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Uptake and associated factors of the second dose of measles–rubella vaccine among children aged 18–23 months in Uganda, August-September 2024

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Abstract

Background

Measles and rubella remain persistent public health threats in low- and middle-income countries despite effective vaccines. Uganda introduced the second dose of the measles–rubella vaccine (MR2) for children aged 18–23 months in 2022. MR2 coverage has stagnated since introduction, yet the behavioral and social drivers of uptake remain poorly characterized. We aimed to estimate national and regional MR2 coverage and identify behavioral and social determinants of uptake among children aged 18–23 months in Uganda, August–September 2024.

Methods

We conducted a two-stage, stratified cluster, cross-sectional household survey across Uganda's four regions (Northern, Western, Central, Eastern). In stage one, 165 of 44,013 enumeration areas were selected with probability proportional to size from the Uganda Bureau of Statistics master frame. In stage two, households within selected areas were systematically sampled. Data were collected from caregivers of children aged 18–23 months using structured electronic questionnaires informed by the BeSD framework. Sampling weights accounted for population size and unequal selection. Weighted MR2 coverage estimates were calculated, and determinants of uptake were analyzed using modified Poisson regression, summarized as adjusted prevalence ratios (aPR) with 95% confidence intervals.

Results

Among 750 children (median age 20 months, IQR 19–22; 51% male), most were born in health facilities (70%) and received vaccines at public facilities (79%). National MR2 coverage was 32.0% (95% CI: 25.5–38.7%), with regional variation: Northern 41.4%, Western 34.5%, Central 27.6%, and Eastern 22.0%. First-born children were more likely to be vaccinated than higher birth orders (aPR = 1.71; 95% CI: 1.10–2.61; p = 0.017). Children from households with ≥ 2 eligible children at survey time had higher uptake (aPR = 2.42; 95% CI: 1.41–4.10; p = 0.002). Each additional month of age increased uptake by ~ 9% (aPR = 1.09; 95% CI: 1.00–1.20; p = 0.039). Caregiver-reported adverse events (aPR = 0.41; 95% CI: 0.23–0.73) and dissatisfaction with services (aPR = 0.18; 95% CI: 0.06–0.51) reduced uptake.

Conclusions

MR2 coverage in Uganda remains well below the ≥ 95% threshold required for measles and rubella elimination. These findings support strengthening second-year-of-life immunisation policies and programmes that prioritise improved caregiver experience, follow-up of eligible children, and targeted

communication on vaccination services and safety to close immunity gaps and accelerate progress toward elimination goals.

Background

Measles and rubella are highly contagious yet preventable childhood diseases that continue to pose major global public health challenges. In 2022, an estimated 136,000 measles-related deaths occurred worldwide, with over 95% reported in low- and middle-income countries (LMICs), highlighting persistent immunisation gaps and systemic weaknesses in health service delivery (1–3). A single dose of measles-rubella (MR) vaccine may leave up to 15% of children susceptible to infection, particularly in high-transmission settings. As a result, to achieve effective measles and rubella control, the World Health Organization (WHO) recommends two doses of the MR vaccine (4, 5), with the first dose (MR1) at 9 months of age and the second (MR2) at 15–18 months of age (4, 6). Global frameworks, including the Immunization Agenda 2030 (IA2030), emphasize equitable access and sustained coverage across the life course and set a target of at least 95% coverage with two doses of measles-containing vaccine in every district to achieve elimination by 2030 (7).

Despite substantial global gains in MR1 coverage, MR2 coverage remains suboptimal (2, 3, 8). Uganda introduced MR2 into its routine immunization schedule in 2022 for children aged 18 months; however, coverage has stagnated. During 2023-24, Health Management Information System (HMIS) data showed that MR2 coverage declined from 49% in 2022 to 21% in 2023 (6, 9, 10). In contrast, MR1 coverage increased steadily from 83% in 2013 to 93% by 2023(9). The widening gap between MR1 and MR2 coverage indicates weaknesses in 2YL immunization delivery. Without improving MR2 uptake, Uganda is unlikely to achieve measles–rubella elimination targets.

