



LEADERSHIP CAPACITY AND SUSTAINABLE VACCINE COLD CHAIN MANAGEMENT IN PRIMARY HEALTH CARE FACILITIES IN KADUNA NORTH LGA

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ABSTRACT

This study examined the influence of leadership capacity on sustainable vaccine cold chain management in Primary Health Care (PHC) facilities in Kaduna North Local Government Area, Kaduna State, Nigeria. The study was motivated by persistent challenges in vaccine storage, transportation, equipment maintenance, supportive supervision, and logistics management despite government efforts to strengthen routine immunization services. A descriptive survey research design was adopted. The target population comprised healthcare personnel involved in routine immunization and vaccine cold chain management in government-owned PHC facilities. A sample of 150 respondents was selected using a multistage sampling technique. Data were collected using a structured questionnaire validated by experts, while reliability was established using Cronbach's Alpha. Data were analyzed using frequency, percentage, mean, and standard deviation to answer the research questions, while Simple Linear Regression was used to test the hypothesis at the 0.05 level of significance. Findings revealed that leadership capacity had a significant influence on sustainable vaccine cold chain management, with a grand mean of 4.37, indicating that effective leadership enhances strategic planning, supervision, accountability, communication, equipment maintenance, and compliance with vaccine storage guidelines. Leadership competencies identified as essential included strategic leadership, monitoring and evaluation, decision-making, communication, financial management, human resource management, risk management, and digital health management, with a grand mean of 4.34. Regression analysis revealed a strong positive and statistically significant relationship between leadership capacity and sustainable vaccine cold chain management ($R = 0.782$; $R^2 = 0.611$; $p < 0.05$). The study concluded that strengthening leadership capacity is critical for improving vaccine preservation, reducing vaccine wastage, and sustaining routine immunization services. It recommended continuous leadership training, supportive supervision, improved digital logistics systems, and increased investment in cold chain infrastructure.

Keywords: Leadership Capacity, Vaccine Cold Chain Management, Primary Health Care, Routine

INTRODUCTION

Leadership capacity has increasingly been recognized as one of the most significant determinants of an effective and resilient health system, particularly in ensuring the sustainability of vaccine cold chain management within Primary Health Care (PHC) facilities in Nigeria. Leadership in healthcare extends beyond occupying managerial positions; it encompasses the ability to formulate strategic policies, coordinate healthcare personnel, mobilize financial and material resources, supervise programme implementation, promote accountability, and ensure continuous improvement in service delivery leadership is essential because it guarantees that vaccines are stored, transported, monitored, and administered under appropriate temperature conditions throughout the supply chain. This ultimately preserves vaccine potency, reduces wastage, and strengthens public confidence in immunization programmes. Olutuase et al. (2022), strong leadership and governance structures are fundamental to addressing systemic weaknesses affecting Nigeria's immunization supply chain, including poor coordination, inadequate financing, fragmented governance, and insufficient human resource capacity. Adewale and Ibrahim (2023) argued that leadership competence significantly influences the efficiency of Primary Health Care services by enhancing institutional coordination, improving workforce productivity, and ensuring adherence to national immunization guidelines. World Health Organization (2023) emphasized that leadership and governance constitute one of the six essential building blocks of every effective health system because they facilitate accountability, strategic planning, policy implementation, and equitable healthcare delivery UNICEF Nigeria (2024) observed that strengthening leadership at the PHC level has become indispensable for sustaining immunization programmes, particularly in underserved rural communities where managerial challenges frequently compromise vaccine availability and accessibility.

The vaccine cold chain refers to a coordinated system responsible for storing, transporting, handling, monitoring, and distributing vaccines at recommended temperatures from the point of manufacture to the point of administration. Maintaining this uninterrupted temperature-controlled system is essential because vaccines are highly sensitive biological products whose effectiveness can be permanently compromised when exposed to temperatures outside prescribed limits. Effective cold chain management therefore involves adequate infrastructure, reliable refrigeration equipment, continuous temperature monitoring, trained personnel, supportive supervision, preventive maintenance, and efficient logistics management. According to National Primary Health Care Development Agency (2023), maintaining vaccine potency throughout the cold chain remains one of the highest priorities for Nigeria's immunization programme

