BMC Pediatrics

RESEARCH

Open Access

Delayed completion of pneumococcal conjugate vaccination among children 4–48 months in rural Uganda: a socio-demographic inquiry

Herbert Malemo[1*], Andrew Tamale[1], Paul Kakwangire[1], Matthew C. Igwe[1], Dickens R. Mwine[2], Isa Asiimwe[1], Solomon A. Mbina[1] and Mary G. Abalinda[3]

Abstract

In spite of the commendable global Pneumococcal Conjugate Vaccine (PCV) coverage in the last two decades, completion and timeliness of receipt of all the required doses are still below target. In Uganda, the 3 + 0 PCV regimen has been reported to have a steady decline in the completion rate and the reasons for the delayed completion are unidentified. This study aimed at assessing the influence of socio-demographic factors on delayed PCV completion among young children. A cross-sectional study design among 362 child/caretakers pairs in Bugongi Town Council was employed. Using stratified sampling – Allocation Proportional to Size, data was collected using pretested questionnaires; entered and analysed using STATA v14 and significant statistical association was considered at $P \leq 0.05$. Of the 362 children, majority (53.87%) were boys. Child mean age was 25.1 ± 14.3 months. 87.6% caretakers were females and majorities of them were aged 20–29yrs (47.8%), peasant farmers (79.8%), married (90.6%), attained primary education (63.5%) and earned average monthly income of UGX 10,000 – UGX 50,000 (41.4%). Of the 362 children, 92 (25.4%) had delayed to receive their PCV-3 doses. Only boy child [cOR = 1.65, (95%CI: 1.03–2.66); $P = 0.039$) and caretaker's age 30–39 [cOR = 2.12 (95%CI: 1.06–4.24); $P = 0.033$) showed statistical significance at bivariate analysis. The multivariate model found parent's age 20–29 years [aOR = 2.39 (1.14–5.01); $P = 0.021$] and 30–39 years [aOR = 2.51 (1.16–5.45); $P = 0.020$] as positively associated factors whereas being married [aOR = 0.20 (0.04–0.96); $P = 0.044$] was the only negatively associated factors to delayed completion of PCV vaccination among young children. Among children who complete the last dose of PCV vaccination, a considerable proportion are actually receiving it late which may result into eventual failure to curb the targeted pneumococcal infections. Thus, concerted efforts in terms of sensitization are un-doubtfully desired especially among caretakers aged 20–39 years as well as those who are not married.

Keywords PCV-3, Delayed completion, Socio-demographic factors, Young children, Western Uganda

*Correspondence:
Herbert Malemo
malemo.herbert@kiu.ac.ug
[1]Department of Public Health, School of Allied Health Sciences, Kampala International University Western Campus, P. O. Box 71, Bushenyi, Uganda
[2]Department of Public Health, Bugongi Town Council, Sheema District Local Government, P. O. Box 160, Kabwohe, Uganda
[3]Department of Medical Laboratory Sciences, School of Allied Health Sciences, Kampala International University Western Campus, P. O. Box 71, Bushenyi, Uganda

Introduction

Since their invention, vaccines have been reported to be an integral tool especially regarding the control and prevention of infectious diseases for more than two centuries [1]. Globally, coverage and number of vaccines against vaccine preventable diseases have generally increased with almost full coverage in developed countries to near target coverage in developing countries [2] however timely completion or age-appropriate receipt of the vaccine doses is still a major concern [3, 4]. This delayed completion is more prevalent among the multi-dose vaccines with potential predictors ranging from child's birth order, caretakers' socio-demographic variations to cultural, religious, political and institutional factors [5–7].

Immunization as a public health intervention provides protection through inducing immunity but also through prevention of person-to-person disease transmission through herd immunity [8]. In such case, there is unlikely disease transmission in a community because the biggest majority of the population is immunized. Delayed or non-vaccination leads to significant breaks in herd immunity leading to increased risk of outbreaks due to these vaccine preventable diseases [9].

Pneumococcal Conjugate Vaccine (PCV) is one of the major routine vaccines as recommended and approved by the World Health Organization (WHO) in 2010 [10]. It is a recombinant vaccine made of polysaccharides from the capsule of the Streptococcus pneumonia bacterium conjugated to a carrier protein. PCV is generally indicated for children below two years of age for protection against pneumococcal disease such as pneumonia, meningitis, otitis media, among others. The PCV vaccine was introduced as early as 2000 in the United States as a heptavalent conjugate through 2010 when the 13-valent combination was officially integrated in the routine immunization [10]. In Uganda, the deca-valent Conjugate was integrated in Uganda National Expanded Program for Immunization (UNEPI) in 2014 and it is offered in 3 doses. The 1st dose is offered at 6weeks of life with an interval of 4 weeks until when the next dose is given [11].

