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Prevalence and determinants of full vaccination coverage according to the national schedule among children aged 12–35 months in Ghana

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Universal immunization of children against common vaccine-preventable diseases is crucial in reducing infant and child morbidity and mortality. Assessing the vaccination coverage is a key step to improve utilization and coverage of vaccines for under-five children. Accordingly, vaccination coverage according to the national schedule assesses the vaccination coverage of children aged 12–35 months. However, there is a scarcity of information on the full vaccination coverage according to the national schedule and its determinants in Ghana. Therefore, this study aimed to assess the prevalence and predictors of vaccination coverage according to the national schedule among children aged 12–35 months in Ghana. A cross-sectional study design using the most recent demographic and health survey data from the Ghana Demographic and Health Survey was used. We included a total weighted sample of 1,823 children aged 12–35 months in the five years preceding the survey. We used a multilevel logistic regression model to identify associated factors for vaccination coverage according to the national schedule in Ghana. The adjusted odds ratio at 95% CI was computed to assess the strength and significance of the association between explanatory and outcome variables. Factors with a p-value of < 0.05 are declared statistically significant. In this study, the full coverage of vaccination according to the national schedule among children aged 12–35 months in Ghana was 56.45% (95% CI 51.77–56.17). Women having an ANC visit were 40% more likely (AOR = 1.40, 95% CI 1.07–1.83), women involved in healthcare decision-making were 35% more likely (AOR = 1.35, 95% CI 1.05–1.75), Women who deliver in a health facility were 1.91 times more likely (AOR = 1.91, 95% CI 1.36–2.66), and communities with high media exposure were 47% more likely (AOR = 1.47, 95% CI 1.06–2.05) to achieve full vaccination coverage as compared to their counterparts. On the other hand, being in the Western (AOR = 0.4, 95% CI 0.18–0.88) and Northern (AOR = 0.33, 95% CI 0.15–0.74) regions decreased the odds of attaining full vaccination coverage according to the national schedule in Ghana. The full vaccination coverage according to the national schedule in Ghana was lower as compared to 90% coverage recommendation by World Health organization, and there is also in-equality among regions. Maternal optimal ANC contact, health facility delivery, women involved in health care decision-making, community media exposure, and region were significantly associated with full vaccination coverage according to the national schedule in Ghana. To improve child immunization coverage, relevant authorities and stakeholders should work together to improve ANC visits, media exposure, facility delivery, and women's empowerment, and attention should be given to deviant regions.

Keywords Vaccination, Vaccination coverage, Full vaccination, National schedule, Children aged 12–23 months, Ghana

Immunization effectively lowers mortality and morbidity in children under-five years of age and is the most economical public health intervention. It is also a fundamental component of infectious disease prevention[1,2].

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The number of mortality among children under-five decreased sharply when the Expanded Program on Immunization (EPI) program was implemented, from 12.6 million in 1990 to 4.9 million in 2022[3]. In low- and middle-income nations, a large number of children under five have been spared from deadly illnesses like polio, measles, diphtheria, tetanus, pertussis, and tuberculosis[4,5].

Every year, vaccinations save the lives of nearly 2.5 million children under the age of five[6,7]. Despite this development, one-fifth of children in Sub-Saharan Africa (SSA) lack access to crucial lifesaving immunizations[8]. Because of this, almost 30 million African children under the age of five suffer from vaccine-preventable mortality, and more than 500,000 of them die annually[9]. To ensure that no kid is left behind, the World Health Assembly established an ambitious aim of lowering the number of unvaccinated children through the vaccination Agenda 2030[10]. This is also included in the Sustainable Development Goals (SDGs), which aim to halt preventable deaths of infants and children under the age of five[11]. Sub-Saharan Africa still has the highest child and under-five mortality rates, which could be related to vaccination use[12,13]. Even with their demonstrated efficacy, reaching the ideal immunization rate is still difficult, especially in low- and middle-income nations like Ghana.

Various factors influence complete vaccination coverage, including access to the vaccination site, parental age and education, household income and wealth status, female child, family characteristics, parental attitude and knowledge, lack of information about vaccination schedule, and place of delivery, which were significant predictors of vaccination coverage[14–18].

The utilization of health care services, including immunization, is a complicated issue involving health care providers, cultural attitudes, parent traits, socioeconomic considerations, and even geographic barriers[19]. It is well acknowledged that comprehensive vaccination coverage and the broader socioeconomic consequences of immunization were linked[20]. However, the benefits of immunization have not yet been realized in many African countries, including Ghana. As the coverage of full immunization among children is below the national and international target, and even not evenly distributed among geographic regions and ethnic groups, it is critical to discover the different factors that may influence being fully immunized[19]. In Ghana, there is a dearth of current evidence, despite the fact that vaccination coverage and related problems are becoming increasingly important global health concerns in many other nations.

