

Vaccination Status of OPV0 and BCG in Preterm Infants and Associated Factors in Southwestern Uganda: A Cross-Sectional Study

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Background: Despite the high Uganda National target of 90% for Bacillus Calmette-Guerin (BCG) and birth dose Oral Polio Vaccine (OPV0), preterm infants in Uganda remain at increased risk for vaccine preventable diseases due to delayed or missed early vaccination. The delay may be a result of poor understanding of the safety and effectiveness of vaccines. The exact estimate of preterm infants vaccinated, the vaccines missed or delayed and drivers of this vaccination status are not well studied in Southwestern Uganda. This study therefore determined the vaccination status of BCG and OPV0 in preterm infants and associated factors in the Southwestern region.

Methods: We conducted a cross-sectional quantitative study between May and September 2023 at Mbarara Regional Referral Hospital and Holy Innocent Children's Hospital. We consecutively recruited 350 preterm infants and their caretakers as they attended the newborn follow-up clinic and extracted data from their medical records. We described the vaccination status and used logistic regression model to determine associated factors.

Results: The median age of preterm infants was 13 weeks Interquartile range (IQR), 4–26 and the median birth weight was 1.6kg, IQR, 1.3–1.8 at the time of the study. Two-thirds 66.6% (233/350) of our preterm infants had received both BCG and OPV0. More preterm infants 65.4% (229/350) had received BCG than OPV0 28% (98/350). Increasing preterm infant age, regular maternal antenatal care attendance and hospital discharge recommendation of vaccination increased the likelihood of vaccinating a preterm infant. However, denial of vaccination at first presentation negatively influenced vaccination of preterm infants.

Conclusion: The vaccination status of BCG and OPV0 among preterm infants in the greater part of Southwestern Uganda is below the national target. Consequently, interventions are needed to improve timely vaccination rates among preterm infants before hospital discharge.

Keywords: vaccination, preterm infants, Southwestern Uganda

Introduction

Vaccination is a primary health care activity estimated to avert between two and three million deaths annually.¹ The majority of vaccination programs are targeted at children under the age of five because of the high burden of infectious diseases in this demographic.² In fact, approximately 5.6 million children under five died, many from vaccine-preventable diseases.³

Worldwide, there is a delay in vaccination of preterm infants with over 50% being under vaccinated at 19 months.⁴ Notably, Uganda's vaccination coverage for all basic vaccinations of children aged 12–23 months has stagnated at around 50%

for the past 10 years with the most recent being 54%. The target for Bacillus Calmette-Guerin (BCG) and Oral Polio Vaccine 0 (OPV0) is 90% and the most current coverage for BCG is 98% with no specific estimate for OPV0.⁵ Health agencies, including the American Academy of Pediatrics and the World Health Organization (WHO), recommend routine vaccination of preterm infants according to the chronological age shown for each vaccine dose excluding the Hepatitis B vaccine for infants weighing less than 2000g.⁶

The BCG and OPV vaccines are live attenuated vaccines given routinely to all newborn infants in developing countries under Universal Immunization Program.⁷ BCG is given at birth to prevent severe forms of Tuberculosis (TB). Preterm infants are more vulnerable to TB exposure particularly if they reside in regions with a high TB prevalence.⁸ On the other hand, OPV0 is given to protect infants from polio early in life before they have a chance to be exposed to the virus. Poliovirus is a highly contagious virus that can cause paralysis and death. Timely vaccination is critically important for this group because their immature immune systems are compromised significantly by reduced trans placental IgG transfer during the third trimester⁹ and an impaired humoral response due to B-cell immaturity.¹⁰ These deficits not only result in lower baseline protective antibodies but also mean that passively acquired maternal antibodies wane to undetectable levels as early as 4 months of life,⁹ collectively resulting in a diminished ability to mount robust, self-generated defenses against diseases.