Evidence from LMICs suggests that low MR2 uptake is driven by reduced caregiver engagement with immunization services after infancy, limited health worker reminders for 2YL vaccines, weak defaulter tracking systems, concerns about adverse events following immunization (AEFI), and socio-cultural influences on vaccine-seeking behavior (11–13). In Uganda, these challenges are compounded by regional inequities in health service access, inconsistent outreach activities, and low caregiver awareness of 2YL vaccination schedules (6, 9, 14). Although Uganda's national immunization strategy prioritizes strengthening 2YL vaccination platforms to improve schedule completion and reduce MR1–MR2 dropout, determinants specific to MR2 uptake remain poorly characterized. Previous studies in Uganda have largely focused on the first dose of the measles–rubella vaccine (MR1) or overall immunization coverage, with limited attention to MR2 and little application of behavioral frameworks such as the Behavioral and Social Drivers (BeSD). To fill this knowledge gap and understand factors influencing MR2 uptake, we conducted a cross-sectional household survey among children aged 18–23 months in Uganda during, August–September 2024. The findings provide timely, policy-relevant evidence to strengthen 2YL immunisation programming, and accelerate Uganda's progress toward measles and rubella elimination.

Methods

Study design and setting

We conducted a cross-sectional household survey during August and September 2024 across 15 districts in Uganda's four geographical regions (Central, Eastern, Northern, and Western). Districts and enumeration areas (EAs) were selected to ensure proportional representation of urban and rural populations, in line with WHO guidance for vaccination coverage cluster surveys. Inclusion of all regions enabled generation of nationally-representative estimates and assessment of regional variation relevant to Uganda's Expanded Programme on Immunization (UNEPI) monitoring priorities.

Study population

The study population comprised children aged 18–23 months and their primary caregivers residing in selected EAs for at least six months. This residency criterion ensured familiarity with local immunization services and minimized potential bias related to recent migration. Only children with vaccination cards were included to ensure objective verification of MR2 status. Caregivers provided written informed consent prior to participation. Caregivers with observable cognitive or severe mental health conditions that could impair reliable responses were excluded based on interviewer assessment during the consent process.

Sampling strategy

The study area was stratified by Uganda's four geographical regions (i.e., Western, Northern, Eastern and Central). A two-stage stratified cluster sampling design was used. In the first stage, 165 EAs out of 44,013 EAs were selected using probability-proportional-to-regional population size based on the Uganda Bureau of Statistics (UBOS) master sampling frame. On average, each region contributed approximately 40 EAs. In the second stage, households within each selected EA were sampled using systematic sampling. Within each household, one eligible child aged 18–23 months was randomly selected; if multiple eligible children were present, we selected one using a lottery method. One caregiver, preferably the primary caregiver, was interviewed per child.

Sample size determination

Sample size was calculated using the WHO Vaccination Cluster Survey Sample Size Calculator (2018) (15). Assuming MR2 coverage of 30% based on 2023 HMIS data, a 5% margin of error, 95% confidence level, a design effect of 2.25 to account for multistage clustering, and a 10% non-response rate, the minimum required sample was 750 children. The sample was proportionally allocated across the four regions/strata (Table 1).

Table 1
Distribution of the study population by region

Region	Randomly selected EAs	Corresponding Districts	Regional Population (2024)	Participant sample size
Northern	7	Kitgum	2,047,118	32
	5	Kotido	1,452,838	23
	14	Yumbe	3,899,084	64
	9	Amolatar	2,567,518	40
Total EAs	**35**			
Eastern	8	Manafwa	2,216,221	36
	9	Butaleja	2,376,744	39
	16	Kaliro	4,372,349	72
	9	Serere	2,462,344	40
Total EAs	**42**			
Western	13	Kiruhura	3,600,747	59
	10	Kibaale	2,792,123	46
	12	Bundibugyo	3,378,840	55
	6	Kabale	1,779,694	29
Total EAs	**41**			
Central	7	Rubaga Division	1,875,834	32
	17	Mityana	4,802,707	78
	23	Lwengo	6,310,885	105
Total EAs	**47**			
Total	**165**	**15**	**45,935,046**	**750**

Data collection and tools

Data were collected through face-to-face interviews using a structured electronic questionnaire programmed in KoboCollect and adapted from the WHO vaccination cluster survey manual (15). The

questionnaire captured socio-demographic characteristics, immunization history, household characteristics, and Behavioural and Social Drivers (BeSD) domains, including confidence, social influence, motivation, and practical access barriers (16). The tool was translated into the two most dominant languages (i.e., Luganda and Runyakitara) and back-translated to ensure linguistic accuracy. It was pilot-tested in a non-study district to assess clarity, flow, and data consistency. Data collectors underwent a five-day standardized training on survey procedures, MR2 immunization context, ethical conduct, and electronic data capture, with competency assessed before field deployment.

