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Impact of Targeted Health Education on Caregivers' Vaccine Knowledge and Attitudes in Osun State, Nigeria: A Quasi-Experimental Follow-Up Analysis

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Abstract

Background: Caregivers' understanding and beliefs regarding routine childhood immunization are crucial factors in determining vaccine acceptance. Educational interventions have been proposed as strategies to strengthen these outcomes, yet evidence of their effectiveness remains mixed. This study examined whether an educational intervention enhanced caregivers' knowledge and attitudes regarding uptake of routine childhood immunisation over a 12-week follow-up period.
Methods: A quasi- experimental design with caregivers of under-five children assigned to intervention and control groups was conducted. Standardised parametric analyses, including paired and independent t-tests, , were used to assess within- and between-group changes in outcome variables at 95% significant level using IBM SPSS and JASP version 0.19.3.0.
Results: Knowledge scores in the intervention group showed small, non-significant increases from baseline to follow-up (mean change = 1.53, t=1.278 (95%CI), p = 0.211), with no meaningful difference relative to the control group (mean change=0.57, t=0.609 (95%CI), p = 0.547). By contrast, attitudes demonstrated significant immediate improvement in the intervention group (mean change = 3.13, t=4.265 (95%CI), p < .001), which remained elevated at follow-up (mean change = 2.03, t=3.238 (95%CI), p = .003). Between-group analyses confirmed a significant intervention effect on attitudes at both post-test (p < .001) and follow-up (p = .004).
Conclusion: While educational programs may not significantly improve caregivers' knowledge, they can lead to substantial short-term improvements in attitudes toward routine childhood immunization. Long-term maintenance of these gains may require reinforcement strategies.

Keywords: Vaccine uptake, Hesitancy, Educational intervention, Caregivers, Routine childhood immunisation, Quasi-experimental follow-up study, Knowledge.

Introduction

The impact of targeted health education on caregivers' vaccine knowledge and attitudes is a pressing public health concern in Nigeria. Vaccination is a highly effective public health measure, preventing 2 to 3 million deaths annually from infectious diseases like pertussis, tetanus, measles, and diphtheria (1). Despite these

successes, vaccine hesitancy has become a major global health concern, with 20% to 40% of people expressing reluctance toward vaccination in various regions (2). This hesitancy threatens immunization coverage (3) and has contributed to the resurgence of vaccine-preventable diseases, such as measles, which had over 869,770 cases worldwide in 2019 (4).

Vaccine hesitancy is driven by many factors, from individual concerns about vaccine safety to broader societal issues like misinformation and distrust in public health systems (5-7). Misconceptions spread through social media have increased skepticism, further damaging trust in vaccination programs. In Africa, hesitancy rates have reached up to 40% in some areas, reflecting the combined effects of cultural beliefs, religious practices, and limited access to accurate information (8-10). Historical mistrust of Western medicine, stemming from past unethical practices, has worsened these concerns. Logistical barriers, such as vaccine stock-outs, long distances to health facilities, and indirect costs, exacerbate the problem, especially in rural communities like Osun State. In 2018, only 31% of children aged 12–23 months received all recommended vaccines, far below the national target of 80% (11-12).

Caregivers' reluctance to vaccinate has been linked to misinformation, cultural beliefs, and persistent mistrust of healthcare providers. In Osun State, vaccine hesitancy among caregivers of children under five is a pressing public health issue. Caregivers often cite religious doctrines, fears of infertility, and misconceptions about long-term health risks as reasons for refusing vaccines (13-19). To address these challenges, educational interventions have emerged as a promising strategy to reduce hesitancy. Evidence suggests that culturally tailored programs, especially those delivered through face-to-face interactions with healthcare providers, can improve caregivers'

understanding of vaccines and foster trust (1, 20-24). In low-literacy settings, community-based approaches using local communication channels and participatory methods have been particularly effective in promoting positive knowledge and attitudes towards vaccination (2,25).

Theoretical frameworks such as the PRECEDE–PROCEED model (3,26) and the Health Belief Model (4,27) provide insights into designing interventions that address both social determinants and individual cognition on vaccination issues. However, studies evaluating educational interventions in Nigeria remain limited, particularly in Osun State. Existing initiatives often lack cultural adaptation and fail to address the interplay of predisposing, enabling, and reinforcing factors that influence caregivers' vaccination behaviors (5, 28-29). This gap highlights the need for controlled studies assessing the effectiveness of context-sensitive educational strategies in enhancing caregivers' knowledge and attitudes toward immunization. By adopting a quasi-experimental follow-up analysis design, this study aims to provide empirical evidence to inform local and national strategies aimed at improving vaccination coverage and reducing vaccine hesitancy among children under five. This study will investigate the impact of targeted health education on caregivers' vaccine knowledge and attitudes in Osun State, Nigeria. The objectives of the study are to:

1.Assess the baseline levels of caregivers' knowledge, and attitudes towards vaccines.
2.Evaluate the effectiveness of a targeted health education intervention in enhancing caregivers' knowledge and attitude.
3.Identify factors that influence the adoption of vaccinated care-givers among caregivers.

Methods

Study Design

This study used a quasi-experimental design to evaluate the impact of a structured educational intervention on caregivers' knowledge and attitudes toward routine childhood immunization in Osun State, Nigeria. Participants were divided into an intervention group, which received targeted educational sessions, and a control group, which did not. Data were collected at baseline, immediately after the four-week intervention, and again at twelve weeks post-intervention to assess both short-term and sustained effects. This design was chosen for its suitability in real-world public health settings, where random assignment is often impractical, and it provided an opportunity to evaluate causal effects while maintaining ecological validity.

Study Setting

The study was conducted in Osun State, located in southwestern Nigeria. Created in 1991, the state covers approximately 14,575 km² and had a projected population of 4.3 million by 2015 [30, 31]. Osun State is administratively divided into 30 Local Government Areas (LGAs) across three senatorial districts. The population is predominantly Yoruba, comprising several sub-ethnic groups such as the Ife, Ijesha, Oyo, Ibolo, and Igbomina, along with minority groups from other regions. Agriculture is the primary occupation, while Christianity, Islam, and traditional beliefs define the religious landscape.

The health infrastructure includes 332 Primary Health Care (PHC) centers, ten (10) general hospitals, and two teaching hospitals. Approximately 55% of the population resides in rural communities, a demographic characteristic that influences healthcare access and immunization uptake [32]. The rural–urban distribution of the population

was particularly relevant to the study, as barriers to immunization are often more pronounced in rural settings.

Study Population and Eligibility

The study population consisted of caregivers of children aged 0–5 years living in communities with PHC facilities in two selected LGAs of Osun State. Inclusion criteria required that participants reside in the study area, serve as primary caregivers for at least one child under five years of age, and provide informed consent to participate. Caregivers who had recently received formal education on vaccination were excluded to avoid bias in baseline knowledge and attitudes.

Sampling and Sample Size

A multi-stage sampling technique was used. First, two senatorial districts, Osun Central and Osun East, were randomly selected. Within each district, one LGA was chosen: Osogbo in Osun Central and Ife North in Osun East. From these LGAs, clusters of communities with functional PHC facilities were identified, and caregivers from these communities were randomly recruited.

Sample size was determined using the power formula described by Moyer et al. [33], applying an estimated prevalence of vaccine hesitancy of 55.5% from a prior study in Nigeria [34]. With 95% confidence and 80% statistical power, the required minimum sample size was calculated as 32 caregivers per group. However, the final sample size used or eligible was 30 participants in the intervention group and 30 in the control group. The Participant Flow were 35 assessed (for each group after 10% increase in sample size to check attrition), and 35 participants allocated to each group. However, only 30 participants completed post-test following lost of interest, inconsistency shown by some particpants and reports of relocation. The 30 participants were followed-up and they completed folow-up which data were analysed for each group.

Intervention

The intervention was a twelve-week structured educational program guided by health models [27,35], delivered once weekly in group sessions which lasted for 45 minutes each. Delivered by trained public and communitiy health educators. Sessions were interactive, using lectures, visual aids, group discussions, and opportunities for questions and answers. Materials were presented in both Yoruba and English to ensure accessibility. The control group continued to receive routine health education services at PHCs without additional structured intervention. They received brief talks on immunisation schedules, and childhood vaccination importance. No structured behavioural intervention, vaccine-hesitancy counselling, or follow-up sessions were provided to the control group. To minimise contamination, intervention and control participants were recruited from separate health facilities, and intervention materials were not shared with the control group. Session attendance was recorded, and the principal investigator periodically monitored delivery to ensure fidelity to the intervention protocol.

