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Preparedness of Health Facilities for Routine Childhood Immunization Services in Benin City, Nigeria: A Cross-Sectional Assessment

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ABSTRACT

Reliable routine immunization requires health facilities that can plan sessions, maintain the cold chain, deploy trained personnel, administer vaccines safely, manage data, and sustain commodity availability. This study assessed the preparedness of health facilities providing routine childhood immunization services in Benin City, Nigeria. A descriptive cross-sectional assessment was conducted among 112 of 165 routine-immunization facilities selected through multistage sampling with proportionate allocation across three Local Government Areas. Routine-immunization focal persons were interviewed using a pretested electronic supportive-supervision checklist; records were reviewed, required items were inspected, and planned sessions were observed in 88 facilities. Data were summarized using frequencies and percentages. Most facilities had updated microplans, session plans, monitoring charts, and functional electrical or solar cold-chain equipment. Routine equipment maintenance and temperature charts were documented in most facilities, but fewer than half had a contingency plan for temperature excursions. During observed sessions, vaccine administration, immediate sharps disposal, tallying, and vaccination recording were generally appropriate. However, only about half of the sessions had all required antigens, with rotavirus vaccine most frequently unavailable. Essential materials and data tools were available in most observed sessions. Facilities demonstrated generally strong planning, cold-chain functionality, staff practices, and data-tool availability, but important gaps persisted in emergency cold-chain planning, session implementation, and uninterrupted vaccine supply. Strengthening contingency planning, last-mile distribution, and routine readiness monitoring may reduce missed opportunities for vaccination.

INTRODUCTION

Immunization is one of the most effective public-health interventions for preventing childhood illness, disability and death. Its benefits, however, depend on both caregiver uptake and the capacity of health facilities to provide potent vaccines safely, consistently and at the scheduled time (WHO, 2020). Recent African evidence shows that routine-immunization services have not fully recovered from pandemic-related disruption and that large numbers of children remain zero-dose or under-vaccinated (Mboussou *et al.,* 2024). In Nigeria, missed vaccination reflects interacting demand- and supply-side barriers, including service availability, distance, security, workforce and logistical constraints (Mahachi *et al.,* 2022). Children may therefore remain unprotected even after reaching a facility when a session is canceled, a required antigen is unavailable, cold-chain integrity is uncertain or essential recording tools are absent (Gooding *et al.,* 2019; WHO, 2015). Facility preparedness is an important supply-side determinant of vaccination performance.

The Immunization Agenda 2030 emphasizes people-centred services, resilient supply chains, competent health workers and data-guided action (WHO, 2020). At facility level, these principles require current microplans, predictable fixed and outreach sessions, adequate staffing, functional cold-chain equipment, uninterrupted vaccine and commodity supplies, safe administration, adverse-event preparedness and complete recording tools. Preparedness is multidimensional because strength in one domain cannot compensate fully for failure in another. For example, trained health workers cannot vaccinate an eligible child when the required antigen is unavailable, while a functional refrigerator cannot guarantee vaccine potency without temperature monitoring and an emergency contingency plan.

Benin City comprises Oredo, Egor and Ikpoba-Okha Local Government Areas and includes public and private facilities at different levels of care. Although household determinants of childhood vaccination have been studied extensively, few published assessments have examined planning, cold-chain and waste management, workforce capacity and practice, vaccine and material availability, and immunization data management together within the city.

This study therefore assessed the preparedness of routine-immunization facilities across these operational domains to identify correctable gaps that may not be apparent from aggregate vaccination-coverage estimates.

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LITERATURE REVIEW

Microplanning links population needs with service delivery by defining target populations, settlements, session sites, schedules, personnel, vaccine requirements, transport and supervision needs. Its value depends on implementation because repeated cancellation of planned sessions increases caregivers' indirect costs, weakens trust and may contribute to incomplete vaccination. Evidence from Sindh, Pakistan, showed that many immunization centres lacked critical components for quality service delivery despite widespread staff training (Siddiqi *et al.,* 2022). Facility performance in western Uganda also varied by geographical location, and the presence of equipment alone did not ensure satisfactory programme performance (Magambo *et al.,* 2020). More recent studies show that partnership-supported microplanning and supportive supervision strengthened routine-immunization delivery in northern Nigeria, while geospatially enabled microplans improved target estimation and service planning in the Democratic Republic of Congo (Dougherty *et al.,* 2024; Ngo-Bebe *et al.,* 2025). Nigerian evidence also identifies training, supervision, financing and data validation as important enablers of integrated immunization delivery (Jimoh *et al.,* 2024). These findings support assessment of both the availability of plans and the actual conduct of scheduled fixed and outreach sessions.