Worldwide, PCV gained exponential increase in vaccine coverage in the ten years preceding 2017 from 4 to 44% coverage but still with great variations in the different WHO regions; where South-east Asia recorded as low as 12% coverage whereas the American region registered as high as 82% coverage [12]. On the other hand, among the 69 Gavi-supported countries, 56 countries had reached 50% coverage of PCV by the year 2016 and 46 countries (67%) had reached the target level for last dose (PCV-3) in the same year [13].

In a systematic review of PCV vaccine failure among children, only 30.6% were found to have received all the required doses of the vaccine [14] whereas in another study on the vaccine coverage and compliance to the recommended schedules of PCV, vaccination coverage was found to be 54.6% with a 16.8% compliance rate [15]. In Uganda, according to WHO and UNICEF Estimated National Immunization Coverage (WUENIC), completion of PCV vaccination has shown a decreasing trend (93–59%) from 2016 to 2019 [16] and data from the Uganda Demographic and Health Survey (UDHS) [17] shows that completion of PCV vaccination rates at 64%. Recent local data from Sheema District Health Information System further shows PCV completion to be 76% but with about 2 in every 10 children have been found to receive the last vaccine dose past the recommended age.

Various studies have found correlation between delayed vaccination for PCV and the number of children at home whereby as the number increases, the likelihood of delayed vaccination also increases for instance in Israel delayed vaccination was highly correlated with high child's birth order [18, 19] as compared to low birth order. Similarly, the age of the infant has also been linked to delays in routine vaccination where children aged 12–15 months have been reported to have more compliance to vaccine as compared to younger infants [15, 19].

The employment status of the mother or primary caretaker has shown significant association to the timeliness of PCV vaccination but with slightly contradictory findings where some literature affirms that an employed mother will most likely delay to take their children for immunization [20] while other findings assert that unemployed primary caretakers were more likely to delay in taking their children for PCV vaccination [19]. In the same regard, findings from Yaounde Cameroon still indicated that father's profession was found to be among the factors contributing to the completeness of immunization [21]. As a factor which influences knowledge and awareness, maternal education has by far shown great association towards timeliness of immunization. In recent studies, an increase in the education of the mother has shown a direct correlation to timely and complete immunization for PCV and others have deducted that lower level of maternal education poses a greater risk of incomplete and late vaccination to the infant [20, 21].

To attain the intended immunity from the multi-dose vaccines, vaccine doses should be received within the recommended ages [22] however delayed or non-vaccination leads to detrimental effects including significant breaks in herd immunity, increased risk of outbreaks and increased prevalence of these vaccine preventable diseases [9]. The study examined the socio-demographic factors associated with delayed completion of PCV vaccination among young children; and the findings should inform immunization policy especially implementation of vaccination programmes.

Materials and methods

Study setting, population and justification

The study was conducted in Bugongi Town Council (TC), Sheema South Constituency Sheema District Southwestern Uganda. Bugongi Town council consists of 4 Wards and 27 Cells. It is a rural area with about 2,732 households. Approximately 22.1% of the households in the town council live 5 or more kilometres away from the nearest public health facility and about 15.1% of the town council population is children 0–4 years of age [23]. The study population was children 4–48 months of age in the town council. Study units included child/caretaker pairs who consented to participate.

According to the 2018 United States Agency for International Development (USAID) – Maternal and Child Survival Program (MCSP) Report for Western Uganda, Sheema District was listed to have registered the highest number of pneumonia cases among children under five years. Additionally, bacterial pneumonia poses a big financial burden to the patients (average cost per case rates at UGX 150,000) [24]. Relatedly, pneumonia forms the vast proportion of the lower respiratory tract infection which ranks 4th among the leading causes of mortality in the country [25]. Furthermore, recent quarterly local data from Sheema District Health Information System (DHIS) (3rd quarter of 2023) revealed that PCV completion stands at 76% but with about 2 in every 10 children being reported to receive the last vaccine dose past the recommended age. The above need for research formed the basis for choosing Bugongi Town Council, Sheema District to act as a case study to understand the factors contributing to delayed completion of PCV vaccination and eventual increase in pneumococcal diseases among young children in the study area.

