ORIGINAL ARTICLE

Factors associated with completion of childhood immunization in Malawi: A multilevel analysis of the 2015-16 Malawi Demographic and Health Survey

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ABSTRACT

Background: Between 2010 and 2015, the percentage of children aged 12–23 months who received full immunization dropped from 81% to 76% in Malawi prompting us to investigate the factors associated with completion of childhood immunization in Malawi.

Methods: Using data from the 2015-16 Malawi Demographic and Health Survey (2015-16 MDHS), the generalized linear mixed models (GLMMs) with logit-link function and binomial distribution were applied on 3,145 children between 12–23 months of age, nested within 850 communities. Complete immunization was defined as the child having received a Bacillus Calmette Guerin (BCG); three doses of pentavalent vaccine; four doses of oral polio vaccine; three doses of pneumococcal vaccine; two doses of rotavirus vaccine and one dose of measles vaccine before their first birthday.

Results: Adjusted multilevel regression showed that children born to mothers with either none or one antenatal care (ANC) visit [adjusted odds ratio (aOR) 0.56; 95% confidence interval (CI): 0.32–0.93], and whose mothers had no card/ no longer had a vaccination card (aOR 0.06; 95% CI: 0.04–0.07) were less likely to receive complete immunization. In addition, children from the poorest households (aOR 0.60; 95% CI: 0.40–0.92), and who resided in communities with a medium (aOR 0.73; 95% CI: 0.53–0.98) and a high percentage (aOR 0.73; 95% CI: 0.53–0.99) of households that perceived the distance to the nearest health facility as a big problem had reduced odds of achieving complete immunization. Furthermore, the findings showed evidence of clustering effects of childhood complete immunization at community levels.

Conclusions: Our findings have shown that an array of sociodemographic, health and contextual factors are associated with the completion of childhood vaccination. Therefore, interventions that aim at increasing the completion of childhood immunization in Malawi should not only address individual needs but also consider contextual factors and their communities addressed in this study.

Keywords: Complete immunization; contextual factors, multilevel analysis; sociodemographic; Malawi

Introduction

Immunization proves to be an effective intervention for the prevention and elimination of life-threatening infectious diseases since the 20th century. The World Health Organization (WHO) estimated that immunization prevents about 2–3 million deaths annually [1–3]. Additionally, the WHO elucidated that with proven strategies vaccination can be accessible even to the most hard-to-reach and vulnerable populations [3]. Despite this, immunization coverage in low-income countries is still far from reaching the 90% target set by the Expanded Program on Immunization (EPI) [4, 5]. Worldwide, the percentage of children who receive recommended vaccines has remained stalled at 86%, with no significant changes [6]. Conversely, in Malawi, the percentage of children aged 12–23 months who received complete vaccination dropped from 81% to 76% between 2010 and 2015 [7], which is less than the WHO recommended benchmark [4, 5].

Vaccines are the safest way to protect young children and communities from potentially life-threatening ailments such as diphtheria, hepatitis A, and B, Haemophilus influenzae type B, measles, mumps, rotavirus, tetanus, rubella, pneumococcal disease, pertussis (whooping cough), polio, influenza etc. [8]. However, despite the medical importance of vaccines, the WHO estimated that 19.5 million infants globally are still missing out on basic vaccines i.e. either partially or none vaccinated [6]. It is well documented that none- or partially-vaccinated children are at an increased risk of developing diseases a factor that could lead to the re-current of almost eradicated diseases [9]. Furthermore, during an outbreak, all children and families of non-vaccinated children may be quarantined and may be excluded from certain areas. Similarly, unimmunized children could also legally be banned from certain day care facilities, as well as after-school programs [10]. Eventually, all these events may have economic implications at household-, community-, and country-level since diseases may become more frequent and severe, thus putting pressure on the household budget and overall total healthcare expenditure as well as healthcare programs [11, 12].

