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Childhood Vaccinations and Associated Factors in 35 Sub-Saharan African Countries: Secondary Analysis of Demographic and Health Surveys Data from 358 949 Under-5 Children

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Abstract

Objective. We examined childhood vaccinations coverage and its associated factors in sub-Saharan Africa (SSA) countries. *Methods*. We used demographic and health surveys (DHSs) data collected between 2008 and 2022 from 35 SSA countries. A sample of 358 949 under-5 children was analyzed. Percentage and multivariable binary logistic regression analyses were conducted. A 5% significance level was set. *Results*. Rwanda (7461/8092; 92.2%), Burundi (10 792/13 192; 81.8%), Gambia (6548/8362; 78.3%), Kenya (14 570/19 530; 74.6%), and Burkina Faso (8739/12 343; 70.8%) had the leading coverage of under-5 children who received all basic vaccinations in the first year of life. For every unit increase in the age of a child, there was 72% increase in the odds of vaccination. Children from older mothers had higher odds of vaccination, when compared with children with mothers aged 15 to 19 years. There was a 6% reduction in the odds of vaccination among children from rural residence, when compared with their urban counterparts. Children with educated mothers had over two times higher odds of vaccination, when compared with those from mothers with no formal education. Children from rich households had higher odds of vaccination, when compared with children from poorest household. There was a 13% increase in the odds of vaccination among children covered by health insurance, when compared with those not covered by health insurance. *Conclusion*. Vaccination uptake for children under-5 in SSA was found to be sub-optimal and associated with several factors. A health educational intervention for pregnant women could potentially increase the uptake of vaccines among children.

Keywords

immunization, vaccination, infant, under-5, sub-Saharan Africa, children

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Background

Vaccination is a crucial public health intervention, protecting children from a variety of infectious diseases.[1] It is one of the most effective public health initiatives as it lowers the rates of mortality and morbidity associated with infectious diseases at a low cost.[2] It is a fundamental approach to ensuring the survival of children, and has been shown to prevent over 1.2 million child mortality annually.[3] To achieve the third Sustainable Development Goal (SDG-3.2), which aims to reduce under-5 mortality to at least as low as 25 per 1000 live births by 2030, is largely dependent on uptake of vaccinations.[4] Despite

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public health advancement, vaccine-preventable deaths, due to lower respiratory infections, meningitis, and measles, has constituted 21·7% of under-5 deaths globally.[5] In addition to the direct protection to those who have received vaccination, high vaccination rates offer indirect protection (herd immunity) to the remaining unvaccinated members of a population. However, there are significant differences in the duration of vaccine effects. While vaccines against measles, rotavirus, and pneumococcal disease have an immediate effect, the effects of vaccinations against human papillomavirus (HPV) and hepatitis B typically take longer to manifest in reduced adult morbidity and mortality.[1]

World Health Organization (WHO) launched the Expanded Programme on Immunization (EPI) in 1974 with the aim of creating and growing vaccination regimens globally.[6] A goal was set in 1977 that all children worldwide will have access to poliomyelitis, tetanus, diphtheria, pertussis, measles, and tuberculosis vaccinations by 1990. Nonetheless, the goal has not been achieved because the program has faced a number of challenges, such as low public and governmental knowledge of the scope of the target diseases; poor program administration; inadequate tools and knowledge for handling and storing vaccines; vaccine hesitancy; and a lack of ways to track the program's impact in terms of rising vaccination rates and falling incidence of the target diseases. In the first year of life, every child is required to receive one dose of BCG, oral polio vaccine (OPV0) at birth, hepatitis B vaccine (HBV1), penta1 and OPV1 at 6 weeks, penta2 and OPV2 at 10 weeks, penta3 and OPV3 at 14 weeks, measles and yellow fever at 9 months.[7]

In sub-Saharan Africa (SSA), however, the full potential of vaccines has not been realized due to various factors including access, education, and cultural beliefs.[8-11] Vaccinations are essential in preventing illnesses such as measles, polio, and pneumonia, which are major causes of childhood morbidity and mortality. According to the WHO, vaccination prevents an estimated 2 to 3 million deaths globally.[12] Despite the proven benefits of vaccinations, several factors hinder their uptake. One of the primary challenges is the lack of access to healthcare services.[13] Many families in rural areas have limited access to vaccination clinics due to distance,[14,15] making it difficult for them to get their children vaccinated. Additionally, the cost of transportation to vaccination centers can be a barrier for low-income families,[16] further reducing vaccine coverage rates. Parental education and health literacy plays a crucial role in vaccination uptake.[9] Cultural beliefs and practices also influence vaccination uptake.[11] With 52% of all deaths in this age group, SSA has the highest under-5 mortality rate globally, where the average under-5 mortality rate in 2018 was 78 deaths per 1000 live births, or 1 in 13 children dying before aged 5 years.[17]

