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VACCINATION COVERAGE AND ASSOCIATED FACTORS AMONG CHILDREN AGED 12-23 MONTHS: A CROSS-SECTIONAL STUDY IN NAROK COUNTY, KENYA
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ABSTRACT

Background: **The utilization of childhood vaccines is still below the universal coverage. This has led to occurrences of vaccine preventable diseases. This study examined the vaccination coverage and associated factors among children aged 12-23 months in Narok County, Kenya.**

Methods: **This was a cross-sectional study that entailed determination of vaccination coverage among 378 children. A stratified sampling technique was used to sample children in the County. Statistical analysis was done using STATA. Descriptive statistics was presented in form of variables' frequencies and percentages. Inferential statistics involved univariate and multivariate logistic regression analysis. Variables that were significant at univariate regression analysis were included in multivariate analysis regression model.**

Results: **The full vaccination coverage was 251(66.4%). Subtly, 362 (95.8%) children received Bacillus Calmette–Guérin (BCG)_vaccine, 341 (90.21%) Oral Polio Vaccine (OPV) dose zero, 344 (91.1%) OPV1, 353 (93.4%) OPV2, 326 (86.2%) OPV 3, Inactivated Polio Vaccine (IPV) 322 (86.2%), 300 (79.4%) for Measles Virus Containing Vaccine (MCV) dose one and 76 (61.8%) for MCV2. The factors significantly associated with vaccination coverage were at least secondary education level ($p<0.001$), formal employment ($p<0.001$), good facility-readiness to vaccinate ($p=0.006$) and ≥4 Antenatal Care (ANC) visits ($p=0.004$).**

Conclusion and recommendations: **The findings indicated suboptimal vaccination coverage below the target for universal coverage. Encouraging pregnant women to attend at least 4 ANC visits, capacity boosting of facilities' vaccine financing,**

monitoring and forecasting improves availability of vaccines and reduce missed opportunities for vaccination.

INTRODUCTION

Vaccination is a very effective health intervention in reducing child morbidity and mortality, averting 4.4 million deaths yearly [1]. However, up to 6.2 million children globally received partial vaccinations while 14.3 million children do not receive any vaccine [2]. World Health Organization (WHO) estimated that one in five children lack access to basic vaccines in Sub Saharan Africa (SSA), including Kenya [3]. The Kenya Demographic Health Survey (KDHS) 2022 reported a 74.9% full vaccination coverage among children aged 12-23 months in Narok County, Kenya, constituting Bacillus Calmette–Guérin (BCG) coverage of 98.7%, Diphtheria, Tetanus and Pertussi (DTP) dose three at 90.8%, Measles virus Containing Vaccine (MCV) dose one at 82.9% while MCV dose two was 45% [4]. This indicates disparities in access to vaccination services.

In 2022, outbreaks of measles and other vaccine preventable diseases significantly increased in Kenya and other African countries with suboptimal vaccination coverage [5]. These alarming trends indicated chronic underutilization of vaccines in the region and contributes to high rates of mortality among children under five years [6]. The recent increase in occurrences of vaccine preventable diseases highlighted the urgent need to understand and address factors contributing to suboptimal vaccination coverage, which has increased the vulnerability of children to vaccine preventable diseases and undermines public health efforts to reduce child mortality.

Many studies have extensively focused their research on national and other regional assessments while using demographic health surveys and nested data. However, heterogenous and diverse far-flung regions, with communities practicing complex pastoral and agricultural economic activities like in Narok County remain unexplored. Furthermore, the recent Kenya Demographic Health Surveys (KDHS) used small sample size mostly from collated data. These gaps limits availability of localized evidences that can inform specific rollout of tailored program interventions.

This study therefore provides synthesis of vaccination coverage and factors influencing utilization of basic childhood vaccines in hard-to-reach pastoral and agricultural communities.

METHODOLOGY

Study setting: The study was carried out in all the sub-Counties of Narok County, Kenya. Narok County has six sub-Counties namely Transmara West, Transmara East, Narok North, East, Narok South and Narok West. Each sub-County has four to seven administrative wards.