Variables

The primary outcome was MR2 vaccination status (Yes/No), verified by vaccination card. Caregiver recall was not used to avoid potential recall and social desirability bias, which can overestimate coverage. Independent variables included socio-demographic (child's age, sex, birth order; caregiver's age, education, occupation, marital status, religion, wealth quintile, residence), health system (vaccination site, stockouts, appointment reminders), and BeSD factors (confidence, trust, satisfaction, AEFIs), categorized per WHO BeSD framework with binary responses. Specifically, Confidence was measured as caregiver agreement that MR2 is safe and effective (binary: confident/not confident); Satisfaction captured the caregiver's overall rating of the most recent vaccination service visit (satisfied/not satisfied); AEFI history was a caregiver-reported yes/no item on whether the child experienced an adverse reaction after any prior vaccine dose (16).

Data analysis

Data were analyzed using Stata version 17 (StataCorp, College Station, TX, USA). Sampling weights were derived as the inverse of the selection probabilities at EA and household levels and were adjusted for non-response. Weighted descriptive statistics were used to summarize participant characteristics and MR2 coverage nationally and regionally. Associations between independent variables and MR2 uptake were assessed using modified Poisson regression with robust standard errors, accounting for clustering at the enumeration area level. Variables with p-value < 0.20 in bivariate analysis and those of conceptual relevance were included in multivariable models. Results were presented as crude and adjusted prevalence ratios (cPRs and aPRs) with 95% confidence intervals. Multicollinearity was assessed using variance inflation factors.

Results

Sociodemographic characteristics

A total of 750 children aged 18–23 months and their primary caregivers were included in the study. The median age of children was 20 months (interquartile range [IQR] 19–22 months). Most children (70%; 544) were born in health facilities, and 566 (79%) received vaccinations at static health facility sessions. Public health facilities administered 86% of the vaccinations. Caregivers were predominantly female

(93%; 702) and had a median age of 28 years (IQR 24–34). Nearly all (93%; 684) were the parents of the child (Table 2).

Table 2
Sociodemographic characteristics (n = 750)

Variable	Unweighted frequency (n)	Weighted Percentage
Sex of caregiver	702	93.6
Female	48	6.4
Male		
Sex of the child	374	51.1
Male	376	49.8
Female		
Occupation	710	94.3
Informal employment	40	5.9
Formal employment		
Caregiver type	684	93.0
Primary (Parent)	66	6.9
Not Primary		
Birth order of child	168	24.6
First born	287	38.5
Second- or third-born	295	36.9
Fourth- or higher-born		
Place of birth of child	544	70.1
Facility	206	29.9
Home		
Place of most vaccination of child	566	78.9
Health facility	184	21.0
Community outreaches		
Health facility type where child received vaccine	684	85.8
Public	66	14.2
Private		

Uptake of MR2: National and Regional

The overall weighted MR2 coverage was 32.0% (95% CI: 25.5–38.7). Coverage varied by region: Northern (41.4%, 95% CI: 29.6–54.2), Central (27.6%, 95% CI: 19.3–37.7), Western (34.5%, 95% CI: 23.3–47.8), and Eastern Uganda (22.0%, 95% CI: 14.6–31.8) (Fig. 1).