Delay in initiation of OPV0 and BCG results in missed opportunities and subsequent delay in other vaccinations leading to an increase in the susceptibility window for VPDs, with increased severity, morbidity and mortality.¹¹ Vaccine delay also leads to outbreaks of vaccine preventable diseases.¹² In 2021, Uganda had an outbreak of polio which was attributed to delayed infant vaccination.¹³ Uganda continues to battle recurring VPD outbreaks. For instance, since January 2024, the Ministry of health has registered measles outbreaks across several districts, including those in the western region.¹⁴ Furthermore, Uganda's neonatal mortality remains unacceptably high at 22 deaths per 1,000 live births.⁵ The severity is amplified in the southwestern region, where studies at MRRH, the major referral center report the incidence of early neonatal mortality (within 7 days) as high as 12% among admitted neonates.¹⁵ At MRRH and nationally, prematurity is the leading cause of neonatal death often complicated by sepsis (diagnosis for up to 36% of admitted neonates).¹⁶ Vaccination delay can be influenced by how caretakers seek, demand and utilize vaccination services or by how services are communicated and delivered. Preterm infants' delayed vaccinations may be a result of caretakers' and health care workers' lack of understanding regarding the safety and effectiveness of vaccines.¹² The delay could also be attributed to the fear of cardio-respiratory adverse outcomes that may occur in extreme preterm infants,¹⁷ the immature Immune System and clinical instability characterized by the frequent presence of acute medical complications in the neonatal intensive care unit (NICU).¹⁸ Furthermore, low birth weight is intrinsically linked to higher clinical fragility and greater risk of complications, and both parents and healthcare workers often fear that the infant is too small and frail to tolerate the vaccine.¹⁹

Given that preterm infants are already prone to both delayed vaccination and increased vulnerability to fatal infections, understanding the regional vaccination status is imperative. However, there is a distinct lack of data in Southwestern Uganda regarding the actual BCG and OPV0 vaccination status of preterm infants and associated factors. This study therefore sought to determine the vaccination status of BCG and OPV0 and associated factors to guide interventions that will promote timely vaccination of preterm infants in Southwestern Uganda.

Methods

Study Design

We conducted a quantitative cross-sectional study to determine the vaccination status of BCG and OPV0 among preterm infants and factors associated with vaccination status of preterm infants. The study was conducted from May to September 2023.

Study Site

We conducted this study at 2 sites; Mbarara Regional Referral Hospital (MRRH) and Holy Innocents Children's Hospital (HICH).

Mbarara Regional Referral Hospital (MRRH)

At MRRH, the study was conducted in the newborn unit, neonatal follow-up clinic, maternity ward and Maternal and Child Health care unit (MCH). MRRH is a government owned facility that also serves as a teaching facility for Mbarara

University of Science and Technology (MUST). This hospital mainly serves low socio-economic status patients and has a large patient population. At MRRH, infants receive at-birth vaccinations from the maternity ward and the subsequent vaccinations are received from the MCH unit. No vaccination services are offered in the newborn unit; however, caretakers are encouraged to take their newborn infants to maternity ward or nearby health facilities for vaccination upon discharge. The maternity ward is about 50 meters from the neonatal unit. MCH on the other hand is about 300 meters from the neonatal unit. While may seem trivial, this short distance requires additional coordination, time and dedicated personnel to move clinically stable yet fragile preterm infants and their accompanying caretakers especially during busy clinic hours. Vaccination services on maternity ward are offered throughout the week while those offered at MCH are given on week days Monday to Friday with no special day for vaccination of preterm infants. The hospital has only 6 nurses that are attached to the vaccination service, 3 in each of the units. All vaccination services are offered between 9:00am to 3:00pm and at no cost. Most of the patients served are of a lower Socio-economic status, with large patient populations and patients, may experience longer delays in seeking or receiving care due to access barriers.

On average preterm infants are discharged at 1–2 weeks of life. The caretakers are normally informed a day earlier about the possibility of discharge and the chronic care plan is discussed with the family; vaccination, danger signs, enrollment and review in the preterm follow-up clinic, breast feeding and KMC, among others. Discharged preterm infants are reviewed every Thursday in the newborn follow-up clinic where their vaccination status is ascertained. Unvaccinated preterm infants or those with missed doses are linked to the vaccination team. About 25 preterm infants are reviewed on each clinic day. Public referral hospitals such as MRRH are characterized by a high turnover of healthcare workers including rotating interns, residents in pediatrics and student services. This frequent rotation introduces significant handoff errors and a fragmentation of service ownership. Non acute but critical administrative tasks like confirming vaccination status and ensuring proper scheduling before discharge are vulnerable to being overlooked during shifts in team responsibility.

Holy Innocents Children's Hospital (HICH)

HICH is a private not for profit church-based children's hospital, located at Nyamitanga in Mbarara district. It is a children only facility owned by the Uganda Catholic Medical Bureau (UCMB). All admissions to HICH are either referrals from nearby health facilities or walk in clients from the neighboring community. Patients at HICH are mostly from a higher socio-economic status or privately insured. The hospital has a newborn unit with a 22 bed capacity NICU. Preterm infants contribute about a quarter of their newborn admissions. The facility runs a free vaccination service every Wednesday and Sunday from 8:00 am to 1:00pm. Babies are either vaccinated before discharge or on their first review in the newborn clinic. Nurses do health talks to the mothers before they vaccinate the children. The newborn clinic takes place on Wednesdays and is run by a pediatrician with about 5 preterm infants reviewed per clinic day. Private hospitals like HICH often rely on a stable core of permanent staff with clear, consistent accountability for patient outcomes.