Study Variables

The primary outcomes are caregivers' vaccine knowledge and vaccine attitudes. The focus is on caregivers' knowledge of vaccination programs and their attitudes toward vaccine-hesitant behavior. Ten items are presented on a four-point scale ranging from "strongly disagree" (1) to "strongly agree" (4) for each knowledge and attitude varables. The scoring system differed depending on the item's wording, with negatively worded statements for the Likert responses, "Strongly Agree" = 0, "Agree" = 1, "Disagree" = 2, "Strongly Disagree" = 3. Positively worded statements for the Likert responses, "Strongly Agree" = 3, "Agree" = 2, "Disagree" = 1, "Strongly Disagree" = 0 with maxxumum mean score of 30 for each of knowledge and attitude

variables. Both scores are collected at three time points, baseline (pre-intervention), immediate post-intervention, and twelve-week follow-up, to capture change attributable to the educational program. Differences between experimental and control groups are examined with paired and independent t-tests. The Generalized Poisson Regression Model estimated intervention effect sizes on these outcomes.

Data Collection

Data were collected using structured questionnaires administered at three time points: baseline (pre-intervention), immediately after the four-week intervention, and at twelve weeks post-intervention. The questionnaire which was used in this study was developed for this study based on the study's variables (see English language version as supplementary file). This made it possible to assessed socio-demographic characteristics, knowledge about routine immunization, and attitudes toward vaccination.

Data Analysis

Data were analyzed using both exploratory and confirmatory statistical approaches. Exploratory analyses involved descriptive statistics, boxplots, and scatter diagrams to illustrate changes within and between groups. Confirmatory analyses included paired-samples t-tests to assess within-group differences over time, and independent-samples t-tests to compare mean differences between the intervention and control groups. Effect sizes were estimated using Cohen's d to quantify the magnitude of observed changes, while generalized Poisson regression models were used to examine associations between the intervention and outcome variables after adjusting for relevant covariates. All statistical tests were conducted at a 5% significance level ($\alpha = 0.05$).

Justification for the use of Generalized Poisson Regression:

The knowledge and attitude outcomes were analysed as discrete composite scores derived from summed questionnaire responses. Because these outcomes were integer-valued and exhibited evidence of dispersion and departures from the assumptions of ordinary least squares regression, generalized Poisson regression was used within a difference-in-differences framework to estimate adjusted intervention effects (Adjusted regression coefficient). Compared with the standard Poisson model, the generalized Poisson model accommodates both overdispersion and underdispersion while allowing adjustment for potential confounders, thereby providing more reliable regression estimates and standard errors.

Results

Demographic Characteristics of Participants

Table 1 presents the socio-demographic characteristics of participants in both the intervention and control groups. The mean age of participants in the control was 28.87 ± 5.58 years (range: 20–42), while the intervention group's was 32.07 ± 5.86 years (range: 19–45). This age difference was statistically significant ($p = 0.03$). Most participants were under 35, with the 18–30 age group being the most common. Most participants in both groups had one or two children under five years old. In the control group, 43.3% had one child and 43.3% had two children, compared to 60.0% and 20.0% in the intervention group, respectively. This difference was not statistically significant ($p > 0.05$). The gender distribution was skewed toward female caregivers, with 96.7% female and 3.3% male in the control group, and 83.3% female and 16.7% male in the intervention group. This difference was also not statistically significant ($p = 0.150$). Other demographic variables, including educational attainment, religion, ethnicity,

and occupation, showed no significant differences between the groups (all $p > 0.05$). In summary, the groups were generally similar except for age (Table 1).

Although most baseline characteristics were comparable between the study groups, caregivers' age differed significantly between the intervention and control groups ($p = 0.03$). Therefore, age was included as a covariate in the multivariable generalized Poisson regression models to control for potential confounding.

Effect of the Intervention on Caregivers' Knowledge

Boxplots (Fig. 1: Boxplots on knowledge showing change pre/post and pre/follow-up within the experiment and control group separately) and (Fig. 2: Boxplots on knowledge comparing change 1 and change 2 between experimental and control groups) showed slight increases in knowledge scores within the intervention group, while the control group showed minimal changes across measurement points. Normality testing, using the Shapiro–Wilk procedure, confirmed that knowledge scores were approximately normally distributed across baseline, post-test, and follow-up assessments in both groups (all $p > 0.05$), thus justifying the use of parametric methods (Table 2). Because normality was violated for the attitude outcome in the control group, bootstrap confidence intervals were computed to assess the robustness of the independent-samples t-test. The bootstrap results were consistent with the parametric findings, indicating that the conclusions were robust despite departures from normality.

Within-group analyses showed that mean knowledge scores in the intervention group increased slightly from baseline ($M = 20.97$) to post-test ($M = 22.27$; Change = 1.30, $t = -0.97$, $p = 0.338$) and to follow-up ($M = 22.50$; Change = 1.53, $t = -1.28$, $p = 0.211$). In the control group, changes were negligible and non-significant (Baseline $M = 20.73$ → Post-test $M = 21.17$, Change = 0.43, $p = 0.669$; Follow-up $M = 21.30$,

Change = 0.57, p = 0.547) (Table 3). Between-group comparisons showed that these variations were not statistically significant. At post-test, the difference-in-differences estimate was 0.87 (t = 0.52, p = 0.606), and at follow-up it was 0.97 (t = 0.64, p = 0.527) (Table 3). Small to negligible effect sizes (−0.23 to 0.16) were reported, suggesting minimal practical improvement in caregivers' knowledge following the intervention.

Generalized Poisson regression enabled estimation of adjusted intervention effects within the difference-in-differences framework while accounting for the discrete composite nature of the outcome scores and allowing adjustment for baseline covariates, including age. This approach provided adjusted estimates of the intervention effect beyond the crude differences observed between study groups.

Generalized Poisson regression models, adjusted for relevant covariates, showed non-significant effects (Post-test*:* $B = 0.872$, p = 0.999; Follow-up: $B = -0.083$, p = 0.819), reinforcing the conclusion that the intervention did not significantly improve caregivers' knowledge (Table 5). Overall, while the intervention group experienced slight knowledge increases, these were not statistically significant and did not differ meaningfully from changes in the control group.

Effect of the Intervention on Caregivers' Attitudes

Boxplots (Fig. 3: Box-plot on attitude showing change pre/post and pre/follow-up within the experiment and control group separately) and (Fig. 4: Boxplots on attitude comparing change 1 and change 2 between experimental and control groups) revealed that attitude scores in the intervention group improved from baseline to post-test and remained elevated at follow-up, whereas the control group exhibited slight declines over the same period. Shapiro–Wilk tests confirmed that the intervention group's post-test (W = 0.935, p = 0.067) and follow-up (W = 0.971, p = 0.577) scores

approximated normality. Conversely, the control group's post-test (W = 0.927, p = 0.040) and follow-up (W = 0.915, p = 0.020) scores significantly deviated from normality, indicating a partial violation of assumptions. Consequently, parametric tests were interpreted cautiously and supplemented with bias-corrected bootstrap confidence intervals (Table 2).

Within-group analyses showed statistically significant improvements in the intervention group. Mean attitude scores increased from baseline (M = 13.77) to post-test (M = 16.90; Change = 3.13, t = −4.27, p < 0.001) and remained above baseline at follow-up (M = 15.80; Change = 2.03, t = −3.24, p = 0.003). In contrast, the control group experienced non-significant declines (Post-test Change = −1.40, p = 0.085; Follow-up Change = −1.47, p = 0.152) (Table 4). Between-group comparisons further demonstrated the intervention's effectiveness. Difference-in-differences testing showed significant positive effects for the intervention group relative to controls, both at post-test (DID-1 = 4.53, t = 4.21, p < 0.001) and at follow-up (DID-2 = 3.50, t = 2.97, p = 0.004) (Table 4). Large Cohen's d values (1.09 post-intervention, 0.77 at follow-up) indicated a significant intervention effect on caregivers' attitudes between groups.

Regression analyses confirmed these findings. Adjusted models indicated a significant positive effect at post-test (B = 1.042, p < 0.001). Although the effect at follow-up was smaller and not statistically significant (B = 0.219, p = 0.389), the trend suggest short-term effectiveness rather than sustained effectiveness after adjustment for baseline covariates (Table 5). In summary, the educational intervention significantly improved caregivers' attitudes toward routine childhood immunization immediately following the program, with moderate gains persisting at 12 weeks.

Discussion

This study used a quasi-experimental design to examine the impact of a targeted educational intervention on caregivers' knowledge and attitudes toward routine childhood immunization in Osun State, Nigeria. The findings presented a mixed pattern: the intervention led to modest, non-significant improvements in knowledge but significant and sustained positive changes in caregivers' attitudes.

Contrary to expectations, caregivers' knowledge of routine immunization did not significantly improve. Although mean knowledge scores in the intervention group increased slightly from baseline to post-test and follow-up, these changes were not statistically significant. The difference-in-differences analysis further confirmed the absence of a meaningful effect compared with the control group. Unlike previous studies [36, 37] which reported improvements in immunization knowledge following educational interventions this study did not see a statistically significant increase. The reason is unclear but could be due to factors such as participant characteristics or differences in program content. An alternative explanation is that many participants already had high levels of initial knowledge, limiting further growth (ceiling effect) .