The objective of this study was to examine at childhood vaccinations coverage and associated factors among under-5 in SSA countries using demographic and health surveys (DHS) data. Over 85 countries have participated in this surveys, which have been conducted every 5 years since 1984. A major advantage of DHS is the same sampling technique used for data collection across all countries, which makes results comparable across borders. Although the DHS was created to supplement the demographic, family planning, and fertility data gathered by the Contraceptive Prevalence Surveys (CPSs) and World Fertility Surveys (WFSs), it has quickly expanded to become the most important population investigation basis for the tracking of population health guidelines, especially in areas with limited resources. Data from the DHS is useful in epidemiologic investigations to calculate prevalence and health inequalities. Information concerning DHS is available in literature.[18]

Methods

Data Source

We examined nationally representative cross-sectional data from the 2008 to 2022 Demographic and Health Surveys (DHS) in SSA countries. The study examined data from: Angola, Benin, Burkina Faso, Burundi, Cameroon, Chad, Comoros, Congo, Congo Democratic Republic, Cote d'Ivoire, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, South Africa, Tanzania, Togo, Zambia, and Zimbabwe. DHS data is publicly available and can be found at http://dhsprogram.com/data/available-datasets.cfm.

Sampling Technique

The selection of 35 out of 49 countries in SSA was based on the availability of relevant data on under-5 children between 2008 and 2022. This ensures that the analysis reflects recent estimates and includes a sufficient time span for meaningful comparisons. The choice of countries with available data allows for comprehensive coverage, representing diverse regions within SSA. Additionally, it ensures data consistency, reducing potential bias that may arise from incomplete or outdated information. By focusing on these countries, the analysis remains robust while providing actionable insights into childhood vaccination coverage across the countries.

Selection and Measurement of Variables

Outcome

According to EPI schedule, every child will receive one dose of Bacillus Calmette Guerin (BCG), Oral Polio Vaccine (OPV0), and Hepatitis B Vaccine (HBV1) at birth, Penta1 and OPV1 at 6 weeks of age, Penta2 and OPV2 at 10 weeks of age, Penta3 and OPV3 at 14 weeks of age and measles and yellow fever at 9 months of age.[7] The outcome variables of this study was measured as: "*yes*" versus "*no*" if a child received each of the essential vaccines. This was further measured as those who received all the basic vaccinations, those who received none or those who ever received vaccination.

Explanatory Variables

Sex of a child (male vs female); age of a child; mother's age (15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49); place of residence (urban vs rural); mother's education (no formal education, primary, secondary, higher); sex of household head (male vs female); mother's exposure to magazine/newspaper (not at all, less than once a week, at least once a week, almost every day); mother's exposure to radio (not at all, less than once a week, at least once a week, almost every day); mother's exposure to tv (not at all, less than once a week, at least once a week, almost every day); mother's age at first childbirth; health insurance coverage (yes vs no); mother's marital status (not in union, married, widowed/separated/divorced); household wealth quintiles (poorest, poorer, middle, richer, richest). The DHS wealth index was kept because it can be found directly in the dataset.[19] The DHS wealth index for the household was constructed by utilizing ownership of asset data to generate a linear index, which was then measured using principal component analysis. The wealth index in the first survey was created by assigning a score to each household and ranking each member of the home according to their score. Subsequently, five equal category distributions were divided, with 20% of the population representing each category. These comprised data on economic indicators, housing standards, household amenities, the quantity of consumer items, and the amount of land holdings.

Statistical Analysis

With the use of Stata survey module ("svy"), sampling weights, clustering, and stratification were taken into consideration in data analysis. This ensures that individuals from underrepresented groups have a proportionate effect on the final estimates. Percentage was used to estimate the coverage of vaccinations. Furthermore, unadjusted or crude logistic regression was conducted to examine the association between childhood vaccination and associated factors at the bivariate analysis. Only the statistically significant factors in the crude or unadjusted regression models were included in the multivariable or adjusted logistic regression model. The adjusted or multivariable logistic regression model was used to determine the factors associated with vaccination. In the multivariable binary logistic regression model, we computed the standard errors of the parameter estimates through several steps. First, the model coefficients were estimated using maximum likelihood estimation. Then, the variance-covariance matrix of the coefficient estimates was computed, which accounts for the uncertainty in the parameter estimates. This matrix was used to calculate the standard errors of the parameter estimates. Finally, confidence intervals for the parameter estimates were constructed using the standard errors. This process accounts for the uncertainty in the estimates and allows for the assessment of the precision of the parameter estimates in the logistic regression model. We set the significant level at 5%. The analysis was performed in Stata 17.0 version (StataCorp, College Station, TX, USA).