Study design, variables and sampling

The study employed a cross sectional study design where quantitative data was collected from September to November 2023. Timeliness of PCV-3 vaccination was the outcome variable and this was obtained from secondary data (children's immunisation cards). The date of birth of the child was obtained from the immunization card, as well as the date of receipt or expected date of receipt of 3rd dose of PCV vaccination. Timeliness of completion of PCV was computed by comparing the child age at receipt PCV-3 or expected age to receive PCV-3 (for those who hadn't received yet) with the WHO recommended ages for receiving PCV-3. According to the WHO recommended ages for completion of PCV vaccination, a child should have received the last dose of PCV when aged between 95 and 126 days of life [22]. Thus, children who had received PCV-3 within the recommended ages were categorized as timely completion whereas those who didn't or hadn't were categorized, as delayed completion. The other studied variables (predictor variables) included the socio-demographic factors of both the child and caretakers as shown under the study results below.

The desired sample size of 381 was obtained using Kish and Leslie formula (1965) using the proportion (45%) of children who miss out on immunization as reported by the 2016 UDHS [17]. However after data collection, fully completed questionnaires were 362 (95% full response rate). A 2 level stratified sampling technique was employed using Allocation Proportional to Size (APS) where a proportionate sub-sample was obtained from each of the 4 strata (Wards) and each of the 27 sub-strata (Cells). The Wards in the town council were used to form the strata whereas the Cells from each Ward were used to form the sub-strata. The sub-samples from each stratum and eventually from each sub-stratum were based on the proportional size of that stratum or sub-stratum to study population size of the town council or study population size of the Ward respectively. This was done using Stratified Random Sampling – Allocation Proportional to Size formula [26].

$$n_x = n\left(\frac{Nx}{N}\right)$$

Where;

n_x = the sub-sample size to be obtained from Stratum X.

n = Study sample size (362 participants).

N_x = Number of potential study participants in Stratum X (these included: 514 for Kyamurari North; 322 for Kyamurari South; 493 for Kyarukunda; and 223 for Isingiro).

N = Number of potential study participants in the entire study population (1552 children under 0–4 years) [27].

This computation was also repeated while obtaining the sub-sample from each of the 27 sub-strata. After calculating the required sub-samples from the sub-strata, the household with the study units (children 4–48 months and their caretakers) were purposively sampled and whoever met the inclusion criteria in a particular household was sampled until the sub-sample from each sub-stratum was obtained.

Data collection tools

A pre-tested (on 5 participants) interviewer administered questionnaire both in English and Local language (Runyankore) version was used to collect data. The reliability of this questionnaire was done by checking for Internal Consistency using Cronbach's Alpha where $\alpha = 0.79$ was obtained. This was obtained by calculating the variance of each questions in the questionnaire and also the variance of the entire tool and figures substituted in the formula

Table 1 Showing Socio-demographic description of the participants

Variable	Frequency (*N* = 362)	Percentage
Age Distribution of Children (in months)		
Mean	25.1	
SD to the Mean	14.3	
Median	24	
Minimum	4	
Maximum	48	
Number of Siblings		
None	70	19.3
1–4	**255**	70.4
5 or more	37	10.3
Gender of the child		
Male	**195**	53.9
Female	167	46.1
Birth Order		
First Born	93	25.7
2nd – 4th Born	**211**	58.3
5th Born or above	58	16.0
Place of Birth		
Health Facility	**353**	97.5
Home/Community/TBA	9	2.5
Age of Parent		
Less than 20 years	6	1.7
20–29	**173**	47.8
30–39	129	35.6
40 years and older	54	14.9
Gender		
Male	45	12.4
Female	**317**	87.6
Occupation		
Peasant Farmer	**289**	79.8
Civil Servant	12	3.3
Self Employed	48	13.4
Other Occupations	13	3.4
Average Monthly Income		
Less than UGX 10,000	123	34.0
UGX 10,000 – UGX 50,000	**150**	41.4
UGX 60,000 – UGX 100,000	44	12.2
Greater than UGX 100,000	45	12.4
Highest Education Level		
No Formal Education	12	3.4
Primary	**230**	63.5
Secondary	96	26.5
Tertiary	24	6.6
Marital Status		
Single	14	3.9
Married	**328**	90.6
Divorced/Separated	20	5.5

for Internal Consistency. The questionnaire was used to gather data on the predictor variables by interacting with the study participants while the data for outcome variables was obtained from the Child's Immunization cards by identifying the date of birth of the sampled child as well as the date of receipt of PCV-3 or expected date of receipt of PCV-3. These dates were used to compute the age of receipt of PCV-3 or expected date of receipt of PCV-3.