Vaccination coverage can be assessed according to the national schedule[21]. Thus, a child aged 12–35 months is considered fully vaccinated according to the national schedule if the child has received all the basic antigens, as well as a birth dose of OPV, a birth dose of Hepatitis B vaccine, a dose of IPV, three doses of pneumococcal vaccine, two doses of Rota virus vaccine, and one dose of yellow fever vaccine in Ghana[22]. Timely delivery of vaccinations helps to monitor the development of vaccination use, the wise use of resources, and the timely suitable actions at the national level[23].

Africa had the lowest DPT3 coverage percentage of any WHO region in 2017 (72%)[24]. Certain African countries have achieved higher and more stable immunization rates than their peers. Consequently, Ghana's vaccination rates increased from 85.1% in 1998 to 95.2% in 2014[25]. To increase vaccination coverage, it is critical to comprehend the factors that affect vaccination utilization. However, recent updates on vaccination coverage and determinants have not been reported yet in Ghana. Therefore, this study aimed to update the prevalence and predictor of vaccination coverage among children aged 12–35 months in Ghana, which will provide important information for concerned bodies to strengthen positive efforts and avoid disabling factors to achieve WHO recommended vaccination coverage.

Method and materials

Study setting

The study setting is the Republic of Ghana. The Republic of Ghana is one of the countries in West Africa and has a total area of 238,533 square kilometers[26]. Its borders are to the north with Burkina Faso, to the east with Togo, to the south by the Atlantic Ocean, and to the west with Côte d'Ivoire. The nation currently consists of 16 regions. The following 16 regions constitute Ghana: Greater Accra area, Central, Eastern, Upper East, Upper West, Volta, Northern, and Ashanti. The other regions include Brong, Oti, Ahafo, Bono East, North East, Savannah, Western North, and Western.

Data source and sampling procedure

This study was done using the data extracted from the standard Ghana Demographic and Health Survey 2022. The data was collected from October 2022 to January 2023, and it is the seventh DHS series. This study used the most recent DHS data set. Every five years, nationwide surveys known as the DHS are conducted worldwide in low- and middle-income nations. Data were collected from a national representative sample of approximately 18,450 households from all 16 regions in Ghana. The sampling procedure used in the 2022 GDHS was stratified two-stage cluster sampling, designed to yield representative results at the national level in urban and rural areas and for most DHS indicators in each country's region.

In the first stage, 618 targeted clusters were selected from the sampling frame using a probability-proportional-to-size strategy for urban and rural areas in each region. Then the number of targeted clusters was selected with equal probability through systematic random sampling of the clusters selected in the first phase for urban and rural areas.

In the second stage, after the selection of clusters, a household listing and map updating were carried out in all of the selected clusters to develop a list of households for each cluster. The list served as a sampling frame for the household sample. A fixed number of 30 households in each cluster were randomly selected from the list for interviews. Thus, 17,993 households were successfully interviewed in 618 clusters. For this study, women who had given a birth within five years before the surveys were included. For mothers having more than two kids aged 12–35 months, the last birth was included and analyzed for the study[27].

Inclusion criteria
All children aged 12–35 months preceding the survey years in the selected EAs who were in the study area were included in the study.

Exclusion criteria
Children in the age category of 12–35 months who had an incomplete vaccination card and had a missing value for the outcome variables were excluded. In addition, if more than two children aged 12–35 months available in the household, only the recent birth included in the study and other children were excluded.

Source population
The source population was all children aged 12–35 months, five years preceding the survey period in Ghana.

Study population
The study population consisted of children aged 12–35 months preceding the five-year survey period in the selected enumeration areas, which are the primary sampling units of the survey cluster. The mother or caregiver was interviewed for the survey in the country, and mothers who had more than one child during the survey period were asked about the most recent child.

Study variables
Outcome of variable
The outcome variable in this study was the probability of the last child aged 12–35 months being fully vaccinated according to the national vaccination schedule of Ghana. It was assessed by the interview responses from mothers and the immunization card report. According to Ghana national vaccination schedule a child aged 12–35 month should receive all the basic antigens, birth dose of OPV, a birth dose of the hepatitis B vaccine, a dose of IPV, three doses of the pneumococcal vaccine, two doses of the rotavirus vaccine, one dose of the yellow fever vaccine, a second dose of the measles-rubella vaccine, and a dose of the meningitis vaccine. To estimate the proportion of fully vaccinated children, we created a composite variable for children who had received all of these vaccines from the age of 12–35 months. For the above vaccines the responses were "yes, incomplete, and no". Then we created a new composite variable and recoded it as "Yes = 1" for children who responded yes for the above vaccines, considered "fully vaccinated," and otherwise as "No = 0" for children who responded as no and had an incomplete response for the above vaccine, considered "not fully vaccinated."