Since the inception of the EPI in Malawi in 1979, the programme aimed to provide the following vaccines: 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 and these vaccines are recommended to be received during the first year of life [13]. In early 2000s, Malawi replaced the DPT vaccines with a pentavalent vaccine that protects against DPT, hepatitis B (HepB), and Haemophilus influenza type b (Hib) [14]. In November 2011 and October 2012, the Government of Malawi further introduced new vaccines namely; the pneumococcal conjugate vaccine (PCV13) against bacterial pneumonia and monovalent human rotavirus vaccine (RV1) against severe diarrhea caused by rotavirus into the nation's infant immunization programme, respectively [7]. The Malawian EPI recommends that the BCG and polio 0 vaccines should be given at birth or within the first 14 days after birth, and the DPT-HepB-Hib, 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 at or soon after the child reaches 9 months of age [14, 15].

Extensive research has demonstrated that factors such as child characteristics [16, 17], maternal characteristics [16, 18, 19], maternal health care utilization [16, 20], the distance to healthcare facilities [17, 21], household wealth [22, 23], immunization schedule [24, 25], parental occupation [21, 26], exposure to media [16, 21], geographical region and place of residence [16, 22], all have significant effects on childhood immunization. However, very few studies have investigated the influence of both individual and contextual factors on childhood immunization and whether the effects still exist after controlling for individual-level and community-level characteristics [16, 17], Thus, identifying the factors that affect childhood immunization at different levels is essential for policymakers to design and implement effective interventions in order to increase the childhood vaccination coverage to the recommended target above and beyond the individual level.

Previous researchers suggested that the community or neighborhood influences an individual's behavior (personal lifestyle choices) and exposes residents to multiple health risks and resources over the course of their life [27, 28]. Thus, drawing inferences of the completion of the childhood immunization on either individual or community level could lead to either atomistic or ecological fallacy [29]. According to our review of the relevant literature, two studies in Malawi were conducted to examine the predictors of childhood immunization coverage and completion of childhood vaccination using nationally representative samples [22, 30]. However, both of these studies suffered from major methodological flaws as they either used the chi-square test or traditional logistic regression. The current study is exceptional as it tried to separate the independent contributions of individual and contextual level influence on the complete immunization. Therefore, using generalized linear mixed models, the current study assessed the potential effects of individual-level factors along with contextual characteristics on complete childhood immunization in Malawi. Specifically, we aimed to investigate the factors associated with completion of childhood immunization following the introduction of PCV 13 and RV 1 into the Malawian EPI schedule.

Materials and methods

Data source and Study design

This is a population-based study that utilized a cross-section of secondary data from the Malawi Demographic and Health Survey (MDHS) 2015-16. Detailed procedures used in the current study have been described in detail elsewhere [7]. In brief, the MDHS was designed to yield a nationally representative sample using a two-stage sampling design.

Data collection

The DHS collected data using face-to-face interviews from women of reproductive age 15–49 years who had children below 5 years of age. The survey was designed to collect information on the measures of population health, sociodemographic, environmental, anthropometry, immunization, and child health care indicators. In the interviewed households, 24 562 of the 25 146 eligible women were interviewed, representing a 98% response rate. Information on vaccination coverage was obtained in two ways; from vaccination cars or women's verbal response. Women were asked to show whether they had a vaccination card for each child born 5 years prior to the data collection. If the woman could not show an immunization card, she was asked; Has (NAME) received any vaccinations that are not recorded on this card, including vaccinations received in a national immunization day campaign? Furthermore, women were asked; Did (NAME) ever receive any vaccinations to prevent him/her from getting diseases, including vaccinations received in a national immunization day campaign? [7, 14].

Outcome variables

The outcome variable of this study was childhood complete vaccination. Complete immunization was defined as any child aged 12–23 months who received all age-appropriate vaccination. All age appropriate vaccination included one BCG, three doses of DPT-HepB-HiB, four doses of oral polio vaccine, three doses of *pneumococcal* conjugate vaccine, two doses of rotavirus vaccine, and one dose of measles vaccine [7] (Table 1). We limited the analysis to one child per household in order to minimize the over-representation of women with more than one child in the age category.