Cold-chain readiness is essential because vaccines must remain within recommended temperature ranges from storage to administration. Temperature monitoring, preventive maintenance, correct storage and written contingency arrangements protect vaccine potency during power failure, equipment breakdown or transport disruption (WHO, 2015). Nigerian supply-chain evidence identifies weaknesses in infrastructure, financing, coordination, information systems and distribution as recurrent constraints (Olutuase *et al.,* 2022). A recent study among cold-chain officers in Ogun State further highlighted unreliable power, equipment deterioration, manpower limitations, difficult transportation and climatic disruptions (Ayowole *et al.,* 2025). Facility-level evidence from Kenya likewise demonstrates the importance of temperature control, stock management, cold-chain equipment and waste-management practices (Wanyonyi *et al.,* 2024). Facilities may therefore possess refrigerators but remain vulnerable when they lack alternative storage sites, emergency transport, designated responsible officers or procedures for managing a suspected temperature excursion.

Health-worker competence connects facility resources to safe service delivery. In Edo State, most primary-healthcare workers assessed by Uwaibi and Erah (2021) had received routine-immunization training, although recent training was less common. Training should be reinforced through supportive supervision and direct observation because correct dose, route, site, diluent selection, sharps disposal, caregiver communication and adverse-event documentation depend on consistent practice. Facility-based evidence from Addis Ababa found that provider communication and waiting time influenced caregiver satisfaction with childhood vaccination services (Tesfaye *et al.,* 2023), while Nigerian health workers identified training and integrated supervision as important enablers of service delivery (Jimoh *et al.,* 2024). Injection-safety lapses can expose children and staff to preventable infection risks, whereas inadequate communication may reduce caregivers' understanding of expected adverse events and return dates. Reliable vaccine and data systems are also central to preparedness. Vaccine stockouts have been associated with reduced immunization coverage in Nigeria because caregivers who overcome financial, geographical and social barriers may still leave a facility without vaccination (Gooding *et al.,* 2019). Forecasting, buffer stocks, timely redistribution and dependable last-mile delivery are therefore necessary (Olutuase *et al.,* 2022). Registers, tally sheets and summary forms are equally important for forecasting, monitoring dropout and identifying underserved populations. Nevertheless, availability of data tools does not by itself establish data quality. Saidu *et al.* (2023) documented inconsistencies between tally sheets and monthly reports in Cameroon, whereas a recent Ghanaian assessment found generally high verification factors but still identified discrepancies at some facilities (Piu *et al.,* 2024).

Facility-level assessment is particularly relevant in urban settings, where population density may improve geographical access but rapid population movement, informal settlements, varied facility ownership and uneven distribution of staff and equipment can create substantial differences in readiness. Administrative coverage estimates may conceal these differences because they aggregate doses across facilities and communities. An assessment combining interviews, record review, physical inspection and direct observation can distinguish the nominal availability of inputs from the reliability of service processes and identify bottlenecks that programme managers can address directly.

This distinction between inputs and functioning processes is important for programme management. A facility may have a microplan that is not implemented, cold-chain equipment without complete temperature records, trained personnel who deviate from safe injection procedures, or most antigens while lacking the vaccine required for a particular child. Reporting readiness domains separately is therefore more informative than relying on a single overall score. It enables supervisors to identify high-consequence failures, determine whether responsibility lies with facility management, training, supply-chain, cold-chain or data teams, and monitor corrective action using specific indicators. Periodic readiness assessment can consequently complement coverage monitoring by showing why apparently available services may not translate into successful vaccination encounters.

MATERIALS AND METHODS

Study Design and Setting

A descriptive cross-sectional facility assessment was undertaken in Benin City, Edo State, Nigeria, as the health-facility component of a broader mixed-methods study of factors influencing full childhood immunization. Benin City comprises 32 wards across Oredo, Egor and Ikpoba-Okha Local Government Areas. Routine immunization is coordinated in the state by the Edo State Primary Health Care Development Agency.

Study Population and Eligibility

The study population comprised health facilities implementing routine immunization and their routine-immunization focal persons. Facilities were eligible if they had actively provided routine immunization during the year preceding data collection. Focal persons were included after consent.

Sample Size and Sampling

The minimum facility sample was calculated using a prior estimate that 66% of facilities met critical criteria for quality immunization services (Siddiqi *et al.,* 2022), a 95% confidence level and 5% precision, followed by finite-population correction for the 165 eligible facilities. The resulting minimum was 111.58 and was rounded to 112 facilities. All three Local Government Areas and their wards were included. Settlements containing implementing facilities were identified, and facilities were selected systematically with proportional allocation by Local Government Area.

Data Collection

Data were collected using a pretested routine-immunization supportive-supervision checklist programmed in Open Data Kit. Trained study personnel interviewed focal persons, reviewed facility records and physically inspected the items recorded on the checklist. Domains included microplanning and session planning; fixed and outreach sessions; monitoring charts; vaccine receipt; cold-chain equipment, maintenance and temperature records; excursion contingency plans; vaccine-management tools; waste disposal; workforce training; injection safety; adverse-event preparedness; vaccine, commodity and data-tool availability; and data recorded for pentavalent-dose-3 and measles vaccination. Direct observation was completed when a planned session was taking place; consequently, session-practice indicators use a denominator of 88 rather than 112.

