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Review

Prevalence and determinants of full immunization among children under five in sub-Saharan Africa: A systematic review and meta-analysis (2013–2025)

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ABSTRACT

Background: Despite global progress in childhood immunization, Sub-Saharan Africa (SSA) continues to report suboptimal coverage and high under-five mortality. This systematic review and meta-analysis assessed the prevalence and determinants of full immunization among children under five in SSA between 2013 and 2025.
Methods: We systematically searched six electronic databases for studies published between January 2013 and May 2025 that reported the prevalence and/or determinants of full immunization in SSA. Eligible studies were original, peer-reviewed quantitative research. Data were analysed using random-effects meta-analysis, with subgroup and sensitivity analyses conducted to explore heterogeneity. Determinants were synthesised using pooled odds ratios (ORs) where applicable.
Results: Thirty-one studies comprising 299,898 children were included. The pooled prevalence of full immunization was 51% (95% CI: 45%–58%), with substantial heterogeneity (I^2 = 100%). Prevalence varied widely across studies from 6% to 96%. Subgroup analyses revealed lower coverage in recent years and in studies with larger sample sizes. Key positive determinants of full immunization included maternal education (OR = 2.70), paternal education (OR = 2.48), antenatal care attendance (OR = 0.23 for non-attendance), institutional delivery (OR = 2.99), and household wealth (OR = 2.45). Children in rural areas (OR = 0.55) and those with mothers of higher parity (OR = 0.67) were less likely to be fully immunised.
Conclusion: Full immunization coverage in SSA remains well below global targets, with wide disparities by country, socioeconomic status, and maternal healthcare utilization. Strengthening maternal health services, improving education, and addressing health system barriers are critical to improving coverage and reducing preventable child deaths in the region.

1. Introduction

Vaccination is universally recognized as one of the most impactful and cost-effective public health interventions which plays a pivotal role in safeguarding child health, averting disease outbreaks, and reducing childhood morbidity and mortality. According to the World Health Organization (WHO), immunization prevents an estimated 3.5 to 5 million deaths annually from diseases such as diphtheria, tetanus, pertussis, influenza, and measles [1]. Among children under five, timely and complete immunization is crucial for building immunity against

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common and potentially fatal diseases, contributing substantially to the global decline in child mortality observed over the past decades. However, this progress has been unevenly distributed across regions, with sub-Saharan Africa (SSA) persistently lagging.

SSA remains the epicenter of under-five mortality globally, accounting for more than half of all deaths in this age group [2]. Children born in SSA are 15 times more likely to die before their fifth birthday than those born in high-income countries [3]. More than half of these deaths are preventable through basic health services, including routine childhood immunization. Despite strong evidence of the benefits of immunization and global policy support, many countries in SSA continue to experience low immunization coverage, high dropout rates, and significant regional and socioeconomic disparities.

National-level surveys and regional studies have documented varying levels of full immunization coverage. In these studies, full immunization is commonly defined as receiving all essential vaccines by a certain age, typically including Bacille Calmette–Guérin (BCG), three doses of diphtheria-tetanus-pertussis (DTP) or pentavalent vaccine, three doses of oral polio vaccine (OPV), and one dose of measles-containing vaccine (MCV). The heterogeneity across SSA is stark. For example, Rwanda has consistently recorded over 90% full immunization coverage while countries like Guinea and regions within Somalia and Somaliland report rates as low as 13% to 24% [4]. A meta-analysis of studies across Africa estimated that 35.5% of children were incompletely immunised [5], far below the 90% target set by the WHO for national coverage by 2030. These statistics reflect missed opportunities for protection and the risk of outbreaks of preventable diseases.

The existing literature has consistently identified a range of intersecting individual, household, and community-level factors associated with full immunization uptake. These include maternal education, which enhances understanding and acceptance of immunization; healthcare service utilization, such as antenatal care (ANC), postnatal care (PNC), and institutional delivery; household wealth, which influences access to services and transport; media exposure, which facilitates knowledge dissemination; and urban residence, often associated with better access to health infrastructure [6,7]. For instance, mothers with secondary or higher education levels were found to be significantly more likely to fully immunize their children and similar patterns were observed for women who delivered in health facilities or who had four or more ANC visits [8]. Health system constraints such as limited cold chain infrastructure, vaccine stock-outs, and workforce shortages, especially in remote and rural settings, exacerbate these disparities. Geographic and regional variations driven by political instability, weak governance, conflict, and fragile health systems also influence immunization outcomes.

While these individual studies and analyses offer important insights, the existing body of evidence is fragmented, with limited efforts to aggregate data across countries and account for methodological differences. To address these gaps, the present study utilised a systematic review and meta-analysis study design to generate robust, pooled estimates of the prevalence of full immunization among children under five in SSA, and to identify the key determinants that influence this coverage. The review synthesizes data from multiple studies and nationally representative surveys to present a more nuanced and comprehensive picture of immunization trends and determinants of full immunization in the region.

2. Methods

2.1. Study design

This systematic review and meta-analysis complied with the guidelines established by the Centre for Reviews and Dissemination (CRD) for conducting systematic reviews in healthcare [9] and adhered to the Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines [10]. The reporting followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA-P) [11].

2.2. Research questions and study eligibility

This study aimed to address the following questions:

- What is the prevalence of full immunization among children under five in SSA?
- What are the determinants of full immunization among children under five in SSA?

The study's eligibility was established through the application of the problem-interest-context (PICo) framework. The problem was identified as incomplete immunization, and children under five were the interest within the context of SSA.

2.3. Inclusion and exclusion criteria

This review includes studies that reported on the prevalence and determinants of full immunization among children under five in SSA, along with associated risk estimates, such as odds ratios or relative risks. The studies were intended to be original quantitative research employing cross-sectional, case-control, or cohort designs, regardless of sample size. Studies must have been peer-reviewed and published in English-language health-related journals between January 1, 2013, and May 30, 2025. Literature reviews, qualitative studies, editorials, systematic reviews, meta-analyses, meta-synthesis, and publications before 2013 were excluded.

2.4. Outcome variable

The outcome variable for this study was full immunization among children under five. Given the variability in national immunization schedules across sub-Saharan Africa and differences in study definitions, full immunization was defined in accordance with how it was reported in each included study. Generally, studies considered a child fully immunised if they had received all basic vaccines recommended by their country's Expanded Programme on Immunization (EPI), most commonly by the age of 12–23 months. These vaccines typically included one dose of Bacillus Calmette–Guérin (BCG), three doses of diphtheria, pertussis, and tetanus (DPT)-containing vaccine or pentavalent vaccine, three or more doses of oral or inactivated poliovirus vaccine (OPV/IPV), and one dose of measles-containing vaccine (MCV1). Some studies also included additional vaccines such as pneumococcal conjugate vaccine (PCV), rotavirus vaccine, hepatitis B, and yellow fever, depending on the national immunization schedule and the child's age range. The method of determining full immunization varied and was based on vaccination cards, maternal recall, or both. This review retained each study's original operational definition to preserve internal validity and reflect the real-world variation in how immunization coverage is measured across contexts.

2.5. Literature sources and search strategy

An electronic search was conducted across various databases for peer-reviewed articles published between January 1, 2013, and May 30, 2025. The databases employed were PubMed, ScienceDirect, Google Scholar, EMBASE, SCOPUS, and Africa Journals Online (AJOL). Databases were searched from June 1 to June 10, 2025.

The search terms employed to gather relevant articles encompassed ‘full immunization’, ‘complete immunization’, ‘determinants’, ‘sub-Saharan Africa’, ‘factors’, ‘children under five years’, ‘infants’, ‘magnitude’, ‘correlations’, and all countries within SSA. Boolean operators were utilised to integrate search terms. All articles with relevant titles were transferred to Covidence (https://www.covidence.org/), a tool specifically designed for systematic reviews.

Following the elimination of duplicates, two independent reviewers (OM and EM) assessed the abstracts of the remaining articles. Two reviewers, OM and EM, retrieved and reviewed the full texts of the eligible articles. Disagreements were resolved through dialogue until consensus was reached. In instances of disagreement, a third reviewer (TD) mediated the discussion to achieve a conclusive decision. The lead reviewer (TD) conducted a reference list search of all included articles to identify potentially relevant studies omitted from the initial search.

