected	49.12	<0.001
Fear of side effects of the vaccine	2.76	1.49	Rejected	28.25	<0.001
Cultural beliefs and practices	2.39	1.36	Rejected	15.79	<0.001
Financial constraints	2.31	1.26	Rejected	10.99	0.004
Lack of awareness about immunization	2.22	1.17	Rejected	11.90	0.003
Poor attitude of health workers	2.09	1.13	Rejected	8.05	0.018
Grand mean	**2.78**				

Criterion mean = 3.0. Chi-square tests relate each factor (three response levels) to baseline utilization level.

Interventions Implemented and their Reception (RQ3)

All 361 respondents reported being involved in the vaccination improvement programme, and all considered the interventions appropriate and said that they would recommend them to other communities (Table 8). The programme was delivered mainly through house-to-house visits (31.0%) and person-to-person contact (26.9%), followed by community gatherings (22.2%), health centres (13.3%) and religious gatherings (6.6%). The component that respondents reported most was health education (41.8%), followed by SMS reminders (24.9%), supportive supervision (19.4%) and telephone calls (13.9%). Each respondent identified one component, so these figures show the component recalled rather than an exclusive exposure, and the unanimous acceptance should be read with caution given the possibility of social desirability.

Table 8: Delivery and Reception of the Community-Based Interventions (n = 361)

Variable	n	%
Mode of delivery		
House-to-house visits	112	31.0
Person-to-person	97	26.9
Community gatherings (meetings)	80	22.2
In health centres	48	13.3
Religious gatherings	24	6.6
Intervention component reported		
Health education	151	41.8
SMS reminders	90	24.9
Supportive supervision	70	19.4
Telephone calls	50	13.9
Perceived the interventions as appropriate	361	100.0
Would recommend to other communities	361	100.0

Changes in Knowledge (RQ4; H_o5)

After the interventions, the proportion of caregivers with good knowledge increased from 34.9% to 63.2% (difference 28.3 percentage points, 95% CI 21.3–35.3), the proportion with moderate knowledge fell from 41.3% to 31.6%, and the proportion with poor knowledge fell from 23.8% to 5.3% (Table 9). The distribution of knowledge levels differed significantly between assessments ($\chi^2 = 76.80$, df = 2, $p < 0.001$), and H_o5 was rejected. The mean knowledge score rose from 4.73 ± 1.50 to 5.84 ± 1.17 of 8 (Cohen's $d \approx 0.83$, a large standardised difference). At the item level (Table 5), the largest gains were for the statements that a healthy child needs vaccination (mean 2.90 to 2.23), that vaccines make the immune system stronger (3.41 to 3.94) and that vaccines are for all age groups (3.20 to 3.71). The items on which baseline knowledge was already highest, namely protection against serious disease and community benefit, hardly changed. The proportion who agreed or strongly agreed that immunization protects children from serious diseases rose from 72.1% to 79.2%, that vaccines strengthen the immune system from 60.1% to 78.7%, and that vaccines are for all age groups from 49.4% to 71.2%. The proportion who rejected the statement that a healthy child does not need vaccination rose from 49.3%

to 78.1%, and the proportion who rejected the statement that the harm of immunization outweighs its benefits rose from 61.8% to 69.8%. Even after the interventions, 33.6% of respondents agreed or strongly agreed that vaccines can cause sudden infant death, so this misconception was reduced rather than removed.

Changes in Immunization Utilization (RQ4; H_o4)

The overall level of utilization improved markedly (Table 9). High utilization increased from 30.5% to 58.4% (difference 27.9 percentage points, 95% CI 21.0–34.9), moderate utilization decreased from 54.3% to 41.0%, and low utilization decreased from 15.2% to 0.6% (2 respondents). The distribution differed significantly ($\chi^2 = 87.76$, df = 2, $p < 0.001$), so H_o4 was rejected. The mean utilization score rose from 8.53 ± 2.70 to 10.67 ± 2.13 of 15 (Cohen's $d \approx 0.88$).

Table 9: Knowledge and Utilization Levels Before and After the Interventions (n = 361 per assessment)

Level	Baseline n (%)	Post-intervention n (%)	Test
Knowledge: poor	86 (23.8)	19 (5.3)	$\chi^2 = 76.80$, df = 2, $p < 0.001$
Knowledge: moderate	149 (41.3)	114 (31.6)	
Knowledge: good	126 (34.9)	228 (63.2)	
Utilization: low	55 (15.2)	2 (0.6)	$\chi^2 = 87.76$, df = 2, $p < 0.001$
Utilization: moderate	196 (54.3)	148 (41.0)	
Utilization: high	110 (30.5)	211 (58.4)	