The use of three complementary verification approaches strengthened measurement. Interview responses described routine procedures and recent service activity; document review established whether plans, charts, registers, and management tools were available and updated; and physical inspection confirmed the presence and apparent functionality of equipment, vaccines, materials, and waste-disposal arrangements. Direct observation was reserved for facilities in which a planned session was occurring during the visit. Observed indicators therefore describe actual session practice in the 88 eligible facilities and were not extrapolated to facilities without an observed session.

Outcome Definition

Preparedness was treated as a multidimensional descriptive construct rather than a single validated score. Domain indicators were reported individually. This approach avoids assigning unvalidated weights to planning, cold-chain, workforce, commodity and information-system components.

Indicators were interpreted according to their relevant denominator. Facility-wide planning and cold-chain indicators used all 112 assessed facilities. Indicators that required a session, including observed administration practices and immediate availability of antigens, commodities, and data tools, used the 88 facilities with an observed session. Item-specific shortages were allowed to co-occur because a facility could lack more than one antigen or material. Data-source volumes were presented in categories from the available dataset; because exact paired facility values were not analyzed, the study did not estimate agreement statistics or claim record-level concordance.

Data Management and Analysis

Data were checked for completeness and consistency, exported from the Open Data Kit server to Microsoft Excel, and analyzed using IBM SPSS Statistics version 25. Categorical variables were summarized using frequencies and percentages. No causal or inferential associations are reported in this facility-readiness analysis.

The analysis was intentionally descriptive. Frequencies quantified the number of facilities or sessions meeting each criterion, while percentages aided comparison across indicators with the same denominator. A composite preparedness index was not calculated because the checklist domains represent distinct operational functions, and no validated weighting scheme was available for combining them. This approach preserves transparency: a programme manager can identify the specific deficiency requiring action rather than interpret an average score that could mask a critical failure.

Ethical Considerations

Ethical approval was obtained from the Ethics and Research Committee of the University of Benin Teaching Hospital, and permission was obtained from the Edo State Primary Health Care Development Agency. Participants provided informed consent and were assured of confidentiality and their right to withdraw.

RESULTS AND DISCUSSION

Results

Planning and Session Implementation

Of the 112 facilities, 91 (81.3%) had an updated microplan and 100 (89.3%) had an updated immunization

session plan. More than one-third had conducted no outreach session during the preceding month. Although 98 (87.5%) reported that all sessions planned for the preceding month were conducted, a planned session was occurring in only 88 (78.6%) facilities at the assessment visit. Nearly all facilities collected vaccines rather than receiving facility delivery.

Table 1: Planning and operational readiness for routine immunization (N = 112)

Indicator	n	%
Updated microplan available	91	81.3
Microplan updated within preceding 6 months	88	78.6
Updated immunization session plan available	100	89.3
No fixed-post session in preceding month	11	9.8
No outreach session in preceding month	40	35.7
All sessions planned for preceding month conducted	98	87.5
Updated routine-immunization monitoring chart	93	83.0
Vaccines collected by facility	109	97.3
Vaccines delivered to facility	3	2.7

Percentages use 112 facilities as the denominator. Categories for vaccine receipt are mutually exclusive

Cold-Chain and Waste-Management Readiness

Functional electrical or solar cold-chain equipment was present in 98 (87.5%) facilities. Routine maintenance and equipment-specific temperature charts were documented in 89 (79.5%). The largest cold-chain preparedness gap was emergency continuity: only 53 (47.3%) facilities had a contingency plan for a temperature excursion. Appropriate waste-disposal arrangements were reported by 107 (95.5%).

Table 2: Cold-chain, vaccine-management and waste-disposal readiness (N = 112)

Indicator	n	%
Electrical or solar cold-chain equipment available	98	87.5
Cold-chain equipment fully functional	98	87.5
Daily, weekly and monthly equipment maintenance conducted	89	79.5
Temperature chart present on each item of equipment	89	79.5
Vaccines stored appropriately	100	89.3
Contingency plan for a temperature excursion	53	47.3
Updated vaccine-management tools (VM1a and VM1b)	94	83.9
Appropriate waste-disposal system or plan	107	95.5

Table 3: Health-worker capacity and observed immunization practices (N = 88 sessions)

Indicator	n	%
Formally trained in routine immunization within preceding year	76	86.4
Knew expected target population for session	88	100.0
Knew safe vaccine-vial-monitor stages	88	100.0
Used correct diluent	88	100.0
Administered correct dose by correct route and site	88	100.0
Used one syringe/needle for each dose	80	90.9
Immediately discarded used syringe/needle into safety box	88	100.0
Tallied each administered vaccine correctly	88	100.0
Recorded vaccination correctly on child card	88	100.0
Provided six key messages to caregiver	88	100.0
Knew definition of adverse event following immunization	75	85.2
Maintained updated adverse-event records	76	86.4

The denominator is the 88 facilities in which a planned routine-immunization session was observed

Observed Service-Delivery Practices

Planned sessions were observed in 88 facilities, all of which were fixed-post sessions. All observed health workers knew the target population and the vaccine-vial-monitor stages considered safe for use. Correct diluent selection, vaccine administration, immediate sharps disposal, tallying, child-card documentation and delivery of six key caregiver messages were observed in every session. Eight workers (9.1%) did not use one syringe and needle for each administered dose. Knowledge of the definition of an adverse event following immunization and updated adverse-event records were present in 85.2% and 86.4%, respectively.