Data analysis

Data was analyzed using STATA v14 statistical software. Both descriptive analyses and logistic regression analyses (bi-variate and multi-variate) were done; and results presented as frequencies, percentages, cross-tabulations and odds ratios at 95% level of confidence. The multivariate model was run for variable with had a P-value of less than 0.2 at bivariate analysis. Statistical significance was considered at $P \leq 0.05$.

Results

As illustrated below (see Table 1) out of the 362 Child-Parent/Caretaker pairs, majority of the children were males (195; 53.9%) and nearly all (353; 97.5%) of the children were reported to have been born from a health facility. The mean age of the children was 25.1 ± 14.3 months and with a median age of 24 months. Most (211; 58.3%) of the children were 2nd through 4th born followed those who were first-borns (93; 25.7%) and lastly those who were 5th born or above (58; 16.0%). Majority of the children had 1–4 siblings (255; 70.4%). Approximately eight in every ten (317; 87.6%) caretakers/parents were females with only 45 (12.4%) of them being males. Majority (173; 47.8%) were aged 20–29 years and the biggest proportion (289; 79.8%) were peasant farmer. 90.6% (328) of caretakers were married with just 14 (3.9%) and 20 (5.5%) who reported to be single and separated respectively. Regarding the highest level of education attained, majority (230; 63.5%) of the parents/caretakers had attained primary level.

Regarding timelines of PCV-3 vaccination (see Fig. 1), out of the 362 sampled young children, 92 (25.4%) had delayed to receive their PCV3 doses while 270 (74.6%) had received their PCV3 doses within the recommended time.

In bivariate analysis of the socio-demographic factors (see Table 2), boy children were 1.65 times more likely to delay on receiving PCV3 vaccination compared to girls (cOR: 1.65. 95%CI: 1.03–2.66, $P = 0.039$). Relative to those aged 40 years and above, mothers aged 30 to 39 years have more than twice the odds of delayed PCV3 vaccination (cOR:2.12, 95%CI: 1.06–4.24, $P = 0.033$). Other factors like number of siblings, birth order, birth place, parent gender, occupation, monthly income, level

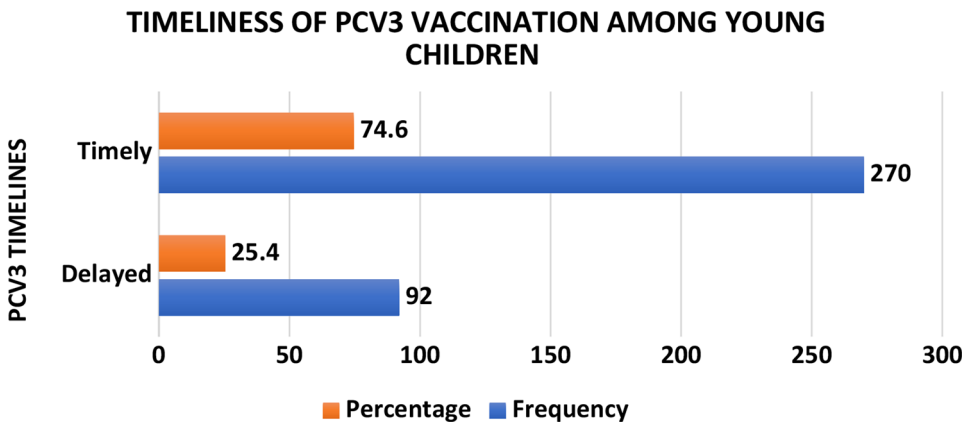

Fig. 1 Showing Timeliness of PCV-3 vaccination among children 4–48months in Bugongi Town Council

of education and not being married were not significantly associated with delayed PCV3 vaccination.

The adjusted multivariate model (see Table 3) only found parent's age 20–29 years [aOR = 2.39 (1.14–5.01); $P = 0.021$] and 30–39 years [aOR = 2.51 (1.16–5.45); $P = 0.020$] as well as being married [aOR = 0.20 (0.04–0.96); $P = 0.044$] that were significantly associated with delayed PCV3 vaccination whereas child's gender didn't show any statistical significance. Further tests of this final model included Multicollinearity and Hosmer-Lemeshow Goodness of Fit which showed no collinearity (Tolerance > 0.1) and with good fit (Chi2 = 0.74; $P = 0.863$) respectively.