2.6. Quality assessment of included studies

Two authors (OM and SJN) independently assessed the methodological quality of the included studies using the standardized Joanna Briggs Institute (JBI) critical appraisal checklist for prevalence studies [12]. Any discrepancies between the reviewers were resolved through discussion and consensus, with input from a third reviewer (EM) when necessary. The JBI checklist consists of eight items assessing aspects such as the clarity of inclusion criteria, the description of study subjects and settings, the validity and reliability of exposure and outcome measurements, identification and management of confounding factors, and the appropriateness of statistical analyses. Each item was rated as "yes," "no," "unclear," or "not applicable." Studies that scored at least 50% (i.e., four or more "yes" responses) were considered to have a low risk of bias. Detailed quality scores for each study are provided in Supplementary File 1.

2.7. Data extraction

The reviewers created and implemented a pilot test of a data extraction form on four of the chosen studies. Data were extracted from the included articles by two reviewers (EM and TD), who subsequently compared their findings. The extracted information from each study comprises the authors, publication year, the country where it was conducted, study design, sampling method, sample size, the definition of full immunization used, the method used to ascertain full immunization, determinants of full immunization, the population studied, and prevalence of immunization.

2.8. Data synthesis and statistical analysis

Data were exported to MetaXL for analysis to determine the pooled prevalence of full immunization among children under five in Sub-Saharan Africa. A random effects meta-analysis model was employed to account for potential heterogeneity across studies. The Q and I^2 tests were utilised to evaluate the statistical heterogeneity of the studies. I^2 cut-off points of 25%, 50%, and 75% signify low, medium, and high heterogeneity, respectively [13]. Subgroup analyses were conducted to examine potential variations in the prevalence of full immunization among children under five, considering the year of publication, sample size, and the number of countries included in the study. Funnel plots were employed to evaluate publication bias. Sensitivity analysis was performed to evaluate the influence of individual studies on the overall prevalence of full immunization in children under five.

Data were exported to IBM SPSS Statistical Package for Windows version 29 to ascertain the pooled effect size of the determinants of full immunization among children under five and the effect size of each determinant in individual studies. Odds ratios were employed to estimate the aggregated effect sizes. Variables were included in the meta-analysis only if they exhibited statistical significance in at least two of the included studies. Non-dichotomous variables were transformed into dichotomous variables prior to the calculation of odds ratios. Forest plots served to visually depict pooled estimates and their corresponding 95% confidence intervals. A *p*-value less than 0.05 was considered statistically significant for all analyses conducted.

3. Results

3.1. Search results

A total of 1487 records were retrieved from six electronic databases. After removing 417 duplicates, 1070 unique records remained. Following title and abstract screening, 945 articles were excluded. Of the 125 full-text articles assessed for eligibility, 94 were excluded (e.g., not conducted in SSA, not focused on under-five children, or qualitative design). Ultimately, 31 studies met the inclusion criteria (Fig. 1).

3.2. Characteristics of included studies

Among the 31 studies included in this study, six were conducted in multiple countries [14–19], five in Ethiopia [20–24], five in Somalia [25–29], four in Nigeria [30–33], two in Cameroon [34,35], two in Zimbabwe [36,37], and one each in Uganda [38], Benin [39], The Gambia [40], Ghana [41], Papua New Guinea [42], Eswatini [43], and Senegal [44]. Seventeen of the studies were cross-sectional studies [19,20,24,25,27–29,32–37,40,42–44], while the other 14 used demographic and health survey (DHS) data [14–18,21–23,26,30,31,38,39,41].

Three of the studies used a systematic random sampling method [24,27,29], one used a combination of two-stage cluster sampling and systematic random sampling [25], while the rest of the studies used a stratified random sampling method. Fourteen of the studies were conducted among children aged 12–23 months [14,16,17,19–23,33,36,37,39,42], six among children under five [25,26,28,29,31,35], three among children aged 15–35 months [15,41,43], two among children aged 12–36 months [24,38], and two among children aged 12–24 months [30,44]. One study each was conducted among children ages 0–11 months [34], 0–12 months [18], 12–59 months [40], and 11–24 months [27]. The studies' sample sizes ranged from 174 [29] to 95,333 [15]. The prevalence of full immunization among children under five ranged from 6.3% [28] to 96.3% [34]. More information is in Table 1.

3.3. The prevalence of full vaccination

3.3.1. Overall prevalence of full vaccination

A total of 31 studies were included in this meta-analysis, comprising 299,898 children under five. Of these, 154,150 (51.4%) were reported to be fully vaccinated according to national immunization schedules. The pooled estimate for the prevalence of full vaccination was 51% (95% CI: 45%–58%), calculated using a random-effects model to account for expected heterogeneity between studies (Fig. 2). Prevalence estimates across individual studies varied substantially, ranging from 6% (95% CI: 6%–7%) to 96% (95% CI: 94%–98%). The heterogeneity across studies was significant, with a Cochran's Q statistic of $Q = 33{,}030.37$ ($p < 0.001$) and an I^2 value of 100%, indicating substantial variability not attributable to chance. This suggests that differences in study settings, populations, or methodologies may have influenced the observed variation in full immunization rates.

3.3.2. Publication Bias

The funnel plot (see Supplementary File 2) indicated visual asymmetry, suggesting potential publication bias or small-study effects. The asymmetry was most notable among studies with higher standard errors and lower sample sizes.

3.3.3. Sensitivity analyses

A leave-one-out sensitivity analysis was conducted to assess the robustness of the pooled prevalence estimate. Each study was sequentially excluded, and the pooled prevalence was recalculated. The results showed that the overall pooled prevalence of full vaccination remained stable, ranging from 51.3% to 52.5%, with overlapping 95% confidence