Vaccine, Material and Data-Tool Availability

All required antigens were available in 46 (52.3%) observed sessions. Rotavirus vaccine was the most frequently unavailable antigen, missing in 36 (40.9%) sessions, followed by oral poliovirus vaccine in 15 (17.0%). Most sessions had all assessed materials and data tools available. Because multiple antigens or materials could be absent in one facility, item-specific percentages are not mutually exclusive.

Table 4: Availability of antigens, session materials and data tools (N = 88 sessions)

Indicator	n	%
All required antigens available	46	52.3
Rotavirus vaccine unavailable	36	40.9
Oral poliovirus vaccine unavailable	15	17.0
Measles vaccine unavailable	2	2.3
Meningococcal A vaccine unavailable	2	2.3
Inactivated poliovirus vaccine unavailable	2	2.3
All assessed session materials available	83	94.3
All assessed data tools available	80	90.9

Item-specific antigen shortages could co-occur; percentages therefore need not sum to 100%. 'All assessed data tools available' corresponds to 'none missing' on the original checklist

Data Recording

The grouped distributions for pentavalent-dose-3 and measles vaccinations were identical across the child-health monthly summary register, tally sheet and NHMIS summary form. This aggregate similarity should not be interpreted as a validated record-level concordance measure because individual facility values were grouped before presentation.

Table 5: Reported vaccination volumes across routine-immunization data sources (N = 112)

Indicator	n	%
PENTA 3 — each of register, tally sheet and NHMIS form		
0–20 children	59	52.7
21–40 children	27	24.1
≥41 children	26	23.2
Measles — each of register, tally sheet and NHMIS form		
0–50 children	88	78.6
51–100 children	15	13.4
≥101 children	9	8.0

The three data sources had identical aggregate category distributions. Record-level agreement was not calculated

Discussion

Planning and Implementation of Immunization Sessions

Most health facilities had updated microplans, immunization session plans and monitoring charts, and generally implemented their planned sessions. This may be explained by the established coordination of routine immunization by the Edo State Primary Health Care Development Agency, periodic supportive supervision and the use of standard planning and monitoring tools by facility focal persons. The finding is important because effective microplanning links target populations to fixed and outreach services, supports rational allocation of vaccines and personnel, and reduces the risk that eligible children will be missed. It also promotes predictable service delivery, which helps sustain caregivers' confidence in the health system. The finding suggests better organizational readiness than that reported by Siddiqi *et al.* in Sindh, Pakistan, where one out of every three immunization centres lacked critical components required for quality vaccination services (Siddiqi *et al.,* 2022). It also contrasts with the health-facility assessment by Magambo *et al.*

in western Uganda, where most facilities had poor immunization-programme performance and performance varied with geographic location (Magambo *et al.,* 2020). Nevertheless, the absence of recent outreach sessions in several facilities suggests that planning did not always translate into services beyond the fixed post. Supportive supervision should therefore routinely compare planned with conducted sessions, document reasons for missed sessions and ensure that outreach plans reflect the needs of underserved settlements. Similar improvements in session planning, supervision and programme accountability were reported following a multi-partner routine-immunization initiative in six northern Nigerian states (Dougherty *et al.,* 2024). Geospatially enabled microplanning in the Democratic Republic of Congo also improved population estimation and the planning of routine-immunization activities (Ngo-Bebe *et al.,* 2025), while Nigerian health workers described training, supervision, financing and data validation as practical enablers of integrated service delivery (Jimoh *et al.,* 2024). The difference between the proportion reporting that all planned sessions had been conducted and the smaller proportion with a session occurring at the assessment visit should be interpreted cautiously because the measures cover different time frames. Nevertheless, it highlights the importance of validating reported implementation against session calendars and other routine evidence. Facilities may postpone sessions because of staff absence, vaccine collection delays, competing clinical duties, low expected attendance, transport constraints, or changes in local demand. Each explanation requires a different response. Supervision should therefore move beyond confirming the presence of a plan to documenting whether each planned session occurred, why any session was missed, and how affected caregivers were informed or redirected. The limited recent outreach activity also has equity implications. Fixed-post services tend to benefit caregivers who live near facilities, can travel during operating hours, and can absorb transport and waiting costs. Children in peripheral settlements, mobile households, or families with inflexible work schedules may depend more heavily on outreach. A programme can therefore appear operationally strong while systematically missing groups that are less able to reach fixed services. Periodic mapping of underserved settlements, defaulters, and zero-dose children should inform outreach frequency and site selection, while session plans should be adjusted when population movement or service-use patterns change.