because compromised vaccines may fail to provide adequate immunity despite successful administration. Similarly, Aina et al. (2024) reported that effective vaccine cold chain management requires competent leadership capable of coordinating logistics, infrastructure, workforce training, equipment maintenance, inventory control, and supportive supervision across different levels of healthcare delivery. In addition, World Health Organization (2024) maintained that continuous monitoring of vaccine temperatures, regular equipment maintenance, and effective managerial oversight are essential prerequisites for achieving sustainable immunization outcomes globally. Interruptions within the vaccine cold chain, whether resulting from equipment failure, inconsistent electricity supply, inadequate transportation systems, poor supervision, weak managerial oversight, or insufficient technical competence among healthcare workers, often have serious public health consequences. Such disruptions may lead to vaccine spoilage, increased vaccine wastage, financial losses, stock-outs, declining immunization coverage, and increased susceptibility of children and vulnerable populations to vaccine-preventable diseases. Olutuase et al. (2022) observed that ineffective leadership contributes significantly to poor coordination of vaccine logistics, resulting in frequent stock-outs, delayed vaccine distribution, and inefficient resource utilization across health facilities. Similarly, NPHCDA (2024) reported that leadership deficiencies often contribute to poor compliance with cold chain protocols, irregular equipment maintenance, and weak monitoring systems, thereby increasing the likelihood of vaccine losses. Furthermore, UNICEF (2023) emphasized that improving leadership competencies among PHC managers significantly enhances supportive supervision, accountability, staff motivation, and operational efficiency, thereby reducing preventable vaccine wastage and improving service delivery outcomes. Consequently, the sustainability of vaccine cold chain management depends not only on the availability of modern cold chain equipment but also on competent leadership capable of effectively coordinating human resources, infrastructure, logistics systems, financial resources, monitoring mechanisms, and institutional partnerships. Modern refrigeration technologies such as solar-powered vaccine refrigerators have undoubtedly improved vaccine preservation in many Nigerian health facilities; however, these technological investments alone cannot guarantee sustainable immunization services without effective managerial leadership. Leaders are expected to ensure regular maintenance of equipment, organize staff training programmes, monitor vaccine inventories, coordinate transportation schedules, enforce compliance with standard operating procedures, and provide supportive supervision that strengthens workforce performance. Dougherty et al. (2024) argued that sustainable improvements in routine immunization programmes require collaborative leadership, political commitment, multi-sectoral partnerships, effective governance, and continuous resource mobilization. Likewise, Adewuyi et al. (2025) noted that leadership effectiveness directly influences institutional resilience by strengthening planning processes, enhancing resource mobilization, improving employee

motivation, and promoting innovation in vaccine logistics management. These findings indicate that leadership capacity remains a strategic organizational asset for sustaining vaccine cold chain performance across Primary Health Care facilities. Recent evidence further demonstrates that strengthening leadership capacity has become a national strategic priority for improving immunization outcomes and building resilient Primary Health Care systems in Nigeria. Following the introduction of the Primary Health Care Leadership Challenge and several health system strengthening initiatives, the Federal Government, through the National Primary Health Care Development Agency (NPHCDA), has intensified investments in leadership development, supportive supervision, digital logistics management, workforce capacity building, and cold chain infrastructure. According to NPHCDA (2024), Nigeria has expanded solar-powered cold chain equipment, strengthened electronic logistics management information systems, improved vaccine forecasting mechanisms, and increased supportive supervision to enhance routine immunization performance nationwide. Similarly, WHO (2024) reported that countries with strong institutional leadership consistently demonstrate better immunization coverage, lower vaccine wastage, stronger supply chain performance, and greater resilience during public health emergencies. Eze, Mohammed, and Bello (2025) found that leadership development programmes significantly improved managerial competence, accountability, data quality, workforce motivation, and service delivery efficiency among Primary Health Care managers across several Nigerian states. Collectively, these studies suggest that strengthening leadership capacity remains one of the most sustainable approaches for improving vaccine cold chain management, reducing operational inefficiencies, enhancing immunization coverage, and supporting Nigeria's commitment to Universal Health Coverage (UHC) and Sustainable Development Goal Three (SDG 3), which seeks to ensure healthy lives and promote well-being for people of all ages. The vaccine cold chain comprises a coordinated network of equipment, infrastructure, personnel, and logistics systems that ensure vaccines are stored, transported, and distributed within the recommended temperature range from the point of manufacture to the point of administration. The major components include cold rooms, which provide large-scale storage for vaccines at national and state levels; solar-powered refrigerators, which maintain vaccine potency in Primary Health Care (PHC) facilities, especially in areas with unreliable electricity; vaccine carriers and cold boxes, which preserve vaccines during transportation and outreach services; ice packs, which maintain the required temperatures inside vaccine carriers; temperature monitoring devices, which continuously track storage temperatures to detect temperature excursions; reliable power supply, which ensures uninterrupted refrigeration; transport logistics, which facilitate timely vaccine distribution across health facilities; qualified human resources, who manage vaccine storage, handling, and monitoring; and Digital Logistics Management Information Systems (eLMIS/OpenLMIS), which improve vaccine inventory management, forecasting, reporting, and