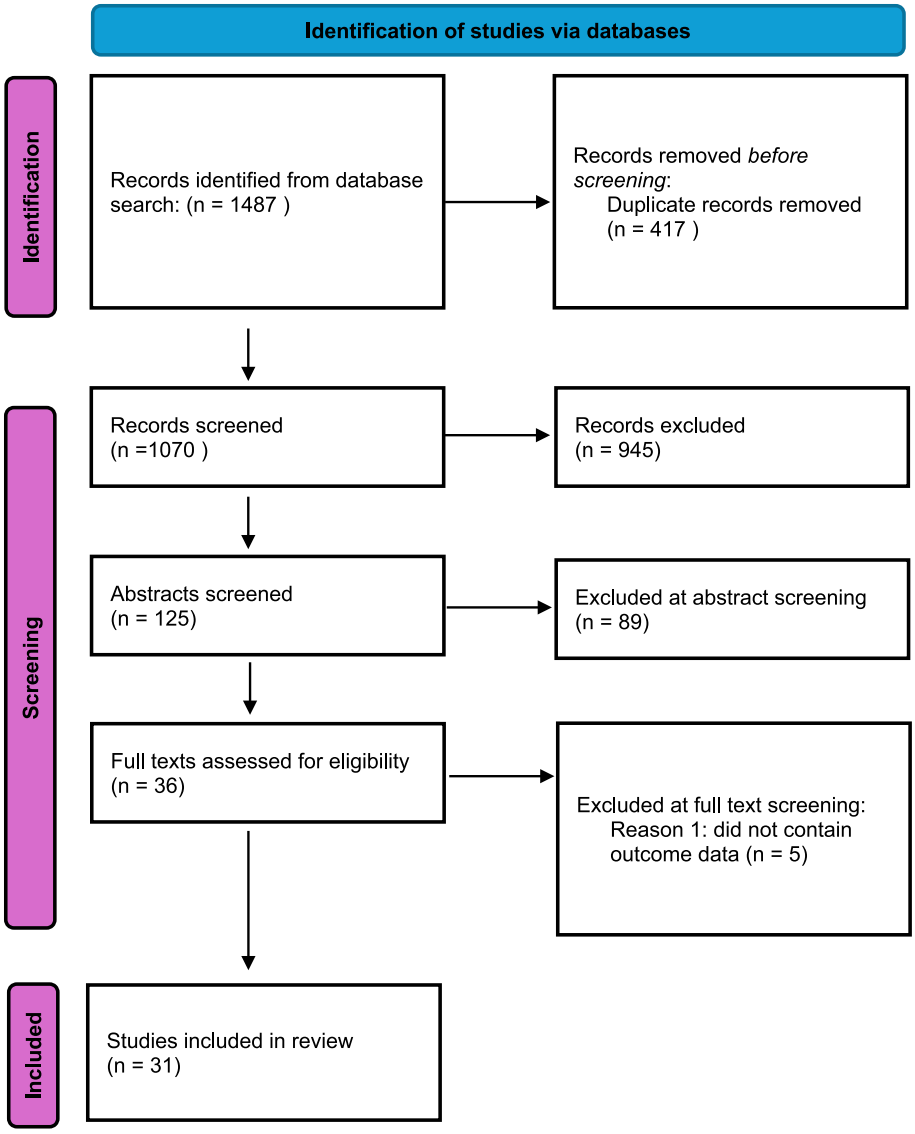

Fig. 1. PRISMA flow diagram illustrating the selection process of studies included in the review.

intervals in all cases. Notably:

- Excluding Bobo et al., 2022 yielded a pooled prevalence of 51.3% (95% CI: 44.1%–58.6%).
- Excluding Oleribe et al., 2017, which reported a relatively low prevalence, resulted in a slightly higher pooled prevalence of 52.5% (95% CI: 46.9%–58.1%).
- Cochran's Q remained high across all iterations (e.g., Q = 32,256.6 to 33,005.3), and I^2 remained near 100%, indicating persistent high heterogeneity even with individual studies removed.

These findings suggest that no single study unduly influenced the overall pooled estimate, strengthening confidence in the robustness of the meta-analytic result. More details are presented in Supplementary File 3.

3.3.4. Subgroup analyses

We performed subgroup analyses to determine the source of heterogeneity. The subgroup analyses were performed by article publication year, sample size, and the number of included countries per study among the included studies.

3.3.4.1. Subgroup analysis by publication year. Studies were grouped into five time periods: 2014–2016, 2017–2018, 2019–2020, 2021–2022, and 2023–2025. Considerable variation in full vaccination prevalence was observed across these periods. The most recent studies (2023–2025) reported a pooled prevalence of 41% (95% CI: 30%–52%), while studies from 2019 to 2020 reported 47% (95% CI: 31%–62%). Studies from 2014 to 2016 and 2021–2022 reported prevalence estimates of 59% (95% CI: 45%–72%) and 68% (95% CI: 56%–79%), respectively.

Fig. 3 presents a Forest Plot of full vaccination prevalence by year of Publication. All subgroups showed substantial heterogeneity, with I^2 values ranging from 99% to 100% ($I^2 \geq 99\%$, $p < 0.001$), and Cochran's Q values indicating statistically significant variability (e.g., Q = 14,423.42 for 2023–2025 subgroup, $p < 0.001$). Substantial variation was observed across time periods, with more recent studies reporting lower coverage.

3.3.4.2. Subgroup analysis by sample size. Studies were divided into two groups based on sample size: those with more than 1000 participants and those with fewer than 1000. The subgroup of larger studies reported a pooled prevalence of 44% (95% CI: 36%–52%), while smaller studies reported a higher prevalence of 63% (95% CI: 51%–75%).

Fig. 4 presents a Forest Plot of full vaccination prevalence by sample

Table 1
Characteristics of included studies.

First Author, Publication year	Country where the study was conducted	Study Design	Sampling method	Definition of full vaccination used	Determination of full vaccination	Population	Sample Size	Number of participants fully vaccinated	Full vaccination coverage (%)
Bobo et al., 2022	25 sub-Saharan African (SSA) countries	Demographic and Health Surveys (DHS)	Stratified random sampling	Children who had all recommended basic vaccines by the age of 12 months	Child vaccination record cards provided by mothers/ caretakers or mothers/ caretakers' verbal reports of children's immunization status	Children 12–23 months old	55,102	31,133	56.5
Dimitrova et al., 2023	26 SSA countries	DHS	Stratified random sampling	Children who had received BCG, DPT 1–3, OPV 1–3, and MCV	Vaccination cards or mothers' recall	Children 15–35 months old	95,333	51,585	54.1
Bbaale 2013	Uganda	DHS	Stratified random sampling	Children who received the eight doses against vaccine-preventable diseases	Vaccination cards shown to the interviewer and from mothers' verbal reports	Children 12–36 months old	7591	4099	54.0
Azubuike et al., 2025	Nigeria	DHS	Stratified random sampling	Children who received one dose of the bacillus Calmette-Guerin (BCG) vaccine, four doses of the oral polio vaccine (OPV), three doses of the Diphtheria, Tetanus, and Pertussis (DTP) vaccine, and one dose of a measles-containing vaccine	Vaccination cards shown to the interviewer and from mothers' verbal reports	Children 12–24 months old	2098	593	28.27
Oleribe et al., 2017	Nigeria	DHS	Stratified random sampling	child who has had the six vaccine preventable disease vaccines of Bacille-Calmette Guerin (BCG), third dose of diphtheria, pertussis and tetanus (DPT3), third dose of oral polio vaccine (OPV3,) and measles by 24 months.	Mother's verbal reports	Children 0–59 months old	27,571	6093	22.1
Budu et al., 2021	Benin	DHS	Stratified random sampling	Child that has received one dose of BCG, three doses of pentavalent, pneumococcal conjugate (PCV), oral polio vaccines (OPV); two doses of Rota virus, and one dose of measles vaccine	Immunization cards or from mothers' verbal responses	Children 12–23 months old	4156	3549	85.4
Tesema et al., 2020	12 East African countries (Burundi, Ethiopia, Comoros, Uganda, Rwanda, Mozambique, Madagascar, Zimbabwe, Kenya, Zambia, Malawi, and Tanzania.)	DHS	Stratified random sampling	Complete basic childhood vaccination achieved when the child received one dose of BCG vaccine, three doses of pentavalent vaccines, three doses of polio vaccines, and one dose of measles vaccines before the age of 12 months	Mother's verbal records and the childhood immunization card	Children 12–23 months old	18,811	13,019	69.21
Legesse et al., 2015	Ethiopia	A community based cross-sectional study	Stratified random sampling	A child between 12 and 23 months who received one dose of Bacille Calmette	Vaccination card plus mother history.	Children 12–23 months old	591	454	76.8

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Table 1 (*continued*)