Independent variables

Based on the insights from reviewing the relevant literature, the following covariates were considered to be suitable and treated as the individual- and community-level characteristics [16, 17, 22, 31].

Individual-level factors

Individual-level factors include child-, women- and household-factors. Child-specific factors were the sex of the child (male and female) and the birth order (1, 2–3, 4–5, and ≥6). Women characteristics were; women's age (15–24, 25–34, and 35–49 years), the women's education (no formal education, primary school education, and secondary and higher education), antenatal (ANC) visits (≤1, 2–3, and ≥4), immunization card (no card/no longer had a card, had a card which was also seen, and had a card which was not seen). The households factors included household wealth index (poorest, middle and richest) and the number of children under the age of 5 years in the household (≤1, 2, and ≥3). The household wealth index is a composite measure of a household's cumulative living standard. It is calculated using easy-to-collect data on a household's ownership of selected assets such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities. Generated with a statistical procedure known as principal component analysis (PCA) by the measure DHS, the wealth index places individual household's on a continuous scale of relative wealth. Each household asset is then assigned a weight (factor score) and the resulting asset scores are standardized in relation to a normal distribution with a mean of zero and a standard deviation of one. Then the scores are summed up for each household and the sample is then divided into quintiles [32].

Community–level factors

The community-level factors were constructed by aggregating individual-level data at the cluster level. We referred to the primary sampling unit (PSU) of the DHS data as a community [33]. We included three continuous variables namely community wealth, distance to the nearest health facility, female education, Community wealth was defined as the percentage of households in the community categorized as the richest (upper 40% quintile), whereas community female education was defined as the percentage of women aged 15–49 in the community with primary education and above. Community distance to the nearest health facility was defined as the proportion of women aged 15–49 in the community who perceived the distance to the nearest health facility as a big problem. All continuous community-level factors were categorized as ‘‘low”, ‘‘medium” and ‘‘high” depending upon each variable’s tertiles to allow for nonlinear effects and provide results that were more readily interpretable in the policy arena. In addition, we included two variables indicating the area of residence, i.e. the place of residence (urban or rural), and geographical region (northern, central, and southern region).

Statistical analyses

The characteristics of the study sample were expressed as frequencies and percentages. Bivariate analyses were performed using Pearson’s Chi-square to test the differences between groups (complete vs incomplete vaccination). The multilevel logistic analyses were conducted using the generalized linear mixed models (GLMMs) with a logit-link function and binomial distribution, fitting four different models which are described below. Model 1 (null model) was an unconditional model with random intercepts and had no predictors. The model was used to decompose the total variance of complete immunization between the contextual and individual levels. Model 2 contained a random-intercept fixed-slope with individual-level factors and Model 3, contained a random-intercept fixed-slope with community contextual factors. Model 4 contained a random-intercept fixed-slope and controlled for both individual and community-level factors. We reported results from the final models of regression analyses only.

The measures of association between the individual-level, contextual risk factors, and complete immunization were reported as adjusted odds ratios (aOR) with their *p*-values and 95% confidence interval 95% (CI) after considering potential confounders. Random effects were expressed in terms of Area variance (AV), Median Odds Ratio (MOR), Intra-Cluster Correlation (ICC) and Proportion Change in Variance (PCV). The fitness of the model was assessed using the Deviance Information Criterion (DIC). Two-tailed Wald test at significance level of alpha equal to 5% was used to determine the statistical significance of the determinants and all the analyses were performed using SAS software version 9.4 (SAS Institute Inc., Cary, NC, USA).

