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Strong at the Center, Fragile at the Periphery: Multi-Tier Evaluation of Effective Vaccine Management in Ghana

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Abstract

Background: Effective vaccine management is vital for safeguarding vaccine potency and attaining high immunization coverage. This study evaluated Ghana's immunization supply chain using the World Health Organization's (WHO) Effective Vaccine Management (EVM) framework to identify operational strengths and systemic vulnerabilities.

Methods: A descriptive cross-sectional study was conducted across nine administrative regions of Ghana, encompassing 17 districts, 18 hospitals, and 68 sub-district facilities (34 health centers and 33 community-based health planning and services [CHPS] compounds). Data were collected from July to August 2024 using the standardized WHO EVM 1.0 tool through structured interviews, observational inspections, and document reviews. Five primary criteria were assessed: temperature control, stock management, vaccine distribution, vaccine management policies, and information systems. At the regional level, two additional criteria (building, equipment, transport and maintenance) were assessed. Performance was benchmarked against the WHO minimum standard threshold of 80%.

Results: Performance varied markedly across administrative tiers. Regional cold rooms consistently achieved the 80% benchmark across all criteria, except for stock management in the Eastern Region (79%) and distribution in the Eastern (41%) and Volta (64%) Regions. In contrast, operational-level facilities exhibited significant shortfalls. Temperature control compliance dropped to 52% at the lowest-performing facility (Lower Dodowa CHPS), with 5.9% of districts, 27.8% of hospitals, 20.6% of health centers, and 29.4% of CHPS failing to achieve the 80% standard. Stock management was below the benchmark in 23.5% of districts, 27.8% of hospitals, 55.9% of health centers, and 64.7% of CHPS compounds. Distribution targets were unmet by 41.2% of districts, 22.2% of hospitals, 23.5% of health centers, and 29.4% of CHPS compounds. Information systems constituted the most critical vulnerability across primary care facilities, falling below the benchmark in 52.9% of districts, 50.0% of hospitals, 76.5% of health centers, and 88.2% of CHPS compounds.

Conclusion: Although the central and regional tiers demonstrated robust capacity, vaccine management remains fragile at the subdistrict and primary healthcare facility levels. Targeted interventions are urgently required to upgrade cold chain infrastructure, optimize last-mile logistics, improve stock governance, and enhance health worker capacity for data management to ensure vaccine security and efficacy in Ghana.

Keywords: Appraisal, Immunization programme, Effective Vaccine Management (EVM), cold chain, Ghana, primary healthcare

Background

Immunization remains one of the most cost-effective and impactful public health interventions globally, substantially reducing the morbidity and mortality associated with vaccine-preventable diseases [1]. Vaccines are thermosensitive biological products that rely on an unbroken cold chain, a temperature-controlled supply chain maintained between +2°C and +8°C from manufacture to the point of administration, to preserve their immunogenicity and potency [2]. Cold chain breaches compromise vaccine efficacy, potentially resulting in programmatic failure, vaccine wastage, loss of public trust, and outbreaks of preventable infectious diseases [3].

To systematically assess and strengthen national immunization supply chains, the World Health Organization (WHO) and UNICEF established the Effective Vaccine Management (EVM) initiative [4]. The framework evaluates supply chain performance across nine core criteria: vaccine arrival procedures; temperature monitoring and control; cold storage, dry storage, and transport capacity; suitability of buildings, cold chain equipment, and vehicles; maintenance infrastructure for equipment and transport assets; stock management systems; distribution efficiency between supply chain tiers; adoption and implementation of vaccine management policies; and information systems and supportive management functions.

Although EVM 2.0 has been introduced, the EVM 1.0 assessment tool was used in this investigation to maintain direct longitudinal comparability with prior national assessments conducted in Ghana in 2010 and 2014 [5].

Historical EVM assessments in Ghana have identified substantial system-wide vulnerabilities, with scores for critical indicators, such as temperature monitoring, failing to reach the WHO minimum target of 80% [6]. Subsequent district-level evidence from the Tolon District [7] corroborated these operational challenges, showing that no assessed facility achieved the 80% benchmark across the evaluated EVM criteria. These persistent bottlenecks pose direct risks to the objectives of the Expanded Programme on Immunization (EPI). Accordingly, this study evaluated the vaccine supply chain across multiple administrative levels in Ghana to assess its

current performance, quantify operational bottlenecks, and generate evidence-based targets for strategic supply chain interventions.