Several factors may explain this outcome. First, relatively high baseline knowledge levels across both groups may have limited the potential for measurable improvement, creating a ceiling effect. Second, the short duration may have been insufficient to reinforce factual knowledge, especially where vaccine misconceptions are deeply rooted. Third, the intervention design may have focused more on attitudinal transformation than detailed factual instruction.

In contrast, caregivers' attitudes toward routine childhood immunization improved significantly following the intervention and remained elevated at the 12-week follow-up, although some attenuation was observed over time. The greater change in caregivers' views was attributed to the Health Belief Model. Although initial knowledge of childhood immunisation was good, the intervention improved perceived advantages and reduced concerns about vaccine hesitancy, suggesting that health beliefs overrode factual knowledge, resulting in a notable shift in attitudes. This aligns with existing evidence suggesting that interventions addressing socio-cultural beliefs, trust in health systems, and perceived benefits of vaccination are more likely to influence attitudes than purely cognitive factors [6, 10, 38, 39].

The durability of attitudinal changes underscores the potential of community-based educational interventions in addressing vaccine hesitancy, particularly in low-resource settings. However, the gradual decline at follow-up highlights the importance of reinforcement strategies, such as periodic booster sessions, integration of immunization messages into routine antenatal and child welfare clinics, and the use of trusted community leaders as advocates. The findings have several implications for immunization programs in Nigeria and similar contexts. First, interventions aimed at caregivers should extend beyond knowledge transfer to include strategies that reshape attitudes and beliefs. Second, integrating education into routine health service delivery may help sustain long-term changes and address barriers such as misinformation and mistrust. Third, the demographic profile of participants, predominantly young female caregivers, reflects the central role of women in child healthcare decision-making. Thus, gender-sensitive approaches that empower women while engaging men as supportive partners may strengthen program outcomes.

Strengths and limitations of the study

The study's strengths include a quasi-experimental design, validated measurement tools, and a thorough analytical approach employing a Generalized Poisson Regression Model, which together support dependable estimates of effect size. Although age differed significantly between the intervention and control groups at baseline, this potential confounding was addressed by adjusting for age in the multivariable regression models. Nevertheless, residual confounding cannot be completely excluded. Nonetheless, the research faces several drawbacks: there is a risk of selection bias, reliance on self-reported information, limited applicability to broader populations, a brief follow-up period, and the possibility that unmeasured confounding factors could affect the observed changes in caregivers' knowledge and attitudes.

Conclusion

This study demonstrated that educational interventions can positively influence caregivers' attitudes toward routine childhood immunization, even when effects on knowledge are limited. By targeting beliefs and attitudes, such interventions can play a critical role in reducing vaccine hesitancy in low-resource settings. However, sustained reinforcement and integration into existing health systems are essential to maintain gains and translate attitudinal improvements into long-term behavioural change.

Declarations

Ethical Approval and Participant Consent

The University of Port Harcourt's Research Ethics Committee granted ethical clearance (Reference: UPH/CEREMAD/REC/MM104/045). All subjects provided written informed consent, and the study was conducted with their confidentiality protected. The research was conducted in accordance with the principles of the

Declaration of Helsinki, and applicable national regulations governing human-subject research.

Consent for publication

Not applicable, as the manuscript does not include any identifiable personal data.

Data Availability

Datasets from this study are available from the corresponding author upon request.

Competing interests

The authors declare no competing interests.

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No specific funding was received for this research.

Authors' contributions

All authors contributed significantly to the study. OOO conceptualised and designed the study, supervised data collection, and led data analysis. DSO and OMA contributed to literature review, interpretation of findings, and manuscript preparation. All authors read and approved the final manuscript.

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TABLES

Table 1. Demographic characteristics of participants at baseline

Variable	Control N=30		Experimental N=30		Total		
	Frequency		Frequency		N	(%)	p-value
	N	%	N	%			
Age	Mean:28.87 ± 5.58		32.07 ± 5.86		30.46 ±5.90		0.03
Range in years	Range: 20 to 42		19 to 45				
Gender:							
Female	29	96.7	26	83.3	54	93.1	0.150
Male	1	3.3	2	6.7	3	5.2	
Educational attainment:							
Non-formal	0	0.0	0	0.0	0	0.0	
Primary	2	6.7	0	0.0	2	3.5	0.012
Secondary	13	43.3	5	16.7	18	31.6	
Tertiary	13	43.3	24	80.0	37	64.9	
No. of children <5 years old	18	60.0	14	46.7	32	55.2	
1	6	20.0	13	43.3	19	32.8	0.065
2	4	13.3	2	6.7	6	10.3	
3	1	3.3	0	0.0	1	1.7	
3>							
Religion	11	36.7	19	63.3	30	50.8	0.015
Christianity	18	60.0	11	36.7	29	49.2	
Muslim	0	0.0	0	0.0	0	0.0	
Others							
Occupation							
Unemployed	2	6.7	1	3.3	3	5.2	0.601
Self-employed	19	63.3	21	70.0	40	69.0	
Employed in public sector	2	6.7	5	16.7	17	12.1	
Employed in private sector	6	20.0	2	6.7	8	13.8	

Note: These variables were included as covariates in the multivariable generalized Poisson regression models to minimise potential confounding.

Table 2. Normality Assumption Checks on Outcomes (Shapiro–Wilk Test)

Knowledge			
Group	Comparison	W	p
Experimental	Pre–Post Knowledge	0.984	.926
Experimental	Pre–Follow Knowledge	0.966	.446
Control	Pre–Post Knowledge	0.951	.182
Control	Pre–Follow Knowledge	0.944	.115
Attitudes			
Experimental	Pre–Post Attitude	0.935	.067
Experimental	Pre–Follow Attitude	0.971	.577
Control	Pre–Post Attitude	0.927	.040
Control	Pre–Follow Attitude	0.915	.020

Note. A Shapiro–Wilk p-value < .05 indicates a significant deviation from normality (assumption violated).Although normality was violated for the attitude outcome in the control group, bootstrap confidence intervals produced findings consistent with the parametric analyses, supporting the robustness of the results.

Table 3. Effect of Intervention on Knowledge of caregivers of under-five children in the same group regarding routine childhood immunisation

Group	Pre Knowledge	Post Knolwedge	Follow Knowledge	Change 1	t-test[a] [df=29]	p-value	Change 2	t-test[a] [df=29]	p-value
	X	X	X	(diff bewteen Pre & Post)		ES *(95% Cl)*	(diff bewteen Pre & Follow)		ES (95% Cl)
Same Group									
Experimental (n=30)	20.967	22.267	22.500	1.300	-0.974	0.338 *[ES=-0.18 (-0.54-0.18)]*	1.533	-1.278	0.211 *[ES= -0.23 (-0.59-0.13)]*
Control (n=30)	20.733	21.167	21.300	.433	-0.432	0.669 *[ES=-0.08 (-0.44 - 0.28)]*	0.567	-0.609	0.547 *[ES= -0.11 (-0.47- 0.25)]*

[a]Paired t-test (to get the 95%CI use the use bias-corrected bootstrap function) ; ES=effect size is given by Cohen's d . Maximum scale point for knaowledge mean score (X)=30

Different group

	Change 1 DID-1*	t-test[a] [df=58]	p-value	Cohen's d (95%CI)		Change 2 DID-2*	t-test[a] [df=58]	p-value	Cohen's d (95%CI)
Experimental vs Control	0.867	0.519	0.606	0.134 *(-0.37-0.64)*		0.967	0.637	0.527	0.164 *(-0.34-0.67)*

[b]Independent t-test (equal variances not assumed), use bias-corrected bootstrap function

*difference-in-differences (DID): The difference-in-differences (DID) estimate was calculated as the difference between the mean change in the intervention group and the corresponding mean change in the control group.