Independent variables
Both individual and community-level factors were reviewed from different literatures, and these include child age and sex, maternal education, working status and educational status, parent (husband) education and employment status, ANC visit, media exposure, place of delivery, number of under-five children, household head sex, wealth index, birth order, PNC visit, and mothers involvement in household decision-making. Whereas, whether distance to a health facility is a problem or not, residence, region, community women's illiteracy level, community poverty level, and community media exposure were community-level variables aggregated from individual-level factors.

The wealth index was re-categorized as poor, middle, and rich[28], but available in poorest, poor, middle, rich and richest quintile in DHS data set.

ANC was classified as optimal if a mother had more than eight visits during her pregnancy[29]. Maternal education status was categorized as no formal education, primary, secondary, and higher in our study and other EDHS[30]. Reading newspapers, watching television, and listening to the radio were three ways that media exposure was computed. When there was exposure to any of the three, these variables were combined and classified as yes, meaning that reading newspapers, listening to the radio, or watching television were present[31].

Mother's involvement in decision-making was aggregated from variables: decision on purchasing large household purchases, decision on husband's earning, decision on respondent's earning, and decision on health care, which is categorized as yes if the mother is involved in the above decision-making and no if she is not involved in the above category.

Data management
After being extracted from the GDHS portal, Stata version 14 was used to enter, code, clean, record, and analyze the data. Stata was initially developed by the Computing Resource Center in California.

Model selection
In DHS, data variables are nested by clusters, and those within the same cluster show more similarities than those with separate clusters. Thus, using the traditional logistic regression model violates the assumptions of independent observation and equal variance across clusters. Therefore, a multi-level logistic regression analysis was employed in this study in order to account for the hierarchical nature of DHS data.

Fixed effect analysis (measure of association)
A bivariate multi-level logistic regression model was employed in the study to identify the variables associated with vaccination coverage. In the analysis, four models were fitted. The first (null) model contains only the outcome variables to test random variability and estimate the intra-cluster correlation coefficient (ICC). The second model contains individual-level variables; the third model contains only community-level variables; and the fourth model contains both individual-level and community-level variables[32]. A p-value of 0.05 was used

to define statistical significance. Adjusted odds ratios with corresponding 95% confidence intervals (CIs) were calculated to identify independent predictors of vaccination coverage.

Hence the log of probability of attaining vaccination coverage was modeled using a two level multilevel by using the Stata syntax xtmelogit[33].

$$logit\ (\pi ij) = log\ [\pi ij/\ (1 - \pi ij)] = \beta 0 + \beta 1xij + \beta 2xij\ \ldots + u0j + e0ij,$$

where, πij: the probability of the ith young children receiving full vaccination, $(1 - \pi ij)$, the probability of young children not receiving full vaccination, β0: intercept, βn: regression coefficient Xij: independent variables u0j: community level error, e0ij: individual level errors[34].

Random effect analysis (measure of association)

Variation of the outcome variable or random effects was assessed using the proportional change in variance (PCV), intra-class correlation coefficient (ICC), and median odds ratio (MOR)[35,36].

The ICC shows the variation in attainment of full vaccination coverage due to community characteristics, which was calculated as: $ICC = \sigma 2/(\sigma 2 + \pi^2/3)$, where σ^2 is the variance of the cluster[37].

The higher the ICC, the more relevant the community characteristics are for understanding individual variation in the attainment of full vaccination coverage.

MOR is the median value of the odds ratio between the areas with the highest vaccination coverage and the area with the lowest attainment of vaccination coverage when randomly picking out two younger children from two clusters, which was calculated as: $MOR = e\ 0.95\sqrt{\sigma^2}$ where σ^2 is the variance of the cluster. In this study, MOR shows the extent to which the individual probability of attainment of vaccination coverage is determined by the residential area[38].

Furthermore, the PCV illustrates how different factors account for variations in the attainment of full vaccination coverage and is computed as PCV=(Vnull-Vcluster)/ Vnull, where $V_{cluster}$ is the cluster-level variance and V_{null} is the variance of the null model[39].

The likelihood of attainment full vaccination coverage and independent variables at the individual and community levels were estimated using both fixed effects and random effect analysis. Due to the hierarchical nature of the model, models were compared using deviation = −2 (log likelihood ratio), and the best-fit model was determined by taking the model with the lowest deviance. By calculating the variance inflation factors (VIF), the variables employed in the models were checked for multi-collinearity; the results were within acceptable ranges of one to ten[40].

Ethics statement and consent to participate

The authors analyzed secondary, publicly available data obtained from the DHS program database. There was no additional ethical approval, and informed consent was obtained by the authors. In order to perform our study, we registered with the DHS web archive, requested the dataset, and were granted permission to access and download the data files. According to the DHS report, all participant data was anonymized during the collection of the survey data. More details regarding DHS data and ethical standards are available online at http://www.dhsprogram.com.