Dose-level results are shown in Table 10. Uptake improved significantly for 13 of the 14 individual doses, with the largest gains for BCG at birth (52.1% to 71.5%), the third dose of PCV (55.1% to 74.0%), the third dose of oral polio vaccine (52.9% to 71.5%) and the oral polio vaccine at birth (48.5% to 66.8%). The first dose of oral polio vaccine did not change (69.8% to 68.7%, $p = 0.747$), possibly because it was already the highest-uptake dose at baseline. The size of the gain varied across the schedule. Increases were 15.5 to 19.4 percentage points for the three birth doses, between −1.1 and 13.9 points for the six-week doses, 13.9 to 16.6 points for the ten-week doses and 10.8 to 18.9 points for the 14-week doses; at nine months the gain was 8.3 points for measles vaccine and 14.7 points for yellow fever vaccine. The proportion of children vaccinated within the recommended timeline rose from 45.4% to 66.8%, an increase of 21.3 percentage points (95% CI 14.3–28.4; $\chi^2 = 33.34$, $p < 0.001$). Post-intervention uptake was highest for the second doses of pentavalent (77.8%) and oral polio (77.6%) vaccines and lowest for measles vaccine (64.3%). Applying a Bonferroni-adjusted threshold of $p < 0.0033$ for the 15 comparisons would leave the changes in PCV 1 ($p = 0.008$) and measles ($p = 0.023$) vaccines non-significant; the other 12 significant results (11 dose-level changes and timeliness) would remain so.

Table 10: Uptake Of Individual Vaccine Doses Before and After the Interventions (N = 361 Per Assessment)

Vaccine / indicator	Baseline %	Post %	χ^2 (df = 1)	p
BCG at birth	52.1	71.5	28.74	<0.001
Hepatitis B at birth	53.2	68.7	18.25	<0.001
OPV at birth	48.5	66.8	24.71	<0.001
Pentavalent 1 (6 weeks)	59.0	72.9	15.41	<0.001
OPV 1 (6 weeks)	69.8	68.7	0.10	0.747
PCV 1 (6 weeks)	59.8	69.3	7.00	0.008
Pentavalent 2 (10 weeks)	61.2	77.8	23.53	<0.001
PCV 2 (10 weeks)	58.7	74.5	20.24	<0.001
OPV 2 (10 weeks)	63.7	77.6	16.69	<0.001
Pentavalent 3 (14 weeks)	57.3	68.1	9.01	0.003
PCV 3 (14 weeks)	55.1	74.0	27.99	<0.001
OPV 3 (14 weeks)	52.9	71.5	26.44	<0.001
Measles (9 months)	56.0	64.3	5.20	0.023
Yellow fever (9 months)	59.8	74.5	17.64	<0.001
Completed within timeline	45.4	66.8	33.34	<0.001

Intervention Type and Post-Intervention Utilization (H_o3)

High post-intervention utilization was found in 64.9% of respondents who reported health education, 55.6% of those who reported SMS reminders, 52.9% of those who reported supportive supervision and 52.0% of those who reported telephone calls (Table 11). These differences were not statistically significant ($\chi^2 = 6.08$, df = 6, $p = 0.41$), and H_o3 was retained. Because the four-by-three table had sparse cells in the low-utilization column (only two respondents), the test has limited power, and the result should not be read as showing that the components were equally effective.

Table 11: Intervention Component Reported and Post-Intervention Utilization, N (row %)

Component reported	Low	Moderate	High	Total
Health education	1 (0.7)	52 (34.4)	98 (64.9)	151
SMS reminders	1 (1.1)	39 (43.3)	50 (55.6)	90
Supportive supervision	0 (0.0)	33 (47.1)	37 (52.9)	70
Telephone calls	0 (0.0)	24 (48.0)	26 (52.0)	50
Total	2 (0.6)	148 (41.0)	211 (58.4)	361

Pearson $\chi^2 = 6.08$, df = 6, $p = 0.41$.

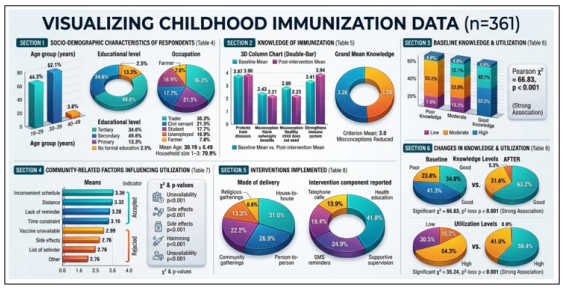
Summary of Hypothesis Tests

The results of the five hypothesis tests are summarized in Table 12. Knowledge and utilization were positively associated at baseline, most community-related factors were associated

with utilization, and both knowledge and utilization improved significantly after the interventions, but no difference was detected between intervention components.