Cold-Chain and Waste-Management Preparedness

Most facilities had functional cold-chain equipment, maintained the equipment, monitored storage temperatures and stored vaccines appropriately; however, contingency planning for temperature excursions was inadequate. The generally favourable cold-chain findings may reflect investment in electrical and solar equipment, regular vaccine-management supervision and the presence of trained routine-immunization focal persons. The gap in contingency planning may arise because facilities focus on normal equipment operation but give less attention to power failure, equipment breakdown, transport interruptions and emergency relocation of vaccines. This is of considerable public-health importance because loss of cold-chain integrity may reduce vaccine potency, waste scarce resources, create missed vaccination opportunities and erode public trust if ineffective vaccines are administered. The finding is consistent with the study by Magambo *et al.* in Uganda, where most assessed facilities had an Expanded Programme on Immunization refrigerator, although overall programme performance remained suboptimal (Magambo *et al.,* 2020). It also broadly compares favourably with the multicentre assessment in Sindh, where important gaps persisted despite most vaccinators having received training in vaccination and cold-chain management (Siddiqi *et al.,* 2022). Every vaccine-storage facility should maintain a written, accessible and periodically rehearsed temperature-excursion plan specifying alternative storage sites, transport arrangements, responsible officers, emergency contacts and procedures for quarantining and documenting exposed vaccines. The identified vulnerability is supported by Nigerian evidence describing infrastructure, financing and distribution weaknesses across vaccine supply chains (Olutuase *et al.,* 2022). It is also consistent with recent findings from Ogun State, where cold-chain officers reported equipment damage, power and transport constraints and manpower shortages (Ayowole *et al.,* 2025), and with a Kenyan facility assessment that emphasized temperature and stock-management gaps despite the availability of cold-chain equipment (Wanyonyi *et al.,* 2024).

The coexistence of functional equipment and weak contingency planning shows why routine functionality should not be equated with resilience. Solar or electrical equipment can perform well under normal conditions yet fail suddenly, and urban congestion or transport delays may complicate emergency relocation of vaccines. A contingency plan should be facility-specific, readily accessible, and understood by more than one staff member. It should identify who confirms an excursion, where vaccines will be transferred, how transport and cold boxes will be obtained, which contacts will be notified, and how exposed stock will be labelled, quarantined, assessed, and documented. Periodic simulation can reveal practical barriers that a written document alone may not detect.

Strong waste-disposal arrangements complement cold-chain readiness by reducing occupational and community exposure to used sharps and contaminated materials. Waste management should be assessed as a continuous pathway from immediate disposal at the vaccination station to temporary storage, collection, treatment, and final disposal. The high level of reported readiness is encouraging, but supervision should verify that safety boxes are not overfilled, storage areas are secure, and collection or treatment occurs before accumulated waste

becomes a hazard. Integrating these checks into routine supportive supervision can sustain safe practice beyond the assessment period.

Health-Worker Capacity and Observed Practices

Health workers generally demonstrated appropriate vaccine-administration, recording, caregiver-communication and waste-disposal practices, although gaps remained in injection safety and adverse-event knowledge and documentation. These favourable practices may be attributable to recent formal training, on-the-job coaching during supportive supervision and repeated use of standardized procedures during routine sessions. Their public-health relevance lies in ensuring that vaccines are administered safely and effectively, that doses are captured for programme monitoring and that caregivers receive information needed to complete the immunization schedule. Conversely, failure to use a separate syringe and needle for every dose can expose children and health workers to avoidable infection risks, while poor adverse-event preparedness may delay recognition and response and weaken vaccine confidence. The finding is similar to that of Uwaibi and Erah in Edo State, who reported that most primary-healthcare workers had received routine-immunization training, but differs in that relatively few workers in their study had been trained within the preceding year (Uwaibi & Erah, 2021). It is also more favourable than the Sindh assessment, where most workers were trained in vaccination and cold-chain management but training in inventory management was comparatively limited (Siddiqi *et al.,* 2022). Regular competency-based refresher training and supportive supervision should therefore retain the strong practices while immediately correcting injection-safety lapses and strengthening adverse-event recognition, documentation and reporting. The importance of provider behaviour is reinforced by evidence from Addis Ababa, where communication about vaccines and shorter waiting time were associated with greater caregiver satisfaction (Tesfaye *et al.,* 2023). Nigerian health workers have similarly identified training and integrated supportive supervision as enablers of immunization service quality (Jimoh *et al.,* 2024).

Universal performance on several observed tasks may reflect both genuine standardization and the effect of being observed. Health workers who know that their practice is under assessment may adhere more closely to recommended procedures than during unobserved sessions. This possibility does not negate the favourable findings, but it supports continued supervision using coaching and periodic observation rather than assuming that one successful assessment guarantees sustained performance. Competency review should focus particularly on the small number of injection-safety deviations because the consequences of unsafe reuse are disproportionate to their frequency.

