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Original Article

When coverage is high: rethinking the role of caregiver perceptions in childhood vaccination uptake in Uganda

Annika K. Gunderson [1,2,*], Taeim Kwon [3], Yohhan Kumarasinghe [3], Yuanyuan Yan [3], Joyce Choe [3], Qikai Jiang [3], Emmanuel Baguma [4], Shem Bwambale [5], John R. Barber [2,6], Raquel Reyes [7], Moses Ntaro [4], Paul L. Delamater [2,8], Edgar M. Mulogo [4], Ross M. Boyce [1,2,9]

[1]Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA
[2]Carolina Population Center, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA
[3]Department of Biostatistics, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA
[4]Department of Community Health, Faculty of Medicine, Mbarara University of Science & Technology, Mbarara, Uganda
[5]Bugoye Level III Health Center, Uganda Ministry of Health, Bugoye, Uganda
[6]Department of Hospital Medicine, Northern Light Mercy Hospital, Portland, ME 04102, USA
[7]Division of Hospital Medicine, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA
[8]Department of Geography and Environment, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA
[9]Institute for Global Health and Infectious Diseases, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA
*Corresponding author: Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA. E-mail: agunderson@unc.edu

Abstract

Background **Beliefs of a child's primary caregiver are known to influence immunization uptake. As coverage increases, the characteristics of households with undervaccinated children may be shifting.**

Methods **We conducted a cross-sectional survey of households with a child 12–23 months of age. Vaccine status was verified by inspection of immunization cards or caregiver report. Composite scores captured caregiver beliefs and experiences with vaccination. Associations between these measures and vaccination status were evaluated using weighted logistic regression.**

Results **Caregivers of 1689 children were surveyed. The odds of full vaccination were not associated with composite beliefs (adjusted odds ratio [aOR] 1.04 [95% confidence interval {CI} 0.95 to 1.14]) or experiences scores (aOR 1.04 [95% CI 0.96 to 1.13]). Specific beliefs that vaccines prevent severe disease (aOR 2.68 [95% CI 1.64 to 4.37]) and protect the community (aOR 1.67 [95% CI 1.10 to 2.53]) were positively associated, whereas beliefs that children receive too many vaccines (aOR 0.60 [95% CI 0.44 to 0.83]) were negatively associated with full vaccination. Positive experiences, including knowing someone affected by a vaccine-preventable disease (aOR 2.10 [95% CI 1.47 to 3.00]) were also linked to full vaccination.**

Conclusions **Although composite scores were not associated with immunization status, individual beliefs and experiences may still factor into caregiver decisions to vaccinate their children.**

Keywords Africa south of the Sahara, cross-sectional studies, measles vaccine, patient beliefs, Uganda, vaccination

Introduction

Over the past 2 decades, Uganda has made progress towards increasing immunization access and uptake.[1] National reports indicate coverage rates between 86% and 96% for childhood vaccines recommended by the Expanded Programme on Immunization (EPI).[2] These vaccination rates exceed the 2022 regional average for sub-Saharan Africa of 72% for tetanus and 69% for measles, reflecting a significant policy and health system achievement.[3] However, subnational heterogeneity in coverage persists. Recent analyses show vaccination rates vary widely by region, household wealth, maternal education and urban–rural location, with some areas reporting full immunization coverage as low as 17% and others >70%.[4–6] In particular, challenges have been noted in rural areas with high dropout rates for later doses of multidose sequences for vaccines such as pneumococcal and rotavirus, with completion rates as low as 8% in some areas in 2019.[5]

The beliefs of caregivers who make healthcare decisions for the child, such as their guardians or parents, have been shown to influence routine immunization uptake in Uganda.[7,8] In particular, perceptions of vaccine safety, trust in health systems and positive prior experiences with immunization services can shape vaccine-seeking behaviour. In contrast, misinformation and fears of side effects and pain during injection can discourage vaccine seeking.[8–11] In prior studies, caregivers in rural southwest Uganda have expressed concerns about vaccine safety driven by known and

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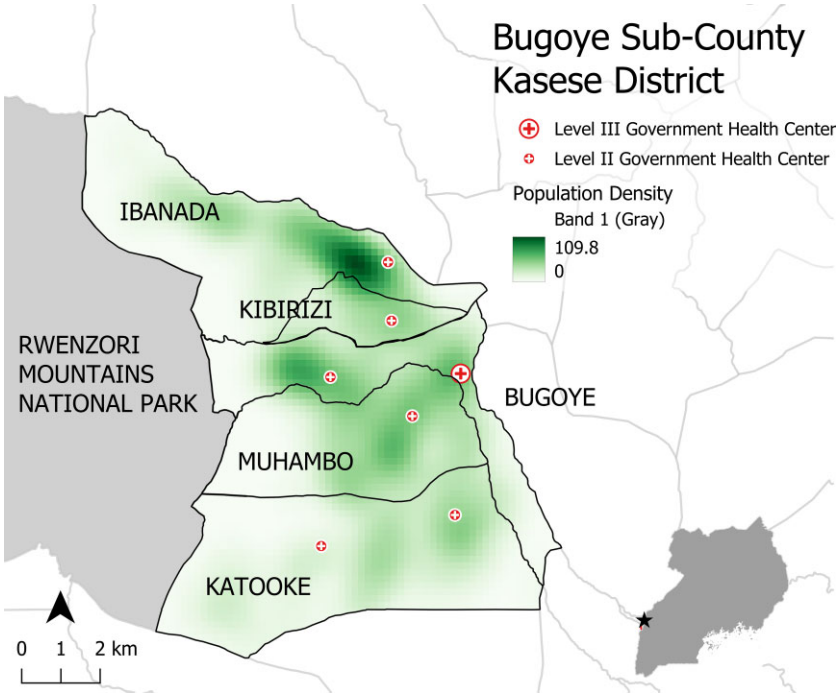


Figure 1 Bugoye sub-county. This is a map of the parishes that compose the Bugoye subcounty as well as the government health facilities in the area. This map was created using QGIS with Ugandan administrative shapefiles from the Humanitarian Data Exchange.

