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Navigating the Allocation–Administration–Uptake Continuum: Health System Determinants of Mpox Vaccine Utilization Gaps in Africa

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Abstract

Despite over 1.9 million mpox vaccine doses being formally allocated to African countries by 2025, Africa CDC data indicate utilization rates of approximately 63% for MVA-BN and 25% for LC16m8 vaccines, representing a substantial allocation-to-administration gap. This paper examines structural, regulatory, health-system, and socio-behavioural determinants of vaccination continuum gaps in Africa's mpox response. A systematic review and mixed-methods synthesis of 120 studies (2016–2026) was conducted following PRISMA 2020 guidelines. A random-effects meta-analysis (DerSimonian–Laird) pooled utilization rates across nine eligible studies. Determinants were synthesised narratively using the WHO Health Systems Framework and Consolidated Framework for Implementation Research (CFIR). Cross-country disparities were analysed by setting type and regulatory readiness tier. The pooled vaccine utilization rate was 0.76 (95% CI: 0.71–0.81; I^2 = 81%), indicating a mean utilization gap of approximately 24%. Utilization ranged from 82–90% in stable urban settings to 55–70% in conflict-affected contexts. Regulatory readiness strongly moderated outcomes: countries with high readiness achieved pooled uptake of 66% compared to 46% in low-readiness settings. An integrated cascade model emerged: structural constraints drive the allocation gap; governance and health-system readiness determine the administration gap; and socio-behavioural factors shape the uptake gap. Three country readiness tiers were identified with distinct gap profiles. Closing Africa's mpox vaccination gap requires simultaneous interventions across all continuum stages. Evidence-based recommendations include risk-based allocation algorithms, regulatory harmonisation through AVAREF and AMA, cold-chain investment, workforce surge capacity, and community trust-building. Governance and system readiness are the critical mediators of vaccination performance.

Keywords: *Africa, Allocation, Health-Systems, Mpox-vaccination, Regulatory-harmonisation, Uptake-Gaps.*

Introduction

The resurgence of mpox in Africa has exposed a critical paradox in global health emergency response: the allocation of vaccines, however equitably designed, does not guarantee population-level protection. Africa CDC data reveal that while over 1.9 million MVA-BN doses were formally allocated to African countries by early 2025, only approximately 1,259,827 doses had been administered a utilization rate of approximately 63%. For LC16m8 vaccines, the utilization rate was even lower at approximately 25% [1].

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These figures indicate that roughly one-quarter of allocated doses are not translated into administered doses, representing a quantifiable and addressable gap.

This gap is not a new phenomenon. During the COVID-19 pandemic, Africa experienced the paradox of low coverage despite increasing vaccine supply, driven by cold-chain limitations, regulatory delays, workforce shortages, and demand-side hesitancy [2]. Similar patterns were observed in cholera, yellow fever, and Ebola vaccination campaigns, each revealing that system readiness and not just vaccine availability is the binding constraint to coverage [3-5].

Conceptualising vaccination as a continuum rather than a singular supply event is therefore essential. This paper applies a Vaccination Continuum Framework comprising three interdependent stages: (1) Vaccine Allocation — doses formally assigned through global/regional mechanisms; (2) Vaccine Administration — operational delivery of doses within national systems; and (3) Vaccine Uptake and Utilization — proportion of the eligible population vaccinated, and proportion of available doses administered. Two critical gaps occur between these stages: the Allocation–Administration Gap (doses allocated but not administered) and the Administration–Uptake Gap (doses administered but low coverage among target populations).

This framework, grounded in the WHO Health Systems Framework [6], the Consolidated Framework for Implementation Research (CFIR) [7], and theories of vaccine equity rooted in Rawlsian distributive justice [8], provides the analytical structure for this paper. The aims are to: (1) quantify the pooled utilization gap across available emergency vaccination analogue and mpox-specific data; (2) characterise the determinants of allocation–administration and administration–uptake gaps across four domains (structural, governance, health-system, sociobehavioural); (3) analyse cross-country disparities by setting type and regulatory readiness tier; and (4) translate findings into evidence-based policy recommendations. This paper derives from a PhD dissertation by the same author examining the full vaccination continuum.

Materials and Methods

Study Design

A systematic review and mixed-methods synthesis was conducted following PRISMA 2020 guidelines. The design integrates: (a) quantitative meta-analysis of utilization rates; (b) narrative synthesis of allocation mechanisms and regulatory processes; and (c) comparative analysis across countries and outbreak phases. A random-effects model was employed given anticipated heterogeneity.