*Change 1 DID-1 (difference between the difference of the experimental and control group difference at post stage [1.300-0.433=0.867])

*Change 2 DID-2 (difference between the difference of the experimental and control group difference at post stage [1.533--0.567=0.967])

Table 4. Effect of Intervention on attitude of caregivers of under-five children regarding routine childhood immunisation

Group	Preattitude	Post attitude	Follow attitude	Change 1	t-test[a]	p-value	Change 2	t-test[a]	p-value
	X	X	X	(diff bewteen Pre & Post)		ES (95% Cl)	(diff bewteen Pre & Follow)		ES (95% Cl)
Same Group									
Experimental (n=30)	13.767	16.900	15.800	3.1333	-4.265	<0 .001 *[ES= 0.78 (-1.18-(-0.36))]*	2.0333	-3.238	0.003 *[ES= -0.59 (-0.98-0.20)]*
Control (n=30)	15.400	14.000	13.933 3	-1.4000	1.782	0.085 *[ES= 0.33 (-0.05-0.69)]*	-1.4667	1.472	0.152 *[ES=0.27(-0.10-0.63)]*

[a]Paired t-test (to get the 95%CI use the use bias-corrected bootstrap function) ; ES=effect size is given by Cohen's d ; Maximum scale point for

attitude mean score (X)=30

Different group								
	Change 1 DID-1*	**t-test[a] [df=58]**	**p-value**	Cohen's d **(95%CI)**	**Change 2 DID-2***	**t-test[a] [df=58]**	**p-value**	Cohen's d **(95%CI)**
Experimental vs Control	4.533	4.214	<0.001	1.088 *(0.541-1.627)*	3.500	2.972	0.004	0.767 *(0.239-1.289)*

[b]Independent t-test (equal variances not assumed), use bias-corrected bootstrap function

*difference-in-differences (DID)
*Change 1 DID-1 (difference between the difference of the experimental and control group difference at post stage [3.1333- (-1.4000)=4.533])
*Change 2 DID-2 (difference between the difference of the experimental and control group difference at post stage [2.0333-(-1.4667)=0.967]=3.500)

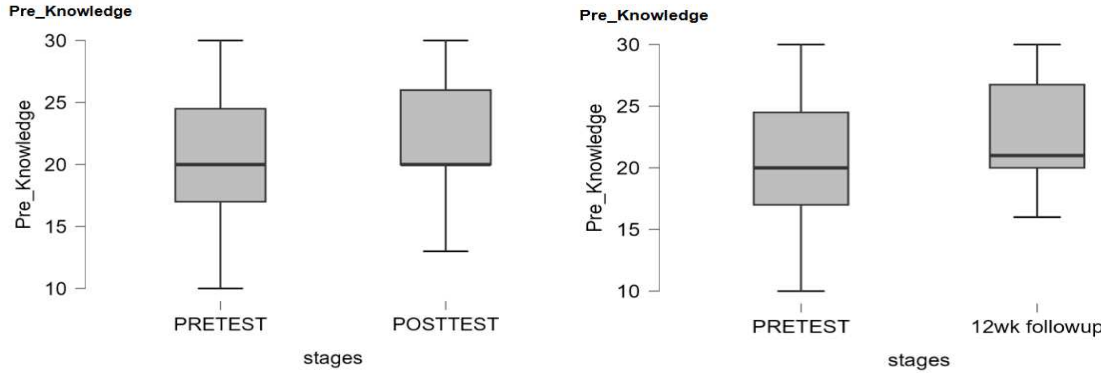
Table 5. Generalized Poisson regression estimates of the adjusted intervention effect on caregivers' knowledge and attitudes towards routine childhood immunisation using a difference-in-differences (DID) framework

Outcome	**Group**	**Baseline Mean**	**Post-intervention Mean**	**Follow-up Mean**	**DID 1 (Pre–Post)**	**DID 2 (Pre–Follow-up)**	**Adjusted regression coefficient (Post)**	**p-value**	**Adjusted regression coefficient (Follow-up)**	**p-value**
Knowledge	Experimental	20.97	22.27	22.50	0.867	0.967	0.872	0.001	−0.083	0.819
	Control	20.73	21.17	21.30	—	—	Reference	—	Reference	—
Attitude	Experimental	13.77	16.90	15.80	4.533	3.500	1.042	<0.001	0.219	0.389
	Control	15.40	14.00	13.93	—	—	Reference	—	Reference	—

***Abbreviations:** DID = Difference-in-Differences; β = adjusted regression coefficient estimated from the generalized Poisson regression model.
*DID-1 (Pre–Post) was calculated as the mean difference between the pre–post change in the intervention group and the corresponding change in the control group.
*DID-2 (Pre–Follow-up) was calculated as the mean difference between the pre–follow-up change in the intervention group and the corresponding change in the control group.
*The adjusted regression coefficients (β) were obtained from multivariable generalized Poisson regression models fitted within the DID framework after adjustment for prespecified covariates. Positive β values indicate greater improvement in the intervention group relative to the control group.

Fig. 1 Boxplots on knowledge showing change pre/post and pre/follow-up within the experiment and control group separately

Experiment:



Control:

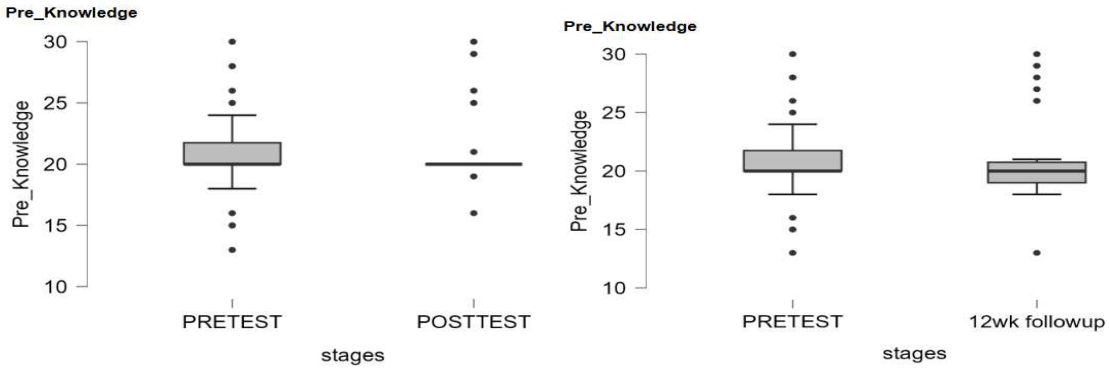
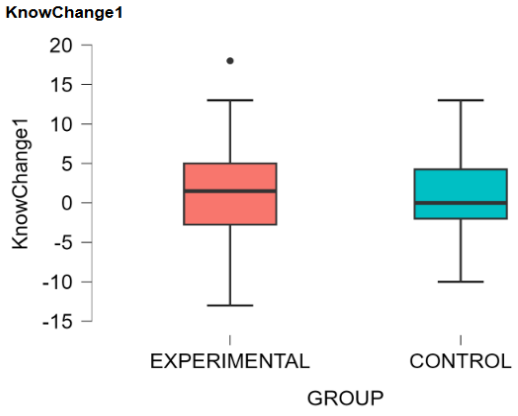
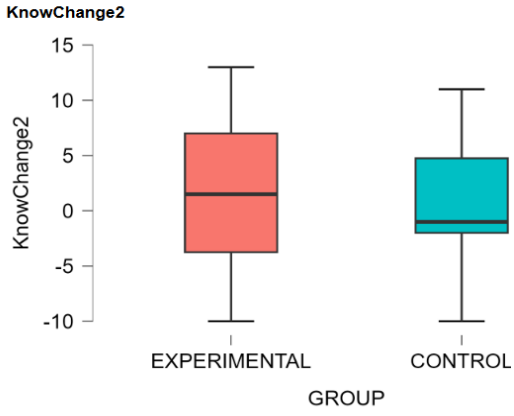


Fig. 2 Boxplots on knowledge comparing change 1 and change 2 between experimental and control groups

Changes 1



Changes 2



Impact of Targeted Health Education on Caregivers' Vaccine Knowledge and Attitudes in Osun State, Nigeria: A Quasi-Experimental Follow-Up Analysis

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Abstract

Background: Caregivers' understanding and beliefs regarding routine childhood immunization are crucial factors in determining vaccine acceptance. Educational interventions have been proposed as strategies to strengthen these outcomes, yet evidence of their effectiveness remains mixed. This study examined whether an educational intervention enhanced caregivers' knowledge and attitudes regarding uptake of routine childhood immunisation over a 12-week follow-up period.
Methods: A quasi- experimental design with caregivers of under-five children assigned to intervention and control groups was conducted. Standardised parametric analyses, including paired and independent t-tests, , were used to assess within- and between-group changes in outcome variables at 95% significant level using IBM SPSS and JASP version 0.19.3.0.
Results: Knowledge scores in the intervention group showed small, non-significant increases from baseline to follow-up (mean change = 1.53, t=1.278 (95%CI), p = 0.211), with no meaningful difference relative to the control group (mean change=0.57, t=0.609 (95%CI), p = 0.547). By contrast, attitudes demonstrated significant immediate improvement in the intervention group (mean change = 3.13, t=4.265 (95%CI), p < .001), which remained elevated at follow-up (mean change = 2.03, t=3.238 (95%CI), p = .003). Between-group analyses confirmed a significant intervention effect on attitudes at both post-test (p < .001) and follow-up (p = .004).
Conclusion: While educational programs may not significantly improve caregivers' knowledge, they can lead to substantial short-term improvements in attitudes toward routine childhood immunization. Long-term maintenance of these gains may require reinforcement strategies.

Keywords: Vaccine uptake, Hesitancy, Educational intervention, Caregivers, Routine childhood immunisation, Quasi-experimental follow-up study, Knowledge.

Introduction

The impact of targeted health education on caregivers' vaccine knowledge and attitudes is a pressing public health concern in Nigeria. Vaccination is a highly effective public health measure, preventing 2 to 3 million deaths annually from infectious diseases like pertussis, tetanus, measles, and diphtheria (1). Despite these successes, vaccine hesitancy has become a major global health concern, with 20% to 40% of people expressing reluctance toward vaccination in various regions (2). This hesitancy threatens immunization coverage (3) and has contributed to the resurgence

of vaccine-preventable diseases, such as measles, which had over 869,770 cases worldwide in 2019 (4).