Methods

Study Design and Setting

A descriptive, health facility-based cross-sectional study was conducted between July and August 2024 across nine administrative regions of Ghana, representing over 50% of the country's regions. Ghana has a decentralized immunization supply chain managed through the Ghana Health Service and aligned with the national Expanded Programme on Immunization (EPI). Vaccines are procured and received centrally and distributed through a tiered system comprising national, regional, district, and service-delivery levels. The system relies on a temperature-controlled cold chain, with vaccines generally maintained at recommended temperatures from central storage through regional and district stores to health facilities and community-based services, including Community-based Health Planning and Services (CHPS) compounds. At the service-delivery level, routine immunization is provided through health centres, hospitals, CHPS compounds, outreach services, and other designated vaccination points.

Sampling

A multi-stage sampling procedure was used to select participating sites: first, the sixteen administrative regions were stratified into three economic zones: higher, middle, and lower, and two regions were randomly selected from each stratum. Within each selected region, districts were stratified into urban, peri-urban, and rural categories, and two districts were randomly selected from each stratum. Within each selected district, four health centers and Community-based Health Planning and Services (CHPS) compounds were each selected using simple random sampling. Data from one regional cold room, one district health directorate store, and one CHPS compound were inadequately collected and were therefore excluded from

the final analysis. The analysis included eight regional cold rooms, 17 district health directorate stores, 18 district hospital/polyclinic stores, 34 health centers, and 33 CHPS compounds. Health personnel designated as the cold chain manager or responsible logistics management at each selected site completed the questionnaire and provided the required information for the assessment.

Data Collection Tools and Procedures

Data collection utilized the standardized WHO EVM 1.0 diagnostic software application (2010 release) with embedded questionnaire (supplementary file 1) [5]. The tool was administered through structured interviews with designated cold chain personnel, paired with direct physical inspection of cold chain hardware, continuous temperature monitors, and on-site document reviews (e.g., daily temperature charts, stock ledgers, requisition forms, and vaccine wastage logs). The appraisal focused on five of the nine EVM criteria from the district to the CHPS compound levels: E2 (Temperature Control): Storage within the mandatory +2°C to +8°C threshold and routine temperature tracking; E6 (Stock Management): Reliability of inventory ledgers, physical count verifications, and wastage control; E7 (Distribution): Efficiency and cold maintenance during intermediate transport; E8 (Vaccine Management): Adherence to standard policies, including multi-dose vial policies (MDVP) and Shake Test procedures; E9 (Information Systems): Integrity of logistics management information systems (LMIS) and data utilization for decision-making. At the regional level, two additional criteria: E4 (Buildings, cold chain equipment, and transport systems) enable the vaccine and consumables supply chain to function effectively and E5 (Maintenance of buildings, cold chain equipment, and vehicles) was satisfactory were assessed.

Data Analysis

Field data were entered into the WHO EVM application, which synthesized composite criterion scores using standardized algorithms. Scores are presented as percentages. In accordance with WHO standards, a score of ≥80% was established as the minimum benchmark for programmatic

effectiveness. For presentation and interpretation, scores were colour-coded as follows: green for scores ≥90%, black for scores of 80–89%, indicating performance that met the minimum benchmark, and red for scores <80%, indicating performance below the WHO benchmark.

Ethical Considerations

Ethical clearance was granted by the Ghana Health Service Ethical Review Committee (Ref: GHS-ERC: 065/04/24). Administrative gatekeeper approvals were obtained from all participating regional and district health directorates. Written informed consent was obtained from all participants following full disclosure of study objectives, institutional procedures, and potential risks and benefits.