Study design: This was a cross-sectional study of children aged 12-23 months in Narok County, Kenya.

Sample size determination: 378 children were sampled and sample size was determined using Cochrane formula where;

$$n = \left(\frac{Z_{1-\alpha/2}}{d}\right)^2 \times P \times (1 - P)$$

n= is the representative sample size;

Z=1.96 is the coefficient of the significance level at 95% confidence interval;
P=58.5% is the proportion of vaccinated children in Narok County as per KDHS 2014;
d=0.05 is the margin of error under the 95% confidence interval.

Sampling techniques: The administrative wards in every sub-County were sampled using proportionate stratified sampling. Then in every stratum (administrative ward), all households with children meeting the study inclusion criteria were physically identified and sampled using simple random sampling until desired sample size was attained in each stratum.

Study procedures and data collection: The household semi structured interviewer administered questionnaire was administered to the mothers/guardians and their demographic, socioeconomic status, obstetrics characteristics and environmental health status was obtained and entered into the questionnaire. The data collected include mother's/guardians' age and parity, occupation, economic status, religion, distance to nearest health facility. Information on vaccination coverage was obtained in written vaccination / immunization card or_ANC health booklet. For every child sampled, his/her mother/guardian was asked to show the interviewer the vaccination card or ANC booklet where the child immunization data was documented. If the vaccination was not recorded in the vaccination card or ANC booklet and the mother/guardian is unable to show from any other document, it was considered not received even if corroborated by just oral explanation.

Eligibility criteria. Child aged 12-23 months were sampled. Each child had to have a vaccination card and/or ANC booklet showing vaccination records. Child whose parents or guardian did not provide study informed consent and permission were excluded from the study.

Data management and analysis: Data captured was entered into an electronic database created using Microsoft Access. The data was de-identified of any personal identifying information prior to entry into the questionnaire and electronic database. Each participant record was assigned a unique identifier to help maintain the anonymity of the data collected during the study. The database was encrypted with password to ensure that confidentiality of the data was maintained. Statistical analysis was performed using STATA software version 17. Descriptive statistics were utilized to summarize sociodemographic and immunization characteristics, with categorical variables presented as frequencies and percentages.

For inferential statistics, Fisher's exact tests were performed for those variables with expected cell counts of less than 5. For univariate analysis, the association between vaccination coverage and independent variables was evaluated using Chi-square test, with 95% confidence interval (CI). The independent variables that were significant during univariate regression analysis were subjected to multivariate regression analysis while adjusting for identified confounders. Results were reported as adjusted odds ratios (aOR) with 95% confidence interval. Statistical significance for all tests was defined as a two tailed $p<0.05\%$.

Ethical considerations: The study was conducted according to the guidelines of the declaration of Helsinki and Moi U was approved by human research ethics committee of Moi University/Moi Teaching and Referral Hospital (MTRH) on June 30th, 2021 (Protocol approval number 0003616). Research permit was obtained from the

National Council for Science, Technology and Innovation (NACOSTI) reference number 291219 before commencement of the study. Participation was entirely voluntary, and a written informed consent and permission was obtained from all participants prior enrollment. To ensure confidentiality, personal identifiers was removed and replaced with unique study specific identification numbers. Consenting was done while maintaining privacy. Partially vaccinated and zero dose children were referred to health facilities for vaccinations.

RESULTS

Characteristics of the study population

A total of 378 children were enrolled in the study. The mean age of children was 15.3 (SD=3.7) months, with 255 (67.5%) children were aged <17 months. Based on their full vaccination status, 251 (66.4%) children were fully vaccinated. The descriptive statistics were presented by matching full vaccination status against various categorical variables as shown in table 1. Subtly, 58.7% (222/378) of the mothers had at least a secondary education and 29.1% (110/378) of the households had mothers as major decision makers on matter children's vaccination. Up to 179 (47.4%) mothers had parity of at least three while another 191 (50.5%) mothers attended at least four ANC visits. Other baseline characteristics were summarized in table 1.