Vaccine hesitancy is driven by many factors, from individual concerns about vaccine safety to broader societal issues like misinformation and distrust in public health systems (5-7). Misconceptions spread through social media have increased skepticism, further damaging trust in vaccination programs. In Africa, hesitancy rates have reached up to 40% in some areas, reflecting the combined effects of cultural beliefs, religious practices, and limited access to accurate information (8-10). Historical mistrust of Western medicine, stemming from past unethical practices, has worsened these concerns. Logistical barriers, such as vaccine stock-outs, long distances to health facilities, and indirect costs, exacerbate the problem, especially in rural communities like Osun State. In 2018, only 31% of children aged 12–23 months received all recommended vaccines, far below the national target of 80% (11-12).

Caregivers' reluctance to vaccinate has been linked to misinformation, cultural beliefs, and persistent mistrust of healthcare providers. In Osun State, vaccine hesitancy among caregivers of children under five is a pressing public health issue. Caregivers often cite religious doctrines, fears of infertility, and misconceptions about long-term health risks as reasons for refusing vaccines (13-19). To address these challenges, educational interventions have emerged as a promising strategy to reduce hesitancy. Evidence suggests that culturally tailored programs, especially those delivered through face-to-face interactions with healthcare providers, can improve caregivers' understanding of vaccines and foster trust (1, 20-24). In low-literacy settings, community-based approaches using local communication channels and participatory

methods have been particularly effective in promoting positive knowledge and attitudes towards vaccination (2,25).

Theoretical frameworks such as the PRECEDE–PROCEED model (3,26) and the Health Belief Model (4,27) provide insights into designing interventions that address both social determinants and individual cognition on vaccination issues. However, studies evaluating educational interventions in Nigeria remain limited, particularly in Osun State. Existing initiatives often lack cultural adaptation and fail to address the interplay of predisposing, enabling, and reinforcing factors that influence caregivers' vaccination behaviors (5, 28-29). This gap highlights the need for controlled studies assessing the effectiveness of context-sensitive educational strategies in enhancing caregivers' knowledge and attitudes toward immunization. By adopting a quasi-experimental follow-up analysis design, this study aims to provide empirical evidence to inform local and national strategies aimed at improving vaccination coverage and reducing vaccine hesitancy among children under five. This study will investigate the impact of targeted health education on caregivers' vaccine knowledge and attitudes in Osun State, Nigeria. The objectives of the study are to:

1.Assess the baseline levels of caregivers' knowledge, and attitudes towards vaccines.
2.Evaluate the effectiveness of a targeted health education intervention in enhancing caregivers' knowledge and attitude.
3.Identify factors that influence the adoption of vaccinated care-givers among caregivers.

Methods

Study Design

This study used a quasi-experimental design to evaluate the impact of a structured educational intervention on caregivers' knowledge and attitudes toward routine childhood immunization in Osun State, Nigeria. Participants were divided into an intervention group, which received targeted educational sessions, and a control group, which did not. Data were collected at baseline, immediately after the four-week intervention, and again at twelve weeks post-intervention to assess both short-term and sustained effects. This design was chosen for its suitability in real-world public health settings, where random assignment is often impractical, and it provided an opportunity to evaluate causal effects while maintaining ecological validity.

Study Setting

The study was conducted in Osun State, located in southwestern Nigeria. Created in 1991, the state covers approximately 14,575 km² and had a projected population of 4.3 million by 2015 [30, 31]. Osun State is administratively divided into 30 Local Government Areas (LGAs) across three senatorial districts. The population is predominantly Yoruba, comprising several sub-ethnic groups such as the Ife, Ijesha, Oyo, Ibolo, and Igbomina, along with minority groups from other regions. Agriculture is the primary occupation, while Christianity, Islam, and traditional beliefs define the religious landscape.

The health infrastructure includes 332 Primary Health Care (PHC) centers, ten (10) general hospitals, and two teaching hospitals. Approximately 55% of the population resides in rural communities, a demographic characteristic that influences healthcare access and immunization uptake [32]. The rural–urban distribution of the population was particularly relevant to the study, as barriers to immunization are often more pronounced in rural settings.

Study Population and Eligibility

The study population consisted of caregivers of children aged 0–5 years living in communities with PHC facilities in two selected LGAs of Osun State. Inclusion criteria required that participants reside in the study area, serve as primary caregivers for at least one child under five years of age, and provide informed consent to participate. Caregivers who had recently received formal education on vaccination were excluded to avoid bias in baseline knowledge and attitudes.

Sampling and Sample Size

A multi-stage sampling technique was used. First, two senatorial districts, Osun Central and Osun East, were randomly selected. Within each district, one LGA was chosen: Osogbo in Osun Central and Ife North in Osun East. From these LGAs, clusters of communities with functional PHC facilities were identified, and caregivers from these communities were randomly recruited.

Sample size was determined using the power formula described by Moyer et al. [33], applying an estimated prevalence of vaccine hesitancy of 55.5% from a prior study in Nigeria [34]. With 95% confidence and 80% statistical power, the required minimum sample size was calculated as 32 caregivers per group. However, the final sample size used or eligible was 30 participants in the intervention group and 30 in the control group. The Participant Flow were 35 assessed (for each group after 10% increase in sample size to check attrition), and 35 participants allocated to each group. However, only 30 participants completed post-test following lost of interest, inconsistency shown by some particpants and reports of relocation. The 30 participants were followed-up and they completed folow-up which data were analysed for each group.

Intervention

The intervention was a twelve-week structured educational program guided by health models [27,35], delivered once weekly in group sessions which lasted for 45 minutes

each. Delivered by trained public and communitiy health educators. Sessions were interactive, using lectures, visual aids, group discussions, and opportunities for questions and answers. Materials were presented in both Yoruba and English to ensure accessibility. The control group continued to receive routine health education services at PHCs without additional structured intervention. They received brief talks on immunisation schedules, and childhood vaccination importance. No structured behavioural intervention, vaccine-hesitancy counselling, or follow-up sessions were provided to the control group. To minimise contamination, intervention and control participants were recruited from separate health facilities, and intervention materials were not shared with the control group. Session attendance was recorded, and the principal investigator periodically monitored delivery to ensure fidelity to the intervention protocol.

Study Variables

The primary outcomes are caregivers' vaccine knowledge and vaccine attitudes. The focus is on caregivers' knowledge of vaccination programs and their attitudes toward vaccine-hesitant behavior. Ten items are presented on a four-point scale ranging from "strongly disagree" (1) to "strongly agree" (4) for each knowledge and attitude varables. The scoring system differed depending on the item's wording, with negatively worded statements for the Likert responses, "Strongly Agree" = 0, "Agree" = 1, "Disagree" = 2, "Strongly Disagree" = 3. Positively worded statements for the Likert responses, "Strongly Agree" = 3, "Agree" = 2, "Disagree" = 1, "Strongly Disagree" = 0 with maxxumum mean score of 30 for each of knowledge and attitude variables. Both scores are collected at three time points, baseline (pre-intervention), immediate post-intervention, and twelve-week follow-up, to capture change attributable to the educational program. Differences between experimental and control

groups are examined with paired and independent t-tests. The Generalized Poisson Regression Model estimated intervention effect sizes on these outcomes.

Data Collection

Data were collected using structured questionnaires administered at three time points: baseline (pre-intervention), immediately after the four-week intervention, and at twelve weeks post-intervention. The questionnaire which was used in this study was developed for this study based on the study's variables (see English language version as supplementary file). This made it possible to assessed socio-demographic characteristics, knowledge about routine immunization, and attitudes toward vaccination.

Data Analysis

Data were analyzed using both exploratory and confirmatory statistical approaches. Exploratory analyses involved descriptive statistics, boxplots, and scatter diagrams to illustrate changes within and between groups. Confirmatory analyses included paired-samples t-tests to assess within-group differences over time, and independent-samples t-tests to compare mean differences between the intervention and control groups. Effect sizes were estimated using Cohen's d to quantify the magnitude of observed changes, while generalized Poisson regression models were used to examine associations between the intervention and outcome variables after adjusting for relevant covariates. All statistical tests were conducted at a 5% significance level ($\alpha = 0.05$).

Justification for the use of Generalized Poisson Regression:

The knowledge and attitude outcomes were analysed as discrete composite scores derived from summed questionnaire responses. Because these outcomes were integer-

valued and exhibited evidence of dispersion and departures from the assumptions of ordinary least squares regression, generalized Poisson regression was used within a difference-in-differences framework to estimate adjusted intervention effects (Adjusted regression coefficient). Compared with the standard Poisson model, the generalized Poisson model accommodates both overdispersion and underdispersion while allowing adjustment for potential confounders, thereby providing more reliable regression estimates and standard errors.