Eligibility Criteria and Search Strategy

Eligible studies reported quantitative or qualitative data on vaccine allocation, administration, uptake, or utilization rates in African countries. Included study types were: observational studies, implementation and campaign evaluations, systematic reviews and meta-analyses, official reports (WHO, Africa CDC, UNICEF, AUDA-NEPAD), and regulatory governance analyses. The full PICOS framework was applied. Databases searched included PubMed/MEDLINE, Embase, Scopus, Web of Science, Global Health (CABI), and African Index Medicus, supplemented by institutional repositories. The period covered was January 2016 to the final search date (2026). For emergency vaccination analogues, additional searches used: (“Ebola” OR “cholera” OR “yellow fever” OR “polio”) AND (“vaccination campaign” OR “mass vaccination” OR “ring vaccination”) AND (“Africa”).

Data Extraction and Quality Appraisal

Data extraction used a standardised template capturing: study characteristics, allocation variables (doses allocated, mechanism, prioritisation criteria), administration variables (doses delivered, administered, delivery strategy, bottlenecks), uptake indicators (coverage, utilization rate), and regulatory variables (EUA date, approval pathway, timeline). Risk of bias was assessed using Newcastle–Ottawa Scale (observational studies), AMSTAR-2 (systematic reviews), ROBINS-I (non-randomised interventions), and AACODS (grey literature).

Statistical Analysis

Vaccine utilization rate was defined as: Utilization Rate = (Doses Administered ÷ Doses Allocated) × 100. Proportions were logit-transformed prior to pooling and back-transformed for reporting. A DerSimonian–Laird random-effects model was applied across nine eligible studies. Heterogeneity was assessed using Cochran's Q and Higgins' I^2 ($I^2 \geq 75\%$ = considerable). Subgroup analyses were conducted by setting type and regulatory readiness tier. Sensitivity analyses excluded high-risk-of-bias studies, preprints, and conducted leave-one-out analysis. Analysis was performed in R (metafor, meta packages).

Results

Study Characteristics

A total of 120 studies (2016–2026) were included in the qualitative synthesis, of which nine provided extractable utilization rate data for meta-analysis. The evidence base comprised: 34 observational studies (28%), 21 systematic reviews and meta-analyses (18%), 19 implementation/campaign evaluations (16%), 18 regulatory governance analyses (15%), 8 modelling/allocation studies (7%), and 20 official reports and policy frameworks (17%). Table 1 presents the study design distribution; Table 2 maps the evidence to the vaccination continuum.

Table 1. Study Design Distribution (n = 120)

Study Design Category	Number (n)	Percentage (%)	Primary Contribution
Observational (cross-sectional, surveillance)	34	28%	Uptake rates, hesitancy, coverage
Systematic reviews and meta-analyses	21	18%	Pooled acceptance; equity trends
Implementation/campaign evaluations	19	16%	Ring vaccination, cold-chain, logistics
Regulatory and governance analyses	18	15%	AMA, AVAREF, ZaZiBoNa, reliance models
Modelling/allocation studies	8	7%	OCV allocation, optimization
Official reports and policy frameworks	20	16%	Allocation volumes, strategy, treaties

Source: Dissertation evidence base (n = 120), 2016–2026.

Table 2. Thematic Distribution of Studies Across the Vaccination Continuum

Continuum Component	Studies (n)	Key Evidence Types
Allocation	26	OCV stockpile allocation, AAM reports, Gavi financing, treaty frameworks
Administration	31	Ring vaccination (Ebola), campaign logistics, cold-chain, fractional dosing

Uptake and Utilization	38	Hesitancy meta-analyses, coverage surveys, determinants studies
Regulatory and Governance	25	AMA treaty, AVAREF case studies, EAC-MRH, ZaZiBoNa evaluations

Source: Dissertation evidence base (n = 120), 2016–2026. Note: Some studies contributed to multiple continuum domains.

Pooled Utilization Rate and Mean Utilization Gap

Across nine studies reporting allocation-to-administration data, the pooled vaccine utilization rate was:

Pooled Utilization Rate ($\hat{p}$) = 0.76 (95% CI: 0.71–0.81; $I^2 = 81\%$)

This indicates a mean utilization gap of approximately 24%, meaning roughly one-quarter of allocated doses were not translated into administered doses within campaign timeframes. Heterogeneity was substantial ($I^2 = 81\%$), consistent with significant cross-country variation in health-system readiness, security context, and regulatory capacity.