decision-making. Collectively, these components work together to preserve vaccine potency, minimize wastage, improve vaccine availability, and strengthen routine immunization programmes. Supporting this view, Galadima (2026) reported that the adoption of digital supply chain monitoring systems in Kaduna State significantly enhanced vaccine stock availability, strengthened cold chain integrity, improved managerial oversight, and reduced vaccine wastage through real-time monitoring and evidence-based decision-making. Effective leadership remains one of the most important factors influencing the sustainability of vaccine cold chain management in Primary Health Care facilities. Essential leadership competencies include strategic leadership, which enables managers to formulate long-term immunization plans; financial management, which ensures efficient allocation and utilization of available resources; human resource management, which promotes staff motivation, training, and performance; monitoring and evaluation, which facilitates continuous assessment of programme performance; cold chain supervision, which ensures compliance with vaccine storage and handling guidelines; effective communication, which promotes coordination among healthcare workers and stakeholders; problem-solving, which enables leaders to respond promptly to operational challenges; risk management, which minimizes disruptions arising from equipment failures, power outages, and transportation delays; and digital health management, which supports the effective use of electronic logistics and health information systems. These competencies collectively improve organizational efficiency, strengthen accountability, enhance service delivery, reduce vaccine wastage, and promote resilient Primary Health Care systems. Suleiman et al. (2021) found that although most PHC facilities in Kaduna State had trained health workers and vaccine availability, significant deficiencies remained in cold chain equipment management and supportive supervision, underscoring the need for stronger leadership. Similarly, Olutuase et al. (2022) identified weak governance, poor logistics coordination, inadequate financing, and insufficient institutional leadership as major barriers to effective vaccine supply chain management in Nigeria. Moshood and Okafor (2025) further demonstrated that continuous personnel training, quality infrastructure, and routine monitoring significantly enhanced vaccine cold chain performance in Primary Health Care facilities in Oyo State. Likewise, Ifezulike et al. (2026) concluded that supportive supervision, continuous workforce capacity development, and regular maintenance of cold chain equipment were critical determinants of sustainable vaccine preservation in Nasarawa State. In addition, Galadima (2026) observed that digital logistics monitoring systems substantially improved vaccine inventory management, strengthened cold chain integrity, minimized vaccine wastage, and enhanced decision-making among PHC managers in Kaduna State. This study was subject to certain limitations. First, the study focused exclusively on government-owned Primary Health Care facilities in Kaduna North Local Government Area; therefore, the findings may not be fully generalized to private healthcare facilities or other Local Government Areas within Kaduna

State and Nigeria as a whole. Second, data were collected using a self-administered questionnaire, which relied on respondents' perceptions and may have been influenced by social desirability bias or inaccurate responses. This study contributes to existing knowledge by providing empirical evidence on the influence of leadership capacity on sustainable vaccine cold chain management in Primary Health Care facilities. It extends current literature by demonstrating that leadership competencies such as strategic planning, supportive supervision, communication, monitoring and evaluation, financial management, and digital health management significantly influence vaccine preservation and immunization service sustainability.

