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Evaluating the Effectiveness of Measles Surveillance Systems in Africa: A Systematic Review of Epidemiological Trends and Laboratory Performance

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ABSTRACT

Background: As efforts to eliminate measles advance, it becomes essential to enhance the sensitivity of surveillance systems. This involves identifying and thoroughly investigating all cases presented with fever and rash. This systematic review evaluates the effectiveness of measles surveillance systems in Africa, focusing on epidemiological trends, vaccination coverage, and laboratory performance.
Subjects and Method: A systematic review was conducted using a secondary research design by collecting and critically analyzing multiple research studies, including quantitative and qualitative articles. Peer-reviewed articles published between 2014 and 2024 were identified through comprehensive searches in five electronic databases: PubMed, MEDLINE, Embase, Scopus, and Google Scholar. Keywords and MeSH terms such as "measles," "surveillance systems," "epidemiological trends," "vaccination coverage," and "Africa" were used with Boolean operators. Articles were screened based on defined inclusion and exclusion criteria. Quality appraisal of included studies was performed using the Critical Appraisal Skills Programme (CASP) tools for both quantitative and qualitative research. Data were synthesized narratively due to heterogeneity across studies.
Results: Findings from the 8 articles used highlight several systemic challenges, including the suboptimal performance of measles surveillance systems, gaps in immunization coverage, and significant regional disparities in disease burden. Common deficiencies include inadequate case reporting, limited laboratory capacity, and insufficient training of frontline health workers. Moreover, low vaccine uptake, especially for the second dose (MCV2), was attributed to supply chain issues, vaccine hesitancy, and geographic barriers.
Conclusion: The review underscores the urgent need for improved laboratory infrastructure, expanded training, community engagement, and equitable access to immunization services. Strengthening these areas is critical to enhancing measles surveillance and achieving elimination goals across the continent.

Keywords: Measles, surveillance systems. Laboratory performance, immunization

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BACKGROUND

Maintaining good health is crucial for Public health surveillance involves the ongoing and systematic collection, analysis, interpretation, and dissemination of data on diseases or health-related events of significant public health concern. This process supports public health actions aimed at reducing morbidity and mortality while improving overall health outcomes (Alemu et al., 2019; Groseclose and Buckeridge, 2017; Kalil et al., 2021). The data produced by these surveillance systems serve as a foundation for immediate public health interventions, program planning and evaluation, monitoring disease trends, and developing research hypotheses (Groseclose and Buckeridge, 2017). Consequently, regular evaluations of these systems are crucial to enhance their efficiency and cost-effectiveness (Calba et al., 2015). To support such assessments, various organizations have established frameworks to guide the design and execution of these assessments (Calba et al., 2015; Ngwa et al., 2016).

Measles is one of the diseases monitored by public health surveillance systems, with its surveillance initiatives commencing in Cameroon in 2001. It is a highly contagious viral infection that leads to significant morbidity and mortality (Ameh and Olayinka, 2016; Park, 2015). The disease is caused by a virus belonging to the myxoviruses group and is characterized by fever and upper respiratory tract symptoms, such as coryza and cough, followed by a distinctive rash (Park, 2015; Sume and Emah, 2014). The virus spreads predominantly via aerosols through direct human-to-human contact. While measles is often self-limiting, its clinical symptoms can resemble those of other viral infections (Coughlin et al., 2017). Despite the availability of a safe and effective vaccine, measles was responsible for over 140,000 deaths globally in 2018, primarily affecting children under five years of age (Owusu and Dam-Park, 2021; WHO, 2019). In Africa, approximately 13 million cases and 650,000 deaths occur annually, with sub-Saharan Africa experiencing the highest burden of morbidity and mortality (Ameh et al., 2016; Korevaar et al., 2020).

Measles is an exceptionally contagious disease, and in communities lacking immune, its introduction can result in over 90% of the population becoming infected (K.PARK, 2015). Before the widespread adoption of the measles vaccine in 1980, the global death toll from measles was approximately 2.6 million annually (Farra et al., 2019). This alarming statistic underscored the urgent need to reduce measles-related mortality. Consequently, the World Health Organization (WHO) and UNICEF committed to ensuring every child received two doses of a measles-containing vaccine through routine immunization programs and Supplementary Immunization Activities (SIAs), alongside strengthening disease surveillance systems (Park, 2015).

As efforts to eliminate measles advance, it becomes essential to enhance the sensitivity of surveillance systems (Makova et al., 2022). This involves identifying and thoroughly investigating all cases presenting with fever and rash (Masresha et al., 2018). Between 2017 and 2019, the incidence of measles rose across all WHO regions. Notably, in 2018, just five countries within the WHO African Region (AFRO) accounted for nearly half of the global measles cases reported (Makova et al., 2022). Despite the fact that all 194 WHO member states con-

ducted measles surveillance in 2019, significant weaknesses in these systems were evident (Dixon and Ferrari, 2020). By the close of 2019, no WHO region had successfully achieved and sustained the measles elimination targets (Dixon and Ferrari, 2020). Additionally, the COVID-19 pandemic introduced substantial operational challenges, resulting in reduced vaccination coverage and further weakening surveillance efforts (Dixon and Ferrari, 2020). This systematic review evaluates the effectiveness of measles surveillance systems in Africa, focusing on epidemiological trends, vaccination coverage, and laboratory performance.