To address potential confounding factors within the datasets, we carefully planned the analytical technique. First, we established that datasets were collected using consistent sampling methods and the variables extracted were defined the same way and similar instruments across countries. If variations existed, we would have adjusted for such differences during statistical analysis. In addition, we applied statistical methods such as multivariable logistic regression analysis and weighting to account for confounders. These methods helped adjust for differences in confounding variables between time points. By using these techniques, we controlled for confounding factors and enhance the reliability of our findings.

We used StatCompiler to create a geospatial map. This was done by first selecting the vaccination indicator from StatCompiler (https://www.statcompiler.com/en/) using available DHS data in SSA countries. We used visualization techniques such as color gradients to represent variations in vaccination coverage across SSA countries. We employed layers to show multiple data points of vaccination coverage and apply legends and labels for clarity. The map generated was exported in a compatible format.

Ethical Approval and Informed Consent

Population-based anonymized public domain datasets were examined in this work. MEASURE DHS/ICF International granted the authors permission to use the

Table 1. Vaccination Coverage in 2008 to 2022 Demographic and Health Surveys in Sub-Saharan Africa (n = 358 949).

Country	Survey year	Number of children (n)	Children under-5 who received all basic vaccinations in first year of life (%)	Children aged 12-23 months who received all basic vaccinations in first year of life (%)	Children under-5 who received no basic vaccinations in first year of life (%)	Children aged 12-23 months who received no basic vaccinations in first year of life (%)
Angola	2015-2016	14 322	25.4	28.2	36.1	32.2
Benin	2017-2018	13 589	51.1	53.7	15.1	13.0
Burkina Faso	2021	12 343	70.8	71.8	3.7	2.6
Burundi	2016-2017	13 192	81.8	83.1	2.0	1.5
Cameroon	2018	9733	48.4	49.1	20.9	17.6
Chad	2014-2015	18 623	9.6	18.3	70.8	60.5
Comoros	2012	3149	26.5	52.8	24.6	16.3
Congo	2011-2012	9329	23.6	42.3	22.9	19.4
Congo Democratic Republic	2013-2014	18 716	22.0	41.2	52.5	50.3
Cote d'Ivoire	2021	10 645	30.3	32.9	13.5	12.9
Eswatini	2006-2007	2812	38.1	73.7	9.3	7.3
Ethiopia	2019	5753	38.3	40.2	42.1	36
Gabon	2019	6376	39.9	40.7	14.9	14.6
Gambia	2019-2020	8362	78.3	79.8	3.0	1.4
Ghana	2022	9353	66.5	68.9	4.2	3.8
Guinea	2018	7951	21.0	21.3	32.6	29.3
Kenya	2022	19 530	74.6	77.0	6.0	5.2
Lesotho	2014	3138	35.0	60.1	15.1	6.6
Liberia	2019-2020	5704	42.5	45.7	11.7	9.7
Madagascar	2021	12 499	43.7	44.6	30.7	28.5
Malawi	2015-2016	17 286	65.7	70.0	8.0	5.1
Mali	2018	9940	36.2	41.2	24.1	23.0
Mauritania	2019-2021	11 628	30.7	32.1	30.8	27.5
Namibia	2013	5046	30.8	62.6	13.7	9.8
Niger	2012	12 558	23.7	43.9	47.7	28.9
Nigeria	2018	33 924	26.4	28.3	43.0	39.8
Rwanda	2019-2020	8092	92.2	93.0	0.7	0.4
Sao Tome and Principe	2008-2009	1931	37.2	67.7	9.9	4.6
Senegal	2019	6125	65.3	67.5	7.0	6.0
Sierra Leone	2019	9899	44.9	49.1	6.4	5.2
South Africa	2016	3548	56.7	57.7	8.9	7.3
Tanzania	2022	10 783	50.4	48.7	12.4	10.6
Togo	2013-2014	6979	28.7	54.8	18.6	12.9
Zambia	2018	9959	66.7	70.3	7.8	6.8
Zimbabwe	2015	6132	67.3	69.0	24.8	20.5

data. The DHS Program complies with all relevant regulations in regards to safeguarding respondents' personal information. ICF International ensures that the survey complies with the Human Subjects Protection Act of the US Department of Health and Human Services. Prior to administering the surveys, the DHS team secured approval from the National Health Research Ethics Committees of multiple nations. For this inquiry, no further permissions were required. For more on our data and ethical standards, please see the link: http://goo.gl/ny8T6X.

