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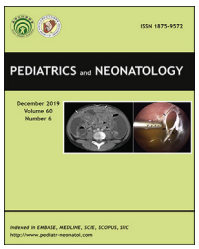

Original Article

Factors associated with non- and under-vaccination among children aged 12—23 months in Malawi. A multinomial analysis of the population-based sample

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Background: Non- and under-vaccination among children in Malawi have received little attention. Between 2010 and 2016, the proportion of children who received full immunization before their first birthday dropped from 81% to 76% in Malawi. This signifies that a certain fraction of children are either non-vaccinated or under-vaccinated. Thus, the present study attempted to examine the predictors of non- and under-vaccination among children aged 12—23 months in Malawi.

Methods: Cross-sectional data obtained from the Malawi Demographic and Health Survey 2015—16 were utilized. The percentage of children aged 12—23 months who were non-vaccinated, under-vaccinated, or fully vaccinated with 1 dose of Bacillus Calmette—Guérin, 3 doses of oral polio vaccine, 3 doses of pentavalent, 2 doses of rotavirus vaccine, 3 doses of pneumococcal vaccine and 1 dose of measles-containing vaccine were calculated. The odds of being non-vaccinated and under-vaccinated compared to full vaccination relative to various sociodemographic factors were assessed using a multivariable multinomial logistic regression with logit link function which accounted for survey design.

Results: Of 3111 children aged 12—23 months, 72% were fully vaccinated, 26% were under-vaccinated, and about 2% were non-vaccinated. The multinomial logistic regression showed that children from the poorest households, and children who did not have postnatal care within two months had increased odds of being under-vaccinated. On the other hand, children who

Abbreviations: 95% CI, 95% confidence interval; AIDS, acquired immunodeficiency syndrome; ANC, antenatal care; aOR, adjusted odds ratios; BCG, bacillus Calmette—Guérin; DHS, Demographic and Health Survey; DPT, diphtheria—tetanus—pertussis; EPI, Expanded Programme on Immunization; GDP, gross domestic product; HIV, human immunodeficiency virus; ICF, international classification of functioning; IRB, Institutional Review Board; MCV, measles-containing vaccine; MDHS, Malawi Demographic and Health Survey; MPHC, Malawi population and housing census; NHSRC, National Health Sciences Research Committee; OVP, oral polio vaccine; PCA, principle component analysis; PNC, postnatal care; SAS, statistical analysis software; SEAs, standard enumeration areas; T.B, Tuberculosis; TTI, Tetanus Toxoid Injection; USA, United States of America; WHO, World Health Organization.

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had no health card or whose card was lost had increased odds of being both non- and under-vaccinated. Additionally, children from the northern region and who resided in households with either none or one under-five child had reduced odds of being non-vaccinated and under-vaccinated, respectively.
Conclusions: Women from the poorest households and those who are not attending PNC should be targeted when designing interventions that aim at improving childhood vaccination in order to reduce the barriers they face in accessing vaccination services.

1. Introduction

Globally, it is estimated that more than 50% of mortality in pre-school aged children is due to diseases that are preventable and treatable through simple and affordable interventions such as a vaccine.[1,2] In 2016, the World Health Organization (WHO) estimated that 5.6 million children under five years old died, translating into 15,000 deaths every day.[1,2] Vaccination has proven to be an effective intervention for the prevention and elimination of life-threatening infectious diseases and is estimated to prevent approximately 2.5 million deaths annually.[3] The WHO elucidated that with proven strategies, vaccines can be accessible to even the most hard-to-reach and vulnerable populations.[4] However, despite the health and economic benefits of childhood vaccinations, the rates of vaccination in low-income countries vary extensively.[5–7]

Even though the vaccination coverage has shown great improvements over the last two decades worldwide, unfortunately, the coverage has remained trapped at 86%, and it has shown no substantial changes over the past years.[8] However, in Malawi, the proportion of preschool-aged children who got all the basic vaccines has fallen from 81% to 76% between 2010 and 2015, which is far below the Global Vaccine Action Plan (GVAP) Monitoring and Evaluation target.[9] Furthermore, about 2% of children aged 12–23 months were reported to be non-vaccinated, which means the remaining 22% were under-vaccinated.[10] In 1979, the Malawi Expanded Programme on Immunization (EPI) began to administer vaccines against the six diseases; a dose of Bacillus Calmette–Guerin (BCG) vaccine against tuberculosis (T.B); three doses of diphtheria, tetanus, and pertussis (DPT), against diphtheria, tetanus, and pertussis; at least three doses of oral polio vaccine (OPV) against polio; and one dose of measles-containing vaccine against measles.[11] These vaccines were programmed to be administered before the first birthday. In the early 2000s, the Malawi government substituted the DPT vaccine with a pentavalent vaccine that protects against DPT, hepatitis B (HepB), and *Haemophilus influenza* type b (Hib) — DPT-HepB-Hib in its EPI.[12] Additionally, in November 2011 and October 2012, the Government of Malawi introduced new vaccines into its EPI; namely, the pneumococcal conjugate vaccine (PCV13) against bacterial pneumonia and monovalent human rotavirus vaccine (RV1) against severe diarrhea caused by rotavirus, respectively.[10] The Malawian EPI recommends that the BCG and polio 0 vaccines should be given at birth or within the first 14 days after birth, while the pentavalent, pneumococcal, rotavirus and oral polio vaccines should be given at approximately 6, 10, and 14 weeks of age. The measles vaccine is recommended to be administered as soon as the child reaches 9 months of age.[13]