Results

Performance Across Eight Regional Cold Rooms

Table 1 and Figure 1 show the performance of eight regional cold rooms across the seven assessed EVM criteria. All eight regional facilities met or exceeded the 80% benchmark for temperature control (range: 80% to 100%). Building, equipment, and transport had 87.5% of the regions meeting the benchmark, with only the Volta region (60%) not meeting it. Three (37.5%) of the regional facilities met the 80% target (range: 40% to 100%). In Stock Management, seven of the eight regions (87.5%) met the standard, with only the Eastern Region (ER) scoring slightly below (79%). Performance in Distribution showed substantial variation; although the regional average reached 81%, Eastern Region (41%) and Volta Region (VR, 64%) fell short of the threshold. Vaccine Management was consistently strong, with all regions exceeding the target (range: 82% to 95%; mean: 88%). Information Systems averaged 89%, with Greater Accra (GAR) and Northern Region (NR) scoring 100% and 99% respectively, while Upper East Region (UER) scored below the threshold at 70%. The mean scores ranged from 72% from Maintenance to 94% for temperature control (Figure 2).

Table 1: Summary of consolidated EVM criteria by eight regions in Ghana

Criteria	GAR	ER	UER	WR	Ahafo	AR	VR	NR
E2: Temperature control	**100%**	**100%**	80%	**100%**	**90%**	**100%**	**97%**	87%
E4: Building, equipment, and transport	82%	**100%**	***98%***	**100%**	100%	100%	60%	**95%**
E5: Maintenance	40%	79%	***80%***	50%	60%	100%	63%	**100%**
E6: Stock management	85%	**91%**	*79%*	89%	**100%**	**93%**	83%	**94%**
E7: Distribution	89%	*41%*	**93%**	**100%**	**90%**	86%	*64%*	84%
E8: Vaccine management	87%	**95%**	82%	84%	**94%**	84%	84%	**92%**
E9: Information system	**100%**	82%	*70%*	**95%**	81%	88%	**95%**	**99%**

GAR = Greater Accra Region; ER = Eastern Region; UER = Upper East Region; WR = Western Region; AR = Ashanti Region; VR = Volta Region; NR = Northern Region

Figure 1: Radar chart showing EVM performance at the regional level

Figure 2: Regional mean scores of effective vaccine management

Performance Across Seventeen District Health Directorates

Table 2 presents the performance of the 17 district health directorates. For Temperature Control, 16 of the 17 directorates (94.1%) met or exceeded the standard, with 52.9% achieving 100%; only Bolgatanga Municipal fell short (77%). In Stock Management, 23.5% of directorates did not attain the standard, with Talensi (71%), Bolgatanga Municipal (75%), Asunafo North (77%), and Manso Adubia (77%) scoring under 80%. Distribution underperformed substantially, with 41.2% (7/17) of directorates failing to reach the benchmark: Manso Adubia (25%), Central Tongu (26%), Shai-Osudoku (36%), Birim South (40%), Bolgatanga Municipal (46%), Talensi (56%), and Asunafo North (63%). Vaccine Management policies were well-implemented overall (mean: 90%), with only Bolgatanga Municipal (75%) and Manso Adubia (78%) scoring below the threshold. Information Systems showed wide deficits: 52.9% (9/17) of directorates failed to achieve 80%, with Manso Adubia recording the lowest performance (41%). Overall district

performance ranged from 63% (Manso Adubia) to 97% (Yilo Krobo). Composite district means were: Temperature Control (94%), Vaccine Management (90%), Stock Management (87%), Distribution (71%), and Information Systems (78%).

Table 2. Consolidated EVM Criterion Scores Across Seventeen District Health

District Health Directorate name	Temperature Control	Stock Management	Distribution	Vaccine Management	Information Systems
Yilo Krobo	100%	100%	100%	100%	86%
Prestea Huni Valley	100%	89%	89%	95%	100%
Accra Metro	90%	97%	93%	89%	86%
Bolgatanga Municipal	77%	75%	46%	75%	66%
Asunafo North	100%	77%	63%	98%	100%
Shai-Osudoku	81%	86%	36%	88%	62%
Talensi	87%	71%	56%	87%	58%
Asutifi North	81%	85%	89%	92%	72%
Wassa Amenfi East	100%	96%	98%	95%	100%
Asante Akim Central	100%	91%	86%	90%	70%
Ketu South	90%	96%	88%	95%	90%
Tamale Metro	100%	96%	93%	92%	100%
Mfantseman	100%	81%	96%	81%	90%
Amansie South	96%	77%	25%	78%	41%
Central Tongu	90%	82%	26%	95%	62%
Birim South	100%	99%	40%	88%	73%
Sagnarigu	100%	89%	84%	100%	77%
District Averages	**94%**	**87%**	**71%**	**90%**	**78%**