Adverse-event preparedness is also central to public confidence. Health workers should be able to recognize events that require reporting, provide immediate clinical care, document the event accurately, and communicate risk without creating unnecessary alarm. Updated records help programme managers detect patterns and investigate signals, whereas incomplete knowledge may delay response. Refresher training should therefore combine definitions with practical scenarios, reporting pathways, emergency supplies, and communication skills. Facilities should also display current contact information for escalation and ensure that responsibility is clear when the routine-immunization focal person is absent.

Availability of Vaccines, Materials and Data Tools

Complete antigen availability was inadequate during the observed sessions, with rotavirus vaccine accounting for much of the shortfall, although essential materials and data tools were generally available. The shortage may be related to forecasting difficulties following the introduction of rotavirus vaccine, delayed resupply, inadequate buffer stocks, distribution constraints or the requirement for facilities to collect vaccines rather than receive last-mile delivery. This finding has major public-health implications because a stockout converts a successful facility visit into a missed opportunity for vaccination, increases the cost of returning for caregivers, contributes to delayed or incomplete immunization and may reduce confidence in routine services. It is consistent with Gooding *et al.,* who demonstrated that vaccine stockouts adversely affected immunization coverage in Nigeria (Gooding *et al.,* 2019). The finding is also comparable with Siddiqi *et al.,* who identified missing critical service components in immunization centres in Sindh (Siddiqi *et al.,* 2022). Vaccine forecasting should incorporate actual consumption, target populations and session plans; stock levels should be monitored frequently; redistribution between nearby facilities should occur before shortages develop; and the feasibility of strengthening last-mile delivery should be assessed. This interpretation is further supported by a Nigerian scoping review that identified procurement, infrastructure, financing, information and distribution constraints across medicines and vaccine supply chains (Olutuase *et al.,* 2022).

The pattern of shortages indicates that overall commodity readiness can conceal antigen-specific vulnerability. A facility with most vaccines may still fail to provide age-appropriate vaccination if the missing antigen is due at that visit. Rotavirus-vaccine shortages are especially important because the recommended schedule has age-related constraints and delayed access may narrow the opportunity for completion. Stock monitoring should therefore use antigen-specific minimum and maximum levels rather than a general judgement that vaccines are available. Consumption trends, target populations, session schedules, wastage, and lead times should inform orders, while nearby facilities should have a defined process for timely redistribution.

The predominance of facility collection over delivery may transfer transport costs, time, and cold-chain

responsibility to service points. This arrangement can be workable when collection schedules are predictable and facilities have suitable carriers and transport, but it may disadvantage small or resource-constrained facilities. Programme managers should examine whether collection frequency, distance, staff availability, and transport reliability are associated with shortages. Strengthening last-mile distribution does not necessarily require a single delivery model; scheduled delivery, hub-and-spoke collection, pooled transport, or targeted support for high-risk facilities may each be appropriate depending on local logistics.

Routine-Immunization Data Management

The grouped vaccination volumes were identical across the child-health register, tally sheet and NHMIS summary form, suggesting that facilities may have transferred reported totals consistently across the three tools. This may reflect availability of standard data tools, familiarity with monthly reporting procedures, supportive supervision and routine reconciliation before submission. Reliable immunization data are of public-health importance because they guide target setting, vaccine forecasting, identification of underserved populations, monitoring of dropout and allocation of programme resources. However, identical grouped distributions do not establish record-level concordance and could conceal discrepancies within the broad categories used in the analysis. This apparent consistency contrasts with the study by Saidu *et al.* in Cameroon, where pentavalent-dose-3 values differed between tally sheets and monthly reports in more than half of assessed facilities and substantial gaps were found in tool use and staff knowledge (Saidu *et al.,* 2023). The exact facility-level counts should therefore be compared across source documents using absolute and relative discrepancies, completeness and timeliness indicators before concluding that the data are concordant; routine data-quality audits and feedback should then target the errors identified. A recent Ghanaian facility assessment found high overall verification factors for pentavalent-vaccine data but still detected under-reporting and over-reporting in individual facilities, demonstrating why aggregate consistency should not replace record-level verification (Piu *et al.,* 2024).

The identical grouped distributions across the three data sources are reassuring only at a broad descriptive level. When values are grouped into ranges, different facility counts can fall within the same category, and transcription errors may remain invisible. A more rigorous data-quality assessment would compare exact values facility by facility and calculate absolute differences, relative discrepancies, completeness, timeliness, and internal consistency. It would also trace selected children or doses from the register to the tally sheet and monthly report. This distinction should guide interpretation: the present results describe similar category distributions, not verified agreement between source documents.

Data-quality improvement should be embedded in routine work rather than reserved for periodic audits. At the end of each session, vaccinators can reconcile opened vials, doses administered, tallies, and child-card entries. Monthly review can then compare register totals with tally sheets and summary forms, investigate discrepancies, and document corrections. Feedback is essential because repeated identification of errors without explanation or coaching may not change practice. Simple dashboards that pair data-quality indicators with service indicators can help managers detect whether an apparent decline reflects reduced delivery, incomplete recording, or both.