All preterm babies admitted to the above two facilities are reviewed routinely until they are about 12–18 months depending on the degree of prematurity and clinical status. Smaller infants who have more clinical concerns are kept longer in the chronic care clinics.

Study Population

We included stable preterm infants and their caretakers from the respective newborn clinics. We collected data from their caretakers and also reviewed their medical records including antenatal cards/books, obstetric scans, discharge forms, preterm review books and child health cards.

Preterm infants who had missing data and had been brought in by a caretaker who could not provide sufficient antenatal, perinatal and post-natal information were excluded from the study.

Sample Size Estimation

The sample size was calculated using the Kish Leslie formula for cross-sectional studies. We based on a study conducted at Mulago National Referral Hospital where the proportion of preterm infants who had received vaccination with BCG was 92%.²⁰ This was the only study in literature with similar settings to ours after adjusting for 10% non-response, our final sample size was 350 preterm babies.

Sampling Procedure

We consecutively sampled caretakers and their preterm infants who came in for follow-up in the newborn clinics at MRRH and HICH.

Study Variables

Dependent Variable

Status of BCG and OPV 0 vaccination among preterm infants; which was categorized as vaccinated and not vaccinated. This was confirmed from the Child Health Card and/or presence of a BCG scar.

Independent Variables

- Socio-demographic characteristics of infant: Sex, place of residence, birth order, birth interval, gestational age at birth and any vaccines received.
- Preterm factors: Place of delivery, birth weight, length of hospital stay and clinical diagnosis during admission.
- Parental factors: Maternal age and parity, paternal age and support, caregiver occupation, family size, education level of caregivers and antenatal care attendance.
- Health system factors: Availability of vaccination services at the facility of delivery, Vaccine stock outs,

Data Collection Procedure

We used a pretested electronic questionnaire designed in Google Forms and also reviewed child health cards, discharge forms, antenatal records and preterm review books /forms. Preterm infants whose caretakers never had child health cards were examined for the BCG scar to confirm the vaccination status. About 10 minutes was spent with each participant. All research activities were done after the preterm babies had completed their routine clinic review.

Data Management

We collected and managed the data using Google forms on android tablets (version 10) that were dedicated to the study. All the data collection forms were password protected and so were the tablets used. We checked all the collected data for completeness immediately after each recruitment. The data was cleaned in MS Excel and transferred to STATA version 15 for analysis.

Data Analysis

The status of vaccination among preterm infants was determined as a proportion of preterm infants who had been vaccinated at the time of the study. Continuous variables were presented as means and standard deviations (if normally distributed) or median and interquartile range (non-normally distributed). Categorical data was presented as percentages. A Chi-square test and Student's *t*-test were used to determine how independent variables are associated with vaccination.

In analytical statistics, to determine the factors associated with vaccination status, we used logistic regression analysis. Factors with a $p < 0.2$ and those that were biologically plausible were included in the multivariable model. Factors with a p -value < 0.05 were considered statistically significant.

Results

Three hundred fifty (350) preterm infants attending the newborn clinic at MRRH and HICH were enrolled in the study with 300 corresponding mothers (50 of the mothers had multiple pregnancy). Of these infants, 88.3% (309/350) were enrolled from MRRH (Figure 1).

Socio-Demographic Characteristics of Preterm Infants

The median age of preterm infants was 13 weeks (IQR 4–26) and the median birth weight was 1.6kg (IQR 1.3–1.8). Over half (52.29%, 183/350) were female. Preterm infants that were vaccinated were about 4 times older than those that were not vaccinated. More than half (61.67%) resided in rural areas (Table 1).