anticipated adverse effects and beliefs that vaccines are profit-driven, while also indicating a general distrust of Western healthcare.[8,10]

Prior studies have documented negative caregiver perceptions and vaccine hesitancy in specific contexts, including rural southwest Uganda, however, less is known about how these factors shape behaviours in the current landscape of higher national vaccine coverage. For example, as uptake increases, the distribution and characteristics of households where children remain undervaccinated may change.[12,13] In particular, children being un- or undervaccinated may become less associated with structural barriers (e.g. distance to clinic, vaccine availability) and more influenced by caregiver beliefs, trust in health systems and perceptions of disease risk.[14,15] Understanding these evolving dynamics is essential to designing targeted interventions to close remaining gaps in immunization coverage. Therefore, this study sought to explore the potential associations between caregiver beliefs and experiences with the receipt of recommended childhood immunizations.

Methods

Study area

This study was conducted in Bugoye subcounty, located in the Kasese District of rural western Uganda. The subcounty, bordering with the Democratic Republic of Congo (Figure 1), is comprised of five parishes including Ibanda, Kibirizi, Bugoye, Muhambo and Katooke. The area sits in the foothills of the Rwenzori Mountains and is marked by steep mountain sides and large changes in elevation ranging from 1200 to 2000 m, which can lead to variations in access to healthcare across communities. At the time of the study there were an estimated 6872 households in Bugoye subcounty, of which an estimated 15–25% had a child 12–23 months of age.[16]

There is one level 3 health facility located in the Bugoye parish, while the other four parishes each have a level 2 government health facility. In addition, there is a second level 3 health facility in Ibanda parish that is private not-for-profit. All of these facilities administer all childhood vaccines.

Study design and data collection

The study protocol detailing data collection has been previously published.[16] In brief, we conducted a cross-sectional study in which all households in the Bugoye subcounty with a child 12–23 months of age were eligible to participate. Study staff assisted by community health workers visited households across all five parishes. After consent was provided, an interviewer administered surveys, both of which were conducted in the local language. Surveys included questions on caregiver and child demographics, attitudes and beliefs about vaccines, prior experiences with vaccines and vaccination, prior hospitalization of the child and related data and vaccination status. If an adult caregiver was not available at the time of the visit, three more attempts were made prior to excluding the household.

Vaccine status was discerned by visual inspection of immunization cards. These cards are distributed at local health facilities when children present for their first vaccination and are a record of all vaccines received, including vaccine type and administration date. In the event the children did not have their vaccine card, we asked the parent to self-report receipt of each vaccine.

Outcome and exposures

The primary outcome of interest was receipt of recommended vaccines specific to the child's age at the time of the visit. A fully vaccinated child was defined as a child who received all eight recommended childhood vaccines including tuberculosis, polio,

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Table 1 Vaccination beliefs and experience component questions.

Category	Component questions
Beliefs/attitudes	Children get more vaccinations than are good for them. (B1) Healthy children do not need immunizations. (B2) Vaccination does more good than harm. (B3) It is better for a child to develop immunity by getting sick than to get a vaccination. (B4) Parents should be allowed to selectively choose the vaccines which they believe their child needs. (B5) It is better for a child to receive two injectable vaccinations in one visit rather than one injectable vaccination in two visits. (B6) Many of the illnesses which vaccinations prevent are severe. (B7) When a parent refuses to vaccinate a child, it harms the entire community through risk of disease. (B8) People in this community have expressed concerns that a child might have a serious side effect from a vaccination. (B9) Following the nationally recommended vaccination schedule is a good idea for a child. (B10)
Experiences	If the national immunization policy states that two injectable vaccines should be given in the same arm/leg, would you allow it? (E1) I believe vaccines are safe. (E2) I believe vaccines protect my child from vaccine preventable disease. (E3) Have you personally seen someone with either polio, pneumonia, measles or whooping cough? (E4) Do you know of someone in your family or community who had either polio, pneumonia, measles or whooping cough? (E5) Have you ever delayed having your child get a vaccination for reasons other than illness or allergy? (E6) Have you ever decided not to have your child get a vaccination for reasons other than illness or allergy? (E7) If you had another infant today, would you want your infant to get all recommended vaccinations? (E8) Do you know the location where you can have your child vaccinated? (E9) Do you know the days and times when vaccination services are offered in your community? (E10) Is access to immunization easy? (E11) If you have to spend more than 1 hour getting a vaccine, are you willing to take the time because you think it is an important vaccine? (E12) Are you able to discuss any concerns you have about vaccinations with your child's healthcare provider? (E13) Do you trust the information that you receive from your local healthcare worker about vaccinations? (E14)

This table includes survey questions used to assess beliefs and attitudes and experiences with vaccination. These questions serve as the components for each aggregated score. Belief and attitude questions were measured using disagree/agree/not sure response options. Experience questions were measured using yes/no/not sure response options.

two doses for rotavirus, measles vaccines and three doses of the combination vaccine for diphtheria, tetanus, pertussis, hepatitis B and *Haemophilus influenzae* type b. Children considered not fully vaccinated are those missing at least one of the included vaccinations. Vaccination status for measles alone was the secondary outcome. Both outcomes were coded as binary variables.

Explanatory variables were caregiver beliefs and previous experience or knowledge about vaccines. Responses were aggregated by domain to generate summary scores as outlined in Table 1. Questions used to construct the aggregate belief and experience scores were modified from questions used in a study in Ghana, developed by the US Centers for Disease Control and Prevention, Emory University, and Ghana Health Service.[17] All component questions were coded to have the same valence and aggregate scores were then calculated as the sum of the component questions answered indicating presence of the belief or experience. Secondary outcomes included each component of the aggregate belief and experience scores assessed independently.