SUBJECTS AND METHOD

1. Study Design

This study adopted a systematic review design, employing a secondary research approach to collect and critically analyze data from previously published literature. Both quantitative and qualitative peer-reviewed articles published between 2014 and 2024 were included to evaluate the effectiveness of measles surveillance systems in Africa with respect to epidemiological trends, vaccination coverage, and laboratory performance.

A tailored search strategy was utilized to perform an extensive systematic review of the effectiveness of measles surveillance systems in Africa: a systematic review of epidemiological trends, vaccination coverage, and laboratory performance. Peer-reviewed articles from 2014 to 2024 were sourced from PubMed, MEDLINE, Embase, Google Scholar and Scopus databases. The search included various terms related to " effectiveness of measles," " surveillance systems," "epidemiological trends," OR vaccination coverage," laboratory performance," and "Africa." Boolean operators were skillfully used to ensure the search was thorough, focusing on articles that explore effectiveness of measles surveillance systems in Africa.

The search terms and Medical Subject Headings (MeSH) terms were thoughtfully selected to align with the focus of this study. To search for articles, using advance search method, the following search terms were employed: " effectiveness of measles " OR " surveillance systems," " vaccination coverage " OR," laboratory performance," AND " Africa," These terms were tailored to meet each database's specific requirements and indexing. This search strategy is meticulously designed to retrieve a wide array of studies that address the research question and objectives of the systematic review.

A comprehensive literature search was conducted using several databases, including MEDLINE, Scopus, PubMed, Embase, and Google Scholar, to identify studies related to the effectiveness of measles surveillance systems, epidemiological trends, and vaccination coverage in Africa. The search terms used included combinations of keywords such as "effectiveness of measles, AND "surveillance systems," AND "epidemiological trends," AND "vaccination coverage," and "Africa", effectiveness of measles," OR " surveillance systems OR Africa. " using Boolean operators to refine the results.

2. Inclusion Criteria

The inclusion criteria for this review consisted of articles that were published between the years 2014 and 2023. The article focused specifically on measles surveillance systems, epidemiological trends, vaccination coverage, and laboratory performance related to measles within African countries.

3. Exclusion Criteria

Conversely, the exclusion criteria eliminated non-peer-reviewed articles, such as editorial, commentaries, and letters, as well as articles written in languages other than English and articles outside of Africa.

4. Operational Definition of Variable

The effectiveness of surveillance systems: was assessed based on performance indicators such as case detection, reporting timeliness, laboratory confirmation rates, and system sensitivity.

Vaccination coverage: refers to the proportion of the target population that received the first (MCV1) and second (MCV2) doses of the measles-containing vaccine.

Laboratory performance: encompassed diagnostic capacity, turnaround time for test results, and geographic accessibility of laboratory services.

Epidemiological trends: included reported case incidence, age distribution, geographic spread, and outbreak frequency.

5. Study Instruments

This review followed the PRISMA flow diagram for study selection and reporting. Relevant articles were identified through systematic database searches using predefined keywords and eligibility criteria. Study quality was assessed using the Critical Appraisal Skills Programme (CASP) checklist appropriate to each study design.

6. Data Analysis

A systematic data extraction process was undertaken to ensure consistency, transparency, and reproducibility of findings. A standardized data extraction format was developed to capture relevant details from each included study. The data were synthesized narratively due to heterogeneity across studies.

RESULTS

By utilising a Boolean operator, the search was narrowed down to encompass only full-text, English-language, peer-reviewed journals published between 2014 and 2024, resulting in 124 findings after removing duplicate articles 15 from MEDLINE, 6 from Scopus, 52 from PubMed, 7 from Embase, and 44 from Google Scholar. Afterwards, inclusion and exclusion criteria were used to reduce the number of articles for further examination. The process of identifying appropriate and unsuitable papers necessitates scouring scholarly publications, with detailed inclusion and exclusion criteria. Post-application of the inclusion criteria, 40 relevant papers related to the subject matter were identified.

These papers underwent scrutiny, evaluating their titles and abstracts to ascertain their methodology and design. This approach facilitated the identification of studies pertinent to the topic while discarding irrelevant ones, particularly those lacking explicit aims and objectives. Consequently, the search yielded only 8 publications meeting the established criteria, which were subsequently retrieved for evaluation. specifically, 1 article from MEDLINE, 3 from PubMed, and 4 from Google Scholar. The Prisma flow chart in Figure 1 gives detailed information on the article selection process. Evaluating the effectiveness of measles surveillance systems in Africa: a systematic review of epidemiological trends, vaccination coverage, and laboratory performance.

Figure 2 illustrates the distribution of the eight studies included in the systematic review across six African countries. Two studies were conducted in Nigeria and two in Ghana, while Uganda, Zimbabwe, Tanzania, and Ethiopia each contributed one study. This map highlights the regional spread and provides a visual representation of the locations where measles surveillance systems have been evaluated, offering insights into geographic patterns of study concentration across the continent.