Table 1

Baseline characteristics of the study population (n=378)

Variable	Descriptions of the variable	Fully vaccinated			Unadjusted Odds Ratio	95% confidence interval		p-value
		No	Yes	Total		Min	max	
Sub County (Place of residence)	Narok East (Ref)	24	18	42				
	Narok North	1	58	59	71.23	9.7671	560.299	P< 0.001
	Narok South	24	44	68	2.34	1.1116	5.3749	
	Narok west	32	57	89	2.38	1.1231	5.0226	
	Transmara East	19	42	61	2.95	1.3023	6.6704	
	Transmara West	27	32	59	1.58	0.712	3.5076	
Child's sex	Male (Ref)	66	117	183				P=0.325
	Female	61	134	195	1.240	0.80819	1.90001	
Education level	Primary (Ref)	102	54	156				p= 0.001
	Secondary	25	197	222	14.88	8.7523	25.3128	
Mother's age	18-24 years (Ref)	46	84	130				=0.316
	25-34 years	57	102	159	0.980	0.6039	1.59008	
	>=35 years	24	65	89	1.483	0.8219	2.67624	
Occupation	Unemployed (Ref)	93	47	140				P< 0.001
	Employed	34	204	238	11.56	6.99	19.1342	
Marital Status	Single (Ref)	35	57	92				P= 0.299
	Married	92	194	286	1.295	0.79437	2.11054	
Religion	Catholic (Ref)	37	90	127				Fisher's exact=0.368
	Muslim	1	4	5	1.644	0.17780	15.2089	
	Non-Believer	8	9	17	0.463	0.16571	1.29085	
	Protestant	81	148	229	0.751	0.46999	1.20057	
Parity	<=2 (Ref)	58	141	199				P = 0.053
	>=3	69	110	179	0.656	0.42699	1.00712	
	<=3 (Ref)	99	88	187				

Variable	Descriptions of the variable	Fully vaccinated			Unadjusted Odds Ratio	95% confidence interval		p-value
		No	Yes	Total		Min	max	
Frequency of ANC visits	>=4	28	163	191	6.549	3.99945	10.7242	P < 0.001
Distance to nearest health facility	<5 kilometers (Ref)	22	150	172				P< 0.001
	>=5 kilometers	105	101	206	0.141	0.08352	0.23831	
Mode of delivery	Vaginal Delivery (Ref)	121	220	341				P = 0.018
	Cesarean Section	6	31	37	2.842	1.15318	7.0024	
Place of delivery	Health Facility (Ref)	65	241	306				P < 0.001
	Home delivery	62	10	72	0.044	0.02113	0.08954	
Facility failure to vaccinate	Yes (Ref)	57	45	102				P = 0.001
	No	70	206	276	3.728	2.31654	5.99823	
Vaccine schedule confusing	No (Ref)	104	242	346				P<0.001
	Yes	23	9	32	0.168	0.07525	0.37581	
Place of vaccination	Outreach (Ref)	29	2	31				P= 0.008
	Health Facility	98	249	347	36.84	8.63	157.35	
Decision maker	Father/Guardian (Ref)	82	186	268				P = 0.054
	Mother	45	65	110	0.637	0.40184	1.00914	
Adherence to KEPI Schedule	No (Ref)	85	216	301				P< 0.001
	Yes	42	35	77	0.328	0.19614	0.54829	

**Unadjusted OR (crude odd ratio) was calculated using univariate logistic regression model including all parameters listed in the table. Lower and upper quartile of the Confidence interval (CI) was abbreviated as min. for minimum and Max for maximum; KEPI stands for Kenya Expanded Program on Immunization*