Result

This study was conducted among a weighted sample of 1823 women-child pairs aged 12–35 months in Ghana. The mean age of children was 17.41 ± 0.05 months, and the mean age of mothers was 29.74 ± 0.05 years. More than two-thirds (70. 26% and 60.34%) of mothers were aged 20–34 years and were married, respectively. Nearly two-thirds (69.06%) of households were headed by men. Nearly half (45.2%) of households were poor, and more than one-third (40.54) of mothers had an ANC visit during their pregnancy. The majority (86.01%) of children's were delivered at health facilities. Majority (82.94%) of women had media exposure. Three-fourth (74.96%) of women were involved in household healthcare decision-making. Nearly half (47.06%) of women's were residing in the urban areas. One-third (74.72%) of women's had no difficulty accessing health facilities. More than two-third (68.78%) of the community had high media exposure. One-fourth (24.8%) of mothers had a high community illiteracy level (Table 1).

The prevalence of full vaccination coverage according to national schedule

The prevalence of full vaccination coverage according to national schedule among children aged 12–35 months in Ghana was 56.45 (95% CI 51.77–56.17). (Fig. 1)

Regional prevalence of vaccination coverage

The highest prevalence of vaccination coverage among children aged 12–35 months in Ghana was observed in greater Accra (71.99%), and the lowest prevalence was observed in the northern region (31.18%). There is a disparity in vaccination coverage among children aged 12–35 months in Ghanaian regions; therefore, special attention could be given to the northern region. (Fig. 2)

Random effect and model fit statistics

The null model was run to determine whether the data supported assessing randomness at the community level. The ICC value in the null model indicates 20.91% of the attainment of vaccination coverage was due to the difference between clusters. In the null model, the odds of attainment of vaccination coverage were 2.43 times variable between high and low clusters (heterogeneous among clusters). Regarding the final model PCV, about

Variables	Response	Vaccination status		Total (*N*,%)
		Not fully vaccinated (*n*, %)	Fully vaccinated (*n*, %)	
Maternal education	No education	227 (58.2)	163 (41.79)	390 (21.39)
	Primary	141 (48.45)	150 (51.55)	291 (15.96)
	Secondary	397 (40.6)	580 (59.4)	977 (53.59)
	Higher	30 (18.18)	135 (81.81)	164 (9.05)
Maternal age	< 20 years	37 (40.66)	54 (59.34)	91 (4.9)
	20–34 years	567 (44.26)	714 (55.73)	1281 (70.27)
	35–49 years	189 (41.90)	262 (58.09)	451 (24.74)
Marital status	Married	479 (43.50)	622 (56.49)	1101 (60.39)
	Other	315 (43.63)	407 (56.37)	722 (39.60)
Husband education	No education	200 (56.82)	152 (43.18)	352 (23.43)
	Primary	63 (40.13)	94 (59.87)	157 (10.45)
	Secondary	331(42.33)	451 (57.67)	782 (52.06)
	Higher	56 (26.54)	155 (73.46)	211 (14.05)
Child sex	Male	419 (45.29)	508 (54.7)	928 (50.9)
	Female	375 (41.85)	521 (58.15)	896 (49.26)
Birth order	First	206 (39.46)	316 (60.54)	522 (28.63)
	Second-third	153 (39.43)	235 (60.57)	388 (21.28)
	Fourth and above	435 (47.65)	478 (52.35)	913 (50.08)
Sex of household head	Male	574 (45.59)	685 (54.4)	1259 (69.06)
	Female	220 (39.00)	344 (60.99)	564 (30.93)
Wealth index	Poor	438 (53.15)	386 (46.84)	824 (45.2)
	Middle	162 (42.97)	215 (57.03)	377 (20.68)
	Rich	195 (31.35)	427 (68.65)	622 (34.12)
ANC visit	Optimal	255 (36.27)	448 (63.72)	703 (40.54)
	Non-optimal	494 (47.91)	537 (52.08)	1031 (59.46)
PNC check	Yes	391 (42.4)	531 (57.59)	922 (53.17)
	No	358 (44.08)	454 (55.91)	812 (46.83)
Mother working	Yes	640 (43.63)	827 (56.37)	1467 (80.47)
	No	154 (43.23)	202 (56.75)	356 (19.53)
Place of delivery	Home	158 (61.96)	97 (38.04)	255 (13.99)
	Health facility	637 (40.56)	932 (59.44)	1568 (86.01)
Number of under five	≤ 2	344 (38.65)	546 (61.35)	890 (48.82)
	≥ 3	450 (48.23)	483 (51.77)	933 (51.18)
Media exposure	Yes	617 (40.8)	896 (59.22)	1513 (82.99)
	No	177 (57.09)	133 (42.9)	310 (17.00)
Women involved in decision	Yes	464 (41.2)	662 (58.79)	1126 (74.96)
	No	186 (49.47)	190 (50.53)	376 (25.03)
Community level variables				
Residence	Urban	315 (36.7)	543 (63.28)	858 (47.06)
	Rural	479 (49.63)	486 (50.36)	965 (52.93)
Distance difficulty	Big problem	231 (50.1)	230 (49.89)	461 (25.28)
	Not problem	563 (41.33)	799 (58.67)	1362 (74.72)
Community media exposure	Low	326 (57.29)	243 (51.81)	569 (31.21)
	High	468 (37.32)	786 (62.68)	1254 (68.78)
Community women illiteracy	High	498 (37.27)	838 (62.72)	1336 (75.14)
	Low	276 (62.44)	166 (37.56)	442 (26.86)
Community poverty level	High	389 (35.85)	696 (64.18)	1085 (59.51)
	Low	405 (54.88)	333 (45.12)	738 (40.48)
Community ANC use	Low	457 (50.33)	453 (48.89)	908 (49.81)
	High	336 (36.92)	577 (63.4)	910 (50.19)
Continued				