Results

Demographic Characteristics of Participants

Table 1 presents the socio-demographic characteristics of participants in both the intervention and control groups. The mean age of participants in the control was 28.87 ± 5.58 years (range: 20–42), while the intervention group's was 32.07 ± 5.86 years (range: 19–45). This age difference was statistically significant ($p = 0.03$). Most participants were under 35, with the 18–30 age group being the most common. Most participants in both groups had one or two children under five years old. In the control group, 43.3% had one child and 43.3% had two children, compared to 60.0% and 20.0% in the intervention group, respectively. This difference was not statistically significant ($p > 0.05$). The gender distribution was skewed toward female caregivers, with 96.7% female and 3.3% male in the control group, and 83.3% female and 16.7% male in the intervention group. This difference was also not statistically significant ($p = 0.150$). Other demographic variables, including educational attainment, religion, ethnicity, and occupation, showed no significant differences between the groups (all $p > 0.05$). In summary, the groups were generally similar except for age (Table 1).

Although most baseline characteristics were comparable between the study groups, caregivers' age differed significantly between the intervention and control groups ($p = 0.03$). Therefore, age was included as a covariate in the multivariable generalized Poisson regression models to control for potential confounding.

Effect of the Intervention on Caregivers' Knowledge

Boxplots (Fig. 1: Boxplots on knowledge showing change pre/post and pre/follow-up within the experiment and control group separately) and (Fig. 2: Boxplots on knowledge comparing change 1 and change 2 between experimental and control groups) showed slight increases in knowledge scores within the intervention group, while the control group showed minimal changes across measurement points. Normality testing, using the Shapiro–Wilk procedure, confirmed that knowledge scores were approximately normally distributed across baseline, post-test, and follow-up assessments in both groups (all $p > 0.05$), thus justifying the use of parametric methods (Table 2). Because normality was violated for the attitude outcome in the control group, bootstrap confidence intervals were computed to assess the robustness of the independent-samples t-test. The bootstrap results were consistent with the parametric findings, indicating that the conclusions were robust despite departures from normality.

Within-group analyses showed that mean knowledge scores in the intervention group increased slightly from baseline ($M = 20.97$) to post-test ($M = 22.27$; Change = 1.30, $t = -0.97$, $p = 0.338$) and to follow-up ($M = 22.50$; Change = 1.53, $t = -1.28$, $p = 0.211$). In the control group, changes were negligible and non-significant (Baseline $M = 20.73$ → Post-test $M = 21.17$, Change = 0.43, $p = 0.669$; Follow-up $M = 21.30$, Change = 0.57, $p = 0.547$) (Table 3). Between-group comparisons showed that these variations were not statistically significant. At post-test, the difference-in-differences

estimate was 0.87 (t = 0.52, p = 0.606), and at follow-up it was 0.97 (t = 0.64, p = 0.527) (Table 3). Small to negligible effect sizes (−0.23 to 0.16) were reported, suggesting minimal practical improvement in caregivers' knowledge following the intervention.

Generalized Poisson regression enabled estimation of adjusted intervention effects within the difference-in-differences framework while accounting for the discrete composite nature of the outcome scores and allowing adjustment for baseline covariates, including age. This approach provided adjusted estimates of the intervention effect beyond the crude differences observed between study groups.

Generalized Poisson regression models, adjusted for relevant covariates, showed non-significant effects (Post-test*:* $B = 0.872$, p = 0.999; Follow-up: $B = -0.083$, p = 0.819), reinforcing the conclusion that the intervention did not significantly improve caregivers' knowledge (Table 5). Overall, while the intervention group experienced slight knowledge increases, these were not statistically significant and did not differ meaningfully from changes in the control group.

Effect of the Intervention on Caregivers' Attitudes

Boxplots (Fig. 3: Box-plot on attitude showing change pre/post and pre/follow-up within the experiment and control group separately) and (Fig. 4: Boxplots on attitude comparing change 1 and change 2 between experimental and control groups) revealed that attitude scores in the intervention group improved from baseline to post-test and remained elevated at follow-up, whereas the control group exhibited slight declines over the same period. Shapiro–Wilk tests confirmed that the intervention group's post-test (W = 0.935, p = 0.067) and follow-up (W = 0.971, p = 0.577) scores approximated normality. Conversely, the control group's post-test (W = 0.927, p = 0.040) and follow-up (W = 0.915, p = 0.020) scores significantly deviated from

normality, indicating a partial violation of assumptions. Consequently, parametric tests were interpreted cautiously and supplemented with bias-corrected bootstrap confidence intervals (Table 2).

Within-group analyses showed statistically significant improvements in the intervention group. Mean attitude scores increased from baseline (M = 13.77) to post-test (M = 16.90; Change = 3.13, t = −4.27, $p < 0.001$) and remained above baseline at follow-up (M = 15.80; Change = 2.03, t = −3.24, p = 0.003). In contrast, the control group experienced non-significant declines (Post-test Change = −1.40, p = 0.085; Follow-up Change = −1.47, p = 0.152) (Table 4). Between-group comparisons further demonstrated the intervention's effectiveness. Difference-in-differences testing showed significant positive effects for the intervention group relative to controls, both at post-test (DID-1 = 4.53, t = 4.21, $p < 0.001$) and at follow-up (DID-2 = 3.50, t = 2.97, p = 0.004) (Table 4). Large Cohen's d values (1.09 post-intervention, 0.77 at follow-up) indicated a significant intervention effect on caregivers' attitudes between groups.

Regression analyses confirmed these findings. Adjusted models indicated a significant positive effect at post-test (B = 1.042, $p < 0.001$). Although the effect at follow-up was smaller and not statistically significant (B = 0.219, p = 0.389), the trend suggest short-term effectiveness rather than sustained effectiveness after adjustment for baseline covariates (Table 5). In summary, the educational intervention significantly improved caregivers’ attitudes toward routine childhood immunization immediately following the program, with moderate gains persisting at 12 weeks.

Discussion

This study used a quasi-experimental design to examine the impact of a targeted educational intervention on caregivers' knowledge and attitudes toward routine childhood immunization in Osun State, Nigeria. The findings presented a mixed pattern: the intervention led to modest, non-significant improvements in knowledge but significant and sustained positive changes in caregivers' attitudes.

Contrary to expectations, caregivers' knowledge of routine immunization did not significantly improve. Although mean knowledge scores in the intervention group increased slightly from baseline to post-test and follow-up, these changes were not statistically significant. The difference-in-differences analysis further confirmed the absence of a meaningful effect compared with the control group. Unlike previous studies [36, 37] which reported improvements in immunization knowledge following educational interventions this study did not see a statistically significant increase. The reason is unclear but could be due to factors such as participant characteristics or differences in program content. An alternative explanation is that many participants already had high levels of initial knowledge, limiting further growth (ceiling effect) .

Several factors may explain this outcome. First, relatively high baseline knowledge levels across both groups may have limited the potential for measurable improvement, creating a ceiling effect. Second, the short duration may have been insufficient to reinforce factual knowledge, especially where vaccine misconceptions are deeply rooted. Third, the intervention design may have focused more on attitudinal transformation than detailed factual instruction.

In contrast, caregivers' attitudes toward routine childhood immunization improved significantly following the intervention and remained elevated at the 12-week follow-up, although some attenuation was observed over time. The greater change in

caregivers' views was attributed to the Health Belief Model. Although initial knowledge of childhood immunisation was good, the intervention improved perceived advantages and reduced concerns about vaccine hesitancy, suggesting that health beliefs overrode factual knowledge, resulting in a notable shift in attitudes. This aligns with existing evidence suggesting that interventions addressing socio-cultural beliefs, trust in health systems, and perceived benefits of vaccination are more likely to influence attitudes than purely cognitive factors [6, 10, 38, 39].

The durability of attitudinal changes underscores the potential of community-based educational interventions in addressing vaccine hesitancy, particularly in low-resource settings. However, the gradual decline at follow-up highlights the importance of reinforcement strategies, such as periodic booster sessions, integration of immunization messages into routine antenatal and child welfare clinics, and the use of trusted community leaders as advocates. The findings have several implications for immunization programs in Nigeria and similar contexts. First, interventions aimed at caregivers should extend beyond knowledge transfer to include strategies that reshape attitudes and beliefs. Second, integrating education into routine health service delivery may help sustain long-term changes and address barriers such as misinformation and mistrust. Third, the demographic profile of participants, predominantly young female caregivers, reflects the central role of women in child healthcare decision-making. Thus, gender-sensitive approaches that empower women while engaging men as supportive partners may strengthen program outcomes.

Strengths and limitations of the study

The study's strengths include a quasi-experimental design, validated measurement tools, and a thorough analytical approach employing a Generalized Poisson Regression Model, which together support dependable estimates of effect size.