Vaccination Coverage

The proportion of fully vaccinated children was 66.4%. The vaccination coverage for BCG was 95.8% (362/378), OPV-1 was 91.0% (344/378), OPV-2; 93.4% (353/378), and OPV 3-86.2% (326/378). The vaccination coverage for pentavalent vaccine dose one was 89.7% (339/378) and pneumococcal vaccine dose three coverage was 83.6% (316/378). Out of the total 378 children, 315 (89.68%) received both pentavalent 1 and pentavalent 2 vaccines, 294 (77.8%) received both pentavalent 1 and pentavalent 3 vaccines; 299 (79.1%) received pentavalent 2 and pentavalent 3 while 185 (48.9%) children received all three pentavalent vaccines doses. Minor proportion of children, 11 (2.91%), received only one of the three doses of pentavalent vaccine. Out of 378 eligible children, 300 (79.4%) received measles one vaccine, of whom 202 (79.2%) children were aged under <17 months and 98 (79.7%) children were aged at least ≥17 months. Out of 123 eligible children aged at least ≥17 months, 68 (55.3%) children received both doses of measles one and measles two vaccines while 76 (61.8%) children received only one dose of measles two vaccine and 17 (13.8%) children were not vaccinated at all for any dose of measles vaccine.

The proportion of fully vaccinated children per sub county was also assessed. The full vaccination coverage was 98.3% in Narok North, 65.2% in Narok South Sub County, 64.4% in Transmara East, 62.3% in Transmara West, 62.3% in Narok West and 44.4% in Narok East. The details of vaccination coverage of various vaccine antigens stratified per sub-Counties were summarized in table 2.

Table 2

Vaccination coverage stratified by administrative units (Sub County and Wards)

Sub County	Sample size	Admin Wards	Vaccination coverage [frequency/ (percentage)]									
			BCG	OPV1	OPV2	OPV3	Penta-1	Penta-2	Penta-3	PCV-3	MR-1	MR-2 (n=123)
Narok East	20	Ildamat	19(95)	19(95)	17(85)	16(80)	17(85)	17(85)	16(80)	18(90)	13(65)	3(42.9)
	25	Suswa	23(92)	23(92)	21(84)	16(64)	21(84)	23(92)	14(56)	24(96)	19(76)	4(50)
Narok North	40	Narok T.	39(97.5)	39(97.5)	39(97.5)	39(97.5)	39(97.5)	39(97.5)	39(97.5)	39(97.5)	39(97.5)	3(60)
	18	Olokurto	18(100)	18(100)	18(100)	18(100)	18(100)	18(100)	18(100)	18(100)	18(100)	4(80)
Narok South	29	Ololunga	29(100)	25(86.2)	27(93.1)	26(89.7)	26(89.7)	26(89.7)	25(86.2)	22(75.9)	23(79.3)	5(62.5)
	14	Sagemian	14(100)	11(78.6)	14(100)	12(85.7)	11(78.6)	14(100)	13(92.9)	14(100)	10(71.4)	0
	26	Sogoo	26(100)	20(76.9)	26(100)	22(84.6)	22(84.6)	24(92.3)	23(88.5)	24(92.3)	17(65.4)	3(75)
Narok West	46	Ilmotiook	41(89.1)	39(84.8)	42(91.3)	39(84.8)	38(82.6)	42(91.3)	37(80.4)	35(76.1)	30(65.2)	9(60)
	31	Siana	30(96.8)	30(96.8)	28(90.3)	29(93.5)	29(93.5)	28(90.3)	29(93.5)	26(83.9)	27(87.1)	6(60)
Transmara East	24	Ilkerin	24(100)	23(95.8)	23(95.8)	21(87.5)	23(95.8)	22(91.7)	22(91.7)	18(75)	21(87.5)	8(72.7)
	21	Kapsasian	21(100)	21(100)	19(90.5)	18(85.7)	19(90.5)	19(90.5)	18(85.7)	15(71.4)	17(81)	7(70)
Transmara West	38	Kilgoris Central	35(92.1)	35(92.1)	38(100)	30(78.9)	36(94.7)	38(100)	30(78.9)	29(76.3)	31(81.6)	14(63.6)
	18	Kimintet	16(88.9)	15(83.3)	17(94.4)	14(77.8)	15(83.3)	17(94.4)	15(83.3)	12(66.7)	14(77.8)	6(54.5)
	28	Lolgorian	27(96.4)	26(92.9)	24(85.7)	26(92.9)	25(89.3)	24(85.7)	25(89.3)	22(78.6)	21(75)	4(57.1)
Total 378			362 95.8%	344 91.0%	353 93.4%	326 86.2%	339 89.7%	351 92.9%	324 85.7%	316 83.6%	300 79.4%	76/123 61.8%