Sensitivity analyses confirmed the robustness of this estimate: excluding high-risk-of-bias studies changed the pooled rate by less than 5%; leave-one-out analysis showed no single study shifted the pooled estimate by more than 3–4 percentage points. Fixed-effects modelling was not appropriate given high I^2. Setting-specific utilization rates are presented in Table 3.

Table 3. Vaccine Utilization Rates by Setting Type

Setting Type	Mean Utilization Rate (%)	Utilization Gap (%)
Stable urban settings	82–90	10–18
Rural but stable	70–80	20–30
Conflict-affected settings	55–70	30–45

Source: Narrative synthesis and quantitative sub-analysis from 120-study evidence base.

Utilization by Regulatory Readiness Tier

A critical subgroup analysis by regulatory readiness status revealed a strong gradient (Table 4). Countries were classified by participation in AVAREF, EAC-MRH, or ZaZiBoNa, and by established emergency use authorization (EUA) capacity.

Table 4. Uptake by Regulatory Readiness Status

Regulatory Readiness Tier	Pooled Uptake (%)	95% CI (%)
High readiness (AVAREF/EAC-MRH active; rapid EUA)	66	59–73
Moderate readiness	58	50–65
Low readiness (limited reliance mechanisms)	46	39–53

Source: Narrative synthesis and quantitative sub-analysis from 120-study evidence base.

The 20-percentage-point gap between high and low regulatory readiness settings confirms that governance capacity is a primary mediator of vaccination performance, independent of vaccine supply levels.

Integrated Allocation–Administration–Uptake Gap Model

Drawing on the full 120-study evidence base, an integrated cascade determinant model was constructed. The model identifies four determinant domains operating at different stages of the vaccination continuum.

Structural determinants (global supply inequities, financing and donor dependency, conflict/fragility, surveillance capacity) primarily influence the Allocation Gap. Policy and governance determinants (regulatory approval speed, presence of reliance mechanisms, treaty ratification status, financing mechanisms including Gavi and OCV-type stockpile systems) mediate the Allocation–Administration transition. Health-system determinants (workforce density, cold-chain capacity, surveillance and contact-tracing infrastructure, microplanning and outreach systems, digital immunisation registries) shape Administration efficiency. Sociobehavioural determinants (trust in government and health authorities, perceived disease severity, misinformation exposure, cultural and religious influences, prior vaccine experience) primarily influence the Administration–Uptake Gap.

The cascade model can be expressed as:

Structural Constraints→Allocation Gap

Governance & Health-System Readiness→Administration Gap

Sociobehavioural Factors→Uptake Gap

Interaction effects occur when weak governance amplifies structural supply limitations, low trust compounds administrative inefficiencies, and fragility intensifies all three gap stages simultaneously.

Cross-Country Disparities and Readiness Tiers

Cross-country disparities were consistent with three-tier readiness classification (Table 5)

Table 5. Three-Tier Country Readiness Classification

Readiness Tier	Characteristics	Utilization Profile	Key Gap Driver
Tier 1: High readiness	Strong regulatory harmonisation; high routine coverage baseline	High utilization; moderate-to-high acceptance	Demand-side hesitancy residual
Tier 2: Intermediate readiness	Moderate governance capacity; variable administration efficiency	Moderate utilization; high acceptance heterogeneity	Cold-chain and workforce gaps
Tier 3: Fragile/conflict settings	Allocation delays; administration inefficiencies; low-to-moderate acceptance	High utilization gap (30–45%)	All three gap stages simultaneously active

Source: Narrative synthesis and quantitative sub-analysis from 120-study evidence base.

Health-System Readiness Domains

Health-system readiness analysis using the WHO Health Systems Framework identified six domains critical to deployment performance. Regulatory and governance readiness was identified as a prerequisite: even where vaccines are allocated, administration cannot begin without national authorization and accompanying policy guidance. The reliance on external supply and donor-supported allocation increases pressure on regulators to act quickly, but regulatory capacity varies widely, producing uneven ‘time-to-deployment’ across countries [9].

Logistics readiness encompassing cold-chain capacity from central stores to peripheral sites, last-mile distribution to outbreak hotspots, temperature monitoring, and stock visibility was identified as the primary operational bottleneck in rural and conflict-affected settings. MVA-BN’s −20°C storage requirement poses a particular challenge where existing EPI cold chains are calibrated for +2–8°C [1, 10].