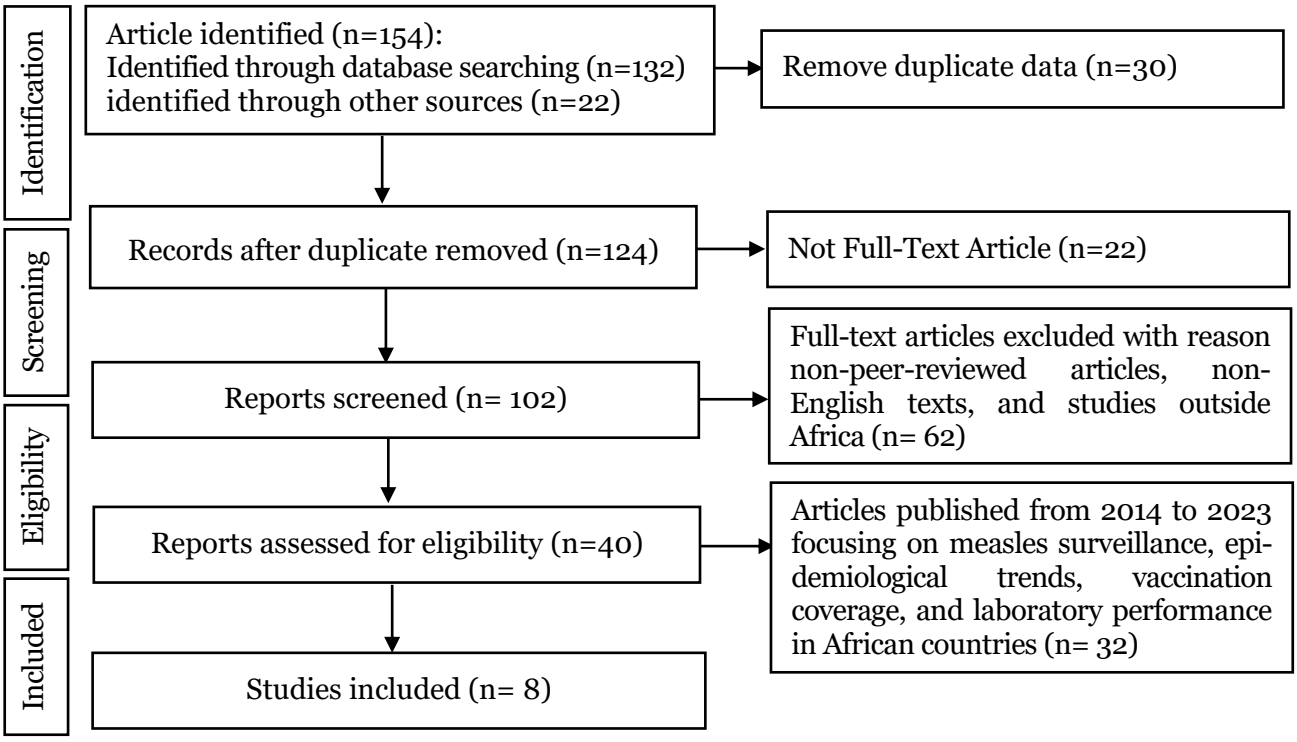

Figure 1. PRISMA-ScR Flow Diagram of the article selection process

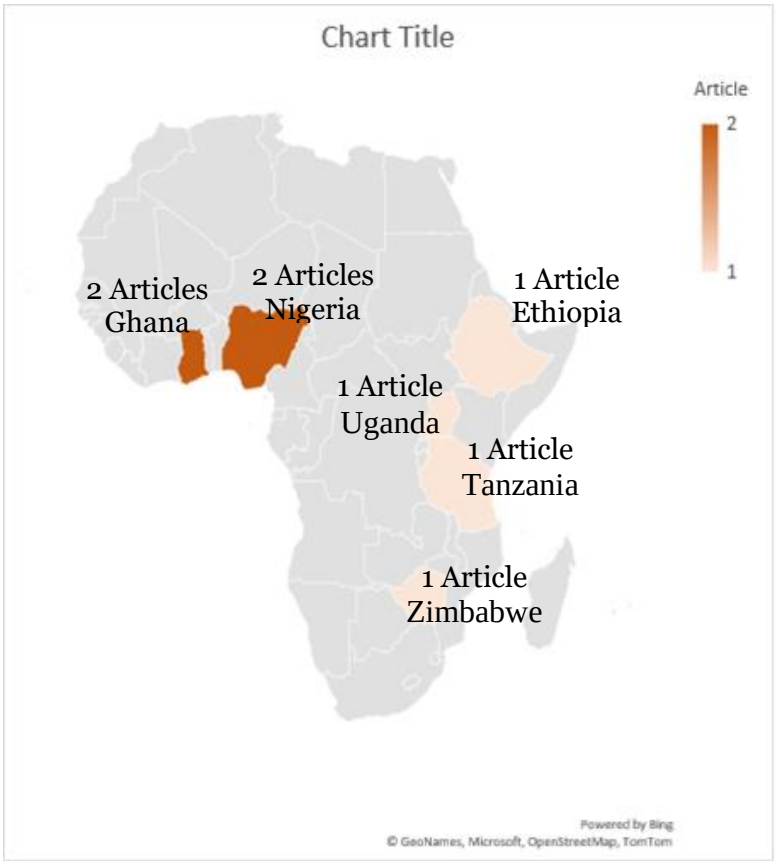

Figure 2. Map of the distribution of articles included in the Systematic review

Quantitative research techniques are designed in a structured manner to support statistical analysis, thereby assisting in drawing conclusions or predictions (Bhandari., 2020). Of the eight (8) selected papers for this review, seven are quantitative. These papers were assessed using the quantitative Critical Appraisal Skills Programme (CASP) evaluation tools, as detailed in Table 3 below. Below is a brief summary of the seven quantitative papers.

Ibrahim et al. (2019) conducted a retrospective quantitative study using secondary data of measles-specific Integrated Disease Surveillance and Response (IDSR) records from all states including Federal Capital Territory in Nigeria over a five-year period (2012-2016). The research utilized data comprising 131,732 recorded measles cases with associated case fatality rates. The analysis focused on regional disparities in disease outcomes. All reported measles cases (both suspected and confirmed) in the IDSR for the study period was reviewed. Data were analyzed for case distribution, fatalities, and laboratory confirmations to assess measles burden and surveillance gaps.

In Utulu et al. (2020) study, a retrospective review of Rivers State's measles/ rubella case-based surveillance data (2011–2018) was conducted. The data was obtained from the Rivers State Primary Healthcare Management Board and WHO field office in Port-Harcourt. Descriptive analysis was used to evaluate surveillance performance metrics, including non-measles febrile rash illness rates, vaccination status, and sensitivity of the system. The study included 1,731 suspected measles cases. Surveillance performance was assessed using standard indicators recommended in the WHO African regional guidelines for measles and rubella surveillance The focus was on district-level performance and the effectiveness of the measles surveillance system Data gaps and missed targets were highlighted.

Makova et al. (2022) conducted a descriptive cross-sectional study guided by the CDC surveillance evaluation framework. Data were collected using interviewer-administered questionnaires and checklists from 19 health facilities and 57 health workers. System attributes, including simplicity and knowledge gaps, were analyzed to evaluate system functionality and training needs. The study population comprises the health care workers who include registered midwives, registered general nurses, doctors, records consisting of outpatients´ department records (T12 and Integrated Management of Childhood and Infant registers), and measles case notification forms. The Frequencies and proportions were generated to identify gaps in system performance.