Results

Table 1 shows the coverage of under-5 who received all and no basic vaccinations in SSA countries. From the results, Rwanda (92.2%), Burundi (81.8%), Gambia (78.3%), Kenya (74.6%), and Burkina Faso (70.8%) had the leading coverage of under-5 who received all basic vaccinations in the first year of life. Chad (70.8%), Congo Democratic Republic (52.5%), Niger (47.7%), Nigeria (43.0%), and Ethiopia (42.1%) had the leading coverage of under-5 who received no basic vaccinations in first year of life. In addition, the coverage of children 12 to 23 months who received all and no basic vaccinations in SSA countries is presented in Table 1. Rwanda (93.0%), Burundi (83.1%), Gambia (79.8%), Kenya (77.0%), Eswatini (73.7%), Burkina Faso (71.8%), Zambia (70.3%), and Malawi (70.0%) had the leading coverage of children 12 to 23 months who received all basic vaccinations in first year of life. Chad (60.5%), Congo Democratic Republic (50.3%), and Nigeria (39.8%) had the leading coverage of children aged 12 to 23 months who received no basic vaccinations in first year of life. See Table 1 below for the details.

Table 2 shows vaccinations in first year of life among children aged 12-23 months. From the results, there is a pattern of variations in the coverage of vaccines in first year of life across all SSA countries. In addition, the variations in coverage also exist for vaccines that should be taken at the same age schedule. The coverage of BCG and Polio 0 varied across all countries, even though these should be taken at the same time—at birth. For 6 weeks, 10 weeks, 14 weeks, and 9 months vaccinations coverage, there were within and between age schedule variations. Rwanda (95.5%), Burundi (92.0%), Kenya (85.9%), Zambia (85.6%), Malawi (85.5%), and Gambia (85.2%) had the leading vaccinations coverage at 9 months in first year of life.

Table 3 shows vaccinations in first year of life among under-5 in SSA countries. From the results, there is a pattern of variations in the coverage of vaccines in first year of life across all SSA countries. Furthermore, the variations in coverage also exist for vaccines that should be taken at the same age schedule. The coverage of vaccines at birth, 6 weeks, 10 weeks, 14 weeks, and 9 months varied across all countries, even for vaccines that should be taken at the same time. The within and between age schedule variations was visible. Rwanda, Burundi, Eswatini, Gambia, Ghana, Kenya, Lesotho, Burkina Faso, Congo, Malawi, Namibia, and Zambia had the leading vaccinations coverage at 9 months in first year of life.

Table 4 shows the sociodemographic factors associated with vaccination in SSA. For every unit increase in the age of a child, there was a 72% increase in the odds of vaccination (aOR = 1.72; 95% CI: 1.69-1.75). Children with older mothers had higher odds of vaccination, when compared with children with mothers aged 15 to 19 years. There was a 6% reduction in the odds of vaccination among children from rural residence, when compared with their urban counterparts (aOR = 0.94; 95% CI: 0.90-0.99). Children with educated mothers had over two times higher odds of vaccination, when compared with those from mothers with no formal education. Children from female headed households had a 9% higher odds of vaccination, when compared with children from male headed households (aOR = 1.09; 95% CI: 1.04-1.14). Children whose mothers were exposed to magazine/newspaper, radio, and tv had a higher odds of vaccination, when compared to children whose mothers were not exposed to media. Children from rich households had a higher odds of vaccination, when compared with children from poorest household. There was a 13% increase in the odds of vaccination among children covered by health insurance, when compared with those not covered by health insurance (aOR = 1.13; 95% CI: 1.02-1.25). Children from mothers that were formerly married had a 21% increase in the odds of vaccination, when compared with children from single women (aOR = 1.21; 95% CI: 1.09-1.33).

Discussion

From the findings of this study, Rwanda (92.2%), Burundi (81.8%), Gambia (78.3%), Kenya (74.6%), and Burkina Faso (70.8%) had the leading coverage of under-5 who received all basic vaccinations in the first year of life Conversely, Chad (70.8%), Congo Democratic Republic (52.5%), Niger (47.7%), Nigeria (43.0%), and Ethiopia (42.1%) had the leading coverage of under-5 who received no basic vaccinations in first year of life. This is consistent with the findings from previous studies.[20,21] The objective of SDG-3.2 is to enhance child health and survival rates. This has led to notable adjustments in both public and private investments, with the goal of facilitating access to reasonably cost-effective programs that enhance children's health, including vaccination schedules.[22] However, several factors have been identified as barriers to complete basic vaccinations.

Children from older mothers were more likely to have received vaccinations compared to children from mothers aged 15 to 19 years old. This could be due to the fact that older mothers learn over time on the importance and benefits of vaccinations and the consequences of having unvaccinated children. This is consistent with the findings from studies.[23,24] As a child gets older, there was higher odds of being vaccinated. This is because, for various reasons the child visits health centers and the missed opportunities for vaccinations are addressed. The emphasis should be in timely vaccinations, as children will become susceptible to various vaccines preventable illnesses due to missed opportunities for vaccinations.

Table 2. Vaccinations in First Year of Life Among Children Aged 12 to 23 Months.