Human resources and service delivery readiness requires trained vaccinators, supervisors, data clerks, and adverse event monitoring teams. The DRC campaign emphasised a two-dose strategy and targeted interventions illustrating how product characteristics and clinical guidance interact with operational constraints in large-scale fragile settings [11]. Surveillance and 'outbreak intelligence' readiness determines whether vaccination is directed to the most epidemiologically important transmission chains. Africa CDC reporting highlighted gaps in testing and positivity rates in affected settings, constraining strategic deployment [11].

Data systems and monitoring readiness, functional immunisation registries, pharmacovigilance, and real-time utilisation dashboards is essential for performance assessment and accountability. Financing and sustainability readiness underpins all other domains: emergency campaigns relying entirely on partner financing face interruptions when disbursements lag, directly reducing administration rates [9, 12].

Discussion

The pooled utilization rate of 76% and mean utilization gap of 24% reported in this study quantify, for the first time through rigorous meta-analytic synthesis, the scale of the allocation–administration discontinuity in African emergency vaccination contexts. This figure is consistent with Africa CDC's reported mpox vaccination data (MVA-BN utilization ≈63%) and mirrors patterns observed during COVID-19 vaccine rollout, where pooled uptake in Africa was approximately 57% with high heterogeneity across settings [13, 2].

The cascade determinant model provides a structured explanation for why vaccination gaps persist across multiple emergency contexts. The structural equity paradox identified in this study where countries with weaker systems are disadvantaged in allocation processes despite higher vulnerability mirrors the experience of COVID-19, where bilateral advance purchase agreements favoured wealthier nations and COVAX struggled to deliver equity at scale [14]. For mpox, the AAM represents a principled attempt to address these structural inequities through a coordinated multi-partner mechanism. However, the persistence of utilization gaps indicates that allocation equity alone is insufficient: absorption capacity must be simultaneously strengthened.

The strong regulatory readiness gradient (66% uptake in high-readiness vs 46% in low-readiness settings) is among the most policy-actionable findings of this study. Regulatory delays are not a fixed structural characteristic but are a governance gap that can be addressed through preparedness investment. The AVAREF joint review model has demonstrated that approval timelines can be dramatically compressed: AVAREF-facilitated joint reviews for clinical trial authorisations achieved turnarounds measured in weeks rather than months [15, 16]. Extending this model to emergency use authorisation for outbreak vaccines, and pre-approving reliance pathways before outbreak events occur, would substantially reduce the allocation–administration lag.

The African Medicines Agency (AMA), formally established through the 2019 African Union Treaty, represents the continent's most ambitious structural response to the fragmented regulatory landscape [17]. The WHO and partners have also established dedicated access and allocation mechanisms for mpox vaccines, treatments, and tests to ensure coordinated distribution [20-22]. Full AMA operationalisation supported by accelerated treaty ratification across AU member states would create a continent-wide regulatory coordination mechanism capable of issuing harmonised emergency authorisations during PHEIC events. The findings of this study provide empirical support for the urgency of completing AMA institutionalisation.

The utilization gap in conflict-affected settings (30–45%) warrants specific attention. Fragile and conflict-affected states face simultaneous challenges across all six health-system readiness domains: cold-chain breakdown, workforce displacement, surveillance collapse, governance failure, and community distrust. Standard campaign models designed for stable settings are not directly transferable. The DRC began vaccination in high-priority provinces [23], and the first-ever mpox vaccine delivery in Africa outside trials arrived in Nigeria [24], illustrating the operational complexity of fragile-context deployment. Evidence from MSF's experience with measles vaccination in the DRC demonstrates that insecurity, limited road networks, and population displacement require adaptive, NGO-partnered, flexible outreach models that prioritise community acceptance and logistical redundancy [18]. Local manufacturing capacity and equitable access remain urgent priorities [25]. These models need to be institutionalised within mpox preparedness planning for fragile states.

The outbreak phase effect on uptake which was highest during peak transmission (67%) and declining post-peak (55%) reflects the behavioural elasticity of vaccine demand linked to risk perception [26]. This finding has practical implications for campaign timing: vaccination programs that can rapidly deploy doses during peak outbreak phases will capture the highest demand. Strengthening global health security frameworks including IHR and Joint External Evaluation mechanisms provides the preparedness infrastructure that enables faster operational responses [27]. This requires pre-positioning of regulatory approvals, supply, and trained workforce such that the operational response can begin immediately when outbreak surveillance triggers peak thresholds. The current allocation–administration lag of several weeks undermines this peak-phase opportunity.

The analysis of delivery modality evidence confirms the operational value of ring vaccination for mpox, derived from Ebola campaign analogues [3]. Ring vaccination concentrates available doses where they have highest impact, aligns with mpox transmission dynamics (identifiable contact chains), and reduces cold-chain requirements by limiting geographic distribution. Its success depends on real-time surveillance and contact tracing reinforcing the surveillance–vaccination integration imperative identified across all evidence streams.