EVM Performance Across Eighteen District Hospitals and Polyclinics

Table 3 summarizes the EVM scores across the 18 sampled secondary healthcare facilities. Thirteen facilities (72.2%) met the 80% benchmark for Temperature Control, with 38.8% recording 100%; Kenyasi Government Hospital had the lowest performance (71%). In Stock

Management, 27.8% of hospitals scored below the target, with Bolgatanga Regional Hospital recording the lowest score (65%). Distribution targets were unmet by 22.2% of facilities, with Bolgatanga Regional Hospital (55%), Konongo Hospital (58%), and Goaso Municipal Hospital (63%) underperforming. Vaccine Management policies were met by 72.2% of facilities; Bolgatanga Regional Hospital and Prestea Government Hospital shared the lowest score (74%). Information Systems demonstrated the poorest compliance, with 50.0% of facilities falling below 80%. Prestea Government Hospital scored the lowest at 13%, while Somanya Polyclinic and Goaso Municipal Hospital reached 100%. Overall hospital composite performance ranged from 63% (Bolgatanga Regional Hospital) to 99% (Somanya Polyclinic). The aggregate means for hospitals were 90% for Temperature Control, 91% for Distribution, 86% for Vaccine Management, 85% for Stock Management, and 69% for Information Systems.

Table 3. Consolidated EVM Criterion Scores Across Eighteen District Hospitals and Polyclinics

Facility Name	Temperature Control	Stock Management	Distribution	Vaccine Management	Information Systems
Adidome Hospital	81%	87%	100%	86%	25%
Bawjiase Polyclinic	100%	75%	100%	86%	94%
Bolgatanga Regional Hospital	77%	65%	55%	74%	44%
Dodowa Hospital	81%	92%	100%	79%	75%
Goaso Municipal Hospital	100%	77%	63%	98%	100%
Kenyasi Government Hospital	71%	68%	100%	80%	69%
Ketu South Municipal Hospital	96%	81%	100%	96%	90%
Konongo Hospital	100%	84%	58%	76%	88%
Mfantseman Polyclinic	100%	100%	100%	100%	88%
Northern Regional Hospital	100%	93%	100%	97%	94%
Prestea Government Hospital	96%	78%	77%	74%	13%
Somanya Polyclinic	100%	100%	100%	97%	100%
St. Andrews' Hospital	77%	93%	100%	75%	44%
St. Lucy Hospital	100%	94%	100%	82%	56%
St. Martins Hospital	77%	84%	100%	77%	88%
Talensi District Hospital	77%	80%	100%	90%	67%

Ussher Hospital	81%	99%	80%	97%	88%
Wassa Akropong Hospital	100%	84%	100%	79%	25%
Facility Average	90%	85%	91%	86%	69%

Performance Across Thirty-Four Health Centers

Table 4 presents the EVM performance across the 34 assessed health centers. In Temperature Control, 20.6% failed to meet the 80% threshold, with Winkogo Health Center recording the lowest score (58%), whereas 52.9% scored 100%. Under Stock Management, 55.9% of health centers failed to meet the standard, with scores ranging from 44% (Bontroase HC) to 100% (Kalpohin HC). In Distribution, 23.5% scored below the benchmark, with Gorogo HC and Mim HC both recording 53%. Vaccine Management scores fell below 80% in 35.3% of facilities, ranging from 65% (Awisa HC) to 100% (Bontroase HC). Information Systems exhibited the most widespread deficiencies: 76.5% (26/34) of facilities scored below the threshold, with Mafi-Sasekpe, Klikor, and Mafi-Kumase recording the lowest performance (13% each). Composite facility averages ranged from 64% (Gorogo HC) to 96% (Boti HC and Mfantseman HC). The aggregate tier averages were 90% for Temperature Control, 89% for Distribution, 81% for Vaccine Management, 77% for Stock Management, and 58% for Information Systems.