Despite the medical significance of vaccines in eliminating life-threatening infectious diseases,[14] the WHO estimated that 19.5 million infants are either partially or none vaccinated.[8,15] It is clearly stated that non- or partially-vaccinated children are at an elevated risk of developing diseases a condition that could read to the recurrent of almost eradicated life-threatening diseases.[16] Moreover, in the course of an outbreak, all children and families of non-vaccinated children may be quarantined and may even be excluded from certain areas. Likewise, non- or partially-vaccinated children could also be lawfully barred from certain facilities, as well as after-school programs.[17] Eventually, all these events may have additive economic negative implications at household-, community-, and country-levels since diseases may be recurring and severe, thus putting pressure on the household economy and overall total healthcare expenditure as well as healthcare programs.[18,19]

Numerous epidemiological studies from low-income countries (LICs) including Malawi have identified several barriers to childhood vaccination including individual-, household, and community-level factors. For example, at the individual level, studies have reported that the sex of the child, birth order, and age have influence on vaccination status.[20,21] At the household level, paternal education,[22,23] maternal characteristics,[22] household income,[22] healthcare utilization,[24] distance to healthcare facilities,[25] religion,[22] and source of information[23] were significantly associated with the children's vaccination status. At the community level, the geographic region and place of residence, communities with high illiteracy rates, socio-economically disadvantaged communities, communities with a higher rate of institutional delivery, and maternal antenatal care were associated with childhood vaccination status.[26,27] However, a preponderance of these studies focused on either complete vaccination or incomplete vaccination and few studies have examined the predictors of childhood vaccination using a three-way category of full vaccination, under-vaccination, and non-vaccination. Similarly, prior studies conducted in Malawi on childhood vaccination have focused either on coverage of individual vaccines or complete and incomplete, vaccination and no

study separated the vaccination status into non-, under, and full – vaccination.[28–30] Therefore, the present study attempted to examine the predictors of non- and under-vaccination among children aged 12–23 months in Malawi. The results of this study will inform policymakers to design intervention that had risen due to methodological and practical problems from prior studies.

2. Materials and methods

2.1. Data source

The current study used publicly available data obtained from the 2015–16 Malawi Demographic and Health Survey (MDHS) collected from October 2015 to February 2016. Methods used in this study are available in elsewhere.[10] Briefly, the 2015–16 MDHS utilized a stratified two-stage cluster sampling design and produced a nationally representative sample. In the first stage, 850 standard enumeration areas (SEAs) were randomly selected with probability proportional to the size. The second stage selected a sample of households with an equal probability systematic selection. The Malawi Population and Housing Census (MPHC), conducted in 2008, was used as the sampling frame for the MDHS survey. The survey collected information from women of reproductive age (15–49 years) who had children below the age of 5 years prior to the survey by means of face-to-face interviews. The main purpose of the MDHS is to provide data on the measures of population health, socio-demographic, environmental, anthropometry, HIV/AIDS, maternal and child health indicators. Data on childhood vaccination status were obtained in two ways. Mothers were asked: "Do you have a health passport or other document where (NAME)'s vaccinations are written down?"[10] If the mother could not show a health or immunization card, she was then asked: "Did (NAME) ever receive any vaccinations to prevent (NAME) from getting diseases, including vaccinations received in campaigns or immunization days or child health days"?[10] Mothers were further asked to report whether the (NAME) received BCG, polio, pentavalent, rotavirus, pneumococcal and measles vaccines. As regards polio, pentavalent, rotavirus, and pneumococcal vaccines, mothers were further asked to report how many times the (NAME) received each specific vaccine.[10]

2.2. Inclusion criteria

Specifically women of reproductive age (15–49 years) who had children under the age of five years old prior to the data collection regardless of current marital status were included. Additionally, children aged 12–23 months were selected, since the WHO recommends that all children should be vaccinated by 12 months of age.