		At birth		At 6 weeks		At 10 weeks		At 14 weeks		At 9 months
Country	Survey year	BCG vaccination received in first year	Polio 0 vaccination received in first year	DPT 1 vaccination received in first year	Polio 1 vaccination received in first year	DPT 2 vaccination received in first year	Polio 2 vaccination received in first year	DPT 3 vaccination received in first year	Polio 3 vaccination received in first year	Measles vaccination received in first year
Angola	2015-2016	70.4	64.3	67.1	65.8	49.7	53.3	38.1	39.9	51.2
Benin	2017-2018	88.1	86.3	84	81.9	77.9	76.7	72.2	64.8	64.5
Burkina Faso	2021	96.5	93.4	94.8	93.1	92.1	89.3	87.4	79.8	81.5
Burundi	2016-2017	97.5	90	99	98.5	98.4	97.3	95.9	91.5	92
Cameroon	2018	86.2	74.9	82.9	85	78.1	79.3	70.8	66.1	61.4
Chad	2014-2015	55.2	36.4	53.5	70.5	43.8	60.3	28.4	42.6	39.8
Comoros	2012	84.6	80.1	80.6	85.5	78.5	78.9	71.2	69.4	63.4
Congo	2011-2012	93.3	76	88	86.3	81.4	76.5	70.7	56.4	68.1
Congo Democratic Republic	2013-2014	82.8	49.5	79.6	89.6	71.9	82.2	58.2	62.9	64.4
Cote d'Ivoire	2021	86.8	69.3	69.5	80.8	62.3	73.4	53.6	61.7	55.1
Eswatini	2006-2007	97	92.8	95.4	96.3	93.8	94.6	90.2	85.9	82.7
Ethiopia	2019	70.4	31.6	75.1	76.7	70.3	70.6	60.3	58.4	54.8
Gabon	2019-2021	88.5	80.3	82.2	81.1	73.5	73.5	66.9	60.2	58.3
Gambia	2019-2020	98.8	98.2	98.2	97.4	96.1	95	92.1	89.8	85.2
Ghana	2022	95	76	96.9	95.4	94.1	91.1	87.9	83.1	80.4
Guinea	2018	72.9	68.6	61.7	64.1	49.4	51.2	39.1	38.6	35
Kenya	2022	96.7	86	97.1	96.5	93.9	94.1	88.9	77.9	85.9
Lesotho	2014	97.6	84.3	98.3	96	95	88.4	83.9	74.9	79.6
Liberia	2019-2020	89.3	85.9	90.9	86	82.5	76.7	67.8	62	68.2
Madagascar	2021	78.2	61.2	77.9	76.3	73.9	70.5	67.2	57.3	58.7
Malawi	2015-2016	97	72	97.2	96.6	95.7	93.2	91.9	79.7	85.5
Mali	2018	82.6	65.2	81.3	77.8	74.6	72.3	68.8	53.2	64.4
Mauritania	2019-2021	87.6	65.7	85.8	81.5	80.3	72.9	68.1	44.9	62.4
Namibia	2013	94.2	89.9	92.3	92.2	88.8	87.4	82.4	73.2	82.9
Niger	2012	82.6	56.4	84.4	90.8	76.8	82.3	64.8	71.1	57.5
Nigeria	2018	66	54.3	64.5	72.7	56.6	65.4	48.3	45.6	48.5
Rwanda	2019-2020	99.1	93.9	99.6	99.6	99.4	99.3	98.8	97.6	95.5
Sao Tome and Principe	2008-2009	95.2	90.3	93.6	94.6	89.4	90.2	86.4	85.7	75.3
Senegal	2019	93.3	79.9	96	95.3	94.5	93.1	91.1	83	76.6
Sierra Leone	2019	95.7	92.4	94.1	89.1	85.4	80.6	76.2	69.5	65.6
South Africa	2016	92.2	92.3	90.1	78	75.1		64.6		82
Tanzania	2022	90.4	51.1	94.5	88.3	92.9	77.2	89.2	58	81.3
Togo	2013-2014	95.1	86.9	93.1	93.9	89	88.8	81.6	73	66.2
Zambia	2018	97	66.4	97.6	96.2	95.4	92.9	91.4	80.6	85.6
Zimbabwe	2015	89.4		89.2	89.2	87.9	87.6	82	81	76.2

Furthermore, we found that, in comparison to their urban counterparts, children in rural areas had a lower likelihood of receiving vaccines. Africa's population is primarily rural, with limited access to health care.[25] Vaccination programs in remote areas are hindered by inadequate workforce levels and inadequate logistical support. Furthermore, due to inadequate transportation infrastructure, around 16% of rural communities lack mobile vaccination programs, and over half of rural health centers face a vaccine shortage.[26] Compared to rural settings, urban vaccination campaigns have higher vaccination coverage due to the aforementioned challenges. These challenges were also reported in a previous study.[27] Variation in vaccination coverage between urban and rural areas in SSA can be attributed to the fact that urban areas generally have better healthcare infrastructure, including clinics and transportation systems, which facilitates easier access to vaccination services. In contrast, rural areas often suffer from inadequate healthcare facilities and poor transportation, making it difficult for residents to access vaccinations. Also, urban centers usually attract more healthcare professionals due

Table 3. Vaccinations in First Year of Life Among Under-5.