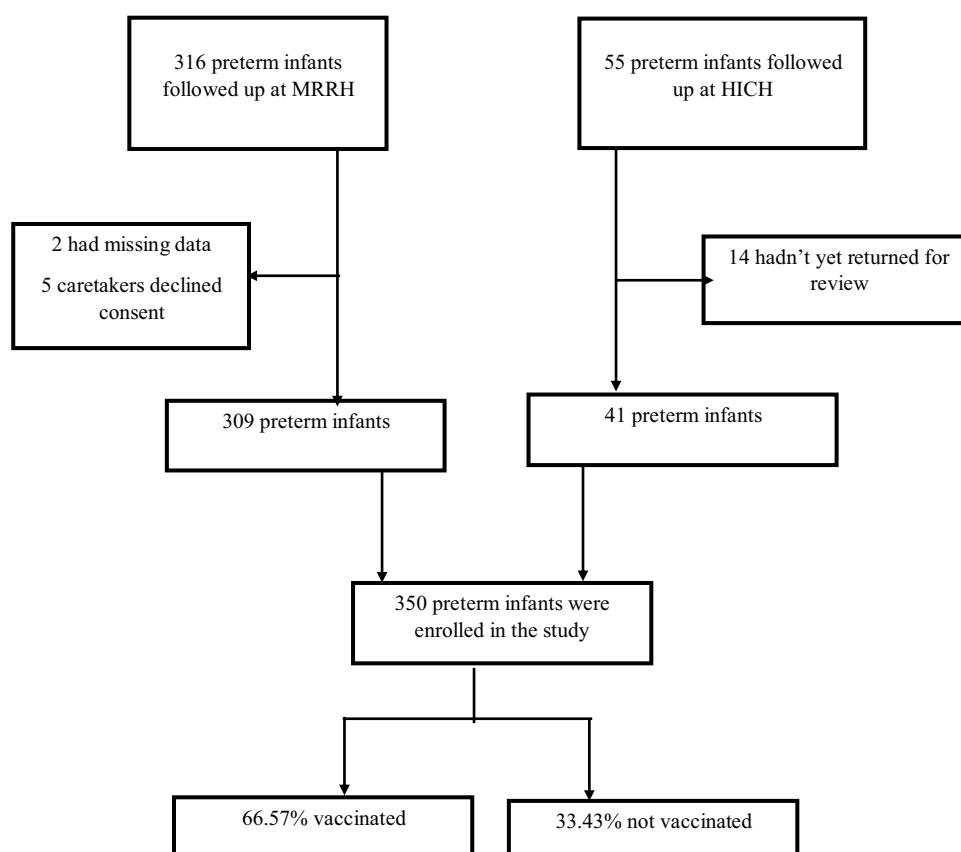


Figure 1 Flow chart summarizing preterm infant numbers.

Maternal Characteristics

The mean maternal age was 28 years (± 6.03). Majority of the mothers were married and about 42.33% (127/300) with at least secondary level of education. Despite the fact that most of the mothers were married (95.33%, 286/300), only 2% (6/300) had their partners available for the review (Table 2).

Table 1 Socio-Demographic Characteristics of Preterm Infants (N=350)

Study Variables	N (%)	Infant Vaccinated		P-value
		No; 117 (33.43%)	Yes; 233 (66.57%)	
Median Age in weeks (interquartile range)	13(4–26)	5(3–9)	21(11–32)	98.68 (<0.001)
Sex				
Female	183 (52.29)	59 (32.24)	124 (67.76)	0.24 (0.622)
Male	167 (47.71)	58 (34.73)	109 (65.27)	
Residence				
Rural	185 (61.67)	68 (36.76)	117 (63.24)	1.63 (0.201)
Urban	115 (38.33)	34 (29.57)	81 (70.43)	

(Continued)

Table 1 (Continued).

Study Variables	N (%)	Infant Vaccinated		P-value
		No; 117 (33.43%)	Yes; 233 (66.57%)	
Birth order				
Median (interquartile range)	2(1–3)	2(1–4)	2(1–3)	0.89 (0.345)
Birth weight (in grams)				
Median (interquartile range)	1600(1300–1800)	1600(1300–1800)	1600(1300–1900)	1.75 (0.185)

Notes: Student *t* test statistic was used for continuous variables and chi-square for categorical variables; bold number: Indicates statistically significant result.

Table 2 Maternal Characteristics N=300

Study variable	N (%)	Vaccinated Infant		P-value
		No (%)	Yes (%)	
Age of mother (in years)				
($\mu \pm \delta$)	28.29 $\pm$ 6.03	27.38 $\pm$ 6.16	28.76 $\pm$ 5.93	–1.88 (0.060)
Educational level				
None	10 (3.33)	6 (60.00)	4 (40.00)	13.92 (0.003)
Primary	68 (22.67)	27 (39.71)	41 (60.29)	
Secondary	127 (42.33)	50 (39.37)	77 (60.63)	
Tertiary	95 (31.67)	19 (20.00)	76 (80.00)	
Marital status				
Married	286 (95.33)	95 (33.22)	191 (66.78)	1.67 (0.196)
Unmarried	14 (4.67)	7 (50.00)	7 (50.00)	
Caretaker available				
Mother only	270 (90.00)	91 (33.70)	179 (66.30)	0.09 (0.993)
Mother and father	6 (2.00)	2 (33.33)	4 (66.67)	
Mother and other relative	14 (4.67)	5 (35.71)	9 (64.29)	
Other relative	10 (3.33)	3 (30.00)	7 (70.00)	
Religious affiliation				
Christians	256 (85.33)	90 (35.16)	166 (64.84)	1.04 (0.308)

Notes: μ = Mean; δ = Standard deviation; Student *t* test statistic was used for continuous variables and chi-square for categorical variables; bold number: Indicates statistically significant result.