2.3. Study variables

2.3.1. Dependent variables

In Malawi, children are considered to be fully vaccinated if they have received all basic vaccinations.[10] The current Malawian Expanded Programme on Immunization (EPI) schedule define basic vaccinations as one dose of BCG, three doses of DPT-HepB-Hib, three doses of oral polio vaccine (excluding polio vaccine given at birth), two doses of rotavirus vaccine, and three doses of pneumococcal vaccine provided at 6, 10 and 14 weeks of age and one dose of measles vaccine at 9 months of age (Table 1).[10] Using EPI recommendations, the outcome of the current study was grouped as (1) Non-vaccinated, (2) Under-vaccinated, and (3) Fully vaccinated. Non-vaccinated was defined as children who did not receive any of the EPI recommended vaccines by 12 months of age. Under-vaccinated was classified as children who received at least one but did not achieve all the recommended vaccines by the age of 12 months. Fully vaccinated was defined as children who received all recommended basic vaccines (one dose of BCG, three doses of DPT-HepB-Hib, three doses of oral polio vaccine (excluding polio vaccine given at birth), two doses of rotavirus vaccine, three doses of pneumococcal vaccine, and one dose of measles vaccine) by 12 months of age.[10]

2.3.2. Covariates

Based on insights from reviewing the relevant literature, the following covariates were deemed appropriate and treated as child-, household-, health service utilization-, and community characteristics. Child-specific factors included the child's sex (male/female) and the birth order (1/2–3/4–5/and ≥6). Household characteristics included women's age in years (15–19/20–24/25–34/35–49), educational attainment (no formal education/primary/secondary education and above), the employment status of the women (no formal employment/white collar/and blue collar), household wealth status (poorest/poorer/middle/richer/and richest), the number of

Table 1 Schedule of the Malawi's Expanded Programme on Immunization.

Age (completed weeks/months)	Vaccine
At birth or first contact	BCG
At birth up to 2 weeks	OPV 0
At 6 weeks	OPV 1 and Pentavalent[a] 1 and PCV[b] 1, RV[c] 1
At 10 weeks	OPV 2 and Pentavalent 2 and PCV 2, RV 2
At 14 weeks	OPV 3 and Pentavalent 3 and PCV 3
At 9 months	Measles

Pentavalent includes DPT, HepB, and Hib. BCG, bacillus Calmette–Guérin; OPV, oral polio vaccine; DPT, diphtheria, pertussis, tetanus; HepB, Hepatitis B; Hib, *Haemophilus influenza* type b; PCV, Pneumococcal conjugate vaccine, RV, rotavirus vaccine.

[a] Introduced into the Expanded Programme on Immunization in 2012.

[b] Introduced into the Expanded Programme on Immunization in November 2011.

[c] Introduced into the Expanded Programme on Immunization in October 2012.

under-5-year children in the household (≤1/2−3/and ≥4), and amount of media exposure (0/1/2/3/and 4). Health services utilization included place of delivery (home and other/hospital/institution), perceived distance to health facility (no big problem/big problem), the number of antenatal care (ANC) visits (inadequate visits/adequate visits), baby postnatal care (PNC) check within 2 months (no/yes), Tetanus Toxoid Injection (TTI) during pregnancy vaccination card (no card/has card but not presented/and has card and presented). Community characteristics included place of residence (urban/rural), and geographical region (northern/central/and southern). The household wealth index is a composite measure of a household's cumulative living standard and was calculated using easy-to-collect data on a household's ownership of selected assets, such as televisions and bicycles. Household asset scores were generated through a principal component analysis (PCA) by DHS program. The resulting asset scores were standardized and categorized into quintiles.[10] Amount of media exposure was created from 3 items namely, the frequency of reading a newspaper or magazine, frequency of listening to the radio, and the frequency of watching television (TV). Amount of media exposure was calculated by summing up the reported number of frequency respondents who had read a newspaper or magazine, listened to the radio and watched TV.

2.4. Statistical analyses

The distribution of the baseline characteristics of the study participants were described as frequencies and percentages. By means of the Chi-Square test, the bivariate analyses were performed to determine the distribution of sociodemographic characteristics according to the childhood vaccination status (non-, under-, and fully-vaccinated). The purposeful selection of covariates was used to determine covariates that should be included in the "best" model. Thus, based on the Rao-Scott Second-Order Chi-Square Test and *p*-value cut-off point of ≤0.25, all the relevant and potentially predictive variables were included in the final models. Because the outcome variable was a three-way category of full vaccination, under-vaccination, and non-vaccination, the multivariate analyses were conducted using a series of multinomial logistic models (i.e., children, maternal/households, health care utilization, and community characteristics) with logit link function to estimate the effects of the sociodemographic factors on the childhood vaccination status. Because of the complex sampling technique, the survey-specific SAS procedures for weighting, clustering, and stratification in the survey design (PROC SURVEYFREQ and PROC SURVEYLOGISTIC) were conducted. In the model, adjusted odds ratios (aORs) and 95% confidence intervals (CIs) with their *p*-values were calculated. Significance was defined as *p*-value <0.05. Multicollinearity was tested by the use of variance inflation factor (VIF) and Tolerance. All VIF values were <10 and tolerance values were >0.1. Hence, no multicollinearity constraints were detected in the regression models. All data analyses were done using statistical analysis software (SAS) for Windows, version 9.4 (SAS Institute, Cary, NC, USA).