Discussion

Timeliness of PCV-3 vaccination among children 4–48months

World Health Organization recommends that all children should receive their last dose of the 3 + 0 regimen of PCV vaccine within 95–126 days of life [22] giving an allowance even to some children who delay to start vaccination especially due to medical reasons. However if delayed, the vaccine impact on mortality prevention through all levels is greatly reduced resulting into greater difficulty to prevent deaths [28]. Delayed PCV-3 receipt is considered when a child receives his/her last dose past 126 days of life. In this current study, a biggest proportion (74.6%) of the sampled young children (4–48 months) had received their PCV-3 within the recommended age (see Table 1); but this rate is still below the "all-appropriate-age" vaccination target [29]. Moreover, the remaining 25.4% (1 in every 4) (see Table 1) is a remarkable proportion which needs stringent attention and intervention. This is because, whereas the overall national PCV-3 coverage is still below target [16, 17] even the age-appropriateness of the received PCV-3 is now revealing to be sub-optimal.

This current rate (1 in 4 children) of delayed completion of PCV is way higher as compared to a 10.1% (1 in 10 children) recorded delay in Israel [30] and a 15.2% delay in Saudi Arabia [31]; but lower as compared to a 40.2% delay as observed in Australia [19], 42.8% in Michigan – United States [32] and 53.7% in Germany [33]. This observed delayed completion could be due to the fact that much as the WHO recommendation sets an age bracket for receipt of PCV3, locally on numerous occasions great focus by the vaccination implementers is put on coverage of the vaccine dose with less attention to timeliness of its receipt. This implies that with the already excellent vaccination acceptance rate, timely receipt of vaccine doses is equally so possible if vaccination services providers always make it a point to provide the vaccination doses within the recommended time.

Socio-demographic factors associated with delayed completion of PCV-3

These findings (see Table 3) have shown that age of parent/caretaker had a significant association to delayed completion of PCV, specifically age 20–29 years and 30–39 years have shown 2.39 times and 2.51 times increased chances of delayed completion respectively as compared to a caretaker aged 40 years and above. Similar observation had earlier been reported in Saudi Arabia where mother's age > 26 years was strongly associated with delayed vaccination [31] as well as in Malawi where maternal age > 30 years was associated with increased risk of delayed vaccination [20]. This tendency may be explained by the fact that most of the caretakers were in this age bracket and were working (occupied); and so busy at work to spare time or even to remember taking their children for immunization in time or at all.

Furthermore, the study has discovered that caretakers who are married are less likely to delay taking their children for PCV3 as compared to caretakers who are not married. Earlier findings had also seen similar associations including the one in Jerusalem where married caretakers were more likely to take their children for the last dose of the vaccine in time as compared to non-married ones [30]. This protective phenomenon expressed

Table 2 Showing Bivariate Logistic Regression Analysis of the Socio-demographic characteristics

Variable	Delayed PCV3 Completion			
	Yes, *n* = 92	No, *n* = 270	cOR (95% CI)	P-value
Number of Siblings, n (%)				
None	20 (28.57)	50 (71.43)	0.58 (0.22–1.54)	0.277
1–4	**65** (25.49)	190 (74.51)	0.68 (0.29–1.63)	0.388
5 or more	7 (18.92)	30 (81.08)	Ref.	
Child Gender, n (%)				
Male	41 (21.03)	154 (78.97)	1.65 (1.03–2.66)	**0.039***
Female	**51** (30.54)	116 (69.46)	Ref.	
Child Birth Order, n (%)				
1st Born	26 (27.96)	67 (72.04)	Ref.	
2nd – 4th born	**48** (22.75)	163 (77.25)	1.32 (0.76–2.30)	0.330
5th born or more	18 (31.03)	40 (68.97)	0.86 (0.42–1.77)	0.686
Child Place of Birth, n (%)				
Health Facility	**89** (25.21)	264 (74.79)	Ref.	
Home/Community	3 (33.33)	6 (66.67)	0.67 (0.17–2.75)	0.583
Parent's Age, n (%)				
< 20 years	1 (16.67)	5 (83.33)	2.94 (0.32–26. 99)	0.340
20–29	**43** (24.86)	130 (75.14)	1.78 (0.93–3.41)	0.083
30–39	28 (21.71)	101 (78.29)	2.12 (1.06–4.24)	**0.033***
≥ 40 years	20 (37.04)	34 (62.96)	Ref.	
Parent's Gender, n (%)				
Male	14 (31.11)	31 (68.89)	0.72 (0.37–1.43)	0.350
Female	**78** (24.61)	239 (75.39)	Ref.	
Parent's Occupation, n (%)				
Peasant Farmer	**75** (25.95)	214 (74.05)	1.78 (0.57–5.62)	0.323
Civil Servant	3 (25.00)	9 (75.00)	1.88 (0.34–10.46)	0.474
Self Employed	9 (18.75)	39 (81.25)	2.71 (0.72–10.26)	0.143
Other occupations	5 (38.46)	8 (61.54)	Ref.	
Monthly Income Category, n (%)				
< UGX 10,000	25 (20.33)	98 (79.67)	Ref.	
UGX 10,000 – UGX 50,000	**44** (29.33)	106 (79.67)	0.62 (0.35–1.08)	0.090
UGX 60,000 – UGX 100,000	15 (34.09)	29 (70.67)	0.49 (0.23–1.06)	0.069
> UGX 100,000	8 (17.78)	37 (82.22)	1.18 (0.49–2.85)	0.713
Parent's Level of Education				
No Formal Education	2 (16.67)	10 (83.33)	1.93 (0.41–9.040)	0.405
Primary Level	**64** (27.83)	166 (72.17)	Ref.	
Secondary Level	20 (20.83)	76 (79.17)	1.47 (0.83–2.59)	0.190
Tertiary Level	6 (25.00)	18 (75.00)	1.16 (0.44–3.46)	0.768
Marital Status, n (%)				
Single	4 (28.57)	10 (71.43)	0.28 (0.04–1.79)	0.178
Married	**86** (26.22)	242 (73.78)	0.31 (0.07–1.38)	0.124
Divorced/Separated	2 (10.00)	18 (90.00)	Ref.	