		At birth		At 6 weeks		At 10 weeks		At 14 weeks		At 9 months
Country	Survey year	BCG vaccination received in first year	Polio 0 vaccination received in first year	DPT 1 vaccination received in first year	Polio 1 vaccination received in first year	DPT 2 vaccination received in first year	Polio 2 vaccination received in first year	DPT 3 vaccination received in first year	Polio 3 vaccination received in first year	Measles vaccination received in first year
Angola	2015-2016	68.4	61.7	64.8	61.5	46.8	50.8	35.1	36.9	50.5
Benin	2017-2018	86.4	84.2	82.6	80.6	76.4	75.3	70.9	62.5	62.8
Burkina Faso	2021	96.1	92.7	93.7	92.5	90.6	88.5	86.1	77.7	81.7
Burundi	2016-2017	97.5	90.4	98.7	98.1	98.2	96.8	95.8	89.2	92.5
Cameroon	2018	84.3	72.6	81.8	83.7	76.7	78.3	69.7	63.4	63.6
Chad	2014-2015	54.7	28.9	50.1	69.6	42.6	61.4	28.9	47.4	41.7
Comoros	2012	80.9	74.1	75.5	79.6	71.6	70.9	62.9	56.8	64
Congo	2011-2012	93.1	75.4	88.6	89.5	83.1	80.4	72.8	56.2	73.6
Congo Democratic Republic	2013-2014	83.8	47.8	80.6	88.3	74.2	79.8	61.5	61.1	70.6
Cote d'Ivoire	2021	87	70.4	69.6	81.2	61.5	73.3	52.6	58.6	55.7
Eswatini	2006-2007	95.4	90.6	94.6	94.9	92.3	91.9	88.4	77.3	84.1
Ethiopia	2019	66.5	32	69.2	72.1	64.4	65.8	54.7	53.8	52.4
Gabon	2019-2021	87.8	81	82.2	80.7	74.5	73.8	66.3	59.1	59.3
Gambia	2019-2020	98.4	96.7	97.7	97.2	95.8	94.5	91	87.8	85.2
Ghana	2022	94.7	75.4	95.9	94.2	92.6	89.3	85.9	79.3	81
Guinea	2018	71	66	61.6	62.4	48.7	50.7	39	37.2	36.5
Kenya	2022	96	85.5	96.4	95.2	92.6	92.3	86.9	72.9	85.5
Lesotho	2014	96	79.5	96.9	95	92.3	87.1	83.5	70.9	84.8
Liberia	2019-2020	90	84	89.9	83.9	78.9	72.8	64.2	57.1	68.3
Madagascar	2021	77.3	60.8	76.8	75.3	72.7	69.6	66.9	55.7	58.9
Malawi	2015-2016	96.1	72.6	96.3	95.6	94.7	92	90.1	76.1	84.4
Mali	2018	82.1	65.6	80.9	76.8	74	70.4	67.1	48.3	62.8
Mauritania	2019-2021	86.6	63.9	84.1	79.1	77.7	70.4	66.6	42.1	63
Namibia	2013	93.5	86.2	91.8	91.6	85.1	84.8	76.4	65.6	83.3
Niger	2012	80.1	46.1	80.3	88.7	73.4	79	61.9	68.8	63.5
Nigeria	2018	64.7	52.4	62.5	71.2	54.6	64.3	46.9	43.7	49
Rwanda	2019-2020	99	94	99.5	99.4	99.1	98.8	98.4	96.7	95.5
Sao Tome and Principe	2008-2009	93.8	88.5	91.7	93.2	88.3	89.1	85.3	82.3	79.3
Senegal	2019	93.3	79.8	95.4	94	94	92.3	90.9	78.8	78.4
Sierra Leone	2019	94.7	91.7	93	86.8	83.5	77.5	73.4	64.2	65.8
South Africa	2016	91.4	89.9	88.5	75.9	72.7		63.3		79.7
Tanzania	2022	90.7	57.7	94.4	88.4	92.6	78.2	88.5	59.5	80.5
Togo	2013-2014	93.4	81.4	91.2	92.8	87.9	88	79.7	64.1	71.5
Zambia	2018	96.6	66.8	97.3	95.8	95	92.1	90.1	78	84.3
Zimbabwe	2015	87.8		87.6	87.7	86.1	85.8	80.4	79.3	74.5