2.5. Ethical clearance

All study participants gave written and informed consent prior to being enrolled in the study. The protocols of the MDHS 2015−16 were reviewed and approved by the Malawi National Health Sciences Research Committee (NHSRC) and the Institutional Review Board (IRB) of ICF Macro to ensure that the protocols were in line with U.S. Department of Health and Human Services regulation for the protection of human subjects.[31] Furthermore, the current study was exempted from ethical approval because secondary analysis was carried out on the dataset which is publicly available at http://dhsprogram.com/data/available-datasets.cfm.

3. Results

3.1. Sample characteristics

In total of 3111 children aged 12−23 months old were analyzed in this current study. A majority of children (72%) had been fully vaccinated. In addition, 26% of children received one or more doses of any of these basic vaccines, but not all of them, while about 1.5% did not receive any of these recommended vaccines (Fig. 1). Table 2 presents the socio-demographic characteristics of the study participants.

3.2. Bivariate analysis

The distribution of participants' characteristics according to the childhood vaccination status is shown in Table 3. Children of second and third birth order, children born to mothers with secondary and above education, children who resided in richest households, children whose households had at most one under-five child, children whose households reported distance to the nearest health facility as no big problem, children whose delivery occurred in health facility and had PNC check within two months, children who had a health card which was presented, and children who resided in the northern region were more likely to have full vaccination. Conversely, children of sixth and above birth order, children born to mothers with no formal education, children who resided in the poorest households, children whose households had four and above under-five children, children whose households reported distance to the nearest health facility as big problem, children whose delivery occurred in a non-health facility and did not have PNC check within two months, children who had no health card, and children who resided in the southern and central region were more likely to be non- and under-vaccinated.

3.3. Factors associated with non-vaccination versus fully-vaccination

Table 4 displays the multinomial logistic regression results of the factors associated with non-vaccination. Compared to children who had a health card and its whereabouts was known, children who had no card (aOR: 143.1; 95% CI: 41.01−499.9), or who had card but its whereabouts was unknown (aOR: 60.03; 95% CI: 12.38−290.9) had increased

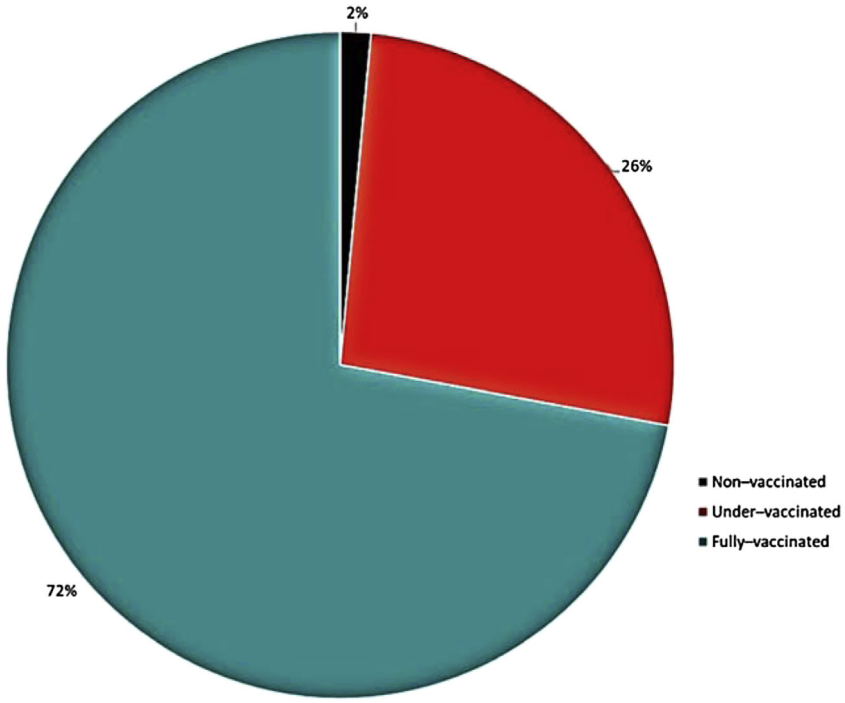

Figure 1 Pie chart showing the proportion of children aged 12—23 months who were none-, under-, and fully-vaccinated.

odds of being non-vaccinated. Furthermore, children from the central region had 83% (aOR: 0.173; 95% CI: 0.054—0.559) reduced odds of being non-vaccinated compared to children from the southern region.