Variables	Response	Vaccination status		Total (*N*,%)
		Not fully vaccinated (*n*, %)	Fully vaccinated (*n*, %)	
Region	Western	65 (57.52)	48 (42.48)	113 (6.2)
	Central	86 (44.56)	106 (54.92)	193 (10.59)
	Greater accra	58 (28.02)	149 (71.98)	207 (11.35)
	Volta	22 (29.33)	53 (70.66)	75 (4.11)
	Eastern	44 (38.26)	71 (61.74)	115 (6.3)
	Ashanti	130 (36.21)	229 (63.79)	359 (16.69)
	Western north	19 (37.25)	32 (62.74)	51 (2.8)
	Ahafo	17 (45.94)	20 (54.05)	37 (2.02)
	Bono	22 (34.37)	42 (65.62)	64 (3.4)
	Bono east	47 (44.34)	59 (55.66)	106 (5.8)
	Oti	26 (46.43)	30 (53.57)	56 (3.07)
	Northern	138 (68.65)	63 (31.34)	201 (11.03)
	Savannah	29 (0.58)	21 (42)	50 (2.74)
	North east	25 (47.17)	28 (52.8)	53 (2.9)
	Upper east	39 (44.83)	48 (55.17)	87 (4.77)
	Upper west	25 (43.1)	33 (56.89)	58 (3.18)

Table 1. Socio-demographic, maternal and child and community level characteristics of children aged 12–35 months in Ghana.

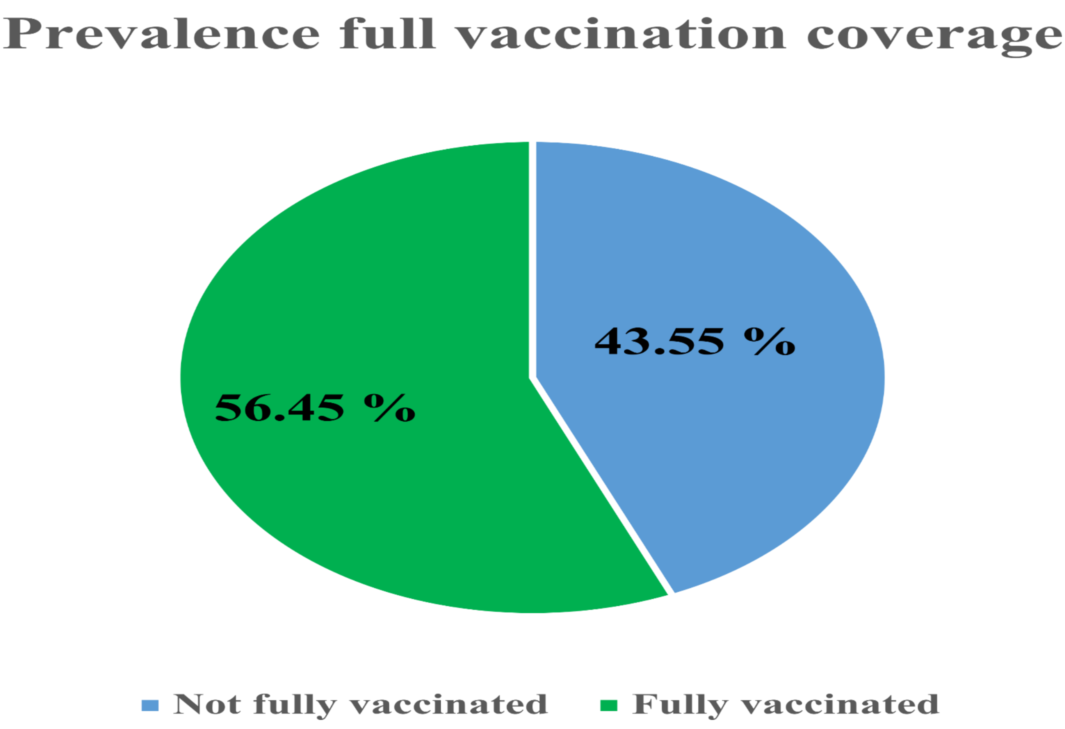

Fig. 1. The national prevalence of full vaccination coverage according to the national schedule among children aged 12–35 months in Ghana.