Ethics statement

The procedures and questionnaires for 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. ICF IRB ensured that the survey complied with the U.S. Department of Health and Human Services regulations for the protection of human subjects (45 CFR 46), while the NHSRC ensured that the survey was conducted in line with Malawian laws and norms [34]. At the beginning of each interview, participants were asked to give verbal and written consent (informed consent). Informed consent statement emphasizes that participation was voluntary and that the respondent may opt to refuse to answer any question. Furthermore, the authors sought permission from the DHS program for the use of the data beyond the primary purpose it was collected.

Results

Population characteristics

A total of 3,125 children age 12–23 months dwelling in 850 different communities were analyzed in this current study. Table 2 shows the descriptive characteristics. Approximately 37% of the children were in the 2–3 birth order. In terms of household characteristics, slightly more women (~43%) were aged between 15 and 24 years and two–thirds (68%) of respondents had at least a primary education. In addition, 50% and ~ 80% of respondents had four above ANC visits and health cards respectively. About 50% of households had none or one under-five child and slight more households were deemed to be the poorest. In terms of community characteristics, a majority of respondents were rural (84%) and southern region (46%) dwellers. Slight more participants (38%) resided in communities with big problems with distance to the nearest health facility.

Bivariate analyses

Table 2 shows also the bivariate analyses between the outcome variable and individual- and community-level characteristics. Complete immunization was highest in children born to mothers with secondary education and above (79%), mothers with two to three ANC visits (75%), children who had immunization card (88%), children from households with at most one under-five child (75%), and richest households (79%).

Factors associated with completion of childhood immunization

Fixed effects

The findings of the multilevel logistic regression fixed effects are shown in Table 3. Model 4 shows the adjusted effects of individual and community–level factors on complete vaccination coverage. Achieving complete vaccination (aOR: 0.56; 95% CI: 0.32–0.93) was significantly lower among children whose mothers had none or at most one ANC visits compared to those born from mothers with four and above ANC visits. Furthermore, achieving complete immunization was much lower among children who had no health card/no longer have a card (aOR: 0.06; 95% CI: 0.04–0.07) and who had a card but the card was not seen (aOR: 0.08; 95% CI: 0.06–0.12) compared children who vaccination can and was seen. Achieving complete immunization was significantly high among children who were born in households with at most one under 5 years old child (aOR: 1.60; 95% CI: 1.09–2.36) compared to children who were born in households with three under-five children and above. Compared to children in richest households, children living in the poorest households had significantly lower odds ratios of achieving complete immunization (aOR: 0.60; 95% CI: 0.40–0.92). At the community level, compared to children from the communities with low percentage of households with perceived distance to the nearest health facility as a big problem, children living in communities with the middle (aOR: 0.73; 95% CI: 0.53–0.98) and high (aOR: 0.73; 95% CI: 0.53–0.99) percentage of the household who perceived the distance to the nearest health facility as a big problem had reduced odds of achieving complete immunization.

Random effects

The findings of the multilevel logistic regression random effects are also shown in Table 3. In Model 4, according to the area variance (AV), the variation remained significant even after adjusting for the potential confounders (individual- and community-level factors) [AV = 0.4687; SE = 0.1324; $p<0.05$]. The PCV showed 44% of the contextual-level variance of complete immunization can be explained by the individual and community-level factors compositional characteristics. The MOR was 1.92 showing that the odds of achieving complete immunization increased by 92% when mothers moved from low to high privileged neighborhoods. However, 12% (ICC) of the total variance remained unexplained.

Discussion

In this study, we examined the influence of individual-level factors along with contextual characteristics on complete childhood immunization in Malawi. Our findings show evidence of clustering effects of complete immunization at community levels. This suggests that children in the same neighborhood are subject to common contextual influences. The EPI aims at achieving immunization coverage of at least 90% of infant's nationwide [4, 5]. Unfortunately, as in 2015, the immunization in Malawi was found to be lower than both national and WHO targets.[7] In this study, the immunization coverage was found to be even lower than what has been previously reported [14, 22]. After adjustments for a wide range of individual- and community-level characteristics, it seems that the number of ANC visits, immunization card, the number of under-five children in the household, household wealth, and community distance to the nearest health facility were significant factors associated with the completeness of immunization.