Overall Public-Health Interpretation

Taken together, the findings indicate that Benin City has a relatively strong operational platform for routine immunization, but weaknesses at a few high-consequence points could interrupt the pathway from planning to effective vaccination. Good plans and trained workers cannot protect a child when a session is not conducted, a required antigen is unavailable or vaccine potency is compromised during an unmanaged temperature excursion. This systems interpretation is consistent with the Immunization Agenda 2030 emphasis on people-centred services, resilient supply chains, partnerships and data-guided action (WHO, 2020). Programme managers should therefore avoid treating preparedness as a single average score and instead use a small dashboard of tracer indicators—session implementation, antigen availability, excursion preparedness, safe injection and data concordance—to trigger timely corrective action. This emphasis is timely because the African Region continues to carry a substantial burden of zero-dose and under-vaccinated children and reported administrative coverage can differ from international estimates (Mboussou *et al.,* 2024). Nigerian evidence similarly shows that service-delivery constraints contribute to zero-dose and missed-dose vaccination (Mahachi *et al.,* 2022).

Strengths and limitations

The study assessed a large proportion of the routine-immunization facilities in Benin City and combined focal-person interviews with record review, physical inspection and direct observation. Proportionate sampling across all three Local Government Areas improved geographic representation. Several limitations should be considered. The cross-sectional design captured readiness at one point in time and cannot establish trends or causal effects on vaccination coverage. Direct observation was possible in only 88 facilities and may have altered health-worker behaviour. Some indicators relied on facility reports or documentation and may be affected by reporting bias. The assessment did not construct or validate a composite readiness score, did not stratify results by ownership or level of care, and did not test associations between readiness indicators and child-level vaccination outcomes. Finally, the grouped data-management table cannot establish facility-level agreement between source documents.

The study also did not assess caregiver experience, waiting time, service hours, informal costs, or the

relationship between facility readiness and population vaccination coverage. These dimensions may influence whether available services are actually used. Private and public facilities may face different supply and reporting arrangements, but the available analysis could not compare them. Future assessments should include ownership and level of care, repeat observation across different days, link readiness indicators to stock records and coverage outcomes, and consider qualitative enquiry into the causes of missed sessions and recurrent shortages.

Programmatic Implications

• Require every vaccine-storage facility to maintain and periodically rehearse a written temperature-excursion contingency plan.

• Use supportive supervision to reconcile planned versus conducted fixed and outreach sessions and document reasons for cancellations.

• Strengthen forecasting, redistribution and last-mile delivery, prioritizing antigens with recurrent shortages.

• Correct injection-safety deviations immediately and reinforce adverse-event recognition, documentation and reporting.

• Audit exact facility-level counts across registers, tally sheets and NHMIS forms rather than inferring concordance from grouped distributions.

• Repeat facility-readiness assessments periodically and stratify findings by Local Government Area, facility ownership and level of care.

Implementation should prioritize a small set of measurable actions. Each facility should maintain evidence that planned sessions occurred, record and escalate antigen-specific stock risks, and rehearse a temperature-excursion plan. Supervisors should verify injection safety and adverse-event readiness through observation, while data review should use exact source values rather than broad categories. These actions are feasible within routine programme management and can be tracked over time without requiring an unvalidated composite preparedness score.

CONCLUSION

Health facilities providing routine childhood immunization in Benin City were generally well prepared in planning, cold-chain functionality, health-worker practices, waste management and availability of materials and data tools. Preparedness was not uniform: contingency planning for temperature excursions was inadequate, some planned sessions were not implemented and complete antigen availability was achieved in only about half of observed sessions. Targeted improvement in emergency cold-chain planning, session reliability and vaccine supply management could strengthen service continuity and reduce missed opportunities for vaccination.

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Declarations

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Author contribution: EDO conceived the study, collected and analyzed the data, interpreted the findings, and drafted and approved the final manuscript.

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REFERENCES

Ayowole, D. J., Adebajo, G. O., Lasisi, T. O., & Bakai, J. G. (2025). Effects of climate change on vaccine storage and cold chain logistics: A qualitative study in Ogun State, Nigeria. *BMJ Global Health, 10*(7), e018990. https://doi.org/10.1136/bmjgh-2025-018990

Dougherty, L., Adediran, M., Akinola, A., Alabi, M., Etim, E.-O., Ohioghame, J., & Adedimeji, A. (2024). An evaluation of a multi-partner approach to increase routine immunization coverage in six northern Nigerian states. *BMC Health Services Research, 24,* 951. https://doi.org/10.1186/s12913-024-11403-3

Gooding, E., Spiliotopoulou, E., & Yadav, P. (2019). Impact of vaccine stockouts on immunization coverage in Nigeria. *Vaccine, 37*(35), 5104–5110. https://doi.org/10.1016/j.vaccine.2019.06.006