First Author, Publication year	Country where the study was conducted	Study Design	Sampling method	Definition of full vaccination used	Determination of full vaccination	Population	Sample Size	Number of participants fully vaccinated	Full vaccination coverage (%)
				Guerin (BCG), at least three doses of pentavalent, three doses of OPV and one dose of measles vaccine					
Ijarotimi et al., 2018	Nigeria	A community based cross-sectional study	Multistage sampling	A child who had received one dose of BCG, three doses of OPV (excluding OPV given at birth), three doses of DPT vaccine and one dose of measles vaccine (MCV1) by 12 months of age	Immunization cards or from mothers' verbal responses	Children 12–23 months old	449	365	81.3
Chiabi et al., 2017	Cameroon	A cross-sectional analytical study	Census sampling	A child who had received all of the doses of the following vaccines: BCG, OPV_0, DTP-$HepB_1$-Hib1, OPV_1, $Rota_1$, $Pneumo13_1$, DTP-$HepB_1$-Hib_2, OPV_2, $Rota_2$, $Pneumo13_2$, DTC-$HepB_1$-Hib_3, OPV_3, $Pneumo13_3$, Measles, Yellow fever and Rubeola vaccines according to the EPI schedule	Mother's verbal records and the childhood immunization card	Children 0–11 months old	400	385	96.3
Kinfe et al., 2019	Ethiopia	DHS	Stratified random sampling	Child received at least one dose of Bacille Calmette-Guerin (BCG), three doses of DPT, three doses of polio and one dose of measles vaccine	Mother's verbal records and the childhood immunization card	Children 12–23 months old	1929	752	39.0
Fenta et al., 2021	9 SSA countries (Ethiopia, Ghana, Democratic Republic of Congo, Senegal, Rwanda, Malawi, Tanzania, Namibia, and Zambia)	DHS	Stratified random sampling	Child having received all eight EPI-recommended doses of vaccine (one dose of Bacille Calmette-Guerin (BCG), three doses of DPT and three doses of polio, and one dose of measles)	Mother's verbal records and the childhood immunization card	Children 12–23 months old	21,148	12,562	59.4
Mohamud Hayir et al., 2020	Somalia	A community based cross-sectional study	A mixture of two-stage cluster sampling and systematic random sampling	Child who received one dose of (Bacillus Calmette-Guerin) BCG, one dose of measles, at least three doses of DPT-HepB-Hib (pentavalent) and four doses of (Oral Polio vaccine) OPV and one dose of (Inactivated Polio Vaccine) IPV	Immunization cards or the mother's verbal reports with the verification of the presence of a BCG scar	<5 years	741	335	45.2
Barrow et al., 2023	Three West African countries (Gambia, Sierra Leone, and Liberia)	DHS	Stratified random sampling	A child who received WHO recommended vaccination against tuberculosis (also known as BCG), three doses of DPT-HepB-Hib (Penta), three doses of polio vaccines, and one dose of vaccination against measles	Mothers' verbal reports	Children 0–12 months old	5368	808	15.1

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Table 1 (*continued*)

First Author, Publication year	Country where the study was conducted	Study Design	Sampling method	Definition of full vaccination used	Determination of full vaccination	Population	Sample Size	Number of participants fully vaccinated	Full vaccination coverage (%)
Odutola et al., 2015	Gambia	A cross-sectional study	Census sampling	Child having received a dose of BCG (birth – 8 weeks), three doses of DPT-Hib-HBV [DPT1/OPV1 (6 weeks – 14 weeks); DPT2/OPV2 (10 weeks – 18 weeks); DPT3/OPV3 (14 weeks – 24 weeks)] and a dose of measles vaccine (38 weeks – 52 weeks) respectively	Immunization cards	Children 12–59 months old	1154	424	36.7
Tekeba et al., 2025	Ghana	DHS	Stratified two-stage cluster sampling	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	interview responses from mothers and the immunization card report	Children aged 12–35 months.	1823	1029	56.45
Tamirat, 2019	Ethiopia	DHS	Two Stage Stratified Sampling	a child that has received one dose of BCG, three doses of pentavalent, pneumococcal conjugate (PCV), oral polio vaccines (OPV); two doses of Rota virus and one dose of measles vaccine.	Vaccination card where available. If not, interview answers from the mother	Babies aged 12–23. months	1909	731	38.3%
Dinga 2025	Cameroon	Cross sectional study	Multistage sampling	Not specified	Caregiver report	Children aged 0–59 months	438	328	74.89%
Budu, 2020	Papua New Guinea	Cross Sectional study	Two stage stratified sampling	a child that has received one dose of Bacillus Calmette–Guérin (BCG), three doses of pentavalent, pneumococcal conjugate (PCV), oral polio vaccines (OPV); two doses of Rota virus, and one dose of measles vaccine	immunization cards or from mothers' verbal responses to these questions	Children aged 12–23 months	709	276	39%
Dires, 2025	East Africa	Cross sectional study	Multistage sampling	a child is deemed fully immunised if they have received all eight vaccines, (one dose of BCG, at least three doses of the pentavalent vaccine, three doses of oral polio vaccine (OPV)	DHS Kids Record (KR) files	Children aged 12 to 23 months	22,734	15,323	67.4%
Dlamini, 2023	Eswatini	Cross sectional study	Multistage sampling	For children aged 12 to 23 months, the outcome variable was computed using nine doses of four vaccines: Bacille Calmette-Guérin	Mothers' or caregivers' verbal responses	12 to 35 months	978	478	68.5%

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Table 1 (*continued*)

First Author, Publication year	Country where the study was conducted	Study Design	Sampling method	Definition of full vaccination used	Determination of full vaccination	Population	Sample Size	Number of participants fully vaccinated	Full vaccination coverage (%)
				(BCG) (1 dose), oral poliovirus vaccine (OPV) (4 doses), DPT (3 doses), and Measles (1 dose) by one year. For children aged 24 to 35 months, the outcome variable was estimated using eleven doses of four vaccines: BCG (1 dose), OPV (5 doses), DPT (3 doses), and Measles (2 doses) by 24 months.					
Hassan, 2024	Somalia	DHS	Multistage sampling	a child is considered fully immunised if they have received one dose of the measles vaccine, three doses of the DPT vaccine, at least three doses of the polio vaccine, and the BCG vaccination,	SDHS Data	Under 5	9290	3233	34.8
Mbengue, 2017	Senegal	Cross sectional study	Multistage sampling	Defined as per WHO guidelines, excluding vaccines introduced in 2012 such as rotavirus vaccine, pneumococcal vaccine and the second dose of measles-contained vaccine.	Immunization cards and mother's recall	Children aged 12–24 months	2199	1381	62.8%
Jama, 2020	Somalia	Cross sectional study	Systematic random sampling	Children who had all recommended basic vaccines appropriate for his/her age	Parents/guardian reports	Children aged 11–24 months	357	70	19.6
Belay, 2025	Somalia	Cross sectional study	Three-stage cluster sampling	Receiving a BCG vaccination, three doses of the DPT vaccine, at least three doses of the polio vaccine, and one dose of the measles vaccine.	Immunization cards or the mother's verbal reports	Children aged 0–59 months	3916	247	6.3
Gebrehiwot, 2025	Ethiopia	DHS	stratified two-stage cluster sampling	Children who had all recommended basic vaccines appropriate for his/her age	Vaccination records	Children aged 12–23 months	5752	2273	39.5
Abdilahi, 2023	Somalia	Cross sectional study	Systematic random sampling	A child who received nine basic vaccines	mother's verbal reports	Children under the age of 5 years.	174	96	55.0
Mukungwa, 2015	Zimbabwe	Cross sectional study	Stratified cluster sampling	Children who had all recommended basic vaccines appropriate for his/her age	Immunization cards or the mother's verbal reports	12–23 months	979	640	65.4
Ahmed, 2024	Nigeria	Cross sectional study	Two-stage cluster sampling	Children who had all recommended basic vaccines appropriate for his/her age	mother's verbal reports	Children aged 12–23 months	5475	1348	24.6
Kusena, 2017	Zimbabwe	Cross sectional study	Modified cluster sampling	Children who had all recommended basic vaccines appropriate for his/her age	Immunization cards or the mother's verbal reports	Children aged 12–23 months	120	77	64.2
Atnafu, 2020	Ethiopia	Cross sectional study	Systematic random sampling	A child aged 12–36 months who received the following vaccines: one dose of BCG, one dose of measles, two doses of	Immunization cards or the mother's verbal reports	Children aged 12–36 months	603	464	77.9

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Table 1 (*continued*)

First Author, Publication year	Country where the study was conducted	Study Design	Sampling method	Definition of full vaccination used	Determination of full vaccination	Population	Sample Size	Number of participants fully vaccinated	Full vaccination coverage (%)
				rota, at least three doses of pentavalent, three doses of OPV and three doses of PCV.					