Having none or at most one ANC visit was significantly associated with reduced odds of complete immunization as compared to higher ANC visits. These findings are in line with the studies conducted in Malawi [22] and other sub-Saharan countries [35–37]. A possible explanation might be that women who have frequent ANC visit might be more satisfied with the healthcare system and become aware of the need for vaccination which in turn may make them more likely to return for child vaccination. Their interactions with the healthcare providers may foster trust and strengthen the female/provider relationship. In turn, this may positively affect women's health-seeking behavior. Evidence has shown that the utilization of antenatal care encourages the use of subsequent maternal and child health services, including vaccination [38, 39].

Mothers in possession of a child health card was previously found to correlate with a child's complete immunization [25, 40]. As in our study, mothers whose children had ‘‘no card/no longer had a card” or ‘‘had a card but not seen” were less likely to be completely immunized. Being in possession of a child's immunization card could allow the mother to follow the immunization schedule and thus may increase the likelihood of her being able to return in time for the immunization of her child. Moreover, having a well-maintained immunization card with a clearly-labeled schedule can help prevent mothers from missing out on vaccination appointments [25]. On the hand, mothers who did not have immunization cards might avoid seeking immunization services for fear of ill-treatment from some healthcare providers as a result of misplaced, lost or damaged child health card [41].

Children from families with at none or one under-five child in the household were more likely to achieve complete immunization which is consistent with prior research [39, 42, 43]. It was reported that women with fewer children in the household may have more time to commit to the care of an individual child, thus making routine immunization visits easier to prioritize [39, 43]. On the contrary, women with multiple children may synchronize health visits for her children, which could influence whether each child adheres to the recommended schedule [39, 43]. For instance, a child may receive their vaccination in conjunction with a sick visit for a sibling rather than on a scheduled visit for vaccination [43].

In line with prior research, household wealth was also an important factor affecting the complete childhood immunization in the present study [31, 44, 45]. Infants born from poor household wealth were less likely to have completed their vaccination. Prior researchers suggest that mothers from the poor households may have barriers to access immunization services such as lack of transportation, compared to mothers from rich households [16]. On the other hand, higher income may be associated with higher chances to obtain better health knowledge and health-seeking behavior.[16,46] Thus, mothers from wealthier families may have higher chances to seek modern/medical health services for their families when necessary pointing to more autonomy.[21]

In addition to individual-level factors, community-level factors were also associated with complete childhood immunization. As observed elsewhere, [22] residing in communities with the middle and high percentage of households who perceived distance to the nearest health facility as a big problem were associated with reduced odds of achieving complete immunization. The distance to the nearest health facility acts as a proxy for healthcare service accessibility and availability. Thus, access to health facilities might be an essential factor for vaccination services utilization. In Malawi, over 80% of the population reside in rural areas. [7] Consequently, poor infrastructures (i.e. lack of electricity to store vaccines and poor road network to transport vaccines) may lead to inequitable distribution of health services in the communities. In turn, accessibility to vaccination services particularly in hard-to-reach areas and vulnerable populations might also be affected.[47] In Egypt, immunization coverage was observed to decline with an increasing distance from the vaccination clinics.[48] In South Africa, the distance to the nearest mobile clinic showed a significant positive association with child vaccination status.[49] Similarly, in Pakistan, children who lived about 2-5 km from the health facility had higher chances of not receiving vaccinations as compared to children who lived <2 km away from the health facility.[50]

Limitations

This study has a few limitations. The results are prone to recall bias as the respondents who did not have the child health cards, who were asked to recall the vaccines that were administered to their children. The cross-sectional nature of the study design limits our ability to draw causal inferences. The use of secondary data limited us to include other variables that could explain complete childhood immunization such as an availability of services, vaccines due to stock-outs, knowledge, and attitude. Our results, like other survey studies, are prone to the interviewer bias (i.e., social desirability effect).