to better working conditions and opportunities for career advancement. Rural areas may face shortages of healthcare workers, impacting the delivery and uptake of vaccination services. Urban areas typically benefit from higher education levels and greater awareness about the importance of vaccinations. In rural regions, lower levels of education and awareness can lead to misconceptions and lower vaccination rates. In addition, supply chain issues are more pronounced in rural areas, where transporting vaccines and maintaining proper storage conditions can be challenging. Urban areas benefit from more efficient logistics and better cold chain management. Furthermore, cultural beliefs and practices can influence vaccination rates. Urban areas might experience more diverse healthcare influences and acceptance, whereas rural areas may have more entrenched traditional beliefs that impact vaccination uptake.

In low-income countries, maternal education is considered to be a significant factor influencing vaccination uptake. Regardless of education level, mothers with higher levels of education have higher vaccination rates for their children, according to a recent systematic review.[9] Additionally, a previous population-based study, showed that mothers with only a primary education had a higher likelihood of their children being fully vaccinated than mothers with no formal education.[28] Furthermore, early marriages and pregnancies are two things that hinder the educational opportunities for women. Africa has a high percentage of child marriages globally, with 40% of females reportedly getting

Table 4. Demographic and Socioeconomic Factors Associated with Vaccinations in SSA.

Variable	Unadjusted odds ratio	95% confidence interval	Adjusted odds ratio	95% confidence interval
Sex of child				
Male	1.00			
Female	1.02	0.99-1.06		
Age of child	1.62	1.60-1.64	1.72	1.69-1.75
Mother's age				
15-19	1.00		1.00	
20-24	1.51	1.43-1.60	1.21	1.13-1.29
25-29	1.54	1.45-1.62	1.26	1.18-1.35
30-34	1.62	1.52-1.71	1.33	1.24-1.43
35-39	1.62	1.52-1.72	1.35	1.25-1.46
40-44	161	1.49-1.74	1.34	1.22-1.47
45-49	1.46	1.30-1.64	1.19	1.03-1.37
Place of residence				
Urban	1.00		1.00	
Rural	0.52	0.50-0.54	0.94	0.90-0.99
Mother's education				
No formal education	1.00		1.00	
Primary	2.21	2.14-2.29	2.06	1.98-2.15
Secondary	3.50	3.35-3.65	2.54	2.41-2.69
Higher	6.10	5.28-7.06	2.93	2.45-3.50
Sex of household head				
Male	1.00		1.00	
Female	1.25	1.20-1.29	1.09	1.04-1.14
Mother's exposure to magazine/newspaper				
Not at all	1.00		1.00	
Less than once a week	2.91	2.67-3.17	1.17	1.06-1.29
At least once a week	2.81	2.55-3.11	1.08	0.97-1.22
Almost every day	2.08	1.49-2.88	0.58	0.41-0.83
Mother's exposure to radio				
Not at all	1.00		1.00	
Less than once a week	1.78	1.70-1.86	1.39	1.32-1.46
At least once a week	2.04	1.96-2.12	1.36	1.29-1.43
Almost every day	2.33	2.08-2.61	1.34	1.17-1.52
Mother's exposure to tv				
Not at all	1.00		1.00	
Less than once a week	1.72	1.62-1.82	1.10	1.02-1.17
At least once a week	2.20	2.10-2.30	1.00	0.94-1.06
Almost every day	3.01	2.64-3.44	1.24	1.07-1.44
Wealth index				
Poorest	1.00		1.00	
Poorer	1.26	1.22-1.31	1.13	1.08-1.18
Middle	1.59	1.53-1.66	1.34	1.27-1.41
Richer	2.08	1.98-2.18	1.58	1.48-1.67
Richest	3.52	3.31-3.73	1.97	1.81-2.15
Mother's age at first childbirth	1.03	1.02-1.04	1.00	0.99-1.01
Health insurance coverage				
Yes	1.67	1.53-1.83	1.13	1.02-1.25
No	1.00		1.00	
Mother's marital status				
Not in union	1.00		1.00	
Married	0.74	0.70-0.79	1.03	0.96-1.11
Widowed/separated/divorced	1.16	1.06-1.26	1.21	1.09-1.33

married before becoming 18 years old.[29] Due to cultural stigmatization, many girls are pressured into young marriages.[30] In an effort to keep girls in school longer and prevent early female marriages, many African countries have committed to implementing universal or mandatory primary education. Re-entry policies have been put in place by countries including South Africa, Cameroon, and Zambia to allow mothers to return to school after giving birth. Nonetheless, young mothers frequently experience social isolation in schools and lack the financial means to attend.[31] In the Ambo area of Ethiopia, for instance, a survey revealed that although the majority of mothers understood the value of vaccination, few of them were aware of the appropriate age to start vaccinating their children.[32]