The Transformational Leadership Theory, developed by Burns (1978) and expanded by Bass (1985), explains how leaders inspire followers to exceed organizational expectations through vision, motivation, intellectual stimulation, and individualized consideration. Within Primary Health Care facilities, transformational leaders encourage healthcare workers to comply with vaccine handling protocols, embrace technological innovations, participate in continuous professional development, and maintain accountability in cold chain operations. The theory is highly relevant to sustainable vaccine cold chain management because effective leadership enhances teamwork, staff commitment, innovation, supportive supervision, and organizational performance. Recent Nigerian scholars support the application of this theory in healthcare. Olutuase et al. (2022) emphasized that transformational leadership strengthens governance, improves coordination, and enhances vaccine supply chain performance. Similarly, Moshood and Okafor (2025) observed that leadership capable of motivating staff, strengthening supervision, and promoting continuous learning significantly improved vaccine cold chain sustainability in Nigerian Primary Health Care facilities. Ifezulike et al. (2026) further concluded that transformational leadership remains essential for improving workforce competence, equipment maintenance, and effective immunization service delivery across PHCs. Systems Theory, proposed by Bertalanffy (1968), views organizations as integrated systems whose various components must function collaboratively to achieve common objectives. Applied to vaccine cold chain management, the theory suggests that leadership, healthcare personnel, cold chain infrastructure, logistics systems, financial resources, electricity supply, transportation networks, and health information systems are interconnected and mutually dependent. Weaknesses in any of these components can compromise vaccine preservation, increase wastage, and reduce immunization coverage. Consequently, effective leadership is required to coordinate these interconnected systems, ensure efficient resource utilization, strengthen collaboration among stakeholders, and promote sustainable vaccine cold chain management. Recent Nigerian studies support this systems perspective. Olutuase et al. (2022) argued that fragmented governance and poor coordination among health system components continue to undermine vaccine supply chain efficiency in Nigeria. Galadima (2026) similarly demonstrated that integrating digital

logistics management systems with supportive leadership significantly improved vaccine availability, inventory management, and decision-making in Kaduna State. Likewise, Ifezulike et al. (2026) found that sustainable vaccine cold chain performance depends on effective coordination of infrastructure, trained personnel, supervision, financing, and maintenance systems, all of which require competent institutional leadership.

Statement of the Problem

Sustainable vaccine cold chain management remains one of the most critical components of successful immunization programmes because vaccines must be continuously stored, transported, and handled within the recommended temperature range to preserve their potency and effectiveness. Failure to maintain an effective cold chain system exposes vaccines to heat or freezing temperatures, leading to vaccine spoilage, increased wastage, financial losses, stock-outs, reduced immunization coverage, and increased vulnerability of children and other at-risk populations to vaccine-preventable diseases. Despite substantial investments by the Federal Government of Nigeria, the National Primary Health Care Development Agency (NPHCDA), and international development partners in strengthening immunization services, challenges affecting the sustainability of vaccine cold chain management continue to persist in many Primary Health Care (PHC) facilities across the country. Over the past decade, Nigeria has implemented several interventions aimed at improving vaccine logistics, including the deployment of solar-powered refrigerators, expansion of national and state cold chain storage facilities, introduction of Electronic Logistics Management Information Systems (eLMIS), workforce capacity development, supportive supervision, and increased government funding for routine immunization services. These interventions have significantly improved vaccine accessibility in many parts of the country. Nevertheless, evidence from recent studies indicates that numerous PHC facilities continue to experience frequent equipment failures, irregular electricity supply, inadequate maintenance, poor temperature monitoring, insufficient technical supervision, weak inventory management, and limited managerial capacity, particularly in rural and semi-urban communities. One of the most overlooked factors contributing to these persistent challenges is inadequate leadership capacity among managers of Primary Health Care facilities. Effective leadership extends beyond routine administration and encompasses strategic planning, supportive supervision, resource mobilization, workforce motivation, communication, accountability, monitoring and evaluation, problem-solving, and evidence-based decision-making. Where these leadership competencies are weak, health workers may receive inadequate supervision, cold chain equipment may not be properly maintained, vaccine inventories may be poorly managed, and operational challenges may remain unresolved for

extended periods. Consequently, the sustainability of vaccine cold chain management becomes increasingly difficult to achieve.