Perinatal Characteristics

The mean weeks of amenorrhea at birth were 32.54 ($\pm$ 2.50). The median number of antenatal visits was 3 (IQR 3–5). The median antenatal visits was higher for mother who had vaccinated their infants than the ones who had not at 3(3–4) vs 4(3–5) (Table 3).

Table 3 Perinatal Characteristics N=300

Study Variables	N (%)	Infant Vaccinated		p-value
		No; 117 (33.43%)	Yes; 233 (66.57%)	
Weeks of amenorrhea at birth ($\mu \pm \delta$)	32.54 $\pm$ 2.50	32.96 $\pm$ 2.18	32.32 $\pm$ 2.63	2.08 (0.038)
Number of antenatal visits Median (IQR)	3(3–5)	3(3–4)	4(3–5)	16.45 (0.001)
Type of pregnancy				
Singleton	250 (83.33)	91 (36.40)	159 (63.60)	
Multiple	50 (16.67)	11 (22.00)	39 (78.00)	3.85 (0.050)
Mode of delivery				
Cesarean section	91 (30.33)	25 (27.47)	66 (72.53)	2.48 (0.115)
Vaginal	209 (69.67)	77 (36.84)	132 (63.16)	
Parity				
Median (interquartile range)	2(1–3)	2(1–4)	2(1–3)	0.74 (0.389)
Maternal comorbidities				
None	214 (71.33)	79 (36.92)	135 (63.08)	6.76 (0.239)
HIV	22 (7.33)	8 (36.36)	14 (63.64)	
Hypertension	21 (7.00)	3 (14.29)	18 (85.71)	
Pre-eclampsia	30 (10.00)	10 (33.33)	20 (66.67)	
Diabetes mellitus	11 (3.67)	2 (18.18)	9 (81.82)	
Others	2 (0.67)	0 (0)	2 (100.00)	

Notes: μ = Mean; δ = Standard deviation; Student t test statistic was used for continuous variables and chi-square statistic for categorical variables. $P < 0.05$ (Statistically significant); bold number: Indicates statistically significant result.

Facility Related Characteristics

The majority of caretakers (92.33%) did not report vaccine stock outs. Most caretakers 53% (159/300) preferred to be vaccinated from the pediatric ward. The median length of hospital stay was 2 weeks (IQR, 1–3) (Table 4).

Vaccination Status of BCG and OPV0 Among Preterm Infants

At the time of the study, 66.6% of preterm infants had received both BCG and OPV0. Among all preterm infants, 65.4% preterm infants had received BCG and about a quarter (28%) had received OPV0 (Figure 2).

Factors Associated with BCG and OPV0 Vaccination

A higher gestational age, AOR 1.21 (95% CI, 1.13–1.30), more antenatal visits, AOR 1.61 (95% CI, 1.06–2.46) and information about vaccination at discharge, AOR 5.25 (95% CI 1.81–15.19) were significantly associated with receiving BCG and OPV0. Preterm infants who were denied vaccination services at first visit were less likely to be vaccinated, AOR 0.03 (95% CI, 0.01–0.14) (Table 5).

Table 4 Facility Related Characteristic N=300

Study variable	N (%)	Infant Vaccinated		p-value
		No (%)	Yes (%)	
Facility (N= 350)				
HICH	41 (11.71)	3 (7.32)	38 (92.68)	14.23 (<0.001)
MRRH	309 (88.29)	114 (36.89)	195 (63.11)	
Availability of vaccines at the health facility of delivery				
Yes	240 (80.00)	76 (31.67)	164 (68.33)	2.91 (0.088)
Vaccine stock outs				
Yes	11 (3.67)	4 (36.36)	7 (63.64)	24.40 (<0.001)
No	277 (92.33)	86 (31.05)	191 (68.95)	
Do not know	12 (4.00)	12 (100.00)	0 (0)	
Preferred vaccination site				
Pediatric ward	159(53.00)	54 (22.22)	105 (66.04)	1.71 (0.427)
Nearby HC	121 (40.33)	41(33.88)	80 (66.12)	
Community outreaches	11 (3.67)	5 (45.45)	6 (54.55)	
Maternity ward	9 (3.00)	2(22.22)	7(77.78)	
Length of hospital stay after birth (in weeks) Median (IQR)	2(1–3)	2(1–3)	2(1–4)	2.88 (0.090)
Informed about vaccination before discharge				
No	282 (80.57)	109 (38.65)	173 (61.35)	17.80 (<0.001)
Informed about vaccination at discharge				
No	98 (32.67)	60 (61.22)	38 (38.78)	48.07 (<0.001)
Yes	202 (67.33)	42 (20.79)	160 (79.21)	
Denied vaccine at first presentation to the vaccination Centre following discharge				
No	200 (66.67)	33 (16.50)	167 (83.50)	117.42 (<0.001)
Yes	45 (15.00)	17 (37.78)	28 (62.22)	
Did not take the child	55 (18.33)	52 (94.55)	3 (5.45)	