Analysis

This study is a secondary analysis of data collected to assess areas of low vaccination to develop methods to target underserved populations. We generated summary statistics for key variables, including the primary outcome of full vaccination status and secondary outcomes such as immunization card availability and, if unavailable, self-reported vaccination status. Main predictors—continuous or ordinal scores for positive beliefs and vaccination experience—were summarized alongside potential confounders, which included caregiver characteristics, child anthropometric measures, vaccination location and childbirth-related variables. The confounding variables were identified using prior knowledge and the associations between each possible confounding variable and outcome or aggregated scores were tested with χ^2, Wilcoxon rank-sum, Kendall's τ and Kruskal–Wallis tests. All statistical tests were performed at a two-sided significance level of 0.05.

To assess caregiver and child factors associated with aggregate belief and experience scores, we used non-parametric tests. The Kendall's τ rank correlation test was used to assess associations between continuous factors and aggregate scores. The Wilcoxon rank-sum test and Cohen's d statistic were used to assess associations between binary factors and aggregate scores. The Kruskal–Wallis test was used to assess associations between factors of more than two levels and aggregate scores. Dunn's test was used to examine multiple comparisons between groups that differed

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in mean rank score and the significance level was adjusted using Holm's method to control the type 1 error rate.

In our aggregated score, the more vaccine-positive response was assigned a score of 1, the less vaccine-positive response was assigned a score of 0 and responses that expressed uncertainty were assigned a score of 0.5. A weighted logistic regression was fitted for the primary outcome, i.e. fully vaccinated status, to obtain adjusted odds ratios (ORs) and 95% confidence intervals (CIs). A weighted random forest was then implemented to compare performance against the weighted logistic regression after splitting the dataset into a train set (80%) and test set (20%). The evaluation metrics included the receiver operating characteristics (ROC) curve, area under the curve (AUC) and κ. Although the weighted random forest outperformed the weighted logistic regression, the performance improvement over the weighted logistic regression was modest (Supplementary Figure S1). Given our focus on interpretability, we chose to use weighted logistic regression. After adjusting confounding variables identified from the exploratory analysis, the final model is given below. Categorical variables with multiple levels were included in the model using indicator variables, with one level (level 0) of each variable treated as the reference category.

$$\begin{aligned}&\text{logit}\left(\Pr\left(\text{Vaccination Status}_i = 1\right)\right)\\&= \beta_0 + \beta_1 \text{Belief Score}_i + \beta_2 \text{Experience Score}_i\\&+ \sum_{j=1}^{4} \beta_{3j} 1\left(\text{Main Vaccination Location}_i = j\right)\\&+ \sum_{j=1}^{3} \beta_{4j} 1\left(\text{Education}_i = j\right) + \sum_{j=1}^{3} \beta_{5j} 1\left(\text{Marital Status}_i = j\right)\\&+ \beta_6 1\left(\text{Bed Net}_i = 1\right) + \beta_7 1\left(\text{Inpatient}_i = 1\right)\end{aligned}$$

To account for recall bias among individuals without immunization cards, sensitivity analysis was conducted by performing these analyses exclusively on data from those with immunization cards (67% of the total sample size).

Results

Study population

Between 20 January 2021 and 30 April 2021, 1689 children were enrolled. Immunization cards were available for inspection for the majority of children (1072 [66.5%]). Of those children, 78 were missing data regarding their vaccination status and were excluded from analyses using full vaccination as the outcome. An additional 212 children were missing data on at least one vaccine but reported that the child received most but not all vaccines and were excluded only from the measles-specific analysis if the vaccine missing data was specifically for the measles vaccine. A further six children had unknown vaccination status for measles and were excluded from the measles-specific analysis.

Most children, 85.7% (1381/1611) were considered fully vaccinated. This included 96.5% (1035/1072) of those with an immunization card, but only 57.3% (309/539) of those without their immunization card (Table 2). The measles vaccine had the greatest variability, with 97.5% (1111/1139) of children having been vaccinated specifically for measles, although 32.6% (543/1689) of children were missing data for this vaccine and thus were unknown. Vaccines were received at a level 3 government health centre and level 2 health facility for 25.8% (415/1608) and 39.8% (640/1608) of children, respectively, with 26.4% (425/1608) of children having been vaccinated at a private facility. A breakdown of the study population by vaccination for each individual vaccine is available in Supplementary Table S1.

Aggregate belief and experience scores

Neither aggregate scores for caregiver beliefs nor experiences suggest higher odds of a child being fully vaccinated for each additional positive belief (aOR 1.04 [95% CI 0.95 to 1.14]) and experience (aOR 1.04 [95% CI 0.96 to 1.13]) compared with children who were not fully vaccinated after adjusting for vaccination location, caregiver education, caregiver marital status, long-lasting insecticidal net (LLIN) use and a history of hospitalization for malaria (Figure 2).

When considering the measles vaccine alone, positive experiences with vaccines were found to have a positive association with vaccination (aOR 1.10 [95% CI 0.82 to 1.48]). However, more positive belief scores were associated with lower odds of vaccination (aOR 0.54 [95% CI 0.39 to 0.73]).

Individual belief and experiences

Of individual belief components, agreeing with the statement 'Children get more vaccinations than are good for them' was strongly associated with lower odds of a caregiver's child being fully vaccinated (aOR 0.60 [95% CI 0.44 to 0.83]) (Figure 3). In contrast, agreement with the statements 'Many of the illness which vaccinations prevent are severe' or 'When a parent refuses to vaccinate a child, it harms the entire community through risk of disease' was associated with higher odds of a caregiver's child being fully vaccinated (aOR 2.68 [95% CI 1.64 to 4.37] and 1.67 [95% CI 1.10 to 2.53], respectively). All other individual beliefs and attitudes were not statistically associated with receipt of all vaccinations.

Regarding individual experiences, prior delay of a child's vaccination for reasons other than allergy or illness was associated with lower odds of a caregiver's child being fully vaccinated (aOR 0.34 [95% CI 0.24 to 0.48]). Being able to discuss any concerns with a child's healthcare provider or knowing a person who had either polio, pneumonia, measles or whooping cough was associated with 2.44 (95% CI 1.35 to 4.41) and 2.10 (95% CI 1.47 to 3.00) times higher odds of a caregiver's child being fully vaccinated, respectively. All other individual experiences were not statistically associated with receipt of all vaccinations. Descriptive details on individual attitudes/beliefs and experiences by vaccination status are included in Supplementary Table S2.