Table 4. Consolidated EVM Criterion Scores Across Thirty-Four Health Centers

Facility Name	Temperature Control	Stock Management	Distribution	Vaccine Management	Information Systems
Adubia HC	100%	65%	63%	82%	53%
Afransie HC	100%	83%	100%	83%	31%
Agbozume HC	100%	77%	100%	72%	19%
Agomeda HC	90%	76%	95%	89%	63%
Anigazanga HC	77%	69%	84%	77%	50%
Apoli HC	77%	59%	100%	66%	29%
Awisa HC	77%	79%	100%	65%	50%
Ayomso HC	81%	66%	55%	69%	56%
Bilpeila HC	96%	98%	100%	94%	88%
Bogoso HC	100%	83%	96%	80%	25%
Bontroase HC	100%	44%	100%	100%	100%
Boti HC	100%	93%	100%	91%	94%
Choggu HC	100%	91%	98%	87%	63%
Dwease HC	100%	67%	100%	90%	58%
Gambia HC	100%	77%	74%	80%	85%
Gorogo HC	62%	73%	53%	83%	47%
Gyedu HC	90%	64%	74%	74%	50%
Himan HC	100%	80%	100%	72%	19%
Jamestown Maternity	81%	81%	100%	92%	75%
Kalpohin HC	100%	100%	91%	93%	63%
Klikor HC	100%	80%	88%	80%	13%
Lardowayo HC	90%	78%	64%	81%	45%
Mafi-Kumase HC	81%	68%	89%	80%	13%
Mafi-Sasekpe HC	67%	84%	88%	71%	13%
Makola HC	90%	98%	63%	80%	88%
Mfantseman HC	100%	90%	99%	95%	94%
Mim HC	100%	72%	53%	74%	38%
Plaza HC	77%	70%	100%	82%	50%
Praaso HC	100%	69%	100%	78%	53%
Saa HC	100%	83%	100%	76%	63%
Somanya HC	81%	83%	98%	87%	100%
Tamale Central HC	100%	87%	100%	91%	94%
Tontokrom HC	100%	68%	100%	68%	19%
Winkogo HC	58%	73%	100%	71%	60%
Tier Average	**90%**	**77%**	**89%**	**81%**	**56%**

Performance Across Thirty-Four CHPS Compounds

Table 5 outlines the EVM findings across the 34 primary CHPS facilities. In Temperature Control, 29.4% failed to reach the 80% threshold; scores ranged from 52% (Lower Dodowa CHPS) to 100%. Stock Management shortfalls were widespread: 64.7% (22/34) of the CHPS compounds scored below 80%. Aduasa CHPS recorded the lowest performance (18%), whereas Malshegu CHPS recorded the highest (97%). In terms of Distribution, 29.4% of compounds failed to meet the target, with Obrachire CHPS scoring 33% and Pumpungu CHPS scoring 38%. Under Vaccine Management, 67.6% (23/34) failed to meet the standard, with Aduasa CHPS recording 35% and Taido CHPS achieving 100% compliance. Information Systems showed severe shortfalls: 88.2% (30/34) scored below the threshold, with Atwedie, Kyekyebiase, Manso Nkran, and Seva recording scores of 13% each. The overall performance at the CHPS level ranged from 48% (Aduasa CHPS) to 98% (Malshegu CHPS). The aggregate tier averages were 87% for Temperature Control, 85% for distribution, 75% for Vaccine Management, 71% for Stock Management, and 47% for Information Systems.