Michael et al. (2024) conducted a descriptive study that analyzed case-based measles surveillance data from the measles surveillance system (MSS) in Tanzania within 2018–2022. Routine surveillance data were collected using case investigation forms and confirmed with laboratory testing. The study was conducted across 195 councils in Tanzania, with 12,253 reported measles cases reviewed from the case-based surveillance system to assess surveillance outcomes. Trends in measles cases, vaccination coverage, and age group distribution were analyzed using descriptive statistics.

In Biru and Alayu's (2022) study, retrospective data from Ethiopia's Public Health Institute (2013–2017) were reviewed to assess measles trends in the Afar region. The study analyzed 400 reported measles cases in the region. Cross-sectional descriptive analysis examined time, place, and person variables. surveillance data gaps, vaccination status, and positivity rates were identified and presented in tables and graphs.

Using CDC guidelines in Tender et al. (2022) research, the Ga West Municipality's measles surveillance system (2012–2016) was evaluated through case reviews, interviews with surveillance officers, and validation of reporting forms. A total of 48 suspected measles cases from 2012–2016 were assessed to evaluate system performance. The study analyzed system performance indicators, such as timeliness, stability, and data representativeness. Measles surveillance data from 2012 – 2016 were abstracted from the DHIMS.

Zumah and Sackey (2023) A descriptive evaluation study based on CDC guidelines for public health surveillance evaluation. Data collection involved observation checklists, questionnaires, and a review of surveillance records. Performance metrics, including case definitions, timeliness, and completeness of reporting, were assessed. The study targeted health workers within the District Health Management Team (DHMT) actively involved in measles surveillance activities. A total of 65 surveillance officers participated in the study, including 34 disease control officers and 28 field technicians who responded to the questionnaire. Participants were selected using a non-probability purposive sampling method, focusing on surveillance officers in the Bono Region due to their direct involvement in and contribution to surveillance efforts. The study utilized a structured questionnaire and an observation checklist, both adapted based on the updated guidelines from the Centers for Disease Control and Prevention (CDC) for evaluating public health surveillance systems.