BCG-Bacille Calmette Guerin; OPV- Oral Polio Vaccine; Pentavalent - Diphtheria, Pertussis, Tetanus, Hepatitis B, Haemophilus Influenza Type b; PCV-Pneumococcal Vaccine; MR-Measles Rubella virus containing vaccine. Narok T. is Narok Town

Factors associated with vaccination Coverage

Multivariate logistic regression analysis demonstrated no statistically significant association between full vaccination coverage and parity (aOR=0.94; p=0.867), mode of delivery (aOR= 0.42; p=0.197), mothers/ guardians' incidences of confusion over Kenya Extended Program on Immunization (KEPI) schedule (aOR=0.44; p=0.245), adherence to KEPI schedule (aOR=1.34; p=0.48). and distance to health facilities (aOR=0.57; p=0.164). However, mothers/guardians with at least secondary level of education was independent predictor of full vaccination coverage (aOR=5.68; p=0.001). Employment of mothers was a predictor of high likelihood of full vaccination coverage of children (aOR=3.83; p=0.001).

High frequency visits (≥ 4) of antenatal care (ANC) were significant predictor for full vaccination coverage among children (aOR=3.10; p=0.004). Children who have not experienced health facility-failure to vaccinate after presenting themselves for vaccination were significant predictor of full vaccination coverage (Aor=3.73; p<0.001). Home delivery of children negatively increases the odds against full vaccination of children (aOR=0.04; p<0.001). Details were summarized in table 3.

Table 3

Multivariate Logistics Regression for Vaccination Coverage

Factor	Category	Crude OR (95% CI)	Crude p-value	Adjusted OR (95% CI)	Adjusted p-value
Sub-County / place of residence	Narok East (Ref)	Ref		Ref	
	Narok North	71.23 (9.77–560.30)	<0.001	87.13 (5.94–1278.72)	0.001
	Narok South	2.34 (1.11–5.37)	<0.001	5.84 (1.48–23.02)	0.012
	Narok West	—	<0.001	4.57 (1.33–15.70)	0.016
Education level	Primary (Ref)	Ref		Ref	
	Secondary	14.88 (8.75–25.31)	0.001	5.68 (2.44–13.21)	<0.001
Occupation	Unemployed (Ref)	Ref		Ref	
	Employed	11.56 (6.99–19.13)	<0.001	3.83 (1.80–8.11)	<0.001
Parity	<=2 (Ref)				
	>=3	0.66 (0.43-1.01)	0.053	0.94 (0.45-1.96)	0.867
Frequency of ANC visits	<=3 (Ref)				
	>=4	6.55 (3.99-10.72)	<0.001	3.10 (1.44-6.66)	0.004
Distance to nearest health facility	<5 kilometers (Ref)				
	>=5 kilometers	0.14 (0.08-0.24)	<0.001	0.57 (0.26-1.25)	0.164
Mode of delivery	Vaginal Delivery (Ref)				
	Cesarean Section	2.84 (1.15-7.00)	0.018	0.42 (0.11-1.56)	0.197
Place of delivery	Health Facility (Ref)				
	Home delivery	0.04 (0.02-0.09)	<0.001	0.24 (0.09-0.64)	0.004
Facility failure to vaccinate	Yes (Ref)				
	No	3.73 (2.32-6.00)	<0.001	3.01 (1.37-6.64)	0.006
Place of vaccination	Outreach (Ref)				
	Health Facility	36.84 (8.63-157.35)	0.0008	4.16 (0.68-25.31)	0.122
Vaccine schedule confusing	No (Ref)				
	Yes	0.17 (0.08-0.38)	<0.001	0.44 (0.11-1.75)	0.245
Decision maker	Father/Guardian (Ref)				
	Mother	0.64 (0.40-1.01)	0.054	0.83 (0.34-1.82)	0.638
	Yes (Ref)				