by married caretakers could be sourced from the family support from the spouse but also most married couples have a stationed home which thus provide a stable location to both allow same site vaccination and also timeliness of the receipt of the doses as compared to the single or separated parents who are most likely to have changed locations.

The above factors associated with delayed completion of PCV may be used to explain delays in completion of and also guide intervention regarding improvement in timeliness of not only completion but also coverage of other multi-dose vaccines like the Pentavalent, Polio, and Rotavirus vaccines; since their administrations are at similar ages and intervals as the studied PCV vaccine.

Conclusions

This survey has confirmed that among the children who complete the last dose of PCV vaccination – an indicator of vaccination coverage, a considerable proportion are actually receiving it late. This phenomenon if not

Table 3 Showing Multivariate Logistic Regression Analysis of Factors associated with delayed PCV-3

Variable	Multivariate analysis	
	aOR (95% Confience Interval)	P-value
Child Gender		
Male	1.52 (0.91–2.54)	0.107
Female	Ref.	
Parent Age Category		
< 20 years	3.56 (0.37–34.56)	0.274
20–29	2.39 (1.14–5.01)	**0.021**
30–39	2.51 (1.16–5.45)	**0.020**
≥ 40 years	Ref.	
Parent Occupation		
Peasant Farmer	2.05 (0.57–7.33)	0.271
Civil Servant	1.64 (0.23–11.74)	0.620
Self Employed	2.45 (0.58–10.31)	0.222
Other occupations	Ref.	
Monthly Income Category		
< UGX 10,000	Ref.	
UGX 10,000 – UGX 50,000	0.61 (0.34–1.12)	0.111
UGX 60,000 – UGX 100,000	0.52 (0.23–1.20)	0.127
> UGX 100,000	1.22 (0.39–3.82)	0.733
Parents Highest Level of Education		
No Formal Education	3.65 (0.71–18.75)	0.122
Primary Level	Ref.	
Secondary Level	1.34 (0.74–2.58)	0.313
Tertiary Level	0.95 (0.26–3.46)	0.942
Marital Status		
Single	0.17 (0.02–1.22)	0.078
Married	0.20 (0.04–0.96)	**0.044**
Divorced/Separated	Ref.	

Entry into Multivariate model was considered for variable with $P<0.2$ at Bivariate analysis

addressed may ultimately lead to failures to curb the targeted pneumococcal infections especially among both the non-vaccinated children and also those who delay to complete the doses. From the study findings, it is also evident that emphasis in terms of sensitization about the detrimental effects of delayed vaccination completion is un-doubtfully desired among caretakers who are aged 20–39 years as well as those who are not married.

Acknowledgements
Special thanks are conveyed to the Dean School of Allied Health Sciences, Assistant District Health Officer – Sheema District and the Head of Public Health Department – School of Allied Health Science; for their technical, professional and parental guidance rendered during the entire research process.

Author contributions
During the entire research process: A. T, P. K, M. C. I and H. M were involved in the development of the research protocol; D. R. M and H. M were wholly involved in data collection and entry while I. A, M. G. A, H. M and S. A. M were involved in data analysis and discussion of results. H.M wrote the manuscript. I. A checked for grammar in the manuscript whereas A. T, P. K, M. C. I, M.G. A, S. A. M, I. A and D. R. M reviewed the manuscript.