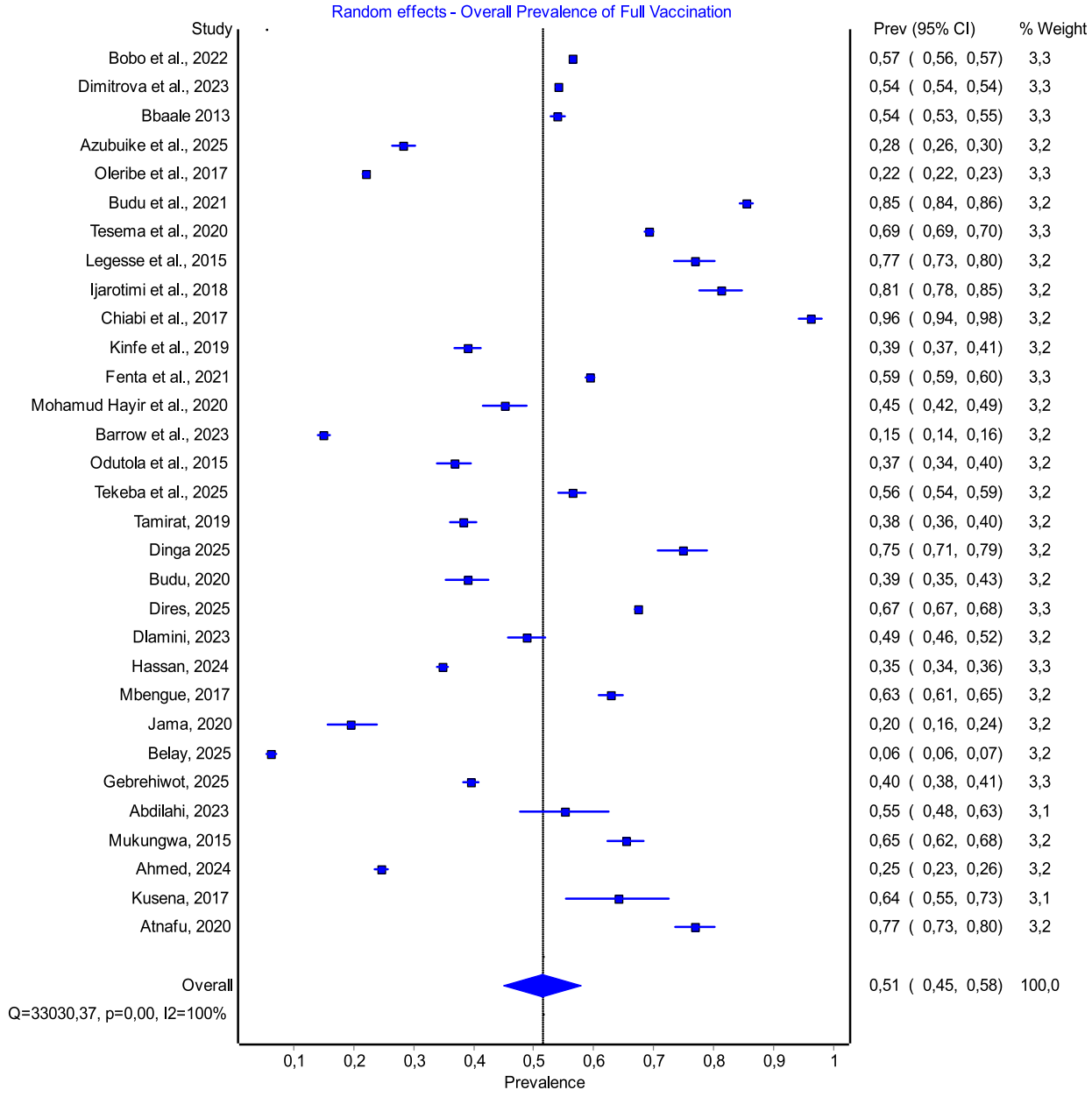

Fig. 2. Forest Plot Showing the Pooled Prevalence of Full Vaccination Among Children Under Five Years.
This forest plot displays the prevalence estimates and 95% confidence intervals for full vaccination among children under five years from 31 studies included in the meta-analysis. The pooled prevalence was calculated using a random-effects model and found to be 51% (95% CI: 45%–58%). The size of the boxes reflects the weight assigned to each study in the meta-analysis. Substantial heterogeneity was observed across studies (Q = 33,030.37, $p < 0.001$; $I^2 = 100\%$).

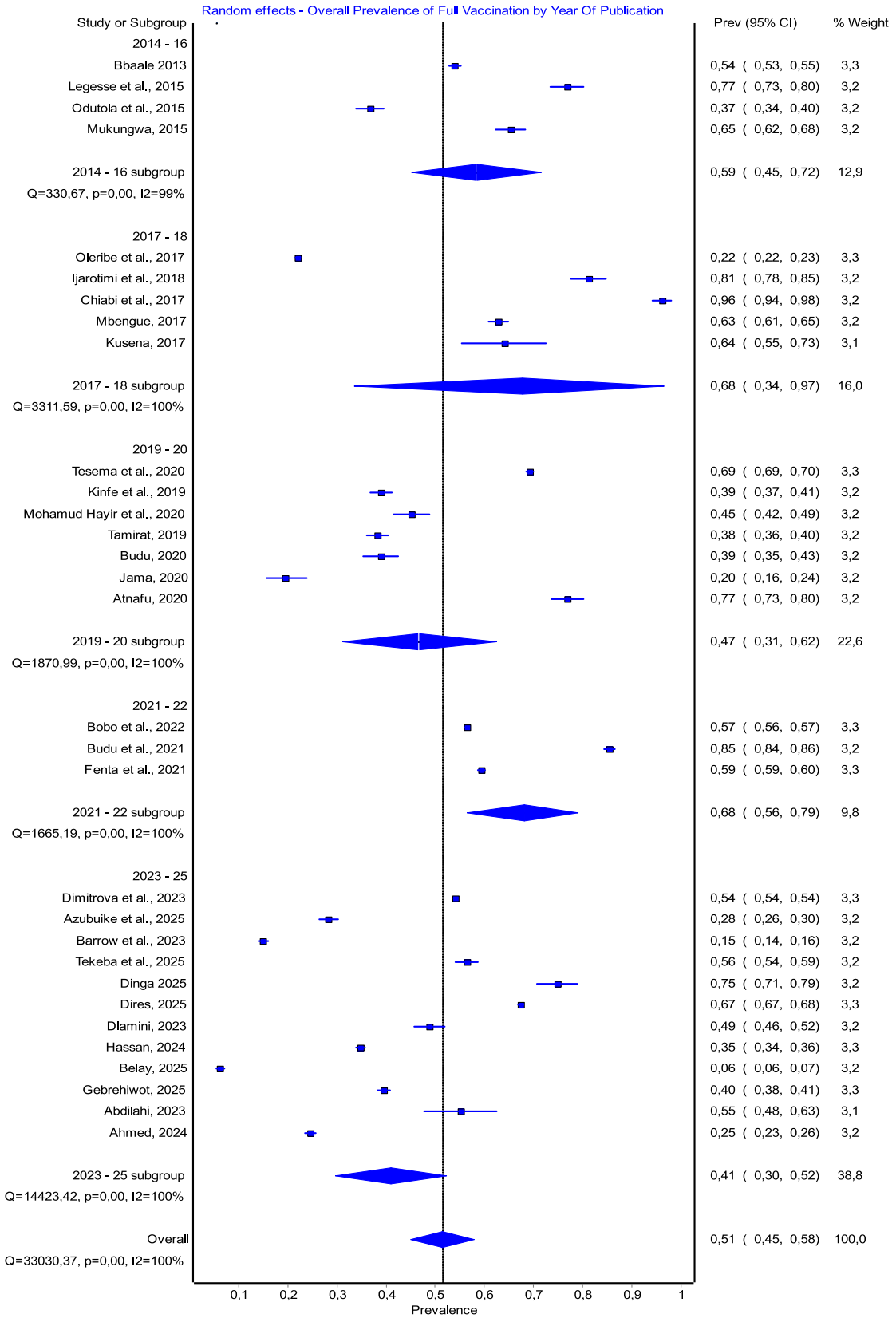

Fig. 3. Funnel Plot of Full Vaccination Prevalence by Year of Publication.
Funnel plot assessing the distribution and symmetry of study estimates by publication year. The asymmetry observed in recent-year studies may reflect small-study effects or changes in study characteristics over time.