Factors associated with belief and experience scores

Several factors were found to be associated with aggregate belief scores, including caregiver education, facility type visited for vaccination, the facility type where the child was born and if the child slept under an LLIN. Bringing the child to government health centres or attending immunization visits to receive vaccinations was associated with a higher aggregate belief score compared with

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Table 2 Characteristics of the study population.

Characteristics	Fully vaccinated[a], n (%)	Not fully vaccinated[a], n (%)	Total population, n (%)
Children	1381 (85.7)	230 (14.3)	1611
Parish of residence			
Bugoye	298 (87.7)	42 (12.3)	340 (21.1)
Ibanda	387 (89.4)	46 (10.6)	433 (26.9)
Katooke	337 (87.5)	48 (12.5)	385 (23.9)
Kibirizi	122 (91.7)	11 (8.3)	133 (8.3)
Muhambo	236 (74.0)	83 (26.0)	319 (19.8)
Missing	1	0	1
Caregiver sex			
Male	173 (78.3)	48 (21.7)	221 (13.8)
Female	1204 (86.9)	182 (13.1)	1386 (86.2)
Missing	4	0	4
Relationship of consenting caregiver to the child			
Mother	1136 (88.3)	151 (11.7)	1287 (80.3)
Father	147 (79.9)	37 (20.1)	184 (11.5)
Grandparent	53 (70.7)	22 (29.3)	75 (4.7)
Aunt or Uncle	27 (69.2)	12 (30.8)	39 (2.4)
Other	11 (64.7)	6 (35.3)	17 (1.1)
Missing	7	2	9
Caregiver education			
No school	115 (76.2)	36 (23.8)	151 (9.4)
Primary school	839 (86.0)	137 (14.0)	976 (60.7)
Secondary school	389 (87.6)	55 (12.4)	444 (27.6)
University	36 (94.7)	2 (5.3)	38 (2.4)
Missing	2	0	2
Caregiver marital status			
Unmarried	65 (80.2)	16 (19.8)	81 (5.0)
Married	1273 (86.7)	196 (13.3)	1469 (91.2)
Divorced	36 (70.6)	15 (29.4)	51 (3.2)
Widowed	7 (77.8)	2 (22.2)	9 (0.6)
Missing	0	1	2
Children in the home			
0	15 (88.2)	2 (11.8)	17 (1.1)
1–2	484 (86.3)	77 (13.7)	561 (35.3)
3–5	571 (87.8)	79 (12.2)	650 (40.8)
6–10	275 (80.6)	66 (19.4)	341 (21.3)
>10	22 (91.7)	2 (8.3)	24 (1.5)
Missing	14	4	18
Was the child born at home?			
No	738 (85.1)	129 (14.9)	867 (55.3)
Yes	607 (86.7)	93 (13.3)	700 (44.7)
Missing	36	8	44
Age of oldest child (years)			
Mean (SD)	9.94 (7.76)	10.76 (8.60)	10.06 (7.88)
Missing	34	8	42

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Table 2 Continued

Characteristics	Fully vaccinated[a], n (%)	Not fully vaccinated[a], n (%)	Total population, n (%)
Location where the child was vaccinated			
Government health centre 3	340 (81.9)	75 (18.1)	415 (25.8)
Government health centre 2	545 (85.2)	95 (14.8)	640 (39.8)
Private health centre or hospital	377 (88.7)	48 (11.3)	425 (26.4)
visit by immunization program	68 (88.3)	9 (11.7)	77 (4.8)
Other	49 (96.1)	2 (3.9)	51 (3.2)
Missing	2	1	3
Child's immunization card availability			
Yes	1035 (96.5)	37 (3.5)	1072 (66.5)
No	309 (57.3)	230 (42.7)	539 (33.5)
Missing	0	0	0

Children were divided into fully vaccinated (having all recommended vaccines in Uganda in 2022) and not fully vaccinated (missing at least one of the recommended vaccines). Values represent the count and percentage of applicable children and mean and standard deviation (SD) for continuous values. Missing values are excluded from percentage calculations.
[a]Fully vaccinated and not fully vaccinated columns use row percentages while the total column uses column percentages.

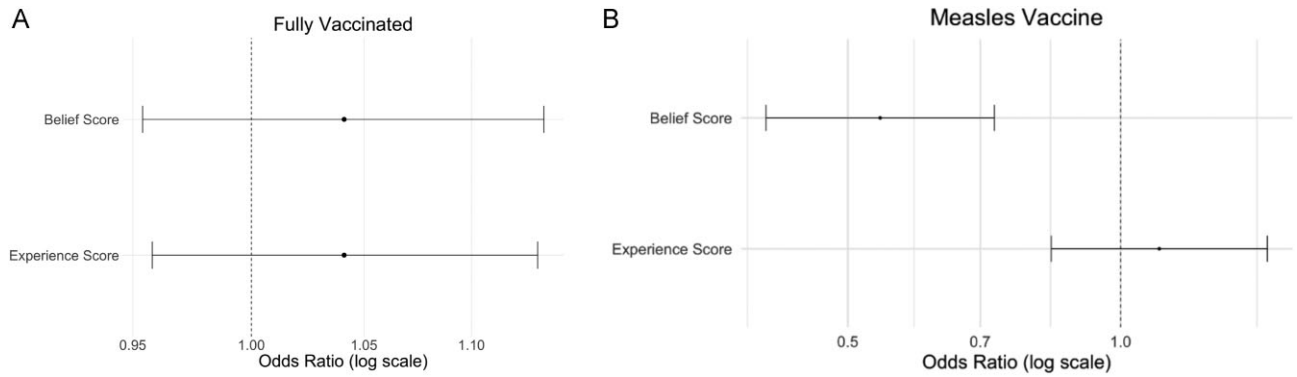


Figure 2 Forest plots of the association between vaccination status and composite scores. Forest plot ORs of the log scale for comparisons of **(A)** children considered fully vaccinated vs not fully vaccinated and **(B)** children with the measles vaccine compared with those without the measles vaccine. Both panels include ORs for the composite scores. Children with data on overall vaccination status but not individual vaccines were still included in panel A. Dots on each bar indicate the point estimate and the 95% CI represented by the bars extending from the point estimate.

those visiting private facilities (Table 3). Caregivers who did not complete school were most likely to have a lower aggregate belief score compared with those who completed primary or secondary school. Further, caregivers of children born at home or at government health facilities were more likely to have a higher aggregate belief score over caregivers using private clinics or hospitals. Children who slept under a bed net the previous night were associated with a higher aggregate belief score.