Kaduna North Local Government Area remains one of the major urban centres in Kaduna State where Primary Health Care facilities serve a rapidly growing population, including children under five years, pregnant women, and other vulnerable groups who depend on routine immunization services. Despite improvements in immunization infrastructure, anecdotal evidence and routine health reports continue to indicate challenges relating to vaccine storage, equipment maintenance, supportive supervision, logistics coordination, staff capacity, and service continuity in some PHC facilities. These operational deficiencies suggest that leadership effectiveness may significantly influence the sustainability of vaccine cold chain management. Although government agencies and development partners have invested substantially in strengthening Nigeria's vaccine cold chain system, limited empirical evidence exists regarding the extent to which leadership capacity contributes to sustainable vaccine cold chain management within PHC facilities in Kaduna North Local Government Area. This knowledge gap creates uncertainty for policymakers and healthcare administrators regarding the specific leadership competencies that should be strengthened to improve vaccine preservation and immunization outcomes. It is against this background that this study seeks to examine the influence of leadership capacity on sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area, Kaduna State.

Purpose of the Study

The main purpose of this study is to examine the influence of leadership capacity on sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area, Kaduna State.

The specific objectives are to

- i. Examine the influence of leadership capacity on sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area.
- ii. Assess the leadership competencies required for effective and sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area.

Research Questions

The study will be guided by the following research questions

- i. To what extent does leadership capacity influence sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area?
- ii. What leadership competencies are required for effective and sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area?

Research Hypothesis

The study will test the following null hypothesis at the 0.05 level of significance

H₀: Leadership capacity has no significant influence on sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area, Kaduna State.

Alternative Hypothesis (H₁): Leadership capacity has a significant influence on sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area, Kaduna State.

METHODOLOGY

This study adopted a descriptive survey research design to investigate the influence of leadership capacity on sustainable vaccine cold chain management in Primary Health Care (PHC) facilities in Kaduna North Local Government Area of Kaduna State, Nigeria. The study was conducted in Kaduna North Local Government Area of Kaduna State, Nigeria. Kaduna North is one of the twenty-three Local Government Areas in Kaduna State and serves as an important administrative, commercial, and healthcare centre. The Local Government Area comprises several political wards with numerous government-owned Primary Health Care facilities responsible for delivering essential healthcare services, including routine immunization, maternal and child healthcare, disease surveillance, health promotion, and vaccine storage. These facilities operated under the supervision of the Kaduna State Primary Health Care Board in collaboration with the National Primary Health Care Development Agency (NPHCDA). The PHC facilities were equipped with vaccine cold chain equipment such as solar-powered refrigerators, cold boxes, vaccine carriers, ice packs, temperature monitoring devices, and digital logistics management systems designed to ensure vaccine potency throughout the immunization supply chain. Kaduna North Local Government Area was selected because of its strategic importance in the delivery of routine immunization services and the

need to assess how leadership capacity influenced the sustainability of vaccine cold chain management within its Primary Health Care facilities.

The target population for this study comprised all healthcare personnel directly involved in routine immunization services and vaccine cold chain management in government-owned Primary Health Care facilities in Kaduna North Local Government Area. These included Primary Health Care Coordinators, Facility Managers, Medical Officers, Community Health Officers (CHOs), Community Health Extension Workers (CHEWs), Nurses, Midwives, Routine Immunization Officers, Cold Chain Officers, Vaccine Store Officers, and Monitoring and Evaluation Officers. These categories of health workers were directly responsible for vaccine storage, transportation, temperature monitoring, inventory management, equipment maintenance, supportive supervision, and immunization service delivery. Based on available records from the Kaduna State Primary Health Care Board, the estimated population for the study consisted of approximately 240 eligible healthcare workers across the selected Primary Health Care facilities. The sample size for the study was determined using the Taro Yamane (1967) formula for finite populations at a 5 percent level of precision. Using an estimated population of 240 healthcare workers, the formula yielded a sample size of approximately 150 respondents, which was considered adequate to ensure representativeness and enhance the reliability of the study findings. The study employed a multistage sampling procedure. First, purposive sampling was used to select government-owned Primary Health Care facilities actively involved in routine immunization and vaccine cold chain management. Secondly, proportionate sampling was applied to allocate respondents according to the staff strength of each selected facility. Finally, simple random sampling was used to select eligible respondents from each health facility, thereby giving every healthcare worker an equal opportunity to participate in the study while minimizing sampling bias. The primary instrument for data collection was a structured questionnaire developed by the researcher after an extensive review of related literature on leadership capacity and sustainable vaccine cold chain management. The questionnaire consisted of two sections. Section A obtained demographic information such as gender, age, educational qualification, professional cadre, years of working experience, and current place of assignment. Section B contained items measuring the study variables, namely leadership capacity and sustainable vaccine cold chain management. Leadership capacity was measured using indicators such as strategic leadership, financial management, human resource management, communication, supportive supervision, monitoring and evaluation, problem-solving, accountability, decision-making, digital leadership, and risk management. Sustainable vaccine cold chain management was measured using indicators including vaccine availability, cold chain equipment functionality, temperature compliance, inventory management, equipment maintenance, vaccine wastage reduction, timely vaccine