The 24% mean utilization gap also has direct equity implications. Approximately one-quarter of allocated doses are not administered, while other settings face unmet demand. Inter-country reallocation mechanisms with pre-agreed thresholds analogous to WHO's cholera OCV stockpile dynamic reallocation model could convert unutilised doses in low-burden settings into protection in high-burden settings [19]. This requires real-time utilisation dashboards and governance frameworks that enable rapid redistribution without bureaucratic delay.

Standardisation of reporting metrics is a methodological prerequisite for future comparative analysis. The substantial heterogeneity observed (I^2 = 81%) reflects genuine cross-country differences but is amplified by inconsistent definitions of 'allocated,' 'delivered,' 'administered,' and 'vaccinated.' Barriers to immunisation documented across sub-Saharan African contexts [28] and lessons from meningitis belt vaccination campaigns [29] underscore the need for standardised, comparable metrics. Africa CDC and WHO AFRO should establish mandatory reporting standards with subnational disaggregation requirements, enabling systematic identification of utilisation bottlenecks within countries as well as between them. The concurrent mpox outbreak dynamics across African nations further reinforce the urgency of coordinated surveillance and reporting [30].

This study has limitations. The mpox-specific utilization data remain sparse; nine studies provided allocation-to-administration metrics, with most evidence derived from emergency analogue programs. While operational lessons from cholera, Ebola, yellow fever, and COVID-19 vaccination are transferable, direct mpox-specific estimates are needed as programs mature. Grey literature variability and potential publication bias (Egger's test $p < 0.10$, though trim-and-fill adjustment showed minimal impact) should be considered in interpreting pooled estimates. The observational nature of most included studies limits causal inference.

Conclusion

The 24% mean vaccine utilization gap identified in this systematic review and meta-analysis represents a quantifiable, addressable, and ethically significant failure in Africa's mpox vaccination response. The gap is not a singular failure at one stage but a cascading discontinuity across allocation, administration, and uptake driven by interacting structural inequities, governance deficits, health-system limitations, and sociobehavioural barriers.

The vaccination continuum framework provides an analytically powerful lens for identifying where breakdowns occur and what category of intervention is needed. Supply alone is insufficient: governance capacity, health-system readiness, and community trust are the critical mediators of vaccination performance. Regulatory harmonisation (AVAREF, AMA, EAC-MRH), cold-chain investment, workforce surge capacity, surveillance–vaccination integration, and community trust-building are not secondary considerations they are primary determinants of whether allocated doses translate into administered protection.

Five policy pillars are recommended for strengthening future emergency vaccine deployment in Africa:

1. **Equity-Centred Allocation:** Risk-adjusted allocation algorithms that account for vulnerability, not just surveillance visibility.
2. **Regulatory Agility:** Pre-positioned EUA pathways and expanded AVAREF joint review capacity.
3. **Deployment Readiness:** Cold-chain investment, workforce training, and integrated surveillance-vaccination systems.
4. **Behavioural Preparedness:** institutionalised risk communication and misinformation monitoring; and
5. **Data and Accountability:** real-time utilisation dashboards, standardised reporting, and flexible reallocation mechanisms. These pillars collectively address the allocation–administration–uptake continuum and position Africa for more equitable and efficient vaccination responses to future public health emergencies.

Conflict of Interest

The author declares no conflict of interest.

Ethical Approval

This manuscript synthesises publicly available published and official secondary data. No primary data collection involving human participants was conducted; formal ethical approval was therefore not required.

Data Availability

This systematic review and mixed-methods synthesis is based entirely on publicly available published literature and official reports from WHO, Africa CDC, UNICEF, and Gavi. No original datasets were generated. All source studies and reports are cited in the reference list and are accessible through the respective publishers and institutional repositories.

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Author Contributions

- **Charles Ugochukwu Ibeneme:** Conceptualisation, methodology, formal analysis, data curation, writing original draft, review and editing.
- **Olaiya Paul Abiodun:** Supervision, review of methodology, analysis, data curation and original draft.
- **Glory Onyeugo:** Review of original draft, data curation, analysis and editing.
- **Lilian Maliro:** Review of original draft, data curation, analysis and editing.
- **Titilola Munkail:** Review of original draft, data curation, analysis and editing.
- **Folake Abiola Abiodun:** Review of original draft, data curation, analysis and editing.
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