Funding
The study was funded by Kampala International University under the Staff Development Scheme Scholarship (Ref No. KIU/HR/APPT/01.04.21-036).

Data availability
Raw data is submitted in the related file attached.

Declarations

Ethics approval and consent to participate
Ethical clearance was sought from Institutional Research Ethics Committee of Bishop Stuart University – Uganda (BSU-REC). Ethical approval number: BSU-REC-2023-166. Voluntary informed consent and proxy consent to participate was both verbal however, participants were also requested to sign on the hard copy consent forms. This was done with reference to the Helsinki guidelines were; respect for individuals (both caretakers and children), right to make informed decisions (caretakers) and recognition of vulnerable groups (children) were considered throughout the data collection process.

Limitation of the study
This study was conducted in Bugongi Town Council Sheema district, a sparsely populated and rural area with relatively same indigenous cultures. This may not be so representative in similar rural settings elsewhere with mixed cultures. There was no time to use longitudinal data thus this study relied on participants/caratakers recall and event records on child's immunization were used.

Consent for publication
This manuscript does not have personal identifying information; thus consent for publication was not applicable.

Competing interests
The authors declare no competing interests.

Received: 21 October 2024 / Accepted: 1 January 2025
Published online: 14 January 2025

References

1. Karafillakis E, Dinca I, Apfel F, Cecconi S, Würz A, Takacs J, Suk J, Velentano LP, Kramarz P, Larson HJ. Vaccine hesitancy among healthcare workers and their patients in Europe. In *Vaccine* 2016; 22(34).
2. Restrepo-méndez MC, Barros JD, Wong LM, Johnson HL, Pariyo G. Inequalities in full immunization coverage: trends in low- and middle- income countries. Bull World Health Organisation. 2016;98(May):794–805.
3. Noh J, Kim Y, Akram N, Yoo KB, Cheon J, Lee LJ, Kwon YD, Stekelenburg J. Determinants of timeliness in early childhood vaccination among mothers with vaccination cards in Sindh Province, Pakistan : a secondary analysis of cross-sectional survey data. BMJ Open. 2019;1–9. https://doi.org/10.1136/bmjopen-2019-028922.
4. Saleh A. Al. Factors associated with delayed vaccination in children. Int J Med Health Res. 2019;5(1):103–5.
5. Tauil MDC, Paula A, Sato S, Waldman EA. Factors associated with incomplete or delayed vaccination across countries: a systematic review. Vaccine. 2016;34(24):2635–43. https://doi.org/10.1016/j.vaccine.2016.04.016.
6. UNICEF. Factors influencing Vaccine Hesitancy and Immunization Coverage in Zimbabwe. Ministry Health ZIMBABWE. 2016;1(2):13–475.
7. Hu Y, Li Q, Chen Y. Timeliness of Childhood primary immunization and risk factors related with delays: evidence from the 2014 Zhejiang Provincial Vaccination Coverage Survey. Int J Environ Res Public Health. 2017;1086(14):13. https://doi.org/10.3390/ijerph14091086.
8. Diekema DS. Personal belief exemptions from school vaccination requirements. Annu Rev Public Health. 2014;35:275–92. https://doi.org/10.1146/annurev-publhealth-032013-182452.
9. McIntosh EDG, Janda J, Ehrich JHH, Pettoello-Mantovani M, Somekh E. Vaccine hesitancy and refusal. J Pediatr. 2016;175:248–e2491. https://doi.org/10.1016/j.jpeds.2016.06.006.
10. Zhao Z, Smith PJ, Hill HA. Factors Associated with missed opportunities for Simultaneous Administration of the Fourth dose of Pneumococcal

