Original Research Article

Completion, timeliness, and under - vaccination of childhood vaccinations in a nomadic pastoralist community of Kenya

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ABSTRACT

Background: Children from nomadic pastoralist communities might not receive all the recommended doses of vaccines at age-appropriate times due to limited access to immunization services. Skipped, delayed or missed vaccination doses result in under vaccination which in turn make children vulnerable to preventable diseases. The purpose of present study was to establish completion timeliness and under-vaccination of all the recommended childhood vaccinations in a nomadic pastoralist community.

Methods: Authors used a cluster sampling technique to identify children aged 0 to 24 months at the household level. Vaccine completion was the accumulation of the required number of doses by infants irrespective of the timing. Timeliness was vaccines administered within the recommended age range. Under vaccination was the sum total of days a delayed vaccine was given after the recommended age range.

Results: Completion of all individual antigens did not meet the target of 90%. The mean number of days a child remained under-vaccinated in days was: OPV0, 20 days; BCG, 39 days; measles vaccine, 47 days; PVC3, 121 days; pentavalent, 117 days, and rotavirus, 103 days. Approximately 42% were severely under-vaccinated for more than six months. Vaccine-specific under-vaccination of more than six months was: pentavalent 3, 20%; PCV 3, 14%; OPV 3, 9.5%; BCG, 3%, and measles vaccine 20%. Overall children remained under-vaccinated for 185 days.

Conclusions: A significant proportion of children remained under vaccinated for extended periods leaving them at risk during a vulnerable period of their life.

Keywords: Childhood vaccinations, Completion, Nomadic pastoralist, Timeliness, Under-vaccination

INTRODUCTION

Timely start of immunization is vital in the first year of life as the trans placental immunity declines rapidly after that.¹ Early or late vaccinations reduce the impact of vaccine programmes on disease burden especially in high-risk groups.² Therefore, giving doses earlier than scheduled time or close to each other may lead to a less optimal immune response. When a child's vaccine is delayed, the interval between doses is increased, and the

optimal vaccine protection may not be attained.³ When a dose is skipped, delayed or missed altogether, the child becomes vulnerable to the specific infection and also 'herd' immunity is compromised.⁴

The Advisory Committee on Immunization Practices (ACIP) allows early vaccination as "age-appropriate" if received within a 4-day grace period before the minimum age for the dose.⁵ Doses of any vaccine administered ≥ 5 days earlier than the minimum range or age are not be

counted as valid and should be repeated.⁶ Studies conducted in Africa have mainly focused on Bacillus Calmette Guerin (BCG) vaccine against tuberculosis at birth/pentavalent (diphtheria-tetanus pertussis-hepatitis B (Hep), *Haemophilus influenza* type B (Hib), vaccination coverage which is the percentage of children who have accumulated the required number of vaccine doses regardless of the timing of these vaccinations. Results of these are given in the demographic health surveys. It does not examine the degree of delay, the duration of time that children remain under-vaccinated or the number of vaccines delayed. Therefore, immunization coverage rates might not necessarily imply age-appropriate vaccination status which is critical for providing maximum effectiveness against vaccine-preventable diseases.⁵ Many children might be unprotected by vaccination for several months despite being 'fully immunized'. Studies have shown that good vaccination coverage for individual vaccines does not necessarily imply timing of vaccine which is important for vaccine effectiveness and safety.^{3,4} Studies on immunization timeliness in Africa are few, and define timeliness in terms of delayed, early vaccination and on time using time ranges in weeks, and not the 4-day grace period prior to the minimum age for the dose.⁵

Delays for a mean of 1- 1.7 weeks have been found for Bacillus Calmette Guerin (BCG) vaccine against tuberculosis at birth.⁹ BCG, 6 days (IQR 1–14).¹⁰ A significant proportion (40- % of children have received their first polio vaccine later than recommended at birth for up to five days, third dose of polio, 107 days.¹⁰