In contrast, higher experience scores were associated with a larger number of children living in the home, if a child had previously stayed overnight in a hospital or clinic compared with those never spending a night in a hospital, and married caregivers compared with unmarried caregivers. Similar to higher belief scores, higher experience scores were also associated with caregivers bringing the child to government health centres for vaccinations. In contrast to belief scores, caregivers who did not complete school compared with those who completed primary and secondary school were associated with a higher aggregate experience score.

Factors associated with immunization card reports

Caregiver sex, relationship to child, marital status, education level and bed net use were significantly associated with immunization card reports (Table 4). Among households with child immunization cards, caregivers were 1.30 times as likely to be female than male. Additionally, mothers were more likely to show immunization cards than fathers, grandparents, aunts, uncles and other caregivers (relative risk 1.28, 1.77, 1.70 and 2.17, respectively). Households with bed nets were 1.43 times as likely to show immunization cards than those without bed nets.

Sensitivity analysis

The sensitivity analysis assessing the impact of having a vaccine card vs incorporating caregiver recall produced similar results to the primary analysis. However, differences exist between the two groups. In the model for vaccine card availability, caregivers with

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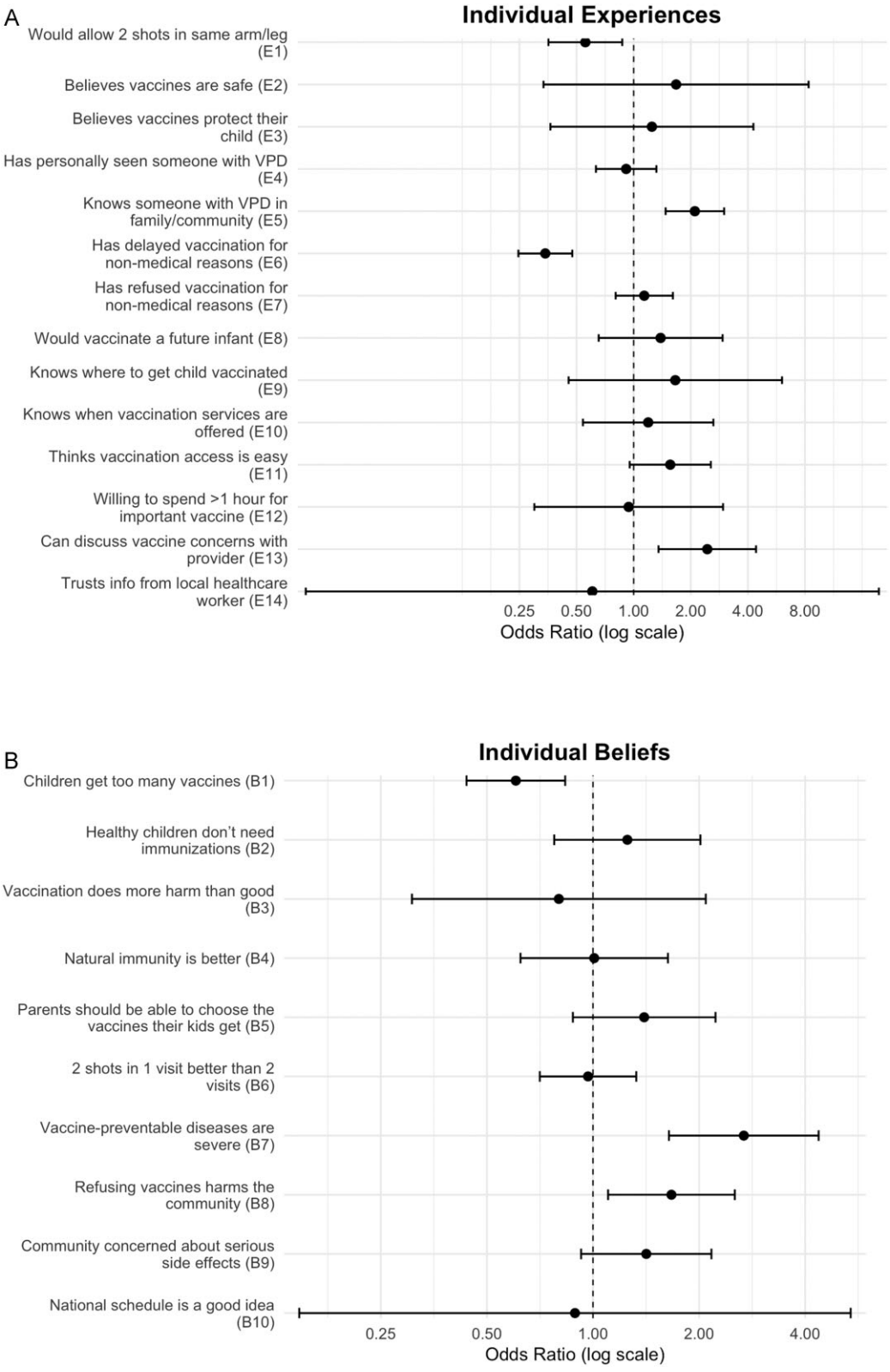


Figure 3 Forest plots of the association between vaccination status and score components. Forest plots show the ORs of the log scale for comparisons of **(A)** individual experience questions and **(B)** individual belief questions with child vaccination status (fully vaccinated vs not fully vaccinated). Children with data on overall vaccination status but not individual vaccines were still included in both panels. Dots on each bar indicate the point estimate and the 95% CI represented by the bars extending from the point estimate.