Table 5. Consolidated EVM Criterion Scores Across Thirty-Four CHPS Compounds

Facility Name	Temperature Control	Stock Management	Distribution	Vaccine Management	Information Systems
Adiembra CHPS	77%	88%	100%	65%	44%
Aduasa CHPS	58%	18%	89%	35%	38%
Ahinkwa CHPS	81%	90%	100%	91%	100%
Akame CHPS	96%	81%	100%	72%	19%
Ankam CHPS	81%	69%	100%	51%	31%
Asikuma CHPS	100%	83%	100%	76%	38%
Asompa CHPS	96%	83%	100%	72%	31%
Atwedie CHPS	77%	56%	100%	71%	13%
Avedo CHPS	96%	74%	55%	70%	38%
Ayikuma CHPS	90%	74%	93%	72%	56%
Baare CHPS	87%	66%	58%	72%	44%
Balungu CHPS	77%	65%	50%	65%	31%
Bawdie CHPS	100%	83%	100%	72%	38%
Bediako CHPS	81%	72%	53%	72%	38%

Bondaye CHPS	96%	80%	100%	71%	25%
Fawohoyedin CHPS	100%	74%	53%	74%	46%
Garizegu CHPS	100%	72%	66%	92%	56%
Goamu Koforidua CHPS	77%	58%	53%	70%	48%
Kalbeo CHPS	58%	61%	84%	76%	35%
Kamokrom CHPS	100%	63%	100%	84%	79%
Korle Norle CHPS	81%	56%	100%	74%	42%
Kpanvo CHPS	77%	51%	100%	70%	58%
Kyekyebiase CHPS	100%	77%	100%	53%	13%
Lower Dodowa CHPS	52%	82%	73%	87%	79%
Malshegu CHPS	100%	97%	100%	95%	100%
Manso Nkran CHPS	77%	69%	100%	70%	13%
Moshie Zongo CHPS	100%	79%	97%	85%	78%
Ngleshie CHPS	81%	56%	100%	80%	60%
Obrachire CHPS	100%	58%	33%	81%	44%
Ponponya CHPS	81%	90%	100%	98%	94%
Pumpungu CHPS	77%	57%	38%	85%	44%
Seva CHPS	96%	68%	89%	60%	13%
Taido CHPS	100%	87%	100%	100%	88%
Tier Average	87%	71%	85%	75%	47%

Discussion

This study evaluated the performance of Ghana's immunization supply chain using the standardized WHO EVM framework. The findings demonstrated an administrative gradient: while regional cold storage hubs maintained high compliance with WHO benchmarks, operational performance declined steadily toward the periphery, with significant deficits observed at health centers and CHPS compounds. This structural disparity reflects patterns reported across low- and middle-income settings, where frontline facilities bear the brunt of logistical constraints, infrastructural deficits and human resource limitations [8, 9].

The high compliance observed across regional cold stores marks clear progress relative to earlier national EVM evaluations in Ghana [6]. This centralized strengthening likely reflects deliberate capital investments in cold chain equipment, regular maintenance contracts, and

closer supervisory accountability at upstream distribution nodes [4]. However, the persistence of operational bottlenecks at district, health center, and CHPS levels underscores an "implementation gap," where upstream system investments fail to translate into sustained capacity at the last mile. Similar logistical constraints: unreliable refrigeration units, inadequate dedicated transport, fragmented stock records, and paper-dependent LMIS tools, have been extensively documented in comparable African healthcare systems [10, 11].

The programmatic consequences of these primary-level shortfalls are significant. Temperature monitoring failures directly compromise the cold chain, increasing the risk of thermal degradation and accidental freeze damage, undermining vaccine potency, and exposing recipients to suboptimal antigen protection [3]. Deficiencies in stock management promote both stockouts of critical antigens and high wastage rates from expired inventory, inflating operational costs, and disrupting routine vaccination schedules [12]. Furthermore, fragile information systems impede accurate local forecasting, stock balancing, and timely decision-making, and transport bottlenecks create systemic delays in replenishing peripheral health outposts [13].

Addressing these vulnerabilities requires a coordinated multi-level strategy, including expanding solar direct-drive (SDD) refrigeration infrastructure and continuous digital temperature loggers in rural clinics, establishing optimized scheduled collection and delivery routes to mitigate last-mile transportation barriers, instituting continuous competency-based on-site mentoring and supportive supervision for frontline healthcare workers, and scaling mobile electronic logistics management information systems (eLMIS) to the sub-district level to bridge the persistent data-to-action divide [14, 15].