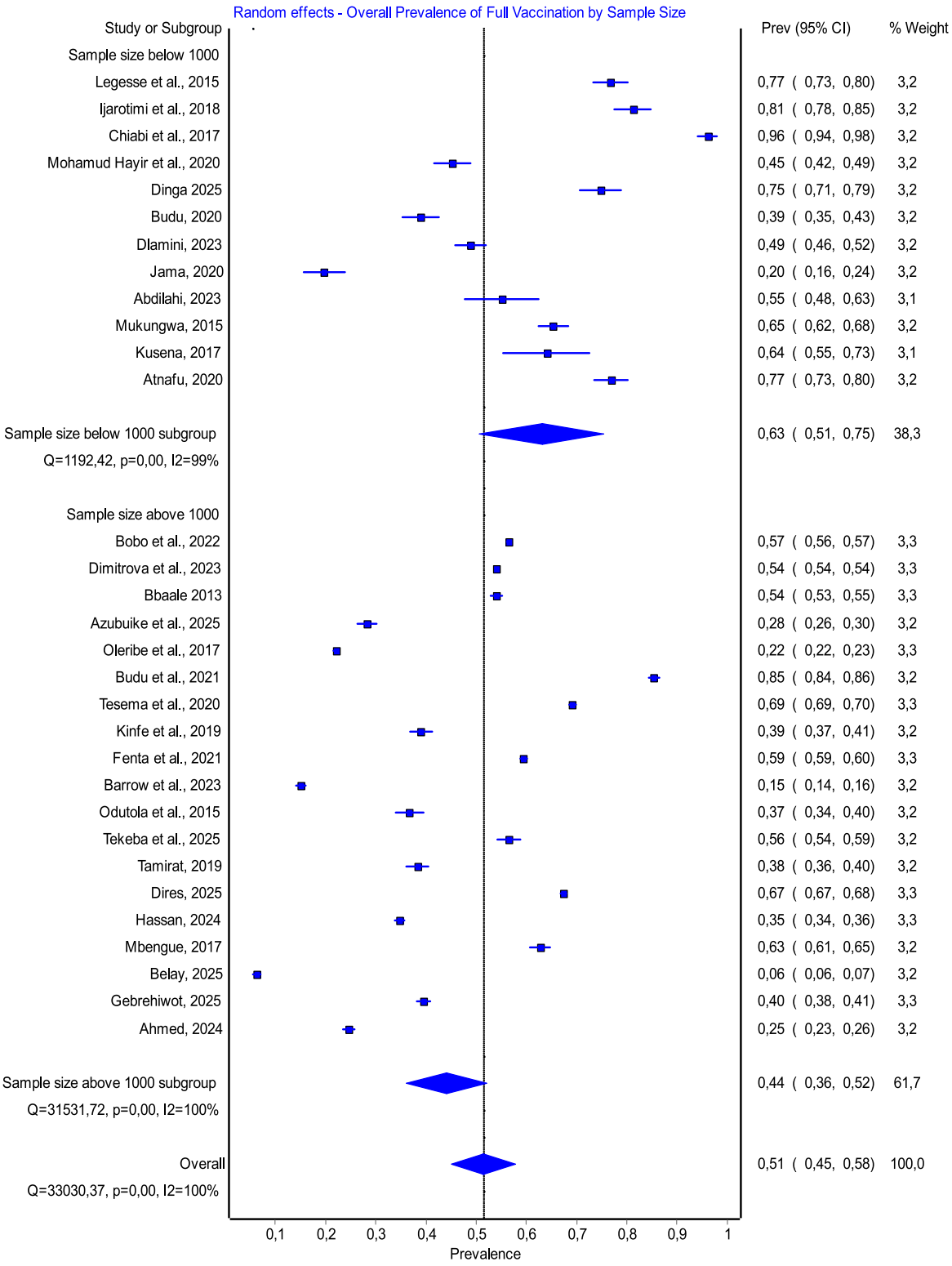

Fig. 4. Funnel Plot of Full Vaccination Prevalence by Sample Size.
Funnel plot examining publication bias or study variability in subgroups based on sample size. Asymmetry was more evident among smaller studies, suggesting potential bias.

size. Again, high heterogeneity was observed in both subgroups, with I^2 values of 100% for large sample studies and 99% for smaller studies, confirming persistent variability regardless of study size.

3.3.4.3. Subgroup analysis by number of countries in the study. Studies were stratified by the number of countries involved:

- Multiple-country studies had a pooled prevalence of 50% (95% CI: 43%–58%)
- Country-specific subgroups showed wide variation:
  - Somalia: 30% (95% CI: 11%–51%)
  - Nigeria: 38% (95% CI: 27%–50%)
  - Ethiopia: 65% (95% CI: 62%–68%)
  - Zimbabwe: 88% (95% CI: 61%–100%)
  - Cameroon: 53% (95% CI: 45%–62%)

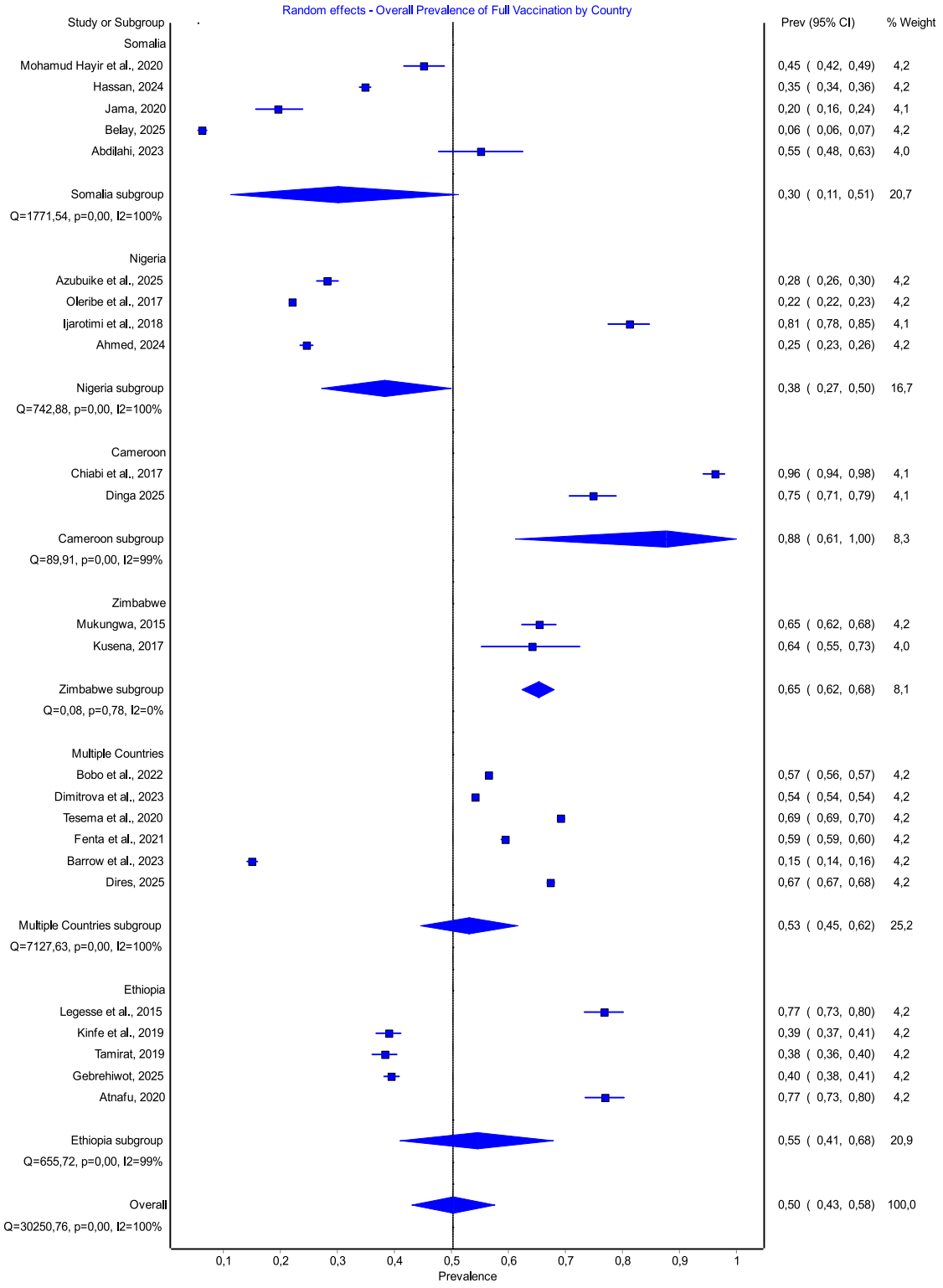

Fig. 5. Forest Plot of Full Vaccination Prevalence by Number of Countries Included.