Table 12: Summary of Hypothesis Tests

Hypothesis	Test result	Decision
H_01: knowledge and baseline utilization unrelated	$\chi^2 = 66.83$, df = 4, $p < 0.001$	Rejected
H_02: community-related factors and baseline utilization unrelated	Significant for 8 of 10 factors ($p = 0.018$ to < 0.001); not significant for distance and session times	Rejected for 8 factors; retained for 2
H_03: intervention type and post-intervention utilization unrelated	$\chi^2 = 6.08$, df = 6, $p = 0.41$	Retained
H_04: no difference in utilization before and after	$\chi^2 = 87.76$, df = 2, $p < 0.001$	Rejected
H_05: no difference in knowledge before and after	$\chi^2 = 76.80$, df = 2, $p < 0.001$	Rejected



Discussion

This PAR study found that, after community-based interventions developed with local stakeholders, caregivers' knowledge and childhood immunization utilization improved significantly in six Anambra communities. The share of caregivers with good knowledge nearly doubled, and the share of children vaccinated within the recommended timeline rose by about 21 percentage points.

The direction and scale of change are consistent with Akwataghibe [17], who reported a 30-point rise in full immunization after PAR in Ogun State, with Oyo-Ita [18], who found higher odds of vaccination after engaging traditional and religious leaders, and with Basheer, who reported gains in knowledge and uptake after interpersonal communication training [33]. The improvement in timely completion supports reminder-based evidence from Ilorin, Kano and Maiduguri [20,21,34]. Interpreted through the Social Ecological Model, the package acted at individual (knowledge), interpersonal (family and neighbors via house-to-house education), community (religious and community gatherings) and organizational (supportive supervision, session times) levels at once, which may explain gains across both knowledge and uptake.

The baseline results also help to explain why the package took the form it did. The community-related barriers that respondents rated highest, namely inconvenient session times, distance, lack of reminders and mothers' time constraints, are practical and service-related, and they correspond to the reminder and supportive supervision components that stakeholders chose. Knowledge was strongly associated with utilization at baseline, which supports the emphasis placed on health education. The finding that distance and session times were the highest-rated barriers but were not associated with baseline utilization, whereas less highly rated factors such as vaccine unavailability and fear of side effects were, shows that perceived barriers and observed behaviour are only partly aligned, and that cross-sectional associations of this kind cannot establish which barriers keep children from being vaccinated.

The gains were also uneven. Items on which baseline knowledge was already high hardly changed, whereas the largest gains were for items on which knowledge had been weakest, such as the need to vaccinate a healthy child and the relevance of vaccines across age groups. Persistent endorsement of the sudden-infant-death misconception (33.6% after the intervention) indicates that safety concerns need continued, targeted communication. The finding that 11 of the 13 significant dose-level improvements remain significant after a Bonferroni adjustment, while those for PCV 1 and measles vaccines do not, suggests that the later and more fragile parts of the schedule remain most in need of sustained attention.

The lack of difference by intervention type should not be read as equivalence of effect. Respondents reported the component they recalled most, not an isolated exposure, so the interventions overlapped, and the comparison was underpowered for a four-by-three table with sparse low-utilization cells. Birth-dose and OPV 1 results are also informative: OPV 1 did not change, possibly because it was already highest at baseline (69.8%), leaving less room for improvement. Measles uptake improved least among the later vaccines (56.0% to 64.3%), suggesting that retention to nine months needs sustained follow-up.

Limitations

The single-group pre/post design without a control group cannot exclude secular trends, concurrent immunization activities or regression to the mean; changes are associations, not proof of effect. Samples were independent cross-sections, not a followed cohort, and convenience recruitment within communities may limit representativeness. Six communities limit generalizability. Knowledge and part of utilization were self-reported, although immunization cards were used where available. The intervention window (about one month of intensive activity followed by a six-month interval) is short for assessing sustainability, and respondents' exposure to individual intervention components overlapped. All respondents reported satisfaction with the interventions, which may reflect social desirability. Community-related factors were measured as caregivers' perceptions and related to utilization in cross-sectional tables, so the associations cannot show which barriers caused non-vaccination. The cut-off points used to classify knowledge and utilization levels, and the possibility that several statistical comparisons produced chance findings, should also be borne in mind.

Conclusion and Recommendations

Community engagement through a participatory approach combining health education, SMS and telephone reminders and supportive supervision was associated with significantly better caregiver knowledge and childhood immunization utilization in selected communities in Anambra State. State immunization programmes should integrate stakeholder-led community dialogue, reminder systems and supportive supervision into routine services and keep vaccines consistently available. Future controlled or stepped-wedge studies with longitudinal follow-up are needed to confirm causal effect and sustainability.

Declarations

Ethics Approval: University of Port Harcourt Research Ethics Committee, ref. UPH/R&D/REC/EXEC/003/018.
Consent: Informed Consent Obtained.
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Conflicts of Interest: None Was Declared
Data Availability: On Request.
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