Policy implications

This study is one of the first to investigate the factors associated with the completion of the childhood immunization in Malawi using a multilevel approach hence addressing the importance of individual-, community-, and contextual factors. In particular, factors such as lack of ANC visits (none or at most one visit), poorest households, no vaccination card (never existed or lost) – which reflect an overall poor health-seeking behavior and problems to access health facilities are associated with incomplete immunization of children. These findings appear as a wake-up call for all health policy makers involved in the development and implementation of childhood vaccination polices. Therefore, the use of adequate ANC visits (4 and above visits) should be strongly emphasized to women during their pregnancy in order to enhance information sharing on the benefits of vaccination including the importance of having a vaccination card. Furthermore, to effectively increase the number of children with complete vaccination in Malawi, family planning programme planners should encourage women of reproductive age to consider the use of contraceptives in order to encourage them to have the number of children they could manage to provide adequate care and support without being hampered. These findings also call for measures to reinforce health education for behavior change, targeting women especially the poorest and those in the remote area where geographical accessibility to healthcare is compromised. Furthermore, the current study highlights the need for an improved collaboration between healthcare professionals and community health workers. Indeed, studies suggest that community health workers are essential for a successful implementation to optimal infant immunization.[51,52] Finally, the Malawi government should continue delivering vaccines through static and outreach clinics across the country as well as increasing cold chain capacity at all levels as we have revealed that at community levels, women who had big problems to reach the nearest health facilities were less likely to take their babies for vaccination services.

Conclusions

Our study has shown that both individual- and community-level factors have influences on complete immunization in Malawi. We found evidence of clustering effects of complete immunization at community-level, implying that children from the same communities tended to have similar contextual influences on immunization status. Thus, public health programmes designed to improve complete childhood immunization should not only address individual needs but also consider contextual factors and their communities addressed in this study.

Abbreviations

95% CI, 95% confidence interval; ANC, antenatal care; aOR, adjusted odds ratios; AV, area variance; BCG, bacillus Calmette-Guérin; DPT, diphtheria-tetanus-pertussis; EPI, Expanded Program on Immunization; ICC, intra-cluster correlation; MCV, measles-containing vaccine; MDHS, Malawi Demographic and Health Survey; OVP, oral polio vaccine; PCV, proportion change in variance; PCV13, pneumococcal conjugate vaccine; RV1, rotavirus vaccine; SE, standard error; WHO, World Health Organization.

Competing interests

None declared

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Contributions

PAMN, PB, TS, TAT, TGM, and ON contributed to the conception and design of the study. PAMN acquired data. PAMN, TAT, and TGM conducted analysis. PAMN, PB, and ON interpreted results. PAMN, TAT, and TS drafted the first article. PB, ON, and TGM revised the draft critically for important intellectual content. PAMN, PB, TS, TAT, TGM, and ON reviewed and approved the final version of the manuscript.

Ethics approval and consent to participate

This study was carried according to the guidelines stipulated in the Declaration of Helsinki and all procedures involving human subjects were approved by the Malawi National Health Science Research Committee (NHSRC) and the Institutional Review Board (IRB) of ICF Macro. Written and verbal consent was obtained at the beginning of each interview and the authors sought permission from the DHS program for the use of the data.

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Table 1: Malawi Expanded Program on Immunization Schedule

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 [†] 1 and PCV [⁑] 1, RV [‡] 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

Note: Pentavalent includes DPT-HepB-Hib; BCG, bacillus Calmette–Guérin; OPV, oral polio vaccine; DPT, diphtheria, pertussis, tetanus; HepB, Hepatitis B; Hib, Hemophilus influenza type b; PCV, Pneumococcal conjugate vaccine, RV, rotavirus vaccine. † introduced into the Expanded Programme on Immunization in 2012; ⁑ introduced into the Expanded Programme on Immunization in November 2011; ‡ introduced into the Expanded Programme on Immunization in October 2012.