Although age differed significantly between the intervention and control groups at baseline, this potential confounding was addressed by adjusting for age in the multivariable regression models. Nevertheless, residual confounding cannot be completely excluded. Nonetheless, the research faces several drawbacks: there is a risk of selection bias, reliance on self-reported information, limited applicability to broader populations, a brief follow-up period, and the possibility that unmeasured confounding factors could affect the observed changes in caregivers' knowledge and attitudes.

Conclusion

This study demonstrated that educational interventions can positively influence caregivers' attitudes toward routine childhood immunization, even when effects on knowledge are limited. By targeting beliefs and attitudes, such interventions can play a critical role in reducing vaccine hesitancy in low-resource settings. However, sustained reinforcement and integration into existing health systems are essential to maintain gains and translate attitudinal improvements into long-term behavioural change.

Declarations

Ethical Approval and Participant Consent

The University of Port Harcourt's Research Ethics Committee granted ethical clearance (Reference: UPH/CEREMAD/REC/MM104/045). All subjects provided written informed consent, and the study was conducted with their confidentiality protected. The research was conducted in accordance with the principles of the Declaration of Helsinki, and applicable national regulations governing human-subject research.

Consent for publication

Not applicable, as the manuscript does not include any identifiable personal data.

Data Availability

Datasets from this study are available from the corresponding author upon request.

Competing interests

The authors declare no competing interests.

Funding

No specific funding was received for this research.

Authors' contributions

All authors contributed significantly to the study. OOO conceptualised and designed the study, supervised data collection, and led data analysis. DSO and OMA contributed to literature review, interpretation of findings, and manuscript preparation. All authors read and approved the final manuscript.

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TABLES

Table 1. Demographic characteristics of participants at baseline

Variable	Control N=30		Experimental N=30		Total		
	Frequency		Frequency		N	(%)	p-value
	N	%	N	%			
Age	Mean:28.87 ± 5.58		32.07 ± 5.86		30.46 ±5.90		0.03
Range in years	Range: 20 to 42		19 to 45				
Gender:							
Female	29	96.7	26	83.3	54	93.1	0.150
Male	1	3.3	2	6.7	3	5.2	
Educational attainment:							
Non-formal	0	0.0	0	0.0	0	0.0	
Primary	2	6.7	0	0.0	2	3.5	0.012
Secondary	13	43.3	5	16.7	18	31.6	
Tertiary	13	43.3	24	80.0	37	64.9	
No. of children <5 years old	18	60.0	14	46.7	32	55.2	
1	6	20.0	13	43.3	19	32.8	0.065
2	4	13.3	2	6.7	6	10.3	
3	1	3.3	0	0.0	1	1.7	
3>							
Religion	11	36.7	19	63.3	30	50.8	0.015
Christianity	18	60.0	11	36.7	29	49.2	
Muslim	0	0.0	0	0.0	0	0.0	
Others							
Occupation							
Unemployed	2	6.7	1	3.3	3	5.2	0.601
Self-employed	19	63.3	21	70.0	40	69.0	
Employed in public	2	6.7	5	16.7	17	12.1	
sector	6	20.0	2	6.7	8	13.8	
Employed in private sector							

Note: These variables were included as covariates in the multivariable generalized Poisson regression models to minimise potential confounding.

Table 2. Normality Assumption Checks on Outcomes (Shapiro–Wilk Test)

Knowledge			
Group	Comparison	W	p
Experimental	Pre–Post Knowledge	0.984	.926
Experimental	Pre–Follow Knowledge	0.966	.446
Control	Pre–Post Knowledge	0.951	.182
Control	Pre–Follow Knowledge	0.944	.115
Attitudes			
Experimental	Pre–Post Attitude	0.935	.067
Experimental	Pre–Follow Attitude	0.971	.577
Control	Pre–Post Attitude	0.927	.040
Control	Pre–Follow Attitude	0.915	.020

Note. A Shapiro–Wilk p-value < .05 indicates a significant deviation from normality (assumption violated).Although normality was violated for the attitude outcome in the control group, bootstrap confidence intervals produced findings consistent with the parametric analyses, supporting the robustness of the results.

Table 3. Effect of Intervention on Knowledge of caregivers of under-five children in the same group regarding routine childhood immunisation

Group	Pre Knowledge	Post Knolwedge	Follow Knowledge	Change 1	t-test[a] [df=29]	p-value	Change 2	t-test[a] [df=29]	p-value
	X	X	X	(diff bewteen Pre & Post)		ES *(95% Cl)*	(diff bewteen Pre & Follow)		ES (95% Cl)
Same Group									
Experimental (n=30)	20.967	22.267	22.500	1.300	-0.974	0.338 *[ES=-0.18 (-0.54-0.18)]*	1.533	-1.278	0.211 *[ES= -0.23 (-0.59-0.13)]*
Control (n=30)	20.733	21.167	21.300	.433	-0.432	0.669 *[ES=-0.08 (-0.44 - 0.28)]*	0.567	-0.609	0.547 *[ES= -0.11 (-0.47- 0.25)]*

[a]Paired t-test (to get the 95%CI use the use bias-corrected bootstrap function) ; ES=effect size is given by Cohen's d . Maximum scale point for knaowledge mean score (X)=30

Different group

	Change 1 DID-1*	t-test[a] [df=58]	p-value	Cohen's d (95%CI)		Change 2 DID-2*	t-test[a] [df=58]	p-value	Cohen's d (95%CI)
Experimental vs Control	0.867	0.519	0.606	0.134 *(-0.37-0.64)*		0.967	0.637	0.527	0.164 *(-0.34-0.67)*

[b]Independent t-test (equal variances not assumed), use bias-corrected bootstrap function

*difference-in-differences (DID): The difference-in-differences (DID) estimate was calculated as the difference between the mean change in the intervention group and the corresponding mean change in the control group.

*Change 1 DID-1 (difference between the difference of the experimental and control group difference at post stage [1.300-0.433=0.867])

*Change 2 DID-2 (difference between the difference of the experimental and control group difference at post stage [1.533--0.567=0.967])

Table 4. Effect of Intervention on attitude of caregivers of under-five children regarding routine childhood immunisation

Group	Preattitude	Post attitude	Follow attitude	Change 1	t-test[a]	p-value	Change 2	t-test[a]	p-value
	X	X	X	(diff bewteen Pre & Post)		ES (95% Cl)	(diff bewteen Pre & Follow)		ES (95% Cl)
Same Group									
Experimental (n=30)	13.767	16.900	15.800	3.1333	-4.265	<0 .001 *[ES= 0.78 (-1.18-(-0.36))]*	2.0333	-3.238	0.003 *[ES= -0.59 (-0.98-0.20)]*
Control (n=30)	15.400	14.000	13.9333	-1.4000	1.782	0.085 *[ES= 0.33 (-0.05-0.69)]*	-1.4667	1.472	0.152 *[ES=0.27(-0.10-0.63)]*

[a]Paired t-test (to get the 95%CI use the use bias-corrected bootstrap function) ; ES=effect size is given by Cohen's d ; Maximum scale point for attitude mean score (X)=30

Different group

	Change 1 DID-1*	t-test[a] [df=58]	p-value	Cohen's d (95%CI)	Change 2 DID-2*	t-test[a] [df=58]	p-value	Cohen's d (95%CI)
Experimental vs Control	4.533	4.214	<0.001	1.088 *(0.541-1.627)*	3.500	2.972	0.004	0.767 *(0.239-1.289)*

[b]Independent t-test (equal variances not assumed), use bias-corrected bootstrap function

*difference-in-differences (DID)
*Change 1 DID-1 (difference between the difference of the experimental and control group difference at post stage [3.1333- (-1.4000)=4.533])
*Change 2 DID-2 (difference between the difference of the experimental and control group difference at post stage [2.0333-(-1.4667)=0.967]=3.500)

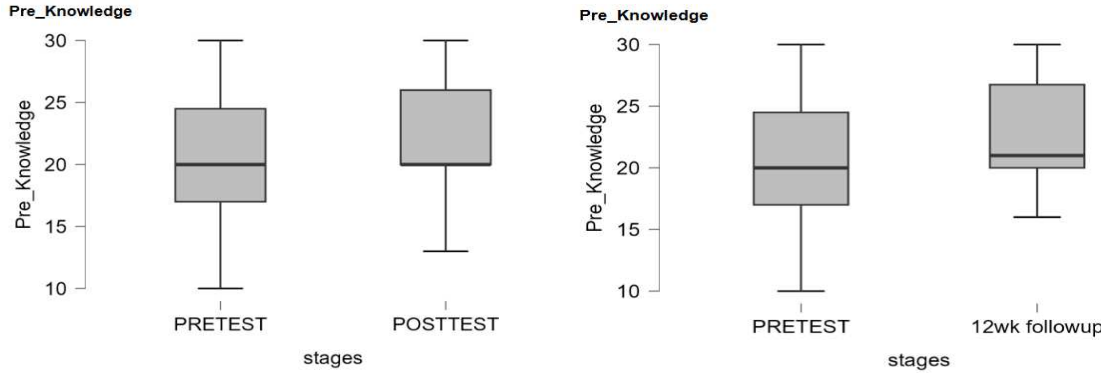
Table 5. Generalized Poisson regression estimates of the adjusted intervention effect on caregivers' knowledge and attitudes towards routine childhood immunisation using a difference-in-differences (DID) framework