Factors associated with MR2 uptake

In the adjusted multivariable analysis **(**Table 3**)**, children of female caregivers had a lower prevalence of MR2 uptake compared with male caregivers (aPR = 0.59 95% CI: 0.39–0.89; p-value = 0.01). Uptake was higher among first-born children (aPR = 1.71 95% CI: 1.10–2.61; p-value = 0.017) and second- or third-born children (aPR = 1.51 95% CI: 1.02–2.24; p-value = 0.041), than children of fourth or higher birth order. Children from households with two or more eligible children had higher MR2 uptake than those from households with one eligible child (aPR = 2.42 95% CI: 1.41–4.10; p-value = 0.002). Increasing age modestly increased MR2 uptake (aPR = 1.09 95% CI: 1.00–1.20; p-value = 0.039). A history of adverse events following immunization (AEFIs) was significantly associated with lower MR2 uptake (aPR = 0.41 95% CI: 0.23–0.73; p-value = 0.002), as was caregiver dissatisfaction with vaccination services (aPR = 0.18 95% CI: 0.06–0.51; p-value = 0.001).

Table 3
Factors associated with uptake of the second dose of measles–rubella vaccine among children aged 18–23 months in Uganda

Variable	cPR (95%CI)	P-Value	aPR (95%CI)	P-value
Sex of caregiver	**0.52 (0.35–0.84)**	**0.006**	**0.59 (0.39–0.89)**	**0.011**
Female	**Reference**		**Reference**	
Male				
Age of the child	**1.12 (0.99–1.19)**	**0.082**	**1.09(1.00-1.20)**	**0.039**
18–23 months				
Birth order	1.68 (1.11–2.72)	0.029	1.71 (1.10–2.61)	**0.017**
First born	1.38 (0.90–2.22)	0.081	1.51 (1.02–2.24)	**0.041**
2-3rd born	Reference		Reference	
4th or higher				
Number of eligible children in care	2.02 (1.22–3.43)	0.009	2.42 (1.41–4.10)	**0.002**
Two or more	Reference		Reference	
1 eligible child				
History of AEFIs**	0.49 (0.33–0.89)	0.011	0.41 (0.23–0.73)	**0.002**
Yes	Reference		Reference	
No				
Confidence in vaccine benefits	0.11 (0.02–0.83)	0.030	0.21 (0.03–1.90)	0.182
Not confident	Reference		Reference	
Confident				
Satisfaction with vaccination services	0.18 (0.05–0.52)	0.002	0.18 (0.06–0.51)	**0.001**
Not satisfied	Reference		Reference	
satisfied				

****AEFI-Adverse events following immunisation**

PR = prevalence ratio; CI = confidence interval

aPRs were estimated using modified Poisson regression with robust standard errors

All models accounted for survey weights and clustering at enumeration area level

Discussion

Measles vaccine uptake among children aged 18–23 months in Uganda is critically low, with only one third receiving MR2 as of September, 2024. Vaccination status was significantly influenced by household characteristics, including caregiver sex, child birth order, and the number of eligible children, as well as behavioral and service-related factors, specifically a history of adverse events following immunization (AEFIs) and caregiver dissatisfaction with vaccination services.

The national MR2 coverage of 32.0% contrasts sharply with Uganda's consistently high MR1 coverage, which was 93% in 2023 (noting that, since children without vaccination cards were excluded, this estimate may represent an overestimate of true national MR2 coverage) (4, 5, 9). The MR1–MR2 gap indicates that, although the health system can effectively deliver infant vaccines, substantial challenges may exist in second-year-of-life (2YL) immunization. These gaps create significant immunity deficits that contribute to sustained measles transmission. Uganda's MR2 performance is also lower than in several neighboring East African countries, where second-dose uptake ranges from 50% to 70% (8, 17). This persistent low coverage in Uganda since MR2 introduction in 2022 likely reflects several interrelated factors, including limited caregiver (18) and health worker awareness of the 2YL schedule, prioritisation of the first dose over the second, missed opportunities during routine visits, and occasional unavailability of the vaccine (11–13). Unlike MR1, which is bundled with multiple early-life vaccines and widely promoted, MR2 is administered when caregivers may perceive children as less vulnerable, contributing to lower motivation to return for vaccination (17, 19, 20).

Regional disparities in MR2 coverage, ranging from 22% in Eastern to 41% in Northern Uganda, reflect patterns of broader immunization inequities including infrastructure, reported in national surveys (10, 21).Similar patterns across sub-Saharan Africa have been observed that indicate that missed opportunities and systemic barriers frequently hinder MR2 uptake (14, 21–22). To close these immunity gaps, Uganda needs strengthened 2YL programming, including more effective defaulter tracing systems, strategies to optimize child health visits for vaccination, and expansion of community and school-based vaccination platforms to reach children who have limited contact with health facilities. Tailored, region-specific approaches that address local service delivery challenges and caregiver needs are essential to improve access, build demand, and ensure timely MR2 uptake.