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Table 3 Caregiver and child factors associated with aggregate belief and experience scores.

	Belief score		Experience score	
Factors	**Effect size**	**p-value**	**Effect size**	**p-value**
Number of children living in the home	−0.001	0.946	0.070	**<0.001*** **
If the child slept under an LLIN the previous night	0.089	**<0.001*** **	0.006	0.808
If the child has ever been hospitalized	0.003	0.623	0.131	**<0.001*** **
Primary vaccination location		**<0.001*** **		**0.002** **
Government health centre 2 vs private health centre or hospital	130	**<0.001*** **	68.8	0.137
Government health centre 3 vs private health centre or hospital	158	**<0.001*** **	−40.2	1.00
Visit by immunization program vs private health centre or hospital	224	**<0.001*** **	−46.5	1.00
Visit by immunization program vs other	242	**0.02***	−38.2	1.00
Government health centre 2 vs government health centre 3	27.3	0.696	109	**<0.001*** **
Education level of the caregiver		**0.006** **		**0.019***
No school vs primary school	−138	**<0.001*** **	103	**0.04***
No school vs secondary school	−132	**0.01***	129	**0.01***
Marital status of the caregiver		0.396		**0.002** **
Married vs unmarried	82.8	0.714	182.4	**0.003** **
Where the child was born		**<0.001*** **		0.833
Home vs private clinic or hospital	102	**0.003** **	−15.2	1.00
Government health facility vs private clinic or hospital	114	**<0.001*** **	−2.32	0.927

The Kendall's τ rank correlation test was used to assess an association between the number of children living in the home and the aggregate score. The Wilcoxon rank-sum test and Cohen's d statistic were used to assess whether a child who slept under an LLIN the previous night or had ever been hospitalized was associated with the aggregate score. The Kruskal–Wallis test was used to assess whether primary vaccination location, caregiver education level, caregiver marital status or child birthplace was associated with the aggregate score. Dunn's test was used to perform multiple comparisons and calculate mean rank differences. The significance level (α) was adjusted to 0.05 using Holm's method.
Significant values in bold.
*$p<0.05$, **$p<0.01$ and ***$p<0.001$.

a secondary-level education, being married and use of an LLIN for the child were more likely to have a vaccine card available for inspection. Importantly, vaccine card presence was significantly associated with positive caregiver experiences as an aggregate score. Further details are available in the Supplementary Material and Supplementary Figure S2.

Discussion

In this cross-sectional survey of rural villages in western Uganda, we found that approximately 85% of children were fully vaccinated—a proportion similar to or slightly higher than the national average and notable for rural settings, where coverage is often more variable. We did see positive associations between vaccination status and caregiver beliefs or experiences relating to vaccine-preventable diseases and perceptions of community benefit. In contrast, children of caregivers who expressed concerns about the number of vaccines children receive and those who had previously delayed vaccines for non-medical reasons were less likely to be fully vaccinated. However, we did not find statistical associations between vaccination status and the belief or experience composite scores.

The lack of association with composite scores, alongside significant effects for individual beliefs and experiences, indicates that overall caregiver attitudes may matter less than particular concerns in shaping vaccination behaviour. Further, in a relatively high-coverage setting, broad caregiver belief and experience measures may have limited the ability to explain differences in vaccination status, and variation is instead concentrated among a smaller subgroup with specific concerns. This may be partly attributed to vaccination being generally accepted in this setting, so most caregivers vaccinate their children by default, highlighting the importance of examining specific beliefs and experiences when designing interventions.

From a programmatic perspective, this suggests that interventions based on generalized vaccine promotion or confidence building may yield diminishing returns in similar settings. Instead, more targeted strategies, such as addressing concerns about vaccination schedules, engaging caregivers who have previously delayed vaccination and working to strengthen continuity of care, may be more effective in reaching the remaining undervaccinated children.

Evidence from other sub-Saharan African settings suggests that as vaccination coverage increases and access improves, undervaccination becomes less associated with physical barriers and more influenced by caregiver beliefs, trust in the health system and perceptions of disease risk.[14,18,19] Our findings diverge somewhat from this expectation. This may reflect that high baseline coverage compresses variability in general attitudes, leaving only specific beliefs or system factors to influence uptake. Instead, what we observe may reflect an overall high level of vaccine confidence in Uganda, where—at least prior to the COVID-19 pandemic—84% of the population believed vaccines are safe, 83% considered them effective and 76% viewed childhood vaccination as important, which leaves little room for perception-related variation in uptake.[20] It may also be that beliefs and attitudes around vaccination work in conjunction with other factors not considered

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Table 4 Caregiver characteristics associated with immunization card reports.

Characteristics	Has immunization card, n (%)	No immunization card, n (%)	p-Value[a]
Caregivers	1138 (67.8)	541 (32.2)	
Caregiver sex			<0.001***
Female	1010 (69.9)	435 (30.1)	
Male	124 (53.9)	106 (46.1)	
Missing	4	0	
Relationship to child			<0.001***
Mother	970 (72.2)	374 (27.8)	
Father	108 (56.3)	84 (43.8)	
Grandparent	31 (40.8)	45 (59.2)	
Aunt or Uncle	17 (42.5)	23 (57.5)	
Other	6 (33.3)	12 (66.7)	
Missing	6	3	
Education level of the caregiver			0.003**
No school	87 (55.4)	70 (44.6)	
Primary school	699 (68.4)	323 (31.6)	
Secondary school	319 (69.5)	140 (30.5)	
University	31 (79.5)	8 (20.5)	
Missing	2	0	
Marital status of the caregiver			0.002**
Unmarried	46 (54.8)	38 (45.2)	
Married	1057 (69.1)	473 (30.9)	
Divorced	27 (50.9)	26 (49.1)	
Widowed	7 (70.0)	3 (30.0)	
Missing	1	1	
LLIN use			<0.001***
Yes	1068 (69.5)	469 (30.5)	
No	68 (48.6)	72 (51.4)	
Missing	2	0	

[a]Pearson's χ^2 test; Fisher's exact test.
*p<0.05, **p<0.01 and ***p<0.001.

in our study, such as familial support and community ties and values.[21,22]

However, receipt of the measles vaccine was associated with the more negative beliefs about vaccines. This finding should be interpreted with caution. In sensitivity analyses including only children with an immunization card, the association of full vaccination status with belief score was positive, suggesting that the observed relationship in the full sample may be driven by differences in measurement between caregivers with and without immunization cards.