Table 2 Sociodemographic characteristics among children aged 12~23 months (n=3,125)

Characteristics	Total Sample	Immunization Coverage	
		Incomplete	Complete
	N (%)	*n (%)*	*n (%)*
Individual-level factors			
Sex of the child			
Male	1581 (50.27)	422 (26.69)	1159 (73.31)
Female	1564 (49.73)	421 (26.92)	1143 (73.08)
Birth order			
1	805 (25.60)	221 (27.45)	584 (72.55)
2 or 3	1175 (37.36)	314 (26.72)	861 (73.28)
4 or 5	720 (22.89)	171 (23.75)	549 (76.25)
≥6	445 (14.15)	137 (30.79)	308 (69.21)
Mother's age (years)			
15~24	1351 (42.96)	380 (28.13)	971 (71.87)
25~34	1277 (40.60)	324 (25.37)	953 (74.63)
35~49	517 (16.44)	139 (26.89)	378 (73.11)
Mother's education			
No formal education	354 (11.26)	111 (31.36)	243 (68.64)*
Primary school	2145 (68.20)	598 (27.88)	1547 (72.12)
Secondary and higher	646 (20.54)	134 (20.74)	512 (79.26)
Antenatal visits			
1 or none	97 (3.08)	42 (43.30)	55 (56.70)*
2 or 3	1463 (46.52)	370 (25.29)	1093 (74.71)
≥4	1585 (50.40)	431 (27.19)	1154 (72.81)
Immunization card			
No card/no longer have a card	443 (14.09)	318 (67.48)	125 (32.52)*
Had card but no seen	200 (6.36)	400 (55.22)	75 (44.78)
Had a card seen	2502 (79.55)	125 (11.59)	2102 (88.41)
No of under-5-year children			
≤1	1543 (49.06)	394 (25.53)	1149 (74.47)*
2	1381 (43.91)	365 (26.43)	1016 (73.57)
≥3	221 (7.03)	84 (38.01)	137 (61.99)
Household wealth			
Poorest	773 (24.58)	237 (30.66)	536 (69.34)*
Poorer	669 (21.27)	186 (27.80)	483 (72.20)
Middle	630 (20.03)	180 (28.57)	450 (71.43)
Richer	538 (17.11)	127 (23.61)	411 (76.39)
Richest	535 (17.01)	113 (21.12)	422 (78.88)
Community-level factors			
Place of residence			
Urban	496 (15.77)	130 (26.21)	366 (73.79)
Rural	2649 (84.23)	713 (26.92)	1936 (73.08)

Geographical region			
Northern	589 (18.73)	143 (24.28)	446 (75.72)
Central	1099 (34.94)	305 (27.75)	794 (72.25)
Southern	1457 (46.33)	395 (27.11)	1062 (72.89)
Distance to the health facility[∫]			
Low	884 (28.11)	217 (24.55)	667 (75.45)
Middle	1064 (33.83)	293 (27.54)	771 (72.46)
High	1197 (38.06)	333 (27.82)	864 (72.18)
Community wealth[††]			
Low	1197 (38.06)	330 (27.57)	867 (72.43)
Middle	1075 (34.18)	293 (27.26)	782 (72.74)
High	873 (27.76)	220 (25.20)	653 (74.80)
Community female education[δ]			
Low	1161 (36.92)	332 (28.60)	829 (71.40)
Middle	968 (30.78)	258 (26.65)	710 (73.35)
High	1016 (32.31)	253 (24.90)	763 (75.10)

Note *P <0.05; [††]percentage of households in the community categorized as richest (upper 40% of quintiles); [∫]percentage of household in the community perceived distance to the health facility as a big problem; [δ] percentage of women in the community with primary or higher education.

Table 3. Multilevel analysis of determinants of complete immunization in children aged 12–23 months in Malawi.