Outcome	Group	Baseline Mean	Post-intervention Mean	Follow-up Mean	DID 1 (Pre–Post)	DID 2 (Pre–Follow-up)	Adjusted regression coefficient (Post)	p-value	Adjusted regression coefficient (Follow-up)	p-value
Knowledge	Experimental	20.97	22.27	22.50	0.867	0.967	0.872	0.001	−0.083	0.819
	Control	20.73	21.17	21.30	—	—	Reference	—	Reference	—
Attitude	Experimental	13.77	16.90	15.80	4.533	3.500	1.042	<0.001	0.219	0.389
	Control	15.40	14.00	13.93	—	—	Reference	—	Reference	—

***Abbreviations:** DID = Difference-in-Differences; β = adjusted regression coefficient estimated from the generalized Poisson regression model.
*DID-1 (Pre–Post) was calculated as the mean difference between the pre–post change in the intervention group and the corresponding change in the control group.
*DID-2 (Pre–Follow-up) was calculated as the mean difference between the pre–follow-up change in the intervention group and the corresponding change in the control group.
*The adjusted regression coefficients (β) were obtained from multivariable generalized Poisson regression models fitted within the DID framework after adjustment for prespecified covariates. Positive β values indicate greater improvement in the intervention group relative to the control group.

Fig. 1 Boxplots on knowledge showing change pre/post and pre/follow-up within the experiment and control group separately

Experiment:



Control:

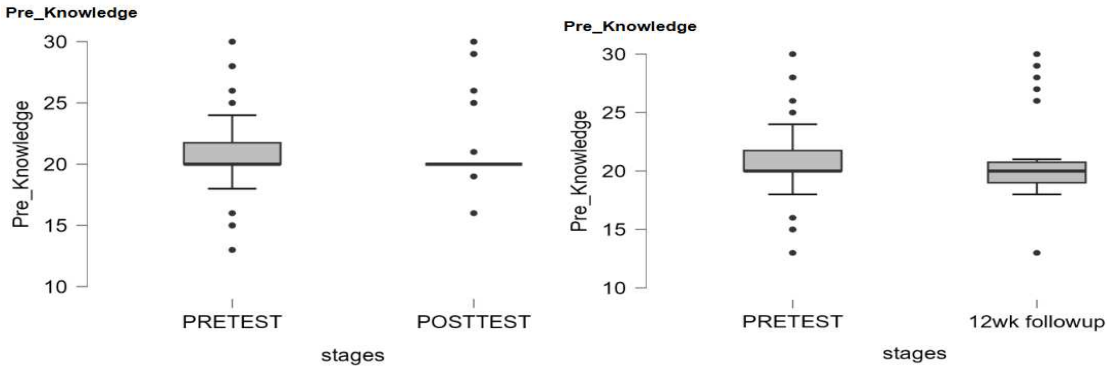
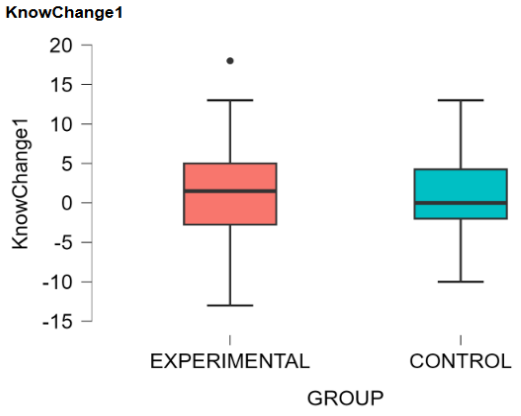


Fig. 2 Boxplots on knowledge comparing change 1 and change 2 between experimental and control groups

Changes 1



Changes 2

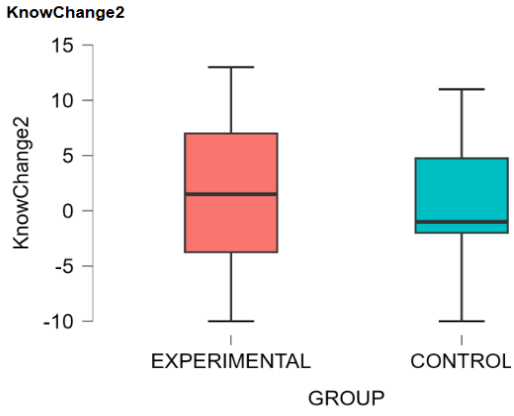
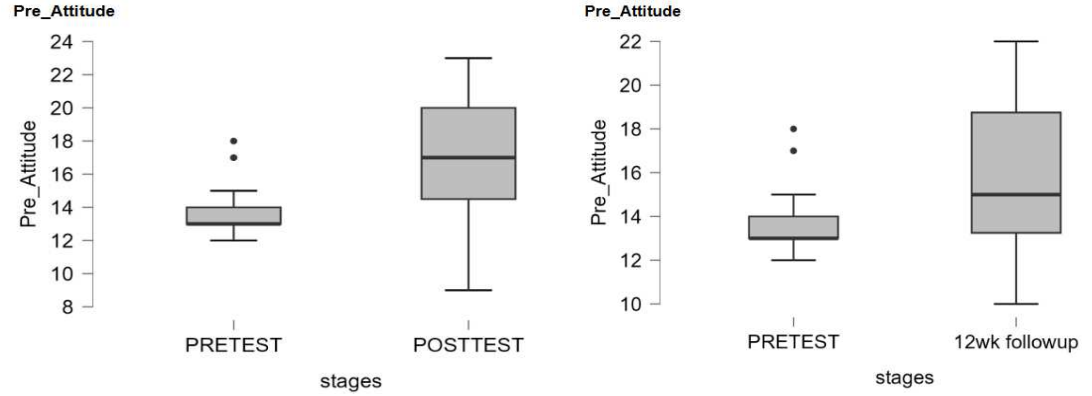


Fig. 3 Boxplots on attitude showing change pre/post and pre/follow-up within the experiment and control group separately

Experiment:



Control:

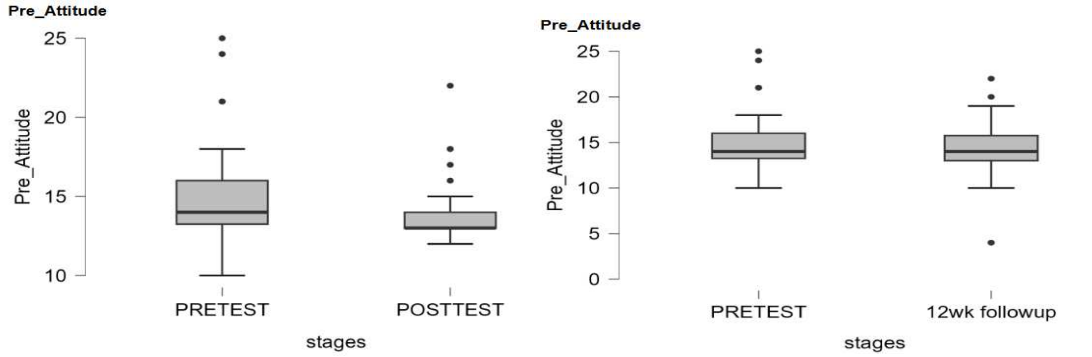
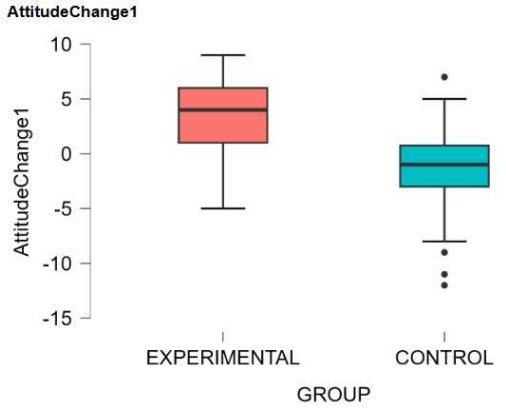
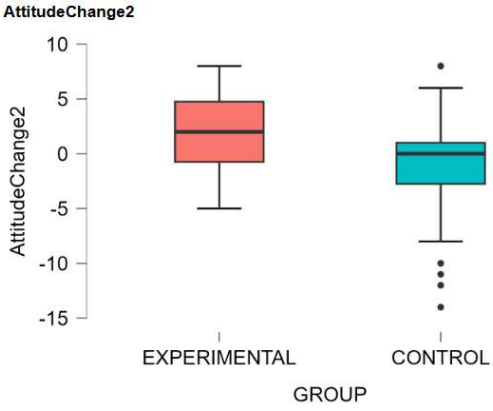


Fig. 4 Boxplots on attitude comparing change 1 and change 2 between experimental and control groups

Changes 1



Changes 2



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