Jimoh, A. U., Filani, O., Awobeku, D., Isiaka, S. D., Dauda, M., Adeshina, E. O., Samuel, O. W., Ayodeji, O. A., Adenipekun, S. A., Okoh, C., Adediran, K., Atobatele, S., Sampson, S., Tinuoye, T., Seluwa, A., Ojo, N., & Omoya, S. (2024). Qualitative assessment of the enablers and barriers of COVID-19 vaccination integration into routine immunization programme at primary health care facilities in Ekiti State, Nigeria. *Discover Public Health, 21,* 94. https://doi.org/10.1186/s12982-024-00217-7

Magambo, N. K., Bajunirwe, F., & Bagenda, F. (2020). Geographic location of health facility and immunization program performance in Hoima District, western Uganda: A health facility-level assessment. *BMC Public Health, 20,* 1764. https://doi.

org/10.1186/s12889-020-09944-1

Mahachi, K., Kessels, J., Boateng, K., Jean Baptiste, A. E., Mitula, P., Ekeman, E., Nic Lochlainn, L., Rosewell, A., Sodha, S. V., Abela-Ridder, B., & Gabrielli, A. F. (2022). Zero- or missed-dose children in Nigeria: Contributing factors and interventions to overcome immunization service delivery challenges. *Vaccine, 40*(37), 5433–5444. https://doi.org/10.1016/j.vaccine.2022.07.058

Mboussou, F., Kada, S., Danovaro-Holliday, M. C., Farham, B., Gacic-Dobo, M., Shearer, J. C., Bwaka, A., Amani, A., Ngom, R., Vuo-Masembe, Y., Wiysonge, C. S., & Impouma, B. (2024). Status of routine immunization coverage in the World Health Organization African Region three years into the COVID-19 pandemic. *Vaccines, 12*(2), 168. https://doi.org/10.3390/vaccines12020168

Ngo-Bebe, D., Mechael, P., Kwilu, F. N., Bukele, T. K., Langwana, F., Lobukulu, G. L., Kalonji, M. I., Kalalizi, B., Tschirhart, K., Luhata, C. L., & Gachen, C. (2025). Assessing the use of geospatial data for immunization program implementation and associated effects on coverage and equity in the Democratic Republic of Congo. *BMC Public Health, 25,* 311. https://doi.org/10.1186/s12889-025-21578-x

Olutuase, V. O., Iwu-Jaja, C. J., Akuoko, C. P., Adewuyi, E. O., & Khanal, V. (2022). Medicines and vaccines supply chains challenges in Nigeria: A scoping review. *BMC Public Health, 22,* 11. https://doi.org/10.1186/s12889-021-12361-9

Piu, L. J., Owusu-Marfo, J., Agyeman, Y. N., Kolekang, A. S., & Kissi, J. (2024). Assessment of expanded programme on immunization routine data quality in the Upper East Region of Ghana. *BMC Health Services Research, 24,* 886. https://doi.org/10.1186/s12913-024-11347-8

Saidu, Y., Gu, J., Ngenge, B. M., Nchinjoh, S. C., Adidja, A., Nnang, N. E., Muteh, N. J., Zambou, V. M., Mbanga, C., Agbor, V. N., Ousmane, D., Njoh, A. A., Flegere, J., Diack, D., Wiwa, O., Montomoli, E., Clemens, S. A. C., & Clemens, R. (2023). Assessment of immunization data management practices in Cameroon: Unveiling potential barriers to immunization data quality. *BMC Health Services Research, 23,* 1033. https://doi.org/10.1186/s12913-023-09965-9

Siddiqi, D. A., Abdullah, S., Dharma, V. K., Khamisani, T., Shah, M. T., Setayesh, H., Khan, A. J., & Chandir, S. (2022). Assessment of vaccination service delivery and quality: A cross-sectional survey of over 1300 health facilities from 29 districts in Sindh, Pakistan, conducted between 2017–18. *BMC Health Services Research, 22,* 727. https://doi.org/10.1186/s12913-022-08098-9

Tesfaye, E., Debie, A., Sisay, F., & Tafere, T. Z. (2023). Maternal satisfaction on quality of childhood vaccination services and its associated factors at public health centers in Addis Ababa, Ethiopia. *BMC Health Services Research, 23,* 1315. https://doi.org/10.1186/s12913-023-10174-7

Uwaibi, N. E., & Erah, F. O. (2021). Assessment of healthcare workers' implementation of childhood routine immunization in primary healthcare centres in Edo State, Nigeria: A mixed-method survey. *Annals of Clinical and Biomedical Research, 2*(1). https://doi.org/10.4081/acbr.2021.117

Wanyonyi, E. N., Sagwa, E., Banzimana, S., & Asingizwe, D. (2024). Vaccine storage and stock management practices in Vihiga County, Kenya. *Journal of Pharmaceutical Policy and Practice, 17*(1), 2337128. https://doi.org/10.1080/20523211.2024.2337128

World Health Organization. (2015). *How to monitor temperatures in the vaccine supply chain.* https://iris.who.int/handle/10665/183583

World Health Organization. (2020). *Immunization agenda 2030: A global strategy to leave no one behind.* https://www.who.int/teams/immunization-vaccines-and-biologicals/strategies/ia2030