In this study, exposure to media such as magazine/newspaper, radio, and tv by mothers had higher odds of vaccinations among under-5. Exposure to media by mothers is a source of knowledge and enlightenment about availability and use for health care services. Previous studies have reported the importance of media as source of health information and promotes knowledge.[33-36] No doubt, this can promote good knowledge of child vaccination among mothers. Research evidence from Ethiopia highlights that maternal understanding of vaccination was found to be a predictor of vaccination uptake.[37] In comparison to children whose mothers had inadequate understanding of vaccination, children of mothers with good awareness of the disease were found to have a threefold higher likelihood of being fully immunized.[37] Similar findings has been reported in another study.[14] Mothers in Burkina Faso who were aware of the preventive benefits of vaccination were more likely to vaccinate their children than those who were not.[27] Poor maternal knowledge of vaccines was found to be the primary factor contributing to poor vaccination uptake, accounting for 50% of the reasons for non-vaccination in a household-level cluster survey of 7815 children conducted in 40 polio high-risk districts of Nigeria.[38] This highlights that exposure to media improves health literacy of the community on vaccinations.

The children from rich households had higher odds of vaccinations, when compared with the poorest counterparts. There exists a correlation between a parent's primary economic pursuits and the completion of vaccinations. Unlike parents who have a job, parents who are poor or unemployed might not be able to afford health care costs. The results of the study indicate a relationship between vaccination coverage and household economic conditions. In most circumstances, household income disparities impact vaccination uptake.[7] A higher vaccination coverage exists in regions with a high economic quartile. A financial constraint has been stated by mothers as one of the reasons they do not vaccinate their children. There are certain countries with good health insurance policies, where access to medical services is convenient.[7,39]

Health insurance coverage has been reported to promote health care services uptake,[40-42] as was also found in this study to increase the odds of vaccinations. A collection of policy levers known as strategic health purchasing must be operationalized in order to direct the money raised via contributions (ie, pooled funds) for national health insurance towards vaccination.[43] It is necessary for these plans to exist in order to give the buyer (national health insurance) the ability to choose what services to acquire (such as vaccination services included in the health benefit package), from whom to purchase them, and how to pay for them.[44] One of the most significant roles in the system was seen to be played by the insurance system, and the introduction of strategic health care purchasing was done so to shield individuals from the financial risk that comes with illness. In addition, children from families headed by women were more likely than those headed by men to receive vaccinations. This may be due to enhanced women's empowerment, decision-making power or high socioeconomic status.

Strengths and Limitations

This study estimated vaccination coverage of under-5. We conducted secondary analysis of nationally representative datasets This could encourage collaboration, new policies and initiatives, and a mobilization of people to support current efforts aimed at improving vaccine uptake. However, DHS did not collect data of income or expenditure, which are two common indicators of wealth. The wealth index used in this study is determined by collecting information on household asset, which is a proxy of the financial situation of households. The results of this index are not always comparable to those resulting from direct revenue and expenditure capacities. Another limitation to the study was the use of data across a 14-year period (2008-2022). For inter-country comparisons, this could be problematic, as it can fail to account for potential temporal trends and variations in demographic, health, and socioeconomic factors.

Conclusion

SSA countries need to prioritize funding for vaccine access, increase vaccine coverage storage, address vaccine hesitancy while identifying priority populations for vaccination in order to address their local vaccination failures and issues. To ensure complete vaccination coverage, extensive community engagement and efficient health communication are essential. While there have been many recommendations for ways to increase vaccination coverage in SSA countries, reaching the required levels to fully reap the advantages of vaccination remains a significant barrier. Healthcare systems and providers working together can do this, and it will benefit individuals as well as the communities and cultures in which they live.

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Author Contributions

Michael Ekholuenetale: Contributed to conception and design; Contributed to data curation, analysis and interpretation; Drafted the manuscript; Discussed the findings; critically revised the manuscript; Gave final approval; Agrees to be accountable for all aspects of work ensuring integrity and accuracy.
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Availability of Data and Materials

Data for this study were sourced from Demographic and Health surveys (DHS) and available here: http://dhsprogram.com/data/available-datasets.cfm.

Declaration of Conflicting Interests

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Ethical Approval and Consent to Participate

This study is a secondary data analysis, which is publicly available, approval was sought from MEASURE DHS/ICF International and permission was granted for this use. The original DHS data were collected in conformity with international and national ethical guidelines. Written consent was obtained from mothers/caregivers and data were recorded anonymously at the time of data collection during the data collection. More details regarding DHS data and ethical standards are available at: http://dhsprogram.com/data/availabledatasets.cfm.

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