Only the Zimbabwe subgroup demonstrated low heterogeneity (I^2 = 0%, p = 0.78), while all others exhibited significant between-study variance ($I^2 \geq 99\%$).

Fig. 5 presents a Forest plot illustrating the pooled prevalence of full vaccination by study scope - single-country versus multi-country studies. Notable country-level variation was seen, with Somalia and Nigeria reporting low coverage and Zimbabwe reporting the highest. Heterogeneity was highest in multi-country studies (I^2 = 100%).

3.4. Determinants of full vaccination in SSA

This review revealed several determinants of full immunization among children under five in SSA. We categorized the determinants into maternal, paternal, household, and health system determinants. The maternal determinants identified include parity, educational level, age, listening to the radio, and watching television. The only identified paternal determinant is educational level, while household determinants are wealth index, sex of household head, and the place of residence. Health system determinants include the place of delivery, antenatal care attendance, postnatal care attendance, and the difficulty of accessing a healthcare facility.

3.4.1. Maternal determinants

This review revealed statistically significant associations between a mother's parity and full immunization of children under 5 in three studies, which had 61,167 participants [14,22,39]. The pooled prevalence revealed that children under the age of five whose mothers had a parity of two or above were 33% less likely to be fully immunised than those whose mothers had a single parity, crude odds ratio (OR) = 0.67, 95% CI (0.57–0.77), I2 = 57%, p = 0.09. This study revealed statistically significant associations between a mother's educational level and full immunization of children under 5 in ten studies, which had 117,107 participants [14,19,21,22,27,30,33,39,44]. Children under the age of five years whose mothers had primary education or above were almost three times more likely to be fully immunised than those whose mothers had no formal education, OR = 2.70, 95% CI (1.98–3.69), I2 = 99%, p < 0.01.

This study revealed a statistically significant association between a mother's age and full immunization of children under 5 in five studies, which had 53,027 participants [17,19,33,36,38]. Children under the age of five whose mothers were 25 years or older were more likely to be fully immunised than those whose mothers were less than 25 years, OR = 1.31, 95% CI (1.01–1.70), I2 = 98%, p = 0.04. A statistically significant association between the mother's radio listening status and full immunization of children under 5 years was observed in two included studies, which had 59,258 participants [14,39]. Children under the age of five years whose mothers listened to the radio were more likely to be fully immunised than those whose mothers did not, OR = 1.85, 95% CI (1.69–2.03), I2 = 38%, p < 0.01. This study revealed a statistically significant association between the mother's television watching status and full immunization of children under 5 in four studies, which had 35,094 participants [17,38,39,44]. Children under the age of five years whose mothers watched television were more likely to be fully immunised than those whose mothers did not, OR = 1.67, 95% CI (1.17–2.39), I2 = 94%, p < 0.01. There were no statistically significant associations observed between full immunization of children under 5 and the mother's employment status or religion. More details are in Supplementary File 4 and Supplementary File 5.

3.4.2. Paternal determinants

This study revealed a statistically significant association between the father's educational level and full immunization of children under 5 in five studies, which had 50,727 participants [17,19,20,30,39]. The meta-analysis revealed that children under five whose fathers had primary education or above were more likely to be fully immunised than those whose fathers had no formal education, OR = 2.48, 95% CI (1.31–4.69), I2 = 99%, p < 0.01. There were no statistically significant associations observed between full immunization of children under 5 and the father's employment status or occupation. More details are in Supplementary File 4 and Supplementary File 5.

3.4.3. Household determinants

This review revealed a statistically significant association between the household wealth index and full immunization of children under 5 in ten studies, which had 114,430 participants [14,17,19,22,30,33,36,37,39,42]. Children under the age of five years from households with a medium or high wealth index were more likely to be fully immunised than those from households with a poor wealth index, OR = 2.45, 95% CI (1.67–3.60), I2 = 99%, p < 0.01. A statistically significant association between the place of residence and full immunization of children under 5 was observed in seven included studies, which had 111,422 participants [14,17,19,30,33,39,42]. Children under the age of five years from rural areas were less likely to be fully immunised than those from urban areas, OR = 0.55, 95% CI (0.40–0.76), I2 = 99%, p < 0.01. There were no statistically significant associations observed between full immunization of children under 5 years and the parents' marital status or sex of the household head. More details are in Supplementary File 4 and Supplementary File 5.

3.4.4. Health system determinants

This study revealed a statistically significant association between the place of delivery and full immunization of children under 5 years in nine studies, which had 90,618 participants [14,19,22,27,33,36,40,42,44]. Children under five delivered at healthcare facilities were more likely to be fully immunised than those delivered at home, OR = 2.99, 95% CI (2.28–3.92), I2 = 98%, p < 0.01. A statistically significant association between antenatal care (ANC) attendance and full immunization of children under 5 was observed in 11 included studies, which had 69,420 participants [17,19–22,33,36,38,39,42,44]. Children under five whose mothers did not attend ANC were less likely to be fully immunised than those whose mothers attended ANC, OR = 0.23, 95% CI (0.16–0.33), I2 = 97%, p < 0.01. This study revealed a statistically significant association between postnatal care (PNC) attendance and full immunization of children under 5 in five studies, which had 50,657 participants [17,19,20,33,42]. Children under five who did not attend PNC were less likely to be fully immunised than those who attended, OR = 0.51, 95% CI (0.40–0.65), I2 = 96%, p < 0.01. A statistically significant association between the accessibility of healthcare facilities and full immunization of children under 5 was observed in two included studies, which had 43,882 participants (Fenta, et al., 2021) (Dires, et al., 2025). Children under five without a big problem of accessing healthcare facilities were more likely to be fully immunised than those with a big problem, OR = 1.31, 95% CI (1.22–1.42), I2 = 20%, p = 0.26. There was no statistically significant association observed between full immunization of children under 5 and possession of a vaccination card. More details are in Supplementary File 4 and Supplementary File 5.

4. Discussion

This systematic review and meta-analysis set out to examine the prevalence and determinants of full immunization among children under five in SSA. The findings reveal important insights into both the extent of immunization coverage in the region and the multiple, interrelated factors that influence whether children receive the complete schedule of routine vaccinations.

The findings of this meta-analysis indicate that the overall pooled prevalence of full vaccination among children under five in SSA is 51% (95% CI: 45%–58%), highlighting significant gaps in immunization coverage. This estimate is lower than figures reported in some prior regional or global reviews, which have shown coverage rates approaching or exceeding 60% in LMICs [45,46], suggesting a decline in recent years. Notably, our subgroup analysis revealed a downward trend

in coverage over time, with the most recent studies (2023–2025) reporting the lowest pooled prevalence at 41%. This decline may reflect the lingering effects of the COVID-19 pandemic on health service delivery, vaccine access, and community trust [47]. The consistently high heterogeneity (I^2 = 99%–100%) across all subgroups, including by publication year, sample size, and geographic scope, suggests that structural, socioeconomic, and health system differences between countries strongly influence immunization outcomes. For example, Zimbabwe showed high coverage (88%) and low heterogeneity, potentially reflecting stronger immunization infrastructure or more stable governance compared to countries like Somalia (30%) or Nigeria (38%), where conflict and systemic health delivery challenges persist [48,49]. Interestingly, smaller studies tended to report higher prevalence, a pattern consistent with previous meta-analyses where smaller samples, often drawn from high-performing or urbanised areas, may overestimate true coverage [50]. These findings underscore the urgent need for context-specific strategies to address persistent inequities and reinforce immunization systems across the region.