Table 1. Critical Appraisal Checklist using CASP (Quantitative Studies)

Author (Year)	Criteria												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
Ibrahim et al. (2019)	2	2	0	1	2	2	2	1	2	2	2	2	20
Utulu et al. (2020)	2	2	0	1	2	2	2	1	2	2	2	2	20
Makova et al. (2022)	2	2	2	1	2	2	2	2	2	2	2	2	23
Michael et al. (2024)	2	2	0	2	2	2	2	2	2	2	2	2	22
Biru et al. (2022)	2	2	0	1	2	2	2	1	2	2	2	2	20
Tender et al. (2022)	2	2	1	2	2	2	2	2	2	2	2	2	23
Zumah et al. (2023)	2	2	0	1	2	2	2	1	2	2	2	2	20

Description of the question criteria:

1 = Focused issue
2 = Appropriate method
3 = Acceptable recruitment
4 = Accurate measurement
5 = Data collection
6 = Adequate participants
7 = Clear results
8 = Rigorous analysis
9 = Clear findings
10 = Local applicability
11 = Research value
12 = Ethical considerations

Answer score description:

0 = No
1 = Can't tell
2 = Yes

Walekhwa et al. (2022) The study employed a descriptive design utilizing qualitative methods to assess immunization and measles surveillance activities in Kasese district, Uganda, between June and August 2020. Participants were purposively sampled to include seven (7) key informants such as district health officials, immunization focal persons, and health workers at BHC. Additionally, seven (7) health workers participated in focus group discussions (FGDs). Data were collected using interviews and FGDs, focusing on immunization activity frequency, vaccine supply, health worker competency, and logistical challenges. Interviews and FGDs were conducted in English, recorded using digital devices, and later transcribed for analysis. Data were analyzed using ATLAS.ti software, applying deductive thematic analysis to identify key themes.

Table 2. Qualitative CASP Appraisal (qualitative checklist)

Author (Year)	Criteria										
	1	2	3	4	5	6	7	8	9	10	Total
Walekhwa et al. (2022)	2	2	2	2	2	1	1	2	2	2	18

Description of the question criteria:

1 = Clearly stated objectives
2 = Appropriate qualitative approach
3 = Suitable research design
4 = Appropriate recruitment strategy
5 = Effective data collection
6 = Researcher-participant relationship considered
7 = Ethical issues addressed
8 = Rigorous data analysis
9 = Clear statement of findings
10 = Research value

Answer score description:

0 = No
1 = Can't tell
2 = Yes

A systematic data extraction process was undertaken to ensure consistency, transparency, and reproducibility of findings. A standardized data extraction format was developed to capture relevant details from each included study. Table 5 gives a detailed analysis of all articles used for this review.

Table 3. Data extraction of articles included in the Systematic review

Reference	Country	Method	Setting and Participants	Study Objective/ Surveillance Focus	Sample Size
Ibrahim et al. (2019)	Nigeria	Secondary data analysis (2012–2016)	Nationwide IDSR data covering all states and FCT	To assess the measles burden and regional disparities using national surveillance data	131,732 measles cases
Utulu et al.	Nigeria	Retrospective	Rivers State,	To evaluate surveillance per-	1,731

Reference	Country	Method	Setting and Participants	Study Objective/ Surveillance Focus	Sample Size
(2020)	(Rivers)	review (2011–2018)	surveillance data from WHO and the state PHC board	formance and case detection effectiveness at the district level	suspected cases
Walekhwa et al. (2022)	Uganda	Qualitative descriptive study	Kasese District; key informants and FGDs with health workers	To explore barriers to immunization and challenges in measles surveillance	14 participants (7 KIIs 7, FGD participants)
Makova et al. (2022)	Zimbabwe	Descriptive cross-sectional study	Kwekwe City: 19 facilities and 57 randomly selected health workers	To assess the measles surveillance system attributes and performance using the CDC guidelines	57 health workers
Michael et al. (2024)	Tanzania	Descriptive analysis (2018–2022)	National surveillance data across 195 councils	To analyze measles trends and MCV coverage over five years	12,253 reported cases
Biru et al. (2022)	Ethiopia (Afar Region)	Retrospective record review (2013–2017)	Afar Region; surveillance data from the national institute	To identify surveillance gaps and vaccination trends using descriptive variables	400 reported cases
Tender et al. (2022)	Ghana (Ga West)	Surveillance system evaluation	Ga West Municipality; data from DHIMS and interviews	To evaluate system effectiveness and performance indicators based on the CDC tools	48 suspected cases
Zumah et al. (2023)	Ghana (Bono Region)	Descriptive cross-sectional evaluation	Bono region; purposive sample of surveillance officers	To assess surveillance system performance and challenges in data reporting	65 surveillance officers

1. Sub-Optimal Performance of Measles Surveillance Systems.

Surveillance systems are failing to meet established performance indicators, such as the ability to detect non-measles febrile rash illness at the target rate of two cases per 100,000 population annually. Utulu et al. (2020) reported that in Rivers State, Nigeria, this target was consistently unmet during the study period. Without sufficient sensitivity, many measles cases go undetected, leading to delayed responses and uncontrolled outbreaks. Additionally, the quality and completeness of case reporting remain subpar. Health workers often fail to report suspected cases promptly, and follow-up investigations are not always conducted. In Kwekwe City, Zimbabwe, Makova et al. (2022) revealed that case investigation forms were not adequately distributed, and only 27.7% of health workers were trained to use them. This indicates systemic gaps in knowledge and resources that hinder timely detection and action.