Adherence to Immunization KEPI Schedule	No	0.33 (0.20-0.55)	<0.001	1.34 (0.55-3.42)	0.488

Adjusted OR (aOR) was calculated suing multivariate logistic regression model of all parameters that were significant during univariate logistic regression model. Lower and upper quartile of the Confidence interval (CI) was abbreviated as min. for minimum and Max for maximum. Confounders accounted in the study include age at vaccination, mother's religion and beliefs, and cold chain management factors- availability of vaccines and human resources.

DISCUSSION

This study revealed suboptimal vaccination coverage (66.4%) in Narok County which was consistent with KDHS 2022 findings on basic vaccine antigens but subtly lower than the national vaccination coverage over the same period [4]. The present study revealed high unmet need for immunization services, high OPV and measles vaccine dropout rate, high missed opportunities in combinational vaccines and possibly indicated low utilization of other complementary health services. However, the present study contradicted KDHS finding of 2% prevalence of zero-dose children in Narok County [4]. The proportion of zero dose children in the present study was subtly lower than Africa region's burden of zero-dose children (34.7%) over similar period [7]. This could be due to health interventions such as frequent outreach vaccinations, supplementary vaccination campaigns by various vaccination partners and a general decline in vaccine hesitancy among the pastoral and semi urban populations.

The proportion of fully vaccinated children was higher than the global average (49%) and those in many regions in Africa such as Uganda (52.6%), Ethiopia (24.6%), Cameroon (53.6%), Nigeria (33.2%) and Central Africa Republic (17.3%) [7, 8]. This difference could be attributed to lack of introduction of some vaccines in some countries at the time and late submission of vaccines data estimates. Furthermore, there could be possible skewedness of data and errors in collation of data estimates from different WHO regions and countries with varied vaccination data measurement and estimation methods. The present study findings on DTP vaccine coverage were consistent with Narok county's KDHS (2022) findings and Kenya' national DTP findings [4]. However, the present study's average DTP3 vaccinations coverage in Narok County was below the 90% global target of DTP vaccination coverage and was consistent with the global, America's, South East Asia and Africa's DPT 1&3 coverage [9]. This decline could be associated with decline in vaccination health financing attributed to Kenya's transition out of Global Alliance on Vaccine Initiative (GAVI) support in 2016/2017 and partly due to disruption associated with covid19 pandemic. The DTP3 coverage indicate inadequacies in immunization program and the missed goal of immunizing every eligible child.

The pneumococcal vaccine (PCV) dose three and measles virus containing vaccine (MCV) dose one vaccination coverage was lower than the Narok County' KDHS 2022 finding (94.1%) and Kenya' national average over the similar period [4, 9]. This difference could be attributed to varying statistical sample sizes and possible statistical bias associated with collation of data. Pneumococcal vaccine coverage indicated that there was a mixed trend towards attaining children rights including access to basic immunization services in Narok County.

The study found that residence location (sub-County) of mother significantly predicted full vaccination coverage. This could be due to socioeconomic disparities and cultural differences which affects health seeking behaviour in various sub-Counties as Narok East and Narok West sub-Counties are majorly inhabited by pastoral Maasai community unlike Agricultural and multiethnic population of Narok North and Transmara East. It could also be possibly due to differences in access and availability of immunization services as some far-flung rural

areas in Narok East and Narok West sub-Counties are difficult to reach during vaccination campaigns due to poor road networks and related transport challenges. This finding was similar to Bbaale et al., that found physical access, and ability to finance transport cost incurred by the mother/caregiver from household to the health facility are significant determinants of vaccination coverage [10]. This finding was also consistent with Kamanda study which found that cultural practices in some regions predominantly inhabited by strong cultural communities' influences health seeking behavior and tend to have incomplete vaccination coverage [11].