Notes: Student t test statistic was used for continuous variables and chi-square for categorical variables; P<0.05 (Statistically significant), bold number: Indicates statistically significant result.

Abbreviations: μ, Mean; δ, Standard deviation; HC, Health Centre; HICH, Holy Innocents Children hospital; MRRH, Mbarara Regional Referral Hospital.

Discussion

Vaccination Status of BCG and OPV0 in Preterm Infants

From our study, 65.4% of preterm infants had received BCG and only 28% had received OPV0 at the time of the study. These findings are way below the 90% Uganda government national target for at birth vaccines. This means that more children in Southwestern Uganda are at high risk of VPDs. The vaccination status in our study was way below that in the Uganda National Referral Hospital, Mulago (MNRH) where 92% had received BCG and 45.4% had received OPV.²⁰ The difference could be because, at MNRH, infants receive BCG and OPV0 in the pediatric ward before discharge. In our study, vaccination was primarily administered on the Maternity Ward, a setup optimized for routine births but which increases the risk of missed opportunities for preterm infants requiring immediate transfer to a separate neonatal unit. In contrast, the high coverage reported at Mulago National Referral Hospital is supported by its protocol of vaccinating on

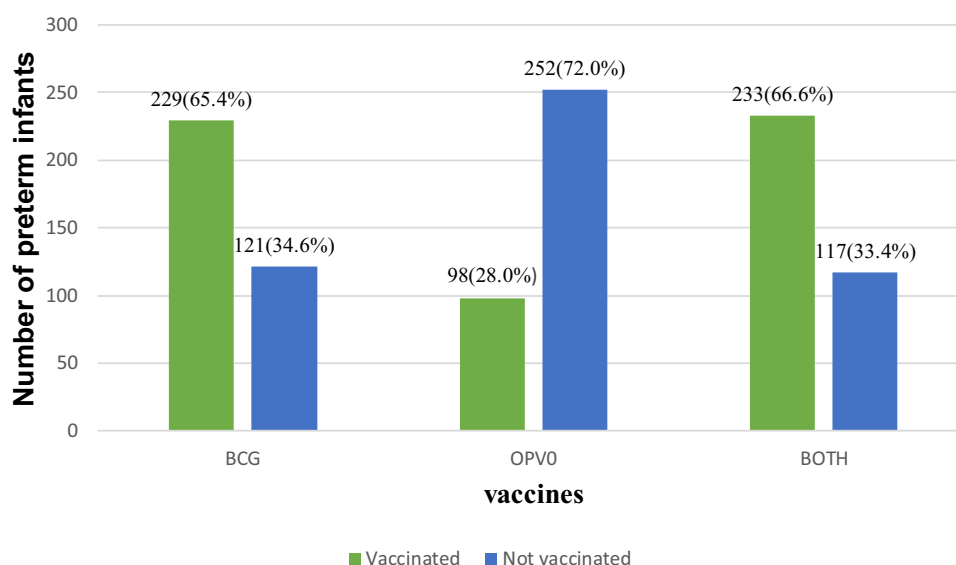


Figure 2 Vaccination status among preterm infants.

the Pediatric Ward (specialized newborn unit). This integration ensures that vaccination is performed when the preterm infant is clinically stable but still hospitalized, making it the final, non-negotiable step before discharge. Furthermore, methodological differences between the studies likely contributed to the disparity in coverage rates. Specifically, the