70.11% of the variability in attainment of vaccination coverage was attributed to both individual and community-level factors. Model IV was selected as the best-fitting model since it had the lowest deviance (Table 2).

Factors associated with full vaccination coverage among children aged 12–35 in Ghana

In the final model (model III) of multivariable multilevel logistic regression, child age, wealth index, male household head sex, currently breastfeeding and Savannah region were significantly associated with attainment of the minimum acceptable among children aged 12–35 months in Ghana.

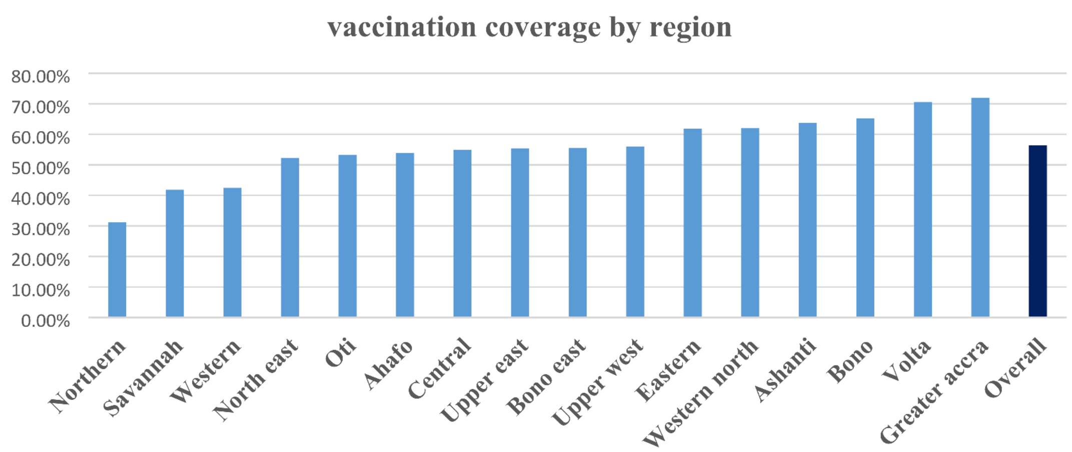

Fig. 2. Regional coverage of vaccination among children aged 12–35 months in Ghana.

Parameters	Model 0	Model I	Model II	Model III
Variance	0.87	0.42	0.44	0.26
ICC	20.91%	11.32%	11.6%	7.32%
MOR	2.43	1.85	1.88	1.62
PCV	Reference	51.72%	49.42	70.11%
Goodness-of-fit				
LLR	-1,328.09	-1,036.32	-1,247.31	-1,024.21
Deviance	2,656.18	2,072.64	2,494.62	2,048.42

Table 2. Random effect and model fit statistics of full vaccine coverage among children aged 12–35 months. Intra-cluster correlation coefficient. *MOR* median odds ratio.

Accordingly, women who had an ANC visit were 40% more likely (AOR = 1.40, 95% CI 1.07–1.83) to have vaccinated their children as compared to women who had no optimal ANC visit. Women involved in household health care decision-making were 35% more likely (AOR = 1.35, 95% CI 1.05–1.75) to attain vaccination coverage as compared to women who did not involve themselves in household health care decision-making. Women who deliver in a health facility were 91% more likely (AOR = 1.91, 95% CI 1.36–2.66) to attain full vaccination coverage as compared to women who deliver at home. Communities with high media exposure were 47% more likely (AOR = 1.47, 95% CI 1.06–2.05) to achieve full vaccination coverage as compared to communities with low media exposure. On the other hand, children residing in the Western region of Ghana had 60% (AOR = 0.4, 95% CI 0.18–0.88) less likely to have vaccination coverage as compared to children residing in the Greater Accra region. Similarly, children residing in Northern regions of Ghana had 67% less likely (AOR = 0.33, 95% CI 0.15–0.74) to have vaccination coverage as compared to children residing in the Greater Accra region (Table 3).

Discussion

Immunization effectively lowers mortality and morbidity in children under five years old and is a cornerstone of infectious disease prevention. Vaccination coverage has increased dramatically in various African countries in recent decades[41]. To meet the Global Vaccine Action Plan target of 90% child vaccination coverage, it is critical to determine the magnitude based on recent statistics and identify enabling and disabling factors in low- and middle-income countries.

This study finding is lower than sub-Saharan African study (59.4%)[42], Malaysia (86.4%)[43], India (71%)[44]. However, This study finding is higher than study done in Afghanistan (45.7%)[45], Ethiopia (31.9%)[46]. The potential explanation for this discrepancy may be due to the presence of health infrastructure, variations in policies against immunization services, variability in awareness of immunization services, and socio-cultural differences. Furthermore, time intervals between study periods may induce variations on the extent of coverage; recent studies may yield greater coverage, whereas remote studies may reveal less coverage.