3.4. Factors associated with under-vaccination versus fully-vaccination

Table 4 also presents the multinomial logistic regression results of the factors associated with under-vaccination. Compared to children from the richest households, children from the poorest (aOR: 2.386; 95% CI: 1.487—3.827), poorer (aOR: 1.731; 95% CI: 1.087—2.755), and middle (aOR: 2.016; 95% CI: 1.275—3.188) wealth advantaged households had increased odds of being under-vaccinated. Children whose households had at most 1 under-five child were 39% (aOR: 0.606; 95% CI: 0.401—0.914) reduced odds of being under-vaccinated, compared to children whose households had 4 and above under-five children. Compared to children who had PNC check within 2 months, those who did not have PNC check (aOR: 1.472; 95% CI: 1.152—1.880) had increased odds of being under-vaccinated. Furthermore, compared to children who had health card and its whereabouts was known, children who had no card (aOR: 12.99; 95% CI: 9.382—18.01), or who had a card but its whereabouts was unknown (aOR: 11.37; 95% CI: 7.630—16.93) had increased odds of being non-vaccinated.

4. Discussion

Utilizing a nationally representative sample, the current study aimed to investigate the predictors of childhood vaccination status specifically using a three-way category of full vaccination, under-vaccination, and non-vaccination. A majority of children (72%) had been fully-vaccinated; however, the coverage continues failing short the benchmark of 90% set by the WHO.[9] In addition, 26% of children received one or more doses of any of these basic vaccines, but not all of them, while about 2% did not receive any of these recommended vaccines. On bivariate analysis, children of second and third birth order, children born to mothers with secondary and above education, children who resided in the richest households, children whose households had at most one under-five child, children whose households had no big problems with distance to the nearest health facility, children whose delivery occurred in a health facility and had PNC check within two months, children who had a health card which was not presented, and children who resided in the northern region were more likely to have full vaccination. The multinomial logistic regression results showed that children who either had no immunization card or had an immunization card which was not presented had higher of odds on being non-vaccinated while those from the central region had reduced odds of being non-vaccinated. On the other hand, children from the poorest households, children who no PNC check within 2 months and those who either had no immunization card or had an immunization card which was not presented had higher of odds on being under-vaccinated. Additionally, children from households with either one or no under-fives were associated with reduced likelihood of being under-vaccinated.

As with prior research conducted in other sub-Saharan African countries,[7,32] the current study revealed that the lack of baby PNC follow-up within two months increased

Table 2 Socio-demographic characteristics of the study participants MDHS, 2015–16 ($n = 3111$).

Covariates	n[a]	%[b]	SE
Child characteristics			
Sex of the child			
Male	1566	49.49	1.09
Female	1545	50.51	1.09
Birth order			
1	798	26.41	1.03
2–3	1157	36.54	1.03
4–5	716	22.49	0.95
≥6	440	14.56	0.75
Household characteristics			
Maternal age (years)			
15–19	329	10.61	0.68
20–24	1008	32.53	1.07
25–29	704	22.30	0.95
30–34	558	17.97	0.77
35–49	512	16.59	0.86
Maternal education levels			
No education	348	12.04	0.81
Primary	2128	67.93	1.12
Secondary and above	635	20.06	0.98
Maternal employment status			
No formal employment	954	29.85	1.07
White collar	324	9.96	0.81
Blue collar	1833	60.19	1.18
Wealth index			
Poorest	767	26.63	1.10
Poorer	664	21.62	0.99
Middle	625	20.39	0.89
Richer	527	15.69	0.89
Richest	528	15.67	0.86
No of under-5-year children			
≤1	1523	49.00	1.23
2–3	1367	44.05	1.16
≥4	221	6.95	0.62
Amount of media exposure[c]			
0	1494	47.94	1.11
1	1003	32.85	1.07
2	449	14.04	0.84
3	165	5.17	0.54
Health service utilization			
Place of delivery			
Home and other	192	6.89	0.69
Hospital/institution[d]	2919	93.11	0.69
Distance to health facility			
No big problem	1385	41.07	1.43
Big problem	1726	58.93	1.42
Antenatal care visits			
Inadequate visits (0–3)	1549	49.71	1.19
Adequate visits (≥4)	1562	50.29	1.19
Baby PNC check within 2 months			
No	1682	54.77	1.12
Yes	1429	45.23	1.12
TTI during pregnancy			
No	335	10.45	0.68
Yes	2776	89.55	0.68
Health card			
No card	436	13.89	0.81
Yes but not presented	198	5.91	0.55
Yes card and presented	2477	80.20	0.94
Community characteristics			
Place of residence			
Urban	489	13.36	0.95
Rural	2622	86.64	0.95
Geographical region			
Northern	585	11.86	0.53
Central	1088	42.27	1.12
Southern	1438	45.87	1.12
Outcome variables			
Vaccination status			
Non-vaccinated	45	1.48	0.29
Under-vaccinated	789	26.44	1.09
Fully-vaccinated[e]	2277	72.08	1.13