Laboratory confirmation is a cornerstone of effective measles surveillance, distinguishing true measles cases from other febrile rash illnesses. However, laboratory networks are often underdeveloped, with delayed sample transportation, insufficient diagnostic capacity, and logistical challenges. For instance, Makova et al. (2022) report that in Kwekwe, Zimbabwe, only 11.6% of suspected cases underwent laboratory testing due to limited access to diagnostic facilities. In Ethiopia's Afar Region, Biru et al. (2022) observe similar limitations, emphasizing that insufficient laboratory equipment and staff training severely restrict the confirmation of measles cases. The absence of robust laboratory support not only delays case confirmation but also reduces the accuracy of epidemiological data. Without reliable diagnostics, public health authorities may

misallocate resources or fail to implement targeted interventions, exacerbating the spread of the disease. Addressing these challenges requires significant investment in laboratory infrastructure, training, and the decentralization of diagnostic services to improve access in rural and remote areas.

Another critical challenge lies in the limited representativeness of surveillance systems, which undermines their ability to capture the true epidemiological picture of measles. In the study by Tender et al. (2022) in the Ga West Municipality of Ghana, private healthcare facilities did not contribute data to the surveillance system, leading to incomplete case reporting. This gap is echoed in Zumah and Sackey (2023), where only half of the districts in Ghana's Bono Region met the standards for supportive functions of the surveillance system. Without comprehensive and representative data, public health officials cannot accurately identify high-risk populations, geographic hotspots, or vaccination coverage gaps.

2. Gaps in Immunization Coverage

One of the most prominent issues affecting immunization coverage is the inconsistent availability of vaccines due to supply chain challenges. Walekhwa et al. (2022) found that frequent vaccine supply disruptions in Kasese District, Uganda, were a major barrier to vaccination uptake. Poor stock management and delays in vaccine delivery to rural areas limited the ability of health facilities to meet immunization demands. Similarly, Ibrahim et al. (2019) observed significant gaps in routine immunization coverage in Nigeria, particularly in northern states, where poor logistics further exacerbated the problem. Without reliable vaccine supply chains, many children remain unvaccinated or partially vaccinated, increasing their susceptibility to measles outbreaks.

Achieving high coverage for the second dose of the measles-containing vaccine (MCV2) is essential to establish herd immunity, especially in settings where the first dose (MCV1) alone does not suffice. However, suboptimal coverage of MCV2 persists in many regions. Michael et al. (2024) reported that while Tanzania maintained over 90% MCV1 coverage since 2013, the gradual increase in MCV2 coverage only reached 88% in 2022. This left a pocket of susceptible individuals who accumulated over time, contributing to a spike in laboratory-confirmed measles cases during the COVID-19 pandemic. Such gaps highlight the critical need for strategies to improve the uptake of both vaccine doses to ensure sustained immunity within communities.

Vaccine hesitancy, driven by misinformation, cultural beliefs, and lack of trust in health systems, is another key factor limiting immunization coverage in this review. Walekhwa et al. (2022) reported that community dependence on traditional medicine as a substitute for vaccines was a significant barrier in Kasese District, Uganda. These beliefs discouraged caregivers from seeking immunization services, particularly in rural areas where access to modern healthcare is already limited. Similarly, Zumah and Sackey (2023) emphasized the need for effective communication and community engagement to address misconceptions about vaccines in Ghana's Bono Region. Efforts to combat vaccine hesitancy must focus on culturally sensitive messaging and engaging trusted local leaders to build public confidence in immunization programs.

3. Regional Disparities in Measles Burden

Many studies in this review highlight significant differences in measles incidence across regions, with certain areas disproportionately affected by recurrent outbreaks. For instance, Ibrahim et al. (2019) noted stark disparities between northern and southern states in Nigeria. The states of the north,

which are predominantly rural and economically disadvantaged, consistently reported higher measles cases than the relatively affluent and urbanized southern states. Similarly, Walekhwa et al. (2022) observed higher measles incidence in the remote Kasese District of Uganda compared to urban centres, driven by limited access to vaccination services and healthcare infrastructure.

Another critical dimension of regional disparities is the urban-rural divide in measles burden. Rural areas are often more vulnerable to measles outbreaks due to inadequate health services and logistical challenges in vaccine delivery. For example, Walekhwa et al. (2022) reported that caregivers in rural Uganda frequently faced long travel distances to vaccination centres, contributing to low immunization rates and high measles incidence. Conversely, urban areas may experience lower routine immunization rates due to the influx of migrant populations or the spread of misinformation about vaccines in densely populated neighbourhoods, as highlighted by Ibrahim et al. (2019) in their study of Nigeria.

Socio-economic factors play a significant role in regional disparities in measles burden. Poorer regions with limited resources are less equipped to implement robust vaccination programs, resulting in higher susceptibility to outbreaks. Makova et al. (2022) found that in Zimbabwe, resource-limited districts struggled to achieve adequate vaccination coverage, particularly in remote border regions. These areas often lacked essential infrastructure, such as cold chain systems, making it difficult to store and transport vaccines effectively.