	Model I	Model II	Model III	Model IV
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Individual-level factors				
Fixed effects				
Sex of the child				
Male		0.98 (0.80–1.19)		0.98 (0.81–1.19)
Female		1.00		1.00
Birth order				
1		1.01 (0.60–1.70)		1.02 (0.60–1.71)
2 or 3		1.18 (0.78–1.78)		1.18 (0.77–1.79)
4 or 5		1.36 (0.94–1.98)		1.37 (0.94–2.00)
≥6		1.00		1.00
Mother's age (years)				
15~24		0.97 (0.62–1.53)		0.97 (0.61–1.53)
25~34		0.93 (0.65–1.33)		0.92 (0.64–1.33)
35~49		1.00		1.00
Mother's education				
No formal education		0.72 (0.47–1.09)		0.72 (0.55–1.11)
Primary school		0.80 (0.60–1.07)		0.80 (0.59–1.06)
Secondary and higher		1.00		1.00
Antenatal visits				
1 or none		**0.54 (0.32–0.92)***		**0.56 (0.32–0.93)***
2 or 3		**1.23 (1.00–1.50)***		**1.24 (1.01–1.51)***
≥4		1.00		1.0
Immunization card				
No card/no longer have a card		**0.06 (0.04–0.08)***		**0.06 (0.04–0.07)***
Had a card but no seen		**0.08 (0.06–0.12)***		**0.08 (0.06–0.12)***
Had card and seen		1.00		1.00
No of under-5-year children				
≤1		**1.62 (1.10–2.39)***		**1.60 (1.09–2.36)***
2		1.31 (0.90–2.39)		1.32 (0.90–1.93)

≥3		1.00		1.00
Household wealth				
Poorest		**0.60 (0.42–0.86)***		**0.60 (0.40–0.92)***
Poorer		**0.60 (0.42–0.87)***		**0.61 (0.41–0.93)***
Middle		**0.60 (0.43–0.87)***		**0.61 (0.41–0.92)***
Richer		0.91 (0.64–1.33)		0.92 (0.62–1.35)
Richest		1.00		1.00
Community-level factors				
Place of residence				
Urban			0.88 (0.61–1.26)	0.83 (0.54–1.30)
Rural			1.00	1.00
Geographical region				
Northern			1.07 (0.81–1.42)	1.08 (0.77–1.52)
Central			0.95 (0.77–1.17)	0.96 (0.75–1.23)
Southern			1.00	1.00
Distance to the health facility[∫]				
Low			1.00	1.00
Middle			0.88 (0.67–1.14)	**0.73 (0.53–0.98)***
High			0.87 (0.67–1.14)	**0.73 (0.53–0.99)***
Community wealth[††]				
Low			1.00	1.00
Middle			0.97 (0.76–1.21)	1.04 (0.80–1.35)
High			1.07 (0.77–1.48)	0.97 (0.67–1.45)
Community female education[δ]				
Low			1.00	1.00
Middle			1.07 (0.84–1.34)	1.04 (0.64–1.38)
High			1.15 (0.89–1.49)	0.96 (0.78–1.32)
Measure of variation				
Random effects				
[τ(SE)]	**0.3252 (0.08899)***	**0.4897 (0.1335)***	**0.3178 (0.08891)***	**0.4687 (0.1324)***
MOR	**1.72**	**1.95**	**1.71**	**1.92**
ICC (%)	9.00	12.96	8.81	12.47
PCV (%)	Reference	–50.58	2.28	–44.13
Model fit statistics				

DIC (-2log likelihood)	3635.03	2916.57	3628.87	2910.48

Note *P-*value* <0.05; [τ (SE)], Area variance; SE, standard error; MOR, Median Odds Ratio; ICC, intraclass correlations; PCV, proportional change in variance; DIC, deviation information criterion; [††]percentage of households in the community categorized as richest (upper 40% of quintiles); [∫]percentage of household in the community perceived distance to the health facility as a big problem; [δ] percentage of women in the community with primary or higher education.