The multi-level multivariable logistic regression model revealed that maternal optimal ANC contact, health facility delivery, women involved in health care decision-making, community media exposure, and region were significantly associated with full vaccination coverage.

Children born at health facility had higher chance of attaining vaccination coverage as compared to children born home. This is supported by studies done in different parts of the world[47–53]. One explanation might be that a mother giving birth in a medical facility has a higher chance of receiving instruction from medical personnel regarding the importance of vaccination. In addition, upon discharge from a medical facility, newborns received

Individual and community level factors	Responses	Model I AOR (95% Cl)	Model II AOR (95% Cl)	Model III AOR (95% Cl)
Maternal education	No education	1		1
	Primary	1.12 (0.78–1.62)		0.93 (0.64–1.36)
	Secondary	1.43 (1.02-2.00)		1.20 (0.85–1.69)
	Higher	2.18 (1.18–4.04)		1.64 (0.88–3.07)
Maternal age	< 20 years	1.73 (0.88–3.40)		1.63 (0.83–3.20)
	20–34 years	1		1
	35–49 years	1.26 (0.95–1.68)		1.17 (0.88–1.56)
Marital status	Married	0.97 (0.72–1.30)		1.11 (0.82–1.52)
	Other	1		1
Husband education	No education	1		1
	Primary	1.36 (0.90–2.05)		1.21 (0.80–1.84)
	Secondary	1.08 (0.78–1.50)		0.96 (0.69–1.35)
	Higher	1.42 (0.89–2.26)		1.41 (0.88–2.26)
Child sex	Male	1		1
	Female	1.12 (0.89–1.39)		1.09 (0.87–1.36)
Birth order	First	0.86 (0.60–1.23)		0.95 (0.66–1.36)
	Second-third	0.96 (0.69–1.32)		1.00 (0.73–1.37)
	Fourth and above	1		1
Sex of household head	Male	1		1
	Female	1.18 (0.89–1.58)		1.08 (0.81–1.43)
Wealth index	Poor	1		1
	Middle	1.03 (0.74–1.45)		0.88 (0.58–1.32)
	Rich	1.26 (0.89–1.78)		0.98 (0.63–1.54)
ANC visit	Optimal	1.45 (1.14–1.85)		1.40 (1.07–1.83)*
	Non-optimal	1		1
PNC check	Yes	1		1
	No	0.87 (0.69–1.09)		0.87 (0.69–1.10)
Mother working	Yes	1		1
	No	0.91 (0.67–1.23)		0.91 (0.68–1.23)
Place of delivery	Health facility	1.99 (1.43–2.77)		1.91 (1.36–2.66)*
	Home	1		1
Number of under five	≤ 2	1		1
	≥ 3	0.88 (0.68–1.13)		0.92 (0.72–1.19)
Media exposure	Yes	1.04 (0.77–1.41)		0.83 (0.59–1.15)
	No	1		1
Women involved in decision	Yes	1.31 (1.02–1.70)		1.35 (1.05–1.75)*
	No			1
Community level factors				
Residence	Urban		1.15 (0.85–1.56)	1.01 (0.74–1.39)
	Rural		1	1
Distance difficulty	Big problem		1.10 (0.86–1.41)	1.20 (0.92–1.56)
	Not big problem		1	1
Community media exposure	Low		1	1
	High		1.49 (1.11–1.98)	1.47 (1.06–2.05)*
Community women illiteracy	High		1.43 (1.04–1.98)	1.34 (0.94–1.91)
	Low		1	1
Community poverty level	High		1.22 (0.88–1.70)	1.06 (0.70–1.60)
	Low		1	1
Community ANC use	Low		1	1
	High		1.38 (1.08–1.77)	1.10 (0.83–1.47)
Continued				

Individual and community level factors	Responses	Model I AOR (95% Cl)	Model II AOR (95% Cl)	Model III AOR (95% Cl)
Region	Western		0.28 (0.13–0.61)	0.40 (0.18–0.88)*
	Central		0.45 (0.22–0.93)	0.59 (0.27–1.32)
	Greater Accra		1	1
	Volta		0.74 (0.34–1.61)	0.85 (0.37–1.96)
	Eastern		0.67 (0.31–1.49)	0.54 (0.23–1.26)
	Ashanti		0.87 (0.43–1.75)	0.97 (0.44–2.14)
	Western North		0.76 (0.36–1.60)	0.77 (0.34–1.73)
	Ahafo		0.56 (0.26–1.20)	0.43 (0.19 – 0.11)
	Bono		0.94 (0.43–2.05)	0.91 (0.39–2.12)
	Bono East		0.69 (0.34–1.40)	0.68 (0.31–1.49)
	Oti		0.76 (0.37–1.57)	0.78 (0.35–1.74)
	Northern		0.30 (0.14–0.61)	0.33 (0.15–0.72)*
	Savannah		0.56 (0.27–1.15)	0.51 (0.23–1.12)
	North east		0.84 (0.41–1.73)	0.82 (0.38–1.81)
	Upper east		0.65 (0.31–1.35)	0.51 (0.23–1.14)
	Upper west		0.70 (0.34–1.43)	0.58 (0.27–1.25)

Table 3. Factors associated with full vaccination coverage in among children aged 6–23 months Ghana.

their first doses of the BCG, polio, and hepatitis B vaccines[54,55]. But some women are not well-informed about the recommended immunization regimen or the significance of booster doses[56]. This is why health care providers need to proactively educate parents about the immunizations that are advised for every child.