These findings may also be explained by differences between those who maintained their immunization cards and those who did not, by programmatic and supply-side challenges rather than caregiver hesitancy or a combination of both factors. Even when caregivers are motivated and supportive, vaccine uptake can be hindered by stockouts or shortages of the measles vaccine at health facilities, a documented issue in Uganda, though not specific to the measles vaccine.[23] Alternatively, these results could be influenced by social desirability bias, as participants may be reluctant to express negative views of government health services or vaccination, potentially leading to overreported confidence in vaccines. This association could also result from uncontrolled confounding. Similar contradictory relationships have been reported in other sub-Saharan African settings where full vaccination was found to be associated with worse health service delivery.[21] In summary, these findings suggest that the observed negative association is unlikely to reflect a true inverse relationship between caregiver beliefs and vaccination uptake, but rather highlights the influence of measurement limitations and health system factors. This supports our broader finding that, in relatively high-coverage settings, residual variation in vaccination may be driven less by caregiver beliefs and more by challenges related to competing the immunization schedule.

Overall, the caregivers who take their children to a government health facility or immunization program, had completed primary or secondary school and delivered their children at a government health facility tended to have more positive beliefs about vaccination. These findings are consistent with other studies demonstrating that maternal education, facility-based delivery and engagement with routine health services are strongly associated with greater vaccine confidence and uptake.[24,25] In addition, presenting the immunization card was more common among female caregivers, most often the mother, and those with higher education, who may also have the ability to take greater care with other health-related behaviours, such as proper use of LLINs, reflecting overall health consciousness.[26]

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Beliefs around vaccines preventing severe disease and harms of vaccine refusal to the community, as well as the ability to discuss concerns with healthcare providers and knowing someone who had previously been infected with a vaccine preventable disease, including polio, pneumonia, measles or whooping cough, was associated with higher odds of a caregiver's child being fully vaccinated. This is in line with other studies that demonstrate how caregiver awareness of disease severity and perceived benefits of vaccination are key drivers of vaccine uptake. In rural areas of western Uganda, mothers who demonstrated a basic understanding of the importance of childhood immunizations were more likely to ensure their children received timely and complete vaccinations.[25] These findings that, in high-coverage settings such as ours, leveraging trusted community health workers to address specific concerns and reinforce completion of the full vaccination schedule may be particularly important for reaching the remaining undervaccinated children.

Limitations

While this study benefited from a large sample size and a census of children from the target population, a relatively large subset of children did not have an immunization card. Sensitivity analyses did indicate differences in results when including the entire sample vs including only caregivers with immunization cards. This difference could be driven by recall bias or systematic differences between the two groups related to card ownership. For example, individuals who are more concerned with making sure their children are fully vaccinated may also be more likely to retain and keep track of the immunization card. To try to assess the potential impact of recall bias, we reran models with datasets representing 10–50% recall bias among those without their immunization cards, which showed little impact on the results in either magnitude or direction.

Additionally, due to the higher-than-expected vaccination coverage for a rural area, there was little variation in outcome measures. This homogeneity limited the study's statistical power and increased the risk of model instability. Given the imbalance in the outcome data, caution should be exercised when interpreting the results.

There is also a possibility of bias given the presence of community health workers during the interviews that might have led participants to report more socially desirable responses regarding vaccination beliefs and experiences. It is also possible that it would lead to overreporting of vaccinations. However, given the ability to check vaccination cards and the results of the sensitivity analysis, we believe this to be small.

Lastly, this study was conducted during the COVID-19 pandemic and attitudes towards vaccination may have changed either positivity or negatively in the wake of the rollout of the COVID-19 vaccine.

Supplementary data

Supplementary data are available at *Transactions* online.

Authors' contributions:

Annika K. Gunderson (Formal analysis [supporting], Writing—original draft [lead], Writing—review & editing [lead]), Taeim Kwon (Formal analysis [equal], Writing—original draft [supporting], Writing—review & editing [equal]), Yohhan Kumarasinghe (Formal analysis [equal], Writing—original draft [supporting], Writing—review & editing [equal]), Yuanyuan Yan (Formal analysis [equal], Writing—original draft [supporting], Writing—review & editing [supporting]), Joyce Choe (Formal analysis [equal], Writing—original draft [supporting], Writing—review & editing [equal]), Qikai Jiang (Formal analysis [equal], Writing—original draft [supporting], Writing—review & editing [equal]), Emmanuel Baguma (Investigation [lead], Writing—review & editing [equal]), Shem Bwambale (Investigation [supporting], Writing—review & editing [equal]), John R. Barber (Writing—review & editing [equal]), Raquel Reyes (Writing—review & editing [equal]), Moses Ntaro (Writing—review & editing [equal]), Paul L. Delamater (Conceptualization [equal], Writing—review & editing [equal]), Edgar M. Mulogo (Conceptualization [equal], Writing—review & editing [equal]), Ross M. Boyce (Conceptualization [equal], Funding acquisition [lead], Writing—review & editing [equal]).

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Competing interests

None declared.

Ethical approval

The study protocol was reviewed and approved by the Mbarara University of Science and Technology Research Ethics Committee (11/11-18), the Uganda National Council of Science and Technology (HS 2617) and the University of North Carolina (UNC) Institutional Review Board (18-2885). Written informed consent was obtained from all adult study participants and the caregivers of children.