[a] Unweighted frequency.
[b] Weighted percentage; SE, standard error; TTI, tetanus toxoid injection; PNC, postnatal care.
[c] Frequency of reading newspaper or magazine, frequency of listening to radio, frequency of watching television.
[d] Government hospital, government health center, government health post/outreach, other public sector, private hospital/clinic, CHAM/MISSION hospital, CHAM/MISSION health center, BLM, other private medical sector; CHAM, Christian Health Association of Malawi; BLM, Banja la Mtsogolo.
[e] BCG, three doses of DPT-HepB-Hib, three doses of oral polio vaccine (excluding polio vaccine given at birth), two doses of rotavirus vaccine, three doses of pneumococcal vaccine and one dose of measles vaccine; BCG Bacillus, Calmette–Guérin; DPT; Diphtheria–Pertussis–Tetanus; HepB, Hepatitis B; Hib, *Haemophilus influenza* type b; MDHS, Malawi Demographic and Health Survey.

the odds of being under-vaccinated. This may suggest that women who did not have PNC follow up had not gotten sufficient information from the health workers about the benefits of getting their babies vaccinated. Conversely, women with PNC follow up might be more satisfied with the health care system and be aware of the need for childhood vaccination.[33,34]

In line with previous studies,[35,36] the current study found that children who had no vaccination card or who had vaccination card but the card was lost had increased odds of being non- and under-vaccinated. It has been reported by prior researchers that being in possession of a child's immunization card may allow the women to follow the immunization schedule easily. Additionally, it has been stated that having an immunization card can prevent women from missing out on vaccinations schedules.[35] Conversely, women who do not have immunization card might avoid seeking immunization services for fear of ill-treatment from some health care providers as a result of a misplaced or damaged child immunization card.[37]

Consistent with prior research,[34,38] children from families with either none or one under-five child in the household had reduced odds of being under-vaccinated. It was reported that women with fewer children in the

Table 3 Vaccination status of children 12–23 months by sociodemographic covariates; MDHS 2015–16.

Covariates	Non-vaccination	Under-vaccination	Full vaccination[a]	*p*-value[a]
	n (%)	*n* (%)	*n* (%)	
Child characteristics				
Sex of the child				0.9398
Male	23 (1.47)	393 (25.10)	1150 (73.43)	
Female	22 (1.43)	396 (25.63)	1127 (72.94)	
Birth order				0.0076
1	15 (1.88)	203 (25.44)	580 (72.68)	
2–3	8 (0.78)	301 (26.02)	847 (73.21)	
4–5	9 (1.12)	162 (22.63)	546 (76.26)	
≥6	13 (2.95)	123 (27.95)	304 (69.09)	
Household characteristics				
Maternal age (years)				0.0742
15–19	10 (3.04)	91 (27.66)	228 (69.30)	
20–24	14 (1.39)	261 (25.89)	733 (72.72)	
25–29	4 (0.57)	182 (25.85)	518 (73.58)	
30–34	7 (1.25)	127 (22.76)	424 (75.99)	
35–49	1127 (1.95)	128 (25.00)	374 (73.05)	
Maternal education levels				0.0001
No education	11 (3.16)	98 (28.16)	239 (68.68)	
Primary	30 (1.41)	563 (26.46)	1535 (72.13)	
Secondary and above	4 (0.63)	128 (20.16)	503 (79.21)	
Maternal employment status				6.5359
No formal employment	17 (1.78)	249 (26.10)	688 (72.12)	
White collar	5 (1.54)	78 (24.07)	241 (74.38)	
Blue collar	23 (1.25)	462 (25.20)	1348 (73.54)	
Wealth index				0.0099
Poorest	13 (1.69)	224 (29.20)	530 (69.10)	
Poorer	8 (1.20)	175 (26.36)	481 (72.44)	
Middle	9 (1.44)	169 (27.04)	447 (71.52)	
Richer	9 (1.71)	115 (21.82)	403 (76.47)	
Richest	6 (1.14)	106 (20.08)	416 (78.79)	
No of under-5-year children				0.0037
≤1	22 (1.44)	368 (24.16)	1133 (74.39)	
2–3	19 (1.39)	341 (24.95)	1007 (73.66)	
≥4	4 (1.81)	80 (36.20)	137 (61.99)	
Amount of media exposure[b]				0.1481
0	30 (2.01)	388 (25.97)	1076 (72.02)	
1	10 (1.00)	254 (25.32)	739 (73.68)	
2	2 (0.45)	106 (23.61)	341 (75.95)	
3	3 (1.82)	41 (24.85)	121 (73.33)	
Health service utilization				
Place of delivery				<0.0001
Home and other	10 (5.21)	53 (27.60)	129 (67.19)	
Hospital/institution[c]	35 (1.20)	736 (25.21)	2148 (73.59)	
Distance to health facility				0.0434
No big problem	17 (1.23)	324 (23.39)	1044 (75.38)	
Big problem	28 (1.62)	465 (26.94)	1233 (71.44)	
Antenatal care visits				0.0190
Inadequate visits (0–3)	31 (2.00)	377 (24.34)	1141 (73.66)	
Adequate visits (≥4)	14 (0.90)	412 (26.38)	1136 (72.73)	
Baby PNC check within 2 months				<0.0001
No	28 (1.66)	447 (28.36)	1177 (69.98)	
Yes	17 (1.19)	312 (21.83)	1100 (76.98)	
TTI during pregnancy				0.7591
No	6 (1.79)	81 (24.18)	248 (74.03)	
Yes	39 (1.40)	708 (25.50)	2029 (73.09)	
Health card				<0.0001