Table 5 Logistic Regression Analysis for Factors Associated with Vaccination

Study Variables		Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age (in weeks)		1.16 (1.21–1.20)	<0.001	1.21 (1.13–1.30)	<0.001
Educational level	None	1		1	
	Primary	2.28 (0.59–8.83)	0.150	3.05 (0.28–32.88)	0.359
	Secondary	2.31 (0.62–8.61)	0.164	5.29 (0.50–55.61)	0.165
	Tertiary	6.0 (1.53–23.41)	0.010	5.92 (0.50–70.11)	0.158
Gestational age at birth		0.90 (0.81–1.00)	0.039	0.86 (0.67–1.12)	0.284
Number of antenatal visits		1.51 (1.24–1.84)	<0.001	1.61 (1.06–2.46)	0.025
Facility	MRRH	1		1	
	HICH	7.40 (2.23–24.53)	0.001	2.18 (0.27–17.86)	0.467
Informed about vaccination before discharge	No	1		1	
	Yes	4.72 (2.17–10.26)	<0.001	1.12 (0.23–5.57)	0.885
Informed about vaccination at discharge	No	1		1	
	Yes	6.01 (3.54–10.22)	<0.001	5.25 (1.81–15.19)	0.002
Denied vaccine at first presentation to the vaccination center following discharge	No	1		1	
	Yes	0.32 (0.16–0.66)	0.002	0.11 (0.03–0.39)	0.001
	Did not take the infant	0.01 (0.003–0.04)	<0.001	0.03 (0.01–0.14)	<0.001

Notes: P<0.05 (Statistically significant). Bold text: Indicates statistically significant result.

Abbreviations: OR, Odds ratio; HICH, Holy Innocents Children Hospital; MRRH, Mbarara Regional Referral Hospital; HC, Health center; CI, Confidence interval.

study conducted at Mulago National Referral Hospital included infants between 6 and 24 months of age, whereas our current study followed infants from birth up to 24 months during their routine newborn clinic reviews. The older enrollment criterion in the Mulago study inherently introduces a survival bias, as only preterm infants who survived the critical first six months of life were included. These survivors are statistically more likely to have received better initial and timely care, which typically encompasses in-hospital vaccinations. By excluding those infants who may have died before six months (who often have lower vaccination rates), the Mulago study's coverage percentage is artificially inflated compared to our cohort, which tracked infants from birth. Similar to the study at the national referral hospital, OPV0 vaccination status was less than BCG and still way below the national target. Majority of our preterm infants miss out on OPV0 because of guidelines that do not recommend OPV0 after the first two weeks of life.²¹ BCG on the other hand can be given at any first contact with the infant,²² hence the disproportions observed. Notably, Uganda is one of the world's thirty high burden countries for TB²³ and a high-risk country for poliomyelitis due to the high influx of refugees more so in the southwestern region. Considering the low vaccination status of BCG and OPV0, and steadily increasing survival of preterm infants in our region, these infants have an increased susceptibility window for vaccine preventable diseases. This moreover increases our risk for outbreaks of VPDs with a further threat to increase in morbidity and mortality from such diseases among preterm infants and any vaccine naive children below 5 years of age.

Factors Affecting Vaccination of Preterm Infants

According to our findings, every unit increase in age by one week increased the likelihood of a preterm infant being vaccinated. This means that preterm infants who take longer in the NICU were more likely to be vaccinated. This could be because of the many health education sessions the parents receive during their hospital stay. A study done in India also reported a significant delay for the first vaccinations; this delay increased as gestational age decreased.^{24,25} Vaccinating preterm infants according to chronological age has several benefits, including better immune response and earlier protection against VPDs.²⁶ As such, all stable preterm infants should be vaccinated according to chronological age regardless of their gestation age or birth weight. This provides them with the best possible protection against VPDs.

Our study further revealed that mothers who had more antenatal visits were more likely to vaccinate their infants compared to those who did not attend antenatal care. This result speaks to the importance of health education given during ANC and how it positively improves vaccination. A systematic review across 42 African countries showed a strong positive relation between attendance of antenatal care and infant vaccination. Women who attended ANC were 1.5 times more likely to vaccinate their infants compared to those who did not.²⁷ Mothers who regularly attend ANC tend to have trust in the healthcare system. This enables mothers get access to health information including vaccination services and are more likely to deliver from hospitals.²⁸ Ultimately, there is a need to promote antenatal care services in order to improve vaccination services in preterm infants.

On the other hand, denial of vaccination services at first visit to the vaccination unit negatively affected the vaccination status of preterm infants. Whereas there is little literature on this subject, many healthcare workers and parents believe preterm infants are too small to be vaccinated. Some HWs think their immune systems are not yet mature enough to handle vaccines and could potentially make them sick. Such myths and misconceptions could contribute to delayed vaccination of preterm infants. When such scenarios happen, some parents may lose trust in the system, develop a bad attitude and fail to follow up on subsequent vaccines. Some may think that preterm infants should never get vaccines at all.