Conjugate Vaccine for children in the United States. Int J Sci Res Methodolog. 2018;9(1):149–62.
11. MoH/UNEPI. Uganda national expanded programme on immunization multi year plan 2012–2016 (Issue. July 2012).
12. Vanderende K, Gacic-dobo M, Diallo MS, Conklin LM, Wallace AS. Global Routine Vaccination Coverage — 2017. US Department Health Hum Services/ Centers Disease Control Prev. 2018;67(45):1261–4.
13. Luthra K, Jin AZ, Vasudevan P, Kirk K, Marzetta C, Privor- L. Assessing vaccine introduction and supported uptake timelines in Gavi- countries: are introduction timelines accelerating across vaccine delivery platforms ? BMJ Global Health. 2021;1–11. https://doi.org/10.1136/bmjgh-2021-005032.
14. Oligbu G, Hsia Y, Folgori L, Collins S, Ladhani S. Pneumococcal conjugate vaccine failure in children: a systematic review of the literature. Pediatr Infect Disease Res Group, 2018; 1–15.
15. Saraiva FO, Minamisava R, Aparecida M, Bierrenbach AL, Andrade AL. Vaccination Coverage and Compliance with three recommended schedules of 10-Valent Pneumococcal Conjugate Vaccine during the First Year of its introduction in Brazil: a cross-sectional study. PLoS ONE. 2015;10(6):1–17. https://doi.org/10.1371/journal.pone.0128656.
16. WHO and UNICEF. *Uganda: WHO and UNICEF estimates of immunization coverage : 2019 revision Uganda*, 2020.
17. UDHS. *Uganda Demographic and Health Survey*, 2016.
18. Stein-zamir C, Israeli A. Age-appropriate versus up-to-date coverage of routine childhood vaccinations among young children in Israel. Hum Vaccines Immunotherapeutics. 2017;13(9):2102–10. https://doi.org/10.1080/21645515.2017.1341028.
19. Lovie-toon YG, Hall KK, Chang AB, Anderson J, Grady KF. O. Immunisation timeliness in a cohort of urban Aboriginal and Torres Strait Islander children. BMC Public Health. 2016. https://doi.org/10.1186/s12889-016-3825-z.
20. Mvula H, Heinsbroek E, Chihana M, Crampin AC, Kabuluzi S, Chirwa G, Mwansambo C, Costello A, Cunliffe A, Heyderman RS, French N. Bar-zeev, N. Predictors of Uptake and timeliness of newly introduced pneumococcal and Rotavirus vaccines, and of Measles Vaccine in Rural Malawi : a Population Cohort Study. PLoS ONE. 2016;11(5):1–15. https://doi.org/10.1371/journal.pone.0154997.
21. Chiabi A, Nguefack FD, Njapndounke F, Kobela M, Kenfack K, Nguefack S, Mah E, Nguefack-tsague G, Iii FA. Vaccination of infants aged 0 to 11 months at the Yaounde Gynaeco-obstetric and pediatric hospital in Cameroon: how complete and how timely ? BMC Pediatr. 2017;17(206):1–7. https://doi.org/10.1186/s12887-017-0954-1.
22. WHO. Recommendations for Routine Immunization-Summary Table 2019.
23. NPHC. National Population and Housing Census 2014 Area Specific Profiles Sheema District (Issue. April 2017).
24. Ekirapa-kiracho E, Broucker G, De, Ssebagereka A, Mutebi A, Racheal R, Patenaude B, Constenla D. The economic burden of pneumonia in children under five in Uganda. Vaccine: X. 2021;8:100095. https://doi.org/10.1016/j.jvacx.2021.100095.
25. CDC. (2018). CDC in Uganda. U. S. Department of Health and Human Services; Factsheet. (Issue Cdc).
26. Sudman S. Applied Sampling. New York: Academic; 1976.
27. Bugongi Town Council. Sheema District Local Government, Uganda: Public Health Department. Under-5years Statistics, Accessed April 2023.
28. Carter ED, Tam Y, Walker N. Impact of vaccination delay on deaths averted by pneumococcal conjugate vaccine: modeled effects in 8 country scenarios. Vaccine. 2019;37(36):5242–9. https://doi.org/10.1016/j.vaccine.2019.07.063.
29. UNEPI. Immunization guidelines by UNEPI (Issue 2015; Table 1, pp. 1–3).
30. Stein-zamir C, Israeli A. Timeliness and completeness of routine childhood vaccinations in young children residing in a district with recurrent vaccine-preventable disease outbreaks. Eurosurveillance. 2019;24(6):1–8. https://doi.org/10.2807/1560-7917.ES.2019.24.6.1800004.
31. Banjari MA, Alamri AA, Algarni AY, Abualjadayel MH. How often do children receive their vaccinations late, and why? Saudi Med J. 2018;39(4):347–53. https://doi.org/10.15537/smj.2018.4.21473.
32. Wagner AL, Eccleston AM, Potter RC, Swanson RG, Boulton ML. Vaccination timeliness at Age 24 months in Michigan Children Born 2006–2010. Am J Prev Med. 2017;54(1):96–102. https://doi.org/10.1016/j.amepre.2017.09.014.
33. Laurenz M, Eiff C, Von, Borchert K, Jacob C, Seidel K, Schley K. Vaccination rates and adherence in pneumococcal conjugate vaccination in mature born infants before and after vaccination schedule change – A claims database analysis. Vaccine. 2021;39(24):3287–95. https://doi.org/10.1016/j.vaccine.2021.04.029.

Publisher's note