Pentavalent 3 vaccination pentavalent (diphtheria-tetanus pertussis-hepatitis B (Hep), *Haemophilus influenza* type B (Hib), which is given at 14 weeks has been delayed up 110-123 days.^{10,11} Measles vaccine which is nine months of age (MV), seen delays of up to 294 days.¹⁰

Pentavalent 3 vaccination which is supposed to be given at 14 weeks had delays of up to was 123 days.¹¹ USA, a developed country study found days under- severe under vaccination the vaccine. The mean number of days under-vaccinated was lowest for MMR (152 days), followed by and PCV (258 days), and highest was rotavirus (475 days). Severe under vaccination occurred more frequently for rotavirus than for any other vaccine, with 33% of children severely under vaccinated.¹²

Most studies in Africa have looked at single vaccines, authors are only aware of two studies from Uganda and South Africa where the timeliness of most nationally recommended vaccines at the time of the study were evaluated.^{7,13} The differences between vaccination coverage and vaccination timeliness were small for most vaccines indicating that most of those who were vaccinated, received their vaccines within the recommended period.¹⁴ However, the proportion who received their vaccines later than recommended for the second and third vaccination visits was substantial.^{7,13} In

the, timely only 18% of the children received all vaccines within the recommended time ranges.⁷ Nonetheless, the Ugandan and South African studies did include rotavirus and PCV as they were added to the program in 2009, after completed data collection.

To the knowledge, no studies have been reported in Africa using minimum range ≤ 4 days, the recommended minimum age interval or age when vaccines are found to be effective. Previous studies in Africa that examined timeliness of vaccinations have been limited in scope regarding vaccines covered, most of which were single vaccines. The studies also used wide time ranges as the cut-off for timeliness of the vaccines. The purpose of present study was therefore to determine completion, timeliness and overall under-vaccination of all the nationally recommended vaccines for young children among a nomadic pastoralist community in Kenya days minimum interval or age.

METHODS

The study was carried out in Magadi and Keekonyokie wards, Kajiado West constituency, Kajiado County, Kenya. Except for BCG, vaccination coverage in this county was below the recommended 90% for all the other vaccines, and the proportion of fully immunized children was 56.2%.¹⁵

Prior to present survey, there had been a severe drought in Kajiado County. Magadi ward had a vegetation condition index (VCI) of 18.95 indicating severe drought situation. It also had abnormal cattle migration due to drought.¹⁶ Magadi ward was therefore, purposively selected for the study. Kekonyokie which is the neighbouring ward with less migration was included in the study.

Authors listed all the villages in each of the sub-locations in the two wards. Each village formed a primary sampling unit (PSU), while the households in the village were secondary sampling units (SSUs). The PSUs (villages) did not have the same population, therefore, authors selected the PSUs using Probability Proportional to Size sampling (PPS). Within the selected households, all mothers with children less than 24 months were interviewed. If there were two index children in the house, the youngest was selected.

Fisher's et al formula, ($n = z^2pq/d^2$) was used determine the sample size using a $p=56.2\%$, giving a minimum sample size of 378.

Study design and measurement of variables

Authors used a descriptive cross-sectional study design. Age of the child who was vaccinated was calculated from the interval between the birth date and the date of the vaccination. Recommended vaccines were based on the Kenya Expanded Program on Immunization, which are

line with the recommendations from the World Health Organization.^{17,18} The vaccines included: Bacillus Calmette Guerin (BCG); Oral Polio Vaccine (OPV); three vaccination doses of OPV, pentavalent, and pneumococcal conjugate vaccine (PCV); two doses of rotavirus vaccine and the initial dose of measles vaccine.

Vaccine completion was defined as the accumulation of the required number of doses administered to infants irrespective of the timing of the vaccine by their first birthday. Early vaccination was defined as any vaccine given ≤ 4 days before recommended age. Delayed vaccination was when a vaccine was given more than 4 days after the recommended age for BCG, OPV, pentavalent, PCV, rotavirus, and more or less than 14 days for the recommended age for measles. Authors assessed the number of days a child was under-vaccinated using the method proposed in several prior vaccine compliance studies.^{12,19,20} Under vaccination was assessed by summing the total number of days a delayed vaccine was given after the recommended age range for each vaccine per child. If a dose was never received by 12 months, the child received the maximum number of days under-vaccinated based on the total number of days between the first day of under-vaccination and age 12 months.