Children born to mothers who attended optimal antenatal care during pregnancy were more likely to be fully immunized[55,57,58]. One possible explanation is that during an ANC visit, mothers will obtain enough positive information regarding childhood vaccination to make them secure in their child's preventative health. Furthermore, during an ANC visit, mothers acquire enough positive information regarding childhood vaccinations to feel confident in their child's preventative health. Furthermore, mothers who visited health facilities throughout their pregnancy may have received counseling on kid immunization, with the need of timely childhood immunization uptake being stressed on a consistent basis. Antenatal care programs typically give information regarding children's care, including the scheduling and importance of immunization for children[52]. Therefore, optimizing optimal ANC use shall be strengthened to improve the coverage of vaccination in children.

Community media exposure is another factor associated with full childhood vaccination. This supported by studies done in Ethiopia[48], Zimbabwe[51], East Africa[59] and SSA[7]. This is due to the media's dissemination of vaccination use information, schedules, and campaigns. Furthermore, media could induce behavioral changes, allowing for the adoption of certain behaviors[48]. Furthermore, media exposure is the most effective health promotion tool to readily access the community and promote health-seeking behavior[60].

In line with other studies, women who had autonomy in making household decisions were more likely to attain full vaccination coverage as compared to women who did not participate in household health care decision-making[61]. This is because mothers' concerns about their children's health care and vaccination use are sparked by their autonomy in making decisions and their awareness of their own health[62]. Therefore, it could be beneficial for parents to learn about their child's immunization through community-based behavior modification programs.

The Northern and Western region of Ghana had lower vaccination coverage as compared to Greater Ghana regions. The possible explanation could be these regions were extreme rural, deep poverty and remoteness[63]. Furthermore, northern Ghana has a vaccination scarcity, poor health infrastructure, low public awareness, and insufficient surveillance and monitoring[64].

Ghana's government must be more resolute in its support of the WHO's 2030 immunization agenda, which calls for universal access to vaccines for the promotion of health and wellbeing at all ages, everywhere[65]. Furthermore, in order to build an integrated, all-inclusive immunization program in Ghana, priorities for implementation must be established.

Strength and limitation

The findings of this study were not without limitations and should be noted. First, the analysis was conducted using potential predictor variables extracted from GDHS. But variable other than those mentioned in the DHS data set would also be likely to be important determinates of full immunization among children aged 12–35 months. Some of these include the distance to immunization centers and the quality of immunization services. Secondly, information on child immunization was reported retrospectively using maternal verbal responses and immunization cards; thus, it is highly susceptible to recall bias. Thirdly, the analysis was conducted using data collected in a cross-sectional survey that causes an egg-chicken dilemma or cause-and effect relationship. Furthermore, as DHS guide recommendations, a vaccinated child might be considered unvaccinated if the child didn't have a vaccination card or the mother was not available to answer for the vaccination status of the child; therefore, it introduces bias and leads to underestimation or overestimation of vaccination coverage.

Therefore, to ensure validity, longitudinally collected data at different times should be used.

Conclusion

The full vaccination coverage according to the national schedule in Ghana was lower as compared to 90% coverage by world health organization recommendation, and there is also inequality among regions. Maternal optimal ANC contact, health facility delivery, women involved in health care decision-making, community media exposure, and region were significantly associated with full vaccination coverage according to the national schedule in Ghana. Therefore, public health programs target emerging or deviant regions. By enhancing ANC visits, media exposure, facility delivery, and empowering women, the relevant authorities and stakeholders should work properly to increase child immunization coverage.

Data availability

The most recent data from the Demographic and Health Survey were used in this study, and it is publically available online at (http://www.dhsprogram.com). The datasets used and/ or analyzed during the current study available from the corresponding author on reasonable request.

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Author contributions
Berhan Tekeba: made conceptualization, drafted the original manuscript, and software analysis.Tadesse Tarik Tamir: made supervision and methodlogy. Alebachew Ferede Zegeye: checked the analysis and made substantial contributions in reviewing the design of the study and the draft manuscript edits and review abstract. He critically reviewed the manuscript for important intellectual content and contributed to the final approval of the version to be submitted. All listed authors have approved the manuscript before submission.

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Competing interests
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