In our study, children with male primary caregivers were more likely to have received MR2 than those with female primary caregivers, a finding that is surprising given the generally recognized role of mothers in child health service utilization. However, this finding should be interpreted with considerable caution: male caregivers constituted only 6.4% of our sample (n = 48), and the association (aPR = 0.59, 95% CI: 0.39–0.89) may partly reflect sample composition rather than a true population-level gender difference. Hypothetically, in many settings, women have limited autonomy, face heavy caregiving workloads, and depend financially on male partners, all of which might restrict their ability to return for 2YL vaccinations (24, 25). Evidence from Uganda and sub-Saharan Africa highlights that women often face structural and economic barriers to accessing child health services, which may influence vaccination uptake,

particularly in low-resource settings (17, 25, 26). These dynamics are compounded by gender norms related to available time, economic independence, and mobility that disproportionately hinder women in low-income settings (27).

Birth order influenced MR2 uptake, with first-born children 70% more likely to receive MR2 than children of fourth and higher birth order. This aligns with global literature showing that later-born children often experience “resource dilution,” in which increased family responsibilities and logistical constraints reduce caregivers’ ability to complete multi-dose schedules (28–30). Additionally, parents may perceive firstborns as more vulnerable, prompting stricter adherence to recommended health behaviors, including immunization. Such challenges are especially pronounced for MR2, which requires a deliberate return visit during the 2YL. Conversely, children from households with multiple eligible children at survey time were more likely to receive MR2, possibly due to more frequent health system contact and synchronized care-seeking during child health days, outreach sessions, or under-five clinics (30–33). In contrast, households with only one child may have fewer routine interactions with health services after infancy, increasing the risk of missed opportunities. These findings highlight the need for household- and gender-responsive approaches to improve MR2 coverage, including engaging fathers in immunization communication, promoting joint decision-making, reducing the opportunity costs for large families, and strengthening appointment systems, home visits, and community mobilization to ensure consistent 2YL contact regardless of household composition.

Children whose caregivers reported previous AEFIs were 59% less likely to receive MR2, highlighting the powerful influence of real, perceived, or rumor-driven safety concerns on vaccination behavior. Evidence consistently shows that fear of side effects is one of the strongest predictors of missed or delayed immunization, particularly for second or subsequent doses (30, 34–36). In Uganda, where AEFIs are frequently under-reported and caregivers often receive limited counseling on expected mild reactions, concerns may escalate into anxiety or mistrust, prompting discontinuation of the vaccination schedule (34). Such fears can be reinforced in settings where misinformation spreads easily, further eroding caregiver confidence (34, 35, 37). Similarly, caregiver dissatisfaction with vaccination services was strongly associated with lower MR2 uptake, reflecting the critical importance of service quality, long waiting times, vaccine stock-outs, poor interpersonal interactions, and inadequate communication, all of which undermine trust and reduce the likelihood of returning for 2YL vaccines(12, 14). For MR2, which requires a deliberate follow-up visit, negative early service experiences will have a disproportionately high impact on continuation. Strengthening AEFI surveillance and communication, providing empathetic and transparent counseling, ensuring reliable vaccine availability, and improving client experience through respectful, timely, and well-organized services are therefore key strategies to sustain caregiver confidence and increase completion of later-dose vaccines within the 2YL platform (12, 22).

Public Health and Policy Implications

Our findings present important implications for immunisation policy and practice in Uganda and similar settings across sub-Saharan Africa. The low MR2 coverage and marked regional disparities highlight the

need to strengthen second-year-of-life (2YL) vaccination as a distinct priority within routine immunisation programmes, supported by clear performance targets, adequate resources, and accountability mechanisms at national and sub-national levels.

The observed association between caregiver dissatisfaction and lower MR2 uptake highlights the importance of improving service quality through reliable vaccine availability, reduced waiting times, and respectful, client-centered communication.