(*continued on next page*)

Table 3 (*continued*)

Covariates	Non-vaccination	Under-vaccination	Full vaccination[a]	*p*-value[a]
	n (%)	*n* (%)	*n* (%)	
No card	34 (7.80)	277 (63.53)	125 (28.67)	
Yes but not presented	7 (3.54)	118 (59.60)	73 (36.87)	
Yes card and presented	4 (0.16)	394 (15.91)	2079 (83.93)	
Community characteristics				
Place of residence				0.8023
Urban	8 (1.64)	119 (24.34)	362 (74.03)	
Rural	37 (1.41)	670 (25.55)	1915 (73.04)	
Geographical region				0.0005
Northern	6 (1.03)	136 (23.25)	443 (75.73)	
Central	5 (0.46)	297 (27.30)	786 (72.24)	
Southern	34 (2.36)	356 (24.76)	1048 (72.88)	

MDHS, Malawi Demographic and Health Survey.

[a] One dose of BCG, three doses of DPT-HepB-Hib, three doses of oral polio vaccine (excluding polio vaccine given at birth), two doses of rotavirus vaccine, three doses of pneumococcal vaccine and one dose of measles vaccine; TTI, tetanus toxoid injection; PNC, postnatal care.

[b] Frequency of reading newspaper or magazine, frequency of listening to radio, frequency of watching television.

[c] Government hospital, government health center, government health post/outreach, other public sector, private hospital/clinic, CHAM/MISSION hospital, CHAM/MISSION health center, BLM, other private medical sector; CHAM, Christian Health Association of Malawi; BLM, Banja la Mtsogolo.

Table 4 Adjusted odds ratios for vaccination status by sociodemographic covariates for children 12—23 months from the MDHS 2015—16.

Covariates	Non-versus fully vaccinated	*p*-value	Under-versus fully vaccinated	*p*-value
	AOR 95% (CI)		AOR 95% (CI)	
Child characteristics				
Birth order				
1	0.227 (0.024—2.151)	0.1961	0.645 (0.334—1.245)	0.1907
2—3	0.099 (0.023—0.426)	0.0020	0.750 (0.436—1.290)	0.2981
4—5	0.478 (0.124—1.850)	0.2847	0.652 (0.415—1.023)	0.0625
≥6	1.00		1.00	
Household characteristics				
Maternal age (years)				
15—19	1.862 (0.207—16.79)	0.5790	1.403 (0.737—2.672)	0.3025
20—24	2.389 (0.424—13.46)	0.3230	1.368 (0.801—2.336)	0.2507
25—29	0.679 (0.096—4.788)	0.6977	1.367 (0.837—2.234)	0.2113
30—34	0.586 (0.137—2.504)	0.4701	0.953 (0.632—1.437)	0.8164
35—49	1.00		1.00	
Maternal education levels				
No education	3.359 (0.626—18.02)	0.1572	1.261 (0.753—2.113)	0.3773
Primary	1.682 (0.399—7.082)	0.4781	1.047 (0.720—1.524)	0.8089
Secondary and above	1.00		1.00	
Wealth index				
Poorest	1.012 (0.306—3.347)	0.9843	2.386 (1.487—3.827)	0.0003
Poorer	1.685 (0.502—5.657)	0.3981	1.731 (1.087—2.755)	0.0209
Middle	1.377 (0.369—5.135)	0.6330	2.016 (1.275—3.188)	0.0028
Richer	1.209 (0.381—3.834)	0.7465	1.128 (0.743—1.712)	0.5724
Richest	1.00		1.00	
No of under-5-year children				
≤1	0.671 (0.078—5.758)	0.7161	0.606 (0.401—0.914)	0.0170
2—3	1.024 (0.187—5.617)	0.9783	0.703 (0.459—1.076)	0.1047
≥4	1.00		1.00	
Amount of media exposure[a]				
0	0.377 (0.054—2.653)	0.3269	0.790 (0.404—1.547)	0.4920
1	0.203 (0.030—1.383)	0.1032	0.960 (0.493—1.872)	0.9056

Table 4 (*continued*)