Limitations

This study has two principal limitations. First, its cross-sectional design captures supply chain performance within a discrete time window, precluding the assessment of seasonal variations

in power supply and road access. Second, the reliance on the EVM 1.0 assessment tool, maintained to ensure direct comparability with prior Ghanaian assessments, excludes updated evaluation parameters and metrics incorporated into the EVM 2.0 framework. Despite these constraints, the study provides a robust, multi-tier evaluation of immunization logistics in Ghana to guide policy and capital investments.

Conclusion

This EVM assessment demonstrates that while Ghana's central and regional immunization cold chains operate satisfactorily, operational vulnerabilities persist at the primary-care delivery level. Substantial deficits in temperature control, stock tracking, local distribution, and information management across health centers and CHPS compounds present a direct risk to vaccine quality and programme resilience. Sustained investments in solarized cold chain infrastructure, routine preventive maintenance, dedicated distribution logistics, supportive staff supervision, and digital inventory systems are necessary to ensure that all children in Ghana receive potent vaccines on schedule.

List of Abbreviations

CHPS: Community-based Health Planning and Services

EPI: Expanded Programme on Immunization

EVM: Effective Vaccine Management

GAR: Greater Accra Region

GHS: Ghana Health Service

HC: Health Center

LMIS: Logistics Management Information System

MDVP: Multi-Dose Vial Policy

SDD: Solar Direct Drive

UHAS: University of Health and Allied Sciences

UNICEF: United Nations Children's Fund

WHO: World Health Organization

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Availability of Data and Materials: The datasets generated and analyzed in the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics Approval and Consent to Participate: Ethical approval was obtained from the Ghana Health Service Ethical Review Committee (Ref: GHS-ERC: 065/04/24). Administrative permissions were granted by all involved regional and district health directorates. Written informed consent was obtained from all participating health personnel prior to data collection. This study was conducted in accordance with the Declaration of Helsinki.

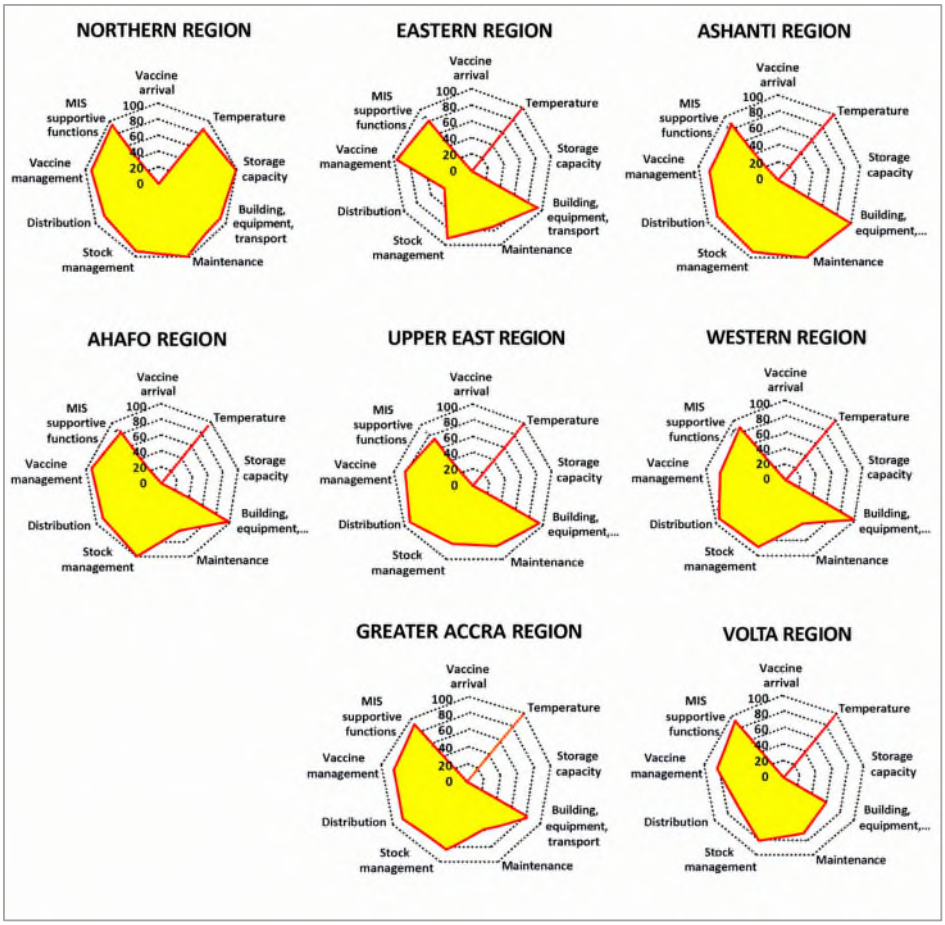
Consent for Publication: Not applicable.