Incorporating routine monitoring of caregiver experience into existing immunisation performance systems could help identify and address barriers to vaccine completion. Similarly, the negative association between reported adverse events following immunization (AEFIs) and MR2 uptake emphasises the need for strengthened AEFI surveillance, consistent caregiver counselling on expected vaccine reactions, and transparent risk communication to maintain confidence in immunization services. The higher uptake observed among households with multiple eligible children suggests opportunities to improve coverage by integrating MR2 delivery into existing child health platforms, including under-five clinics, outreach services, and child health days.

Collectively, these findings provide evidence to inform Uganda's immunisation policies and programme planning, including implementation of the Uganda National Expanded Programme on Immunisation (UNEPI).

Study strengths and limitations

Our study has several strengths, including verification of MR2 vaccination status using child health cards, which minimised misclassification and strengthened internal validity, as well as the application of robust analytical methods to identify determinants of immunization in the second year of life (2YL). While vaccination card verification ensures accurate measurement of MR2 uptake and reduces recall bias, children without documented cards were excluded from the study. We recognize that this exclusion may introduce selection bias, as children without cards may systematically differ from those with documented records in ways that affect vaccination uptake. Additionally, because the absence of vaccination cards was applied as a screening criterion during enrollment, the number of children excluded for this reason was not systematically recorded. Importantly, since children without cards may be systematically less likely to have been vaccinated, our coverage estimate of 32.0% may represent an overestimate of true national MR2 coverage, which should be considered when interpreting and applying our findings. This approach was therefore a trade-off between maximizing accuracy and maintaining generalisability.

Reliance on caregiver-reported AEFIs and service satisfaction introduces recall and social desirability bias, which may have led to misclassification and affected the observed associations. As with all cross-sectional designs, causality cannot be inferred, and unmeasured confounders, such as caregiver autonomy or household mobility, may have influenced the findings. Finally, the absence of qualitative data limits the depth of interpretation regarding caregivers' perceptions of AEFIs, service dissatisfaction,

and decision-making. Future mixed-methods studies would provide a richer contextual understanding of barriers to MR2 uptake.

Conclusion

MR2 coverage in Uganda remains critically low, with substantial regional variations, highlighting persistent gaps in second-year-of-life immunization despite high MR1 coverage. Key determinants, associated with MR2 uptake, including caregiver sex, birth order, household composition, prior AEFIs, and service dissatisfaction, suggest multifaceted barriers to timely completion of the second dose. These findings provide evidence-informed guidance for strengthening 2YL programming through targeted, household- and gender-sensitive approaches, including improving caregiver experience, ensuring vaccine availability, supporting AEFI communication and surveillance, and implementing reminder systems. Addressing these associated factors may help close immunity gaps and support Uganda's progress toward measles and rubella elimination goals; however, intervention studies are needed to establish causality and determine which strategies are most effective in the Ugandan context.

Abbreviations

AEFI	Adverse Events Following Immunization
aPR	Adjusted Prevalence Ratio
cPR	Crude Prevalence Ratio
CI	Confidence Interval
BeSD	Behavioural and Social Drivers
UNEPI	Uganda National Expanded Programme on Immunization
UBOS	Uganda Bureau of Statistics
LMICs	Low- and Middle-Income Countries
MR	Measles-Rubella vaccine
MoH	Ministry of Health
WHO	World Health Organization
EAs	Enumeration Areas

Declarations

Ethics approval and Accordance

The study was conducted as part of routine public health surveillance to inform immunisation programming under administrative clearance and approval from the Uganda Ministry of Health, which

served as the national-level authorisation for this public health surveillance activity. The U.S. Centers for Disease Control and Prevention Human Subjects Review Board (National Institute for Occupational Safety and Health Institutional Review Board) determined the activity to be non-research public health practice, precluding the need for CDC IRB review and approval. No additional institutional review board approval was required or obtained beyond the Ministry of Health administrative approval. The study was conducted in accordance with applicable federal laws and CDC policy (45 C.F.R. part 46; 21 C.F.R. part 56; 42 U.S.C. §241(d)). All human-related procedures were carried out in accordance with the Declaration of Helsinki and the Council for International Organizations of Medical Sciences (CIOMS) International Ethical Guidelines.

Consent to participate

Participation was voluntary, written informed consent was obtained from all caregivers, interviews were conducted privately, and all data were securely stored with restricted access.