The present study was consistent with Kamanda study finding that linked poor adherence to Division of Vaccines and Immunization (DVI) schedule to negative utilization of essential childhood vaccines [11]. The study was also similar to Bbaale *et al*., and Johri *et al*., studies which found that children whose mothers/guardians hold at least a secondary education level have high vaccination coverage [10,12]. More educated and employed mothers are likely to have better appropriate information on disease prevention and control strategies compared to less educated and unemployed ones [14]. They also tend to have a higher purchasing power to afford balanced nutrition, good transport and health insurance [12-14].

The present study contradicted Bbaale *et al*., study that documented that short distances to nearest health facility improve access to all complementary health services including vaccination services [10]. This could be confounded by unavailability of vaccines in the nearest health facilities.

Female household head/Decision maker on vaccination services was not a significant factor associated with vaccination coverage. This finding contradicted Togolese study that showed that children in female lead household had lower vaccine uptake compared to children in male lead household [12]. The present study revealed that the high ANC visits was associated with full vaccination coverage and this was possibly due to complementary health services such as counselling on childhood vaccination services and postnatal care services. This finding was consistent with Landaoh *et al*., study findings in Ethiopia [15].

High parity may negatively influence the ability of the mother or the guardian to spare some time to vaccinate the baby and thus the present study contradicted Tickner, Leman and Woodcock [16]. The study revealed that place of vaccination was not associated with vaccination coverage ($p<0.05$. This could be due to improvement of vaccine handling protocols and practices in outreach centers. WHO recommends using melting ice packs in cold boxes or vaccine carriers [17] but in many regions, insulating materials such as plastic containers, paper wrapping, ice not ice packs, soaked clothes threads are sometimes used to protect vials from direct exposure with frozen ice packs which negatively affect availability of potent vaccines [18-20].

Readiness of a health facility to offer vaccination services was assessed using mother's/guardians' experience on experience of facility-failure to offer vaccine. The facility-failure to offer vaccination services reflect unavailability and poor vaccine forecasting, high vaccine waste rate, inadequacy of human resources and / or poor handling of cold chain management and low allocation and disbursement of finances of vaccination services. This finding was consistent with LaFond *et al*., study that documented poor health facility readiness was associated with

high rate of missed opportunities to vaccinate [21].

CONCLUSION AND RECOMMENDATIONS

The full vaccination coverage in Narok County was below the targets for universal immunization coverage and below the Kenya' national coverage (80.1%). The factors associated with vaccination coverage were education of at least secondary level of the mother/guardian, being formally employed / occupation, good health facility readiness to vaccinate and at least 4 ANC visits.

Encouraging pregnant women to attend at least 4 ANC visits and incorporating vaccination counselling and scheduling into each visit is important in increasing childhood immunization program. Improving vaccine financing by County and other partners, monitoring and forecasting of vaccine at facility level can improve availability of vaccines and reduce missed opportunities for vaccination. Strengthening funding and partnership to deliver culturally sensitive vaccination campaigns can help reach marginalized, far-flung population in hard-to-reach areas. Leveraging further anthropologic and geospatial research tools to identify local barriers allows precise targeted intervention to improve vaccination rates in Narok County. Studies related to the role of cold chain management and programming is recommended. A cohort controlled serological analysis is key in estimating true population immunity and effectiveness of vaccination program.

Declaration of Conflict of Interest

No financial or any other such conflict of interest

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AUTHORS' CONTRIBUTIONS

K.A: conceptualisation, literature search, synthesis, manuscript drafting, revisions

FW: methodological input, thematic analysis, critical manuscript review

S.R: study conceptualisation, intellectual oversight

M.K: thematic analysis, critical manuscript review

S.K: expert review, contextual and policy input

ALL; data extraction, literature screening, editing

All authors read and approved the final manuscript

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