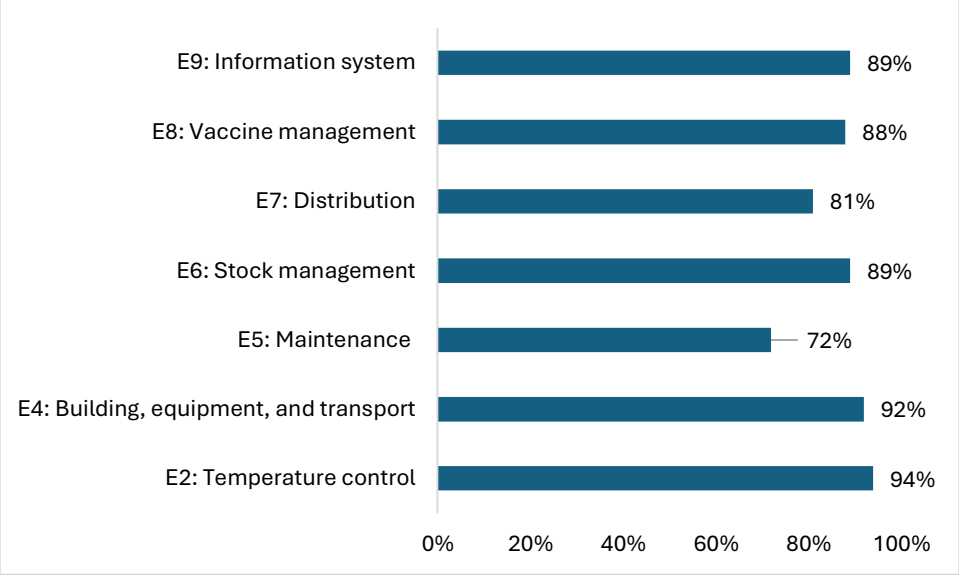
Competing Interests: The authors declare no competing interests.

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NORTHERN REGION
Vaccine arrival
Temperature
Storage capacity
Building, equipment, transport
Maintenance
Stock management
Distribution
Vaccine management
MIS supportive functions
EASTERN REGION
Vaccine arrival
Temperature
Storage capacity
Building, equipment, transport
Maintenance
Stock management
Distribution
Vaccine management
MIS supportive functions
ASHANTI REGION
Vaccine arrival
Temperature
Storage capacity
Building, equipment,...
Maintenance
Stock management
Distribution
Vaccine management
MIS supportive functions
AHAFO REGION
Vaccine arrival
Temperature
Storage capacity
Building, equipment,...
Maintenance
Stock management
Distribution
Vaccine management
MIS supportive functions
UPPER EAST REGION
Vaccine arrival
Temperature
Storage capacity
Building, equipment,...
Maintenance
Stock management
Distribution
Vaccine management
MIS supportive functions
WESTERN REGION
Vaccine arrival
Temperature
Storage capacity
Building, equipment,...
Maintenance
Stock management
Distribution
Vaccine management
MIS supportive functions
GREATER ACCRA REGION
Vaccine arrival
Temperature
Storage capacity
Building, equipment, transport
Maintenance
Stock management
Distribution
Vaccine management
MIS supportive functions
VOLTA REGION
Vaccine arrival
Temperature
Storage capacity
Building, equipment,...
Maintenance
Stock management
Distribution
Vaccine management
MIS supportive functions


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