Consent for publication

Not applicable.

Clinical Trial Number: Not applicable

Availability of data and materials

The datasets generated and analysed during this study are the property of the Uganda Public Health Fellowship Program and are not publicly available to protect participant confidentiality. Data can be made available from the corresponding author upon reasonable request, subject to approval by the Uganda Public Health Fellowship Program.

Competing interests

The authors declare no competing interests.

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Authors' contributions

SN conceptualized the study, led data collection and analysis, and drafted the manuscript. DM, IS, BBK supported data analysis and technical review of the draft manuscript .PA, NM, AMN, and EOO supported revision of the first manuscript draft. RM, YN, MN, and AMN contributed to tool development, field coordination, and data quality assurance. RM, BK, DK provided technical input during the study design

and data interpretation. YN, BK and RM supervised the study and reviewed the manuscript for critical intellectual content. All authors read and approved the final manuscript.

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Disclaimer

The findings and conclusions presented in this report are those of the authors and do not necessarily reflect the official views of the Centers for Disease Control and Prevention.

AI assistance disclosure

During the preparation of this work the authors used Claude (Anthropic, version accessible January 2026) and ChatGPT (OpenAI; version GPT-4o, o1) for tasks including formatting, cross-checking of data and English language fluency editing. All scientific interpretations, data analysis, and conclusions remain the sole responsibility of the authors, who reviewed and verified all AI-generated edits for accuracy and appropriateness.

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Figures

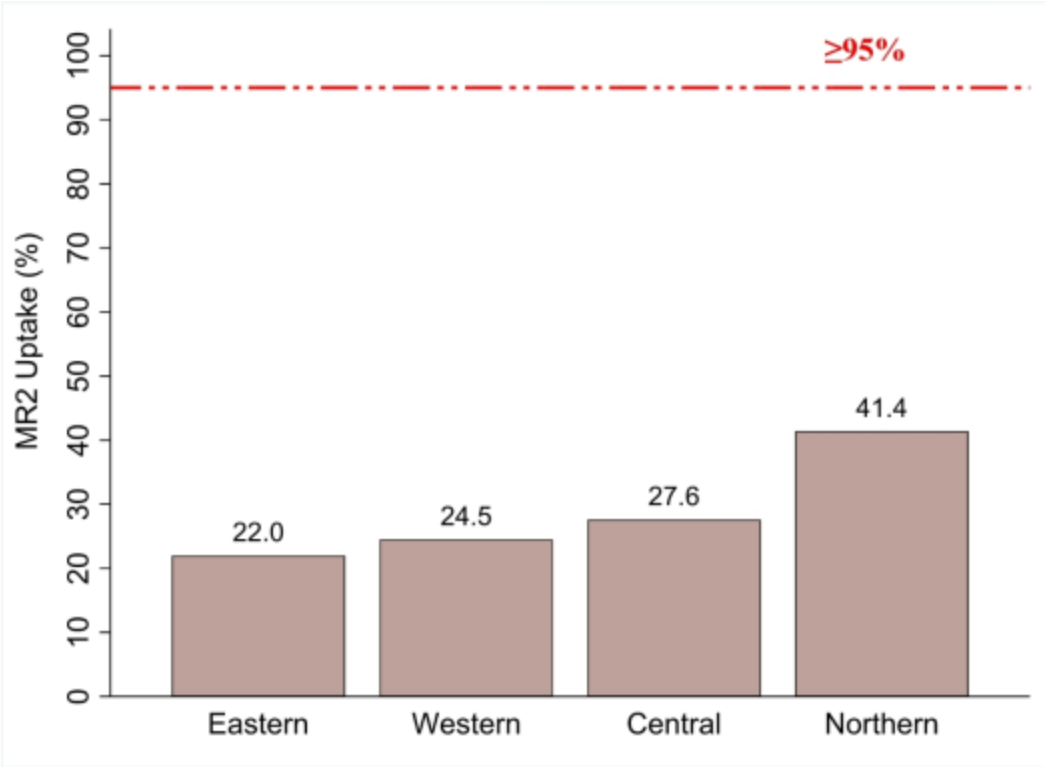


Figure 1

MR2 coverage by region in Uganda, August-September 2024