4. Challenges in Resource Allocation and Health System Logistics

One of the primary barriers to effective measles control is insufficient and inconsistent funding for surveillance and immunization programs. Competing priorities in healthcare budgets can divert resources away from immunization efforts. Walekhwa et al. (2022) highlighted that in Uganda, limited government funding was often allocated to addressing immediate healthcare crises at the expense of routine immunization programs. This reactive approach to health resource allocation leaves measles immunization underfunded and vulnerable to disruption.

The logistical challenges of maintaining a reliable vaccine supply chain and cold chain system are another major obstacle. Measles vaccines require strict temperature controls to remain effective, but many regions lack the infrastructure to ensure this. For instance, Walekhwa et al. (2022) found that in rural Uganda, inadequate cold storage facilities led to vaccine spoilage, resulting in wasted resources and interrupted vaccination campaigns.

Similarly, Makova et al. (2022) and Walekhwa et al. (2022) reported that vaccines often failed to reach remote areas due to poor road networks and transportation challenges. The study emphasized that supply chain bottlenecks not only delay vaccination efforts but also erode public trust in health services when scheduled campaigns are cancelled or rescheduled. Human resource constraints are a significant issue in many low-resource settings. Vaccination campaigns and a good surveillance system require skilled personnel to administer vaccines, conduct community outreach, and manage logistics.

Furthermore, Walekhwa et al. (2022) highlighted that in Uganda, the overburdened healthcare workforce struggled to balance routine immunization with other responsibilities, such as responding to maternal and child health needs or disease outbreaks. Insufficient training and support for health workers further exacerbated these challenges, leading to gaps in service delivery and

reduced immunization coverage. During measles outbreaks, the demand for resources and logistics increases exponentially, often overwhelming health systems. Makova et al. (2022) found that in Zimbabwe, outbreak response efforts were hampered by a lack of pre-positioned vaccines and logistical preparedness. This lack of readiness delayed the deployment of vaccination teams to affected areas, allowing outbreaks to spread further before being contained.

DISCUSSION

The reviewed studies highlighted significant gaps in measles surveillance systems, including underreporting of cases, delayed detection of outbreaks, and insufficient laboratory capacities. For instance, Ibrahim et al. (2019) noted that in Nigeria, the surveillance system's sensitivity was compromised by limited resources and trained personnel, leading to delayed outbreak responses. Similarly, Walekhwa et al. (2022) reported that in Uganda, the lack of integration between surveillance and immunization programs hindered effective monitoring and control of measles transmission. Global assessments corroborate these findings, indicating that inadequate surveillance systems are a widespread issue. A study by Branda et al. (2024) emphasized that the COVID-19 pandemic further disrupted global surveillance efforts, leading to declines in vaccination rates and increased vulnerability to measles outbreaks. The World Health Organization (WHO) also reported that the sensitivity of measles and rubella surveillance remains sub-optimal in endemic countries, resulting in underreporting and underestimation of disease burden (WHO, 2024). The convergence of evidence underscores the critical need to strengthen surveillance systems. Robust surveillance is essential for timely outbreak detection, resource allocation, and the implementation of targeted immunization strategies. Enhancing laboratory capacities, training personnel, and integrating surveillance with immunization programs are pivotal steps toward effective measles control.

The studies reviewed identified significant disparities in immunization coverage, often influenced by socio-economic factors, geographic location, and public health infrastructure. Ibrahim et al. (2019) observed that in Nigeria, immunization rates were notably lower in rural and northern regions, attributed to limited healthcare access and vaccine hesitancy. Walekhwa et al. (2022) similarly reported that in Uganda, remote districts like Kasese exhibited lower vaccination rates due to logistical challenges and insufficient healthcare services. These findings align with global data indicating persistent inequalities in measles vaccination coverage. A study conducted in Brazil aligns with this study finding, which shows that Measles vaccination coverage in the Northern Region of Brazil varied between 56.88% and 104.02%, not reaching the recommended percentage (Parra and de Abreu, 2022). The consistent evidence of coverage gaps highlights the necessity for targeted interventions to reach underserved populations. To address under-vaccination in remote or underserved areas, it is essential to improve the delivery of immunization services. Mobile vaccination units, outreach programs, and community-based vaccination initiatives can help to reach children in hard-to-reach areas.

The reviewed studies emphasized significant regional disparities in measles incidence. Ibrahim et al. (2019) highlighted higher measles cases in Nigeria's northern states compared to the south, linked to differences in healthcare infrastructure and socio-economic status. Walekhwa et al. (2022) reported similar patterns in Uganda, with remote districts experiencing a higher

measles burden due to limited access to vaccination services. This study's findings align with the results of several studies outside this review, such as those carried out in Ethiopia and Nigeria. For example, Zegeye et al. (2024) research demonstrates that measles vaccination dropout rates among under-five children in Ethiopia were high due to poor living conditions in the rural area. Similarly, In Nigeria, Measles cases increased, with the highest fatality rate in the north-central region (Dappa and Ogbonnaya, 2023). Addressing regional disparities requires context-specific strategies, including strengthening health systems in underserved areas, ensuring equitable resource distribution, and tailoring immunization campaigns to the unique challenges of each region. Focusing on high-burden areas is crucial for reducing overall measles incidence and achieving global elimination targets.