The findings from our study continued to show that caretakers who were informed to vaccinate at discharge were 5 times more likely to vaccinate compared to those with no recommendation at discharge. The absence of recommendations could be due to insufficient knowledge about vaccination of preterm infants among health care workers. If vaccination is not prioritized in discharge care plans, it leads to delayed preterm infant vaccination.^{29,30} Additionally, it is essential to continue providing training to healthcare workers at newborn units and vaccination units regarding the specific considerations for vaccinating infants. When sharing information about vaccination with various communities through social media and community outreach efforts, it is important for the Ministry of Health to provide additional details about specific vulnerable groups, such as preterm infants.

The findings from this study provide clear direction for future public health strategies. Future interventions must prioritize ensuring vaccination before hospital discharge and implementing targeted, evidence-based health education for both caretakers and healthcare workers to counteract misconceptions about vaccine safety that lead to denial of service. For longitudinal tracking beyond the end of infancy (12 months), the observed initial delay is a strong predictor of subsequent missed doses in the entire immunization schedule; therefore, existing preterm follow-up clinics must be strengthened to proactively monitor and catch-up all required vaccines up to 18–24 months. The study's results are highly transferable to similar low- and middle-income resource settings internationally, especially those where BCG and OPV0 are routine “at-birth” vaccines under the Universal Immunization Program, and where similar challenges such as low antenatal care attendance, reliance on discharge recommendations, and operational barriers contribute to preventable delays in this high-risk population.

Strength of the Study and Limitations

The study was done in two busy health care facilities involved in management of preterm infants in south western Uganda. With respect to missing data, these observations were considered from caretakers having forgotten their medical documents or Poor documentation (antenatal books /cards, delivery notes and /or discharge forms). However, caretakers were encouraged to return with their documents on the next visit for their infants to be enrolled into the study. Recall bias:

There could also have been recall bias especially for caretakers of older preterm infants. This was minimized by extracting data from several medical documents. Potential for selection bias: The recruitment of infants exclusively from newborn follow-up clinics introduces selection bias. This method excludes preterm infants who were prematurely lost to follow up, died early or those who were never fully engaged with the formal Healthcare system post discharge. This systematic exclusion could lead to an overestimation of the true vaccination coverage rate in the entire preterm infant population in Southwestern Uganda.

Conclusion

The vaccination status of BCG and OPV0 among preterm infants in southwestern Uganda is below the national average. Antenatal care attendance, increasing age of the infant and recommendation at discharge to vaccinate positively impacted vaccination status whereas denial of vaccination services at first visit to vaccination unit negatively influenced vaccination.

Recommendations

In order to promote early vaccination of preterm infants, healthcare workers should provide information about vaccination of preterm infants at the earliest opportunity with caretakers. This can be done by establishing low-literacy, visual information sheet detailing the preterm vaccination schedule and its importance. This material must be mandatorily distributed and briefly explained to the primary caretaker upon infant admission to the neonatal ward. Hospitals should also ensure preterm infants are vaccinated before they leave hospital. This can be done by availing vaccination services on Pediatric ward, ensuring a discharge form is given after evidence of a vaccination card or revising the newborn discharge form to include the recommended date for vaccination. Targeted education about preterm infant vaccination for healthcare workers and caretakers coupled with written guidelines about vaccination in newborn units, vaccination units and maternity units of all hospitals that admit and follow-up preterm infants will increase access to vaccination information and bridge the knowledge gap including addressing barriers like vaccine denial myths. Parents should also be encouraged to attend antenatal care visits by all healthcare workers. This can be done by empowering community health care workers to address socio-cultural norms that discourage early pregnancy disclosure and dispel myths about antenatal care. To effectively translate these recommendations into practice and ensure integration into national programs, facilities should establish Visible Staff Standard Operating Procedures through strategically placed posters to standardize staff practice and reduce reliance on individual memory.

Ethical Considerations

This research obtained ethical approval from Mbarara University of Science and Technology Research Ethics Committee (Reference number: MUST-2023-789) and administrative clearance from the Hospital Directors of MRRH and HICH. The research team adhered to the Declaration of Helsinki, with all personnel trained in Good Clinical Practice and Responsible conduct of research. To prioritize participant protection, written informed consent was obtained from every participant. The forms were translated into the relevant local language and read aloud to the participants, guaranteeing they fully understood the content and had the chance to ask any questions before agreeing to take part.

Acknowledgments

The authors wish to thank caretakers of preterm infants who actively participated in this study.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

The study was entirely funded by the corresponding author.

Disclosure

All authors have no conflicts of interest to disclose for this article.

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