Statistical analysis

This analysis was based on children who were less than 24 months and who had a vaccination card at the time of the interview. Data were entered using Statistical Package for the Social Sciences (SPSS), version 20 for Windows. Data checking and cleaning methods included examining ranges of responses for each variable through frequency distributions for possible oversight upon entry, normality,

and outliers. Missing data were addressed through System-missing for blank cells using -1 value for missing value. Fisher test of skewness was used to assess whether or not the continuous data were normally distributed.

Total scores were created for overall under vaccination. Means and standard deviations were used to summarize continuous variables. Frequency distributions and percentages were used to summarize key study variables. Counts and proportions were used to summarize the categorical variables. Under vaccination was categorized as, severely under-vaccinated if the child was under vaccinated for more than 6 months.

RESULTS

The study was carried out in February 2016. It covered 45 villages/ clusters and 512 households who had children aged below 24 months. Eighty-five percent (85.4%) of the children had vaccination cards. The sample had slightly more males (52.8%) than females (47.2 %). The mean age of children was 51.3 ± 28.9 weeks.

Forty two percent (42.2%) of the children had not received any of the vaccines by the 24th month of life. Descriptive data on vaccine completion and timeliness by type of vaccine are presented in Table 1. Among vaccines given at birth, BCG had the highest completion (66%). Completion rates were lowest for the second dose of rotavirus and measles vaccine where the completion was 26% and 20% respectively. The completion rate for the third doses of pneumococcal conjugate, pentavalent and oral polio was approximately 40%. Proportion of children immunized on time was highest for measles (57.1%).

Table 1: Descriptive data on vaccine completion and timeliness by type of vaccine.

Vaccine	Number	Minimum acceptable age for vaccination	Completion			Timeliness
			Early	Timely	Late	
BCG	344	0	66.2	0	17.6	82.4
OPV0	114	0	22.1	0	34.2	65.8
OPV1	275	42	53.0	20.1	16.1	63.7
OPV2	263	70	51.1	16.4	17.9	65.8
OPV3	200	98	38.8	20.0	19.5	64.5
Pentavalent1	312	42	55.0	19.1	15.9	64.7
Pentavalent2	265	70	51.1	15.1	11.7	73.2
Pentavalent3	223	98	43.3	15.2	19.7	65.0
PCV1	312	42	60.4	19.9	20.6	59.5
PCV2	277	70	53.6	15.6	18.5	65.9
PCV3	204	98	39.6	9.3	16.2	74.5
Rotavirus1	188	42	63.7	12.3	15.5	72.2
Rotavirus2	135	70	26.2	11.9	13.3	74.8
Measles	105	252	20.4	5.7	57.1	37.1

The second dose of rotavirus had lowest compliance (13.3 %), while among the multi-dose vaccines PCV3 had the lowest compliance (16.2%). Most untimely vaccinations were given too late.

The mean number of days a child remained under-vaccinated by vaccine are presented in Table 2. The results show that the mean number of days a child remained under-vaccinated in days was: OPV0, 20 days; BCG, 39 days; measles vaccine, 47 days; PVC3, 121 days; pentavalent, 117 days, and rotavirus, 103 days. Overall a child remained under vaccinated for 185 days in the first year of life.

Table 2: Mean number of days a child remained under-vaccinated by vaccine.