Findings from several studies reviewed in this research show that insufficient and inconsistent funding is a major barrier to effective measles control, as healthcare budgets often prioritize immediate crises over routine immunization programs and good surveillance systems. In Uganda, limited government funding has left measles immunization underfunded and vulnerable to disruptions (Walekhwa et al., 2022). Logistical challenges, such as maintaining a reliable vaccine supply chain and cold storage, exacerbate the problem. Rural areas in Uganda, for instance, lack adequate cold storage facilities, leading to vaccine spoilage and interrupted campaigns (Walekhwa et al., 2022). This study's findings agree with research conducted by Sibeudu and Onwujekwe (2020) in the Anambra state of Nigeria. Their study found that the cost per child immunized with the measles vaccine through supplemental immunization activities in Nigeria is relatively high, highlighting the need for efficient resource allocation and program management. These challenges are echoed in global assessments. The WHO reported that the COVID-19 pandemic exacerbated existing issues in immunization efforts, leading to declines in vaccination rates and increased susceptibility to measles outbreaks (WHO, 2023). To overcome these challenges, it is imperative to invest in health infrastructure, strengthen supply chains, ensure sustainable funding, and build workforce capacity. Implementing efficient resource management and logistical planning will enhance the effectiveness of immunization programs and contribute to the goal of measles elimination.

This review shows that many African countries face similar problems when it comes to tracking and controlling measles. For example, issues with lab testing are not only seen in Nigeria. In Zimbabwe, Makova et al. (2022), found that only 11.6% of suspected measles cases were tested in labs because diagnostic tools were hard to access. A similar situation was reported in Ethiopia's Afar Region, where Biru and Alayu's (2022) pointed out serious lab limitations. This shows that poor lab facilities are a common problem across the continent. Challenges in rural areas are also widespread. In Uganda's Kasese District, Walekhwa et al. (2022)noted that people struggled to get vaccines due to long distances to health centers and unreliable cold storage. Similar problems were found in rural parts of Ghana (Zumah and Sackey, 2023) and northern Nigeria (Ibrahim et al., 2019). Altogether, these studies show that weak labs, poor transport systems, and limited rural healthcare are common issues that go beyond individual countries. Recognizing these shared problems can help drive regional solutions instead of tackling them country by country.

Unlike past studies that often focus on one country at a time, this review looks at patterns across Africa. It combines findings from eight countries in West, East, and Southern Africa to show the big-picture challenges that weaken measles surveillance and vaccination programs. These include poor lab coordination, underreporting of cases, and low uptake of the second dose of the measles vaccine (MCV2). What makes this review stand out is its mix of numbers and real-life events, which helps give a fuller picture of what's happening on the ground. It also pays special attention to the difficulties faced in rural areas, making a strong case for fair and inclusive healthcare improvements across the continent. The findings aim to guide policymakers and health leaders in designing wide-reaching solutions that can help end measles in Africa.

In conclusion, this study systematically reviewed existing literature on measles surveillance systems in Africa, focusing on epidemiological trends, vaccination coverage, and laboratory performance. Using a targeted search across multiple databases and a thorough quality assessment, the review identified key themes, including weak surveillance performance, immunization gaps, regional disparities, and logistical challenges in healthcare systems. Despite progress through programs like the Integrated Disease Surveillance and Response (IDSR), many countries still face poor case reporting, limited lab capacity, and low detection of measles-like illnesses, undermining outbreak control efforts.

Vaccination coverage remains inadequate, with factors like vaccine shortages, logistical issues, hesitancy, and cultural barriers contributing to periodic outbreaks, especially in marginalized communities. The review highlights the unequal burden of measles in conflict-affected and low-resource areas, pointing to the need for region-specific strategies and equitable access to healthcare. Laboratory diagnostics were also found to be a major weakness, with many countries relying on epidemiological links instead of lab confirmation due to infrastructure constraints.

The study calls for strengthened lab systems, improved funding, trained health workers, and better community engagement to enhance surveillance and immunization. Ultimately, achieving measles elimination in Africa will require integrated efforts, combining strong surveillance, expanded vaccination, equitable healthcare delivery, and international collaboration, while also adapting lessons from global successes to the African context.

AUTHOR CONTRIBUTION

Kayode Akanbi oversaw data acquisition, critically revised the review for intellectual content, and gave final approval of the version to be published. Olaniyi Felix Sanni contributed to the conceptualization, methodology design, literature search, data extraction, analysis of findings, and preparation of the initial draft of the manuscript. Olanrewaju Olaiya was involved in literature screening and quality assessment, interpretation of results, and assisted in writing the manuscript. Islamiyyat Adekemi Olatinwo provided methodological guidance, ensured adherence to systematic review protocols, and reviewed the manuscript for accuracy and coherence. Imaobong Udo Isang supported data management and visualization, contributed to data synthesis, and participated in the revision of the manuscript. Sunday Thomas Sola assisted with the critical review of the literature, contributed to the discussion section, and ensured compliance with PRISMA guidelines.

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CONFLICT OF INTEREST

There are no conflicts of interest.

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