Data availability

Deidentified individual data that supports the results will be made available provided the investigator who proposes to use the data has approval from an institutional review board, independent ethics committee or research ethics board, as applicable, and executes a data use/sharing agreement with UNC. The principal investigator should submit a request to the UNC Industry Contracting team (OSPContracting@unc.edu) to initiate the data use/sharing agreement.

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References

1 Ssebagereka A, de Broucker G, Ekirapa-Kiracho E et al. Equity in vaccine coverage in Uganda from 2000 to 2016: revealing the multifaceted nature of inequity. *BMC Public Health*. 2024;24(1):185.

2 World Health Organization. Immunization dashboard African Region. Available from: https://immunizationdata.who.int/dashboard/regions/african-region

3 World Health Organization African Region. *Ending disease in Africa: status of immunization coverage in Africa as of the end of 2022*. Brazzaville: World Health Organization African Region; 2023.

4 Wasswa R, Kananura RM, Waiswa P et al. Subnational trends and inequalities of under-immunisation and zero-dose among children aged 12–23 months in Uganda: a national population-based cross-sectional study. *BMJ Open*. 2025;15:e093619.

5 Jammeh A, Muhoozi M, Kulane A et al. Comparing full immunisation status of children (0–23 months) between slums of Kampala City and the rural setting of Iganga District in Uganda: a cross-sectional study. *BMC Health Serv Res*. 2023;23:856.

6 Uganda Bureau of Statistics. *Uganda Demographic and Health Survey 2022*. Kampala: Uganda Bureau of Statistics; 2023.

7 Babirye JN, Engebretsen IMS, Makumbi F et al. Timeliness of childhood vaccinations in Kampala Uganda: a community-based cross-sectional study. *PLoS One*. 2012;7(4):e35432.

8 Kigongo E, Opollo MS, Nalwoga V et al. Perspectives of pediatric vaccination among the Batwa community in western Uganda: a qualitative study. *Glob Pediatr Health*. 2024;11:2333794X241298834.

9 Oduwole EO, Mahomed H, Laurenzi CA et al. Point-of-care vaccinators' perceptions of vaccine hesitancy drivers: a qualitative study from the Cape Metropolitan District, South Africa. *Vaccine*. 2021;39(39):5506–12.

10 Adeyanju GC, Sprengholz P, Betsch C et al. Caregivers' willingness to vaccinate their children against childhood diseases and human papillomavirus: a cross-sectional study on vaccine hesitancy in Malawi. *Vaccines (Basel)*. 2021;9(11):1231.

11 Mavundza EJ, Cooper S, Wiysonge CS. A systematic review of factors that influence parents' views and practices around routine childhood vaccination in Africa: a qualitative evidence synthesis. *Vaccines (Basel)*. 2023;11(3):563.

12 Ozigbu CE, Olatosi B, Li Z et al. Correlates of zero-dose vaccination status among children aged 12–59 months in sub-Saharan Africa: a multilevel analysis of individual and contextual factors. *Vaccines (Basel)*. 2022;10(7):1052.

13 Ikilezi G, Augusto OJ, Sbarra A et al. Determinants of geographical inequalities for DTP3 vaccine coverage in sub-Saharan Africa. *Vaccine*. 2020;38(18):3447–54.

14 Bangura JB, Xiao S, Qiu D et al. Barriers to childhood immunization in sub-Saharan Africa: a systematic review. *BMC Public Health*. 2020;20:1108.

15 Fenta SM, Biresaw HB, Fentaw KD et al. Determinants of full childhood immunization among children aged 12–23 months in sub-Saharan Africa: a multilevel analysis using Demographic and Health Survey Data. *Trop Med Health*. 2021;49:29.

16 Boyce RM, Delamater P, Muhindo R et al. Accessible metrics of access: novel tools to measure immunization coverage in rural sub-Saharan Africa. *Gates Open Res*. 2019;3:1540.

17 Wallace AS, Wannemuehler K, Bonsu G et al. Development of a valid and reliable scale to assess parents' beliefs and attitudes about childhood vaccines and their association with vaccination uptake and delay in Ghana. *Vaccine*. 2019;37:848–56.

18 Tamirat KS, Sisay MM. Full immunization coverage and its associated factors among children aged 12–23 months in Ethiopia: further analysis from the 2016 Ethiopia demographic and health survey. *BMC Public Health*. 2019;19:1019.

19 Lakew Y, Bekele A, Biadgilign S. Factors influencing full immunization coverage among 12–23 months of age children in Ethiopia: evidence from the national demographic and health survey in 2011. *BMC Public Health*. 2015;15:728.

20 Vaccine Confidence Project. Vaccine confidence in Uganda. Available from https://www.vaccineconfidence.org/vci/country/ug/ [accessed 7 November 2025].

21 Bell J, Lartey B, Fernandez M et al. A structural equation modelling approach to understanding the determinants of childhood vaccination in Nigeria, Uganda and Guinea. *PLOS Glob Public Health*. 2023;3:e0001289.

22 Bell J, Lartey B, Spickernell G et al. Applying a social-ecological model to understand factors impacting demand for childhood vaccinations in Nigeria, Uganda, and Guinea. *SSM Qual Res Health*. 2022;2:100180.

23 World Health Organization. Immunization and vaccine-preventable communicable diseases. Available from: https://www.who.int/data/gho/data/themes/immunization [accessed 7 November 2025].

24 Fadl N, Abdelmoneim SA, Gebreal A et al. Routine childhood immunization in Sub-Saharan Africa: addressing parental vaccine hesitancy. *Public Health*. 2024;226:66–73.

25 Vonasek BJ, Bajunirwe F, Jacobson LE et al. Do maternal knowledge and attitudes towards childhood immunizations in rural Uganda correlate with complete childhood vaccination? *PLoS One*. 2016;11(2):e0150131.

26 Li W, Sewolo F, Aoun A et al. Characteristics of studies focusing on vaccine series completion among children aged 12–23 months in sub-Saharan Africa: a scoping review. *Children (Basel)*. 2025;12(4):415.

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