Covariates	Non-versus fully vaccinated	*p*-value	Under-versus fully vaccinated	*p*-value
	AOR 95% (CI)		AOR 95% (CI)	
2	0.156 (0.014–1.679)	0.1252	0.865 (0.444–1.686)	0.6706
3	1.00		1.00	
Health service utilization				
Place of delivery				
Home and other	1.927 (0.598–6.212)	0.2714	0.857 (0.559–1.314)	0.4794
Hospital/institution[b]	1.00		1.00	
Distance to health facility				
No big problem	0.619 (0.259–1.482)	0.2815	0.913 (0.698–1.194)	0.5040
Big problem	1.00		1.00	
Antenatal care visits				
Inadequate visits (0–3)	1.357 (0.581–3.165)	0.4799	0.814 (0.654–1.013)	0.0655
Adequate visits (≥4)	1.00		1.00	
PNC check within 2 months				
No	2.301 (0.902–5.866)	0.0809	1.472 (1.152–1.880)	0.0020
Yes	1.00		1.00	
Health card				
No card	143.1 (41.01–499.9)	<0.0001	12.99 (9.382–18.01)	<0.0001
Yes but not presented	60.03 (12.38–290.9)	<0.0001	11.37 (7.630–16.93)	<0.0001
Yes card and presented	1.00		1.00	
Community characteristics				
Geographical region				
Northern	0.626 (0.219–1.787)	0.3806	0.764 (0.468–1.247)	0.2818
Central	0.173 (0.054–0.559)	0.0034	0.964 (0.748–1.242)	0.7759
Southern	1.00		1.00	

MDHS, Malawi Demographic and Health Survey; AOR, adjusted odds ratio; 95% CI, 95% confidence interval; TTI, tetanus toxoid injection; PNC, postnatal care.

[a] Frequency of reading newspaper or magazine, frequency of listening to radio, frequency of watching television.

[b] Government hospital, government health center, government health post/outreach, other public sector, private hospital/clinic, CHAM/MISSION hospital, CHAM/MISSION health center, BLM, other private medical sector; CHAM, Christian Health Association of Malawi; BLM, Banja la Mtsogolo.

household may have more time to commit to the care of an individual child, thus making routine immunization visits easier to prioritize.[34,38] On the contrary, women with multiple children may not harmonize health care visits for their children due to the lack of family resources, including time and attention, which could influence whether each child adheres to the recommended schedule.[34,38]

It is well recognized that household wealth plays an important role in women's' utilization of health services. The current study found that children born from the poorest households had increased odds of being under-vaccinated. This result has also been reported in other epidemiological research elsewhere.[39,40] It is well known that women from the poorest households may have obstacles in getting childhood immunization services which include lack of transportation and distance to the nearest health facility compared to their richest counterparts.[26] On the other hand, higher income may be linked to a higher prospects to acquire improved health knowledge and health-seeking behavior.[26]

The geographical region was the other determinant factor of immunization status in pre-school aged children. We found out that children from the central region had reduced odds of being non-vaccinated. This result is contrary to what previous studies from Malawi have reported. Munthali, found out that on average the central region had the lowest vaccination coverage compared to the other two regions.[28] Similarly, Ntenda et al., reported that the odds of achieving vaccination coverage and complete immunization were lowest in the central region.[30] However, this result is consistent with what was reported in the MDHS 2015–16. According to the MDHS, the percentage of children aged 12–23 months who received no vaccination by region was lowest in the central region (1.5% in the Northern, 0.5% in the Central and 2.6%, in the Southern region).[10] Hence, our finding forms a basis through which future research should explore the reason for the shift of this variation gradient.

4.1. Strengths and weaknesses

The strengths of this study are (1) the use of huge sample size and nationally representative sample which allow the findings to be generalized in Malawi, and (2) the current study separated the dependent variable into a three-way category so that methodological and practical problems could be addressed. However, the findings of the current study should be interpreted in light of several limitations. First, the results of this study are prone to recall bias as the

respondents who did not have the child health card, were asked to recall the vaccines that were administered to their children. However, previously it has been reported that in nations where immunization records are not available, maternal recall provides accurate population-level estimates of vaccination coverage. Second, the MDHS 2015—16 is a cross-sectional survey; thus, no causal inference can be warranted. Third, the use of secondary data limited us to include other variables that could have explained childhood vaccination status. For example, the MDHS 2015—16 did not record any information on unavailability of vaccines due to stock-outs, access to services, such as training of health workers, lack of adequate vaccine supply, and inconsistent scheduling of vaccination supply.

5. Conclusion

In spite of the health and economic benefits of childhood vaccinations, the present study found that childhood vaccination rates remain unacceptably low and a certain fraction of children remains non- and under-vaccinated in Malawi. We also revealed that the full vaccination status was below the 90% benchmark target set by the WHO on the vaccination schedule for reducing the burden of childhood illness and death. After controlling for potential confounders, the multinomial logistic regression results showed that the immunization card and geographical region were associated with non-vaccination. Additionally, household wealth, the number of under-5-years old children in the household, baby PNC check within 2 months, and immunization card were significantly associated with under-vaccination among children aged 12—23 months in Malawi. The variation reported in study highlights the need for policymakers to design and implement interventions that aim at narrowing the disparities of childhood immunization in Malawi. Precisely, women from the poorest households, women with four and above under-five-year-old children in the household, and those who are not attending PNC within the designated schedule should be targeted when designing these public health interventions in order to reduce the barriers that they face in accessing vaccination services.

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Competing interests

The authors declare that they have no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pedneo.2019.03.005.