When examined at the subregional level, our findings suggest notable differences across SSA. West Africa, represented by countries such as Nigeria, Ghana, and Burkina Faso, generally showed lower pooled coverage compared to East Africa, where countries like Ethiopia, Uganda, and Kenya reported relatively higher rates. These regional contrasts may be explained by differences in health system infrastructure, donor engagement, political stability, and cultural perceptions of vaccination. For instance, East African countries have historically benefited from strong partnerships with global immunization initiatives, while persistent conflict and systemic challenges in parts of West and Central Africa continue to undermine routine service delivery. These findings underscore the importance of tailoring interventions not only at the national but also at the subregional level, accounting for context-specific barriers and strengths. However, it is important to emphasize that the consistently high heterogeneity observed in this meta-analysis means that the pooled prevalence should be interpreted with caution. While the summary estimate provides a useful overview of immunization coverage in SSA, the wide variation across countries, populations, and study designs indicates that no single figure can fully capture the complexity of vaccination uptake in the region. In this sense, the statistical significance of pooled associations should not be viewed as definitive evidence of uniform patterns but rather as an indication of broad trends.

Beyond quantifying coverage levels, this review identified a wide array of maternal, paternal, household, and health system determinants associated with full immunization. These determinants illustrate the complex socio-economic and health service environment in which immunization decisions and behaviours are embedded. Our analysis underscores the central role of maternal characteristics in shaping immunization outcomes. Most prominently, maternal education emerged as a strong positive predictor of full immunization, with children of mothers who had primary education or higher being nearly three times more likely to be fully vaccinated compared to those whose mothers had no formal education. This finding aligns with earlier studies across SSA and globally, which suggest that educated mothers are more likely to possess knowledge about vaccination schedules, perceive its importance, and navigate health systems effectively [2]. Education likely enhances maternal agency and health literacy, enabling proactive healthcare-seeking behavior.

Maternal age was also positively associated with child immunization, with children of mothers aged 25 years or older exhibiting a 31% higher likelihood of being fully vaccinated. This may reflect greater life experience, decision-making autonomy, and exposure to healthcare systems among older mothers. Parity, on the other hand, showed an inverse relationship; mothers with two or more children were significantly less likely to fully vaccinate all children compared to first-time mothers. This suggests potential issues related to resource constraints, time, or competing caregiving demands in larger families an observation supported by prior studies from Ghana [51], and Ethiopia [52].

Mass media exposure also demonstrated notable associations. Mothers who listened to the radio or watched television were significantly more likely to have fully immunised children. This indicates the influential role of mass media in health promotion and information dissemination, especially in contexts where formal education may be limited. These findings support integrating immunization messaging into media programming as a strategy to improve coverage [53,54]. Interestingly, no significant associations were found between full immunization and maternal employment status or religion. This may suggest that in the SSA context, socioeconomic and informational factors outweigh employment status or religious affiliation in determining vaccine uptake.

Fathers' educational attainment also showed a significant and positive influence on child immunization outcomes. Children whose fathers had at least a primary level of education were more than twice as likely to be fully immunised. This highlights the role of male partners not only as potential financial providers but also as health decision-makers within households, especially in traditionally patriarchal communities [55]. Paternal involvement in health decisions can create an enabling environment for women to access maternal and child health services. These findings advocate for a more inclusive approach to immunization education that targets both mothers and fathers. No significant associations were observed between paternal occupation or employment status and immunization, indicating that economic activity alone may not necessarily translate into improved health-seeking behavior unless accompanied by knowledge and awareness.

Household wealth index was another significant determinant, with children from middle and upper-income households being more than twice as likely to be fully immunised than those from poorer households. This relationship may reflect better financial access to transportation, fewer opportunity costs of visiting health facilities, and greater exposure to health information. The influence of wealth also echoes broader global evidence suggesting that economic inequality contributes to health disparities, including in vaccination coverage [56–59].

Rural residence was negatively associated with full immunization. Children residing in rural areas were significantly less likely to be fully immunised compared to their urban counterparts, reinforcing long-standing concerns about geographic and infrastructural inequities in healthcare access. Factors such as travel time, poor road networks, limited health worker availability, and lower community outreach in rural settings may contribute to this disparity.

The sex of the household head and parental marital status were not significantly associated with full vaccination. This might suggest that household decision-making dynamics related to child health are more strongly influenced by individual characteristics such as education and media exposure rather than family structure.

Health system factors exhibited some of the strongest associations with full childhood immunization in SSA. Children delivered at health facilities were nearly three times more likely to be fully vaccinated than those born at home. This likely reflects the integration of immunization with maternal and newborn care in institutional settings and suggests that health facility births offer a crucial opportunity to initiate and promote the immunization schedule.

Similarly, ANC attendance showed a robust positive association with full immunization. Mothers who attended ANC were substantially more likely to fully immunize their children, underscoring the role of ANC as a platform for health education and vaccination counselling. The strength of this relationship supports WHO's recommendation to integrate immunization services within the broader reproductive, maternal, and child health (RMNCH) continuum.

PNC attendance was also positively associated with immunization, though to a slightly lesser extent. This finding supports efforts to ensure continued engagement with health services after childbirth to promote vaccine schedule adherence. Ease of access to health facilities, specifically whether distance to a facility was perceived as a major problem,

was significantly related to immunization status. This emphasizes the persistent challenge of physical accessibility in many parts of SSA and the need for strategies such as mobile clinics and outreach campaigns to reach underserved populations [60]. It is noteworthy that the possession of a vaccination card was not significantly associated with full immunization. This may reflect variations in record-keeping practices or card retention, especially in informal or rural settings, and warrants further investigation.

5. Limitations

Several limitations should be acknowledged in this study, which also highlight opportunities for future research.. First, heterogeneity across studies was consistently high, with I^2 values approaching or reaching 100% in all analyses. While subgroup analyses helped to explain some of this variability, a substantial portion of the heterogeneity remains unexplained, suggesting the need for future studies that use standardized measures and more comparable designs. Second, visual inspection of the funnel plot revealed asymmetry, suggesting potential publication bias. This may indicate an overrepresentation of smaller studies with more extreme prevalence estimates, which could have inflated the overall pooled estimate. Third, there was notable geographic concentration in the data, with countries like Nigeria and Ethiopia disproportionately represented, while others were either underrepresented or entirely absent. This imbalance limits the generalizability of the findings to the broader SSA region. This gap signals the need for expanded research in underrepresented countries, particularly in Central Africa, to enhance regional generalizability. Fourth, although all studies assessed "full vaccination," there was some variation in how this was defined, particularly in relation to the specific immunization schedule or age groups included. This inconsistency may introduce conceptual ambiguity in interpreting the pooled estimate. Finally, although studies were subgrouped by publication year, the actual data collection periods often predated publication. As a result, some associations with recent developments, such as the impact of COVID-19 or changes in national immunization policies, may not be fully captured, potentially weakening temporal relevance. Future primary studies with real-time or post-pandemic data would be invaluable in assessing these emerging influences.

6. Conclusion

Despite global commitments to universal immunization, this meta-analysis reveals that only half of children under five in the studied contexts are fully vaccinated. Regional, temporal, and methodological disparities reflect deep-rooted inequities in immunization services' access, awareness, and delivery. To achieve the Sustainable Development Goals and prevent vaccine-preventable deaths, urgent, context-specific public health interventions are needed. These include strengthening health systems, addressing vaccine hesitancy, expanding outreach in underserved communities, and ensuring reliable immunization tracking and reporting. Tailored strategies, rather than one-size-fits-all policies, are essential to close the immunization gap and protect the most vulnerable.

CRediT authorship contribution statement

Tafadzwa Dzinamarira: Writing – original draft, Methodology, Formal analysis, Conceptualization. **Oscar Mano:** Writing – review & editing, Methodology, Formal analysis. **Godfrey Musuka:** Writing – review & editing. **Roda Madziva:** Writing – review & editing. **Noah Mataruse:** Writing – review & editing. **Elliot Mbunge:** Writing – review & editing. **Sphamandla Josias Nkambule:** Writing – review & editing, Formal analysis. **Enos Moyo:** Writing – review & editing, Supervision.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2026.128228.

Data availability

No data was used for the research described in the article.

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