Vaccine	No.	Mean days under-vaccinated	SE	Skewness
BCG	341	39	2.3	2.3
OPV0	113	20	2.6	3.3
OPV1	273	53	2.3	2.2
OPV2	248	93	3.8	2.2
OPV3	185	115	3.4	1.8
Pentavalent1	277	52	2.1	2.4
Pentavalent2	264	84	2.7	1.8
Pentavalent3	208	117	3.3	1.9
PCV1	295	63	3.2	2.4
PCV2	264	93	3.6	2.9
PCV3	203	121	3.5	1.4
Rotavirus1	211	72	4.2	1.9
Rotavirus2	135	103	3.9	1.1
Measles	111	47	3.5	3.1

Approximately 42% were severely under-vaccinated for more than six months. Vaccine - specific under-vaccination of more than six months was: pentavalent 3, 20%; PCV 3, 14%; OPV 3, 9.5%; BCG, 3%, and measles vaccine 20%. Figure 1 shows distribution of the proportion (%) of children who completed all the required doses of vaccines on time. Only 2% of children had received all vaccinations at the recommended time.

Figure 1: Proportion (%) of children who completed all the required doses of vaccines (n=496).

DISCUSSION

Vaccine completion in present study was comparable to the proportion of fully immunized children (FIC) reported in Kajiado County.¹⁵ The extremely low proportion of children who received all doses on time in present study provides support that a significant percentage of children are not adequately immunized between birth and 12 months. Present study revealed substantial differences in vaccination between completeness and compliance, further supporting the fact that most of those who were vaccinated, did not receive their vaccines within the recommended period. Highest compliance was observed for measles vaccine, with the lowest being the second dose of rotavirus and the last dose of PCV. However, though the delay of measles vaccine was considerably short, a substantial proportion of children remained under-vaccinated for more six months highlights risk and potential for measles outbreaks. The substantial proportion of children who remained severely under-vaccinated, may point to issues of access to health facilities, vaccine delivery, or uptake.

The higher coverage for vaccines given during an infant's early part of life than vaccines given later in life observed in present study was consistent with findings from other African studies, except South Africa where the coverage was higher.^{10,13,21,22} Higher compliance in the South African could be explained by better accessibility of health facilities.

The low proportion of children who received all doses in present study is consistent with findings from the USA, and from other African countries.^{7,12,13,19} Present study revealed substantial differences in vaccination between completeness and compliance which is akin to other studies.^{19,23,24} However, on the contrary, results from a study conducted in South Africa found no large differences between most vaccines indicating that the differences between vaccination coverage and vaccination timeliness were not large, which meant that most of those who were vaccinated, received their vaccines within the recommended time period.¹³ Short delays of measles vaccine was found in other studies.^{9,12,20,25}

The high proportion of children were severely under-vaccinated found in present study was consistent with findings from the USA.¹² Severe under-vaccination may point to issues to do with access to immunization services, vaccine delivery.

This study has some limitations. Though data from cards representing 85% of the sample, eliminated the possibility of introducing recall bias, excluding children without a vaccination card may impact the internal validity of the results. Vaccine coverage among excluded children may differ from children with an observed vaccination card. The study was conducted in a nomadic pastoralist community, and therefore the estimated

completion and compliance and under vaccination may only represent similar populations.

The study nonetheless had several strengths. Present study contributed to the documentation of patterns of timeliness and under-vaccination of immunization in pastoral nomadic communities, whereas the other studies reviewed were conducted in stable or settled communities and health facilities. This study to present knowledge was the first documented study to use the clinically recommended age-ranges of ≤ 4 days to assess under-vaccination. Present study also included assessment of the pneumococcal vaccines and rotavirus vaccines which are fairly recent and were not included in earlier studies.

CONCLUSION

A significant proportion of children remained under vaccinated before age one year, leaving them at risk of vaccine-preventable diseases. Therefore, current benchmarking of fully immunized children at one-year masks the actual situation of immunization status. Future immunization monitoring should focus not only on whether children get immunized, but also when whether they are immunized at age-appropriate times.

The approach used in this study could be used, in other data sources, such as vaccine surveillance which is captured in nationally from various geographic regions.

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Ethical approval: The study was approved by the Great Lake's University of Kisumu (GLUK) Institutional Review Board (IRB). Caregivers provided verbal or thumbprint consent for participation

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