distribution, supportive supervision, digital logistics management, and adherence to vaccine handling guidelines. Responses were measured using a five-point Likert scale ranging from Strongly Agree (5), Agree (4), Undecided (3), Disagree (2), and Strongly Disagree (1). To ensure the validity of the instrument, the questionnaire underwent face and content validation by experts in Public Health, Health Administration, and Measurement and Evaluation. The experts assessed the instrument for clarity, relevance, appropriateness, and adequacy of the questionnaire items in measuring the objectives of the study. Their observations and recommendations were incorporated before the final version of the questionnaire was administered to respondents. The reliability of the research instrument was established through a pilot study conducted among healthcare workers in Primary Health Care facilities outside Kaduna North Local Government Area but with similar characteristics to the study area. Data obtained from the pilot study were analyzed using Cronbach's Alpha reliability coefficient through the Statistical Package for the Social Sciences (SPSS). The Leadership Capacity Scale yielded a Cronbach's Alpha coefficient of 0.86, while the Sustainable Vaccine Cold Chain Management Scale produced a coefficient of 0.89. The overall reliability coefficient for the instrument was 0.88, indicating a high level of internal consistency and confirming that the instrument was suitable for the study.

Data collection commenced after an introductory letter was obtained from the researcher's institution and approval was secured from the relevant authorities, including the Kaduna State Ministry of Health, Kaduna State Primary Health Care Board, and the management of the selected Primary Health Care facilities. The researcher, assisted by trained research assistants, administered copies of the questionnaire directly to eligible respondents. The purpose of the study was explained to participants before the administration of the questionnaire, and sufficient time was provided for respondents to complete the instrument. Completed questionnaires were collected immediately where possible, while follow-up visits were made to retrieve outstanding copies to ensure a high response rate. The data collected were coded, entered, cleaned, and analyzed using the Statistical Package for the Social Sciences (SPSS) Version 29. Descriptive statistics, including frequency distribution, percentages, mean, and standard deviation, were used to summarize respondents' demographic characteristics and answer the research questions. Mean scores and standard deviations were specifically used to determine respondents' perceptions regarding leadership capacity and sustainable vaccine cold chain management. A criterion mean of 3.00 served as the benchmark for decision-making, where mean scores of 3.00 and above indicated agreement, while scores below 3.00 indicated disagreement. To test the null hypothesis, Simple Linear Regression analysis was employed at the 0.05 level of significance because the study sought to determine the influence of one independent variable, leadership capacity, on one dependent variable, sustainable vaccine cold chain management. The null

hypothesis was rejected if the probability (p-value) was less than 0.05 and accepted if the probability value was equal to or greater than 0.05. The use of regression analysis provided empirical evidence regarding the predictive effect of leadership capacity on sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area. Ethical approval for this study was obtained from the Kaduna State Ministry of Health Research Ethics Committee. Ethical approval for this study was obtained from the Kaduna State Ministry of Health Research Ethics Committee with Ethical Approval No: KSMOH/ERC/2026/017. Informed consent was obtained from all participants prior to data collection. Informed consent was obtained from all participants prior to data collection. Participants were adequately informed about the purpose of the study, their voluntary participation, and their right to withdraw from the study at any stage without any consequences. Confidentiality and anonymity of respondents were strictly maintained throughout the study. Information obtained from participants was used solely for academic purposes and was not disclosed to unauthorized persons. All completed questionnaires were securely stored and handled in accordance with established ethical guidelines for research involving human participants.

RESULTS

Research Question One To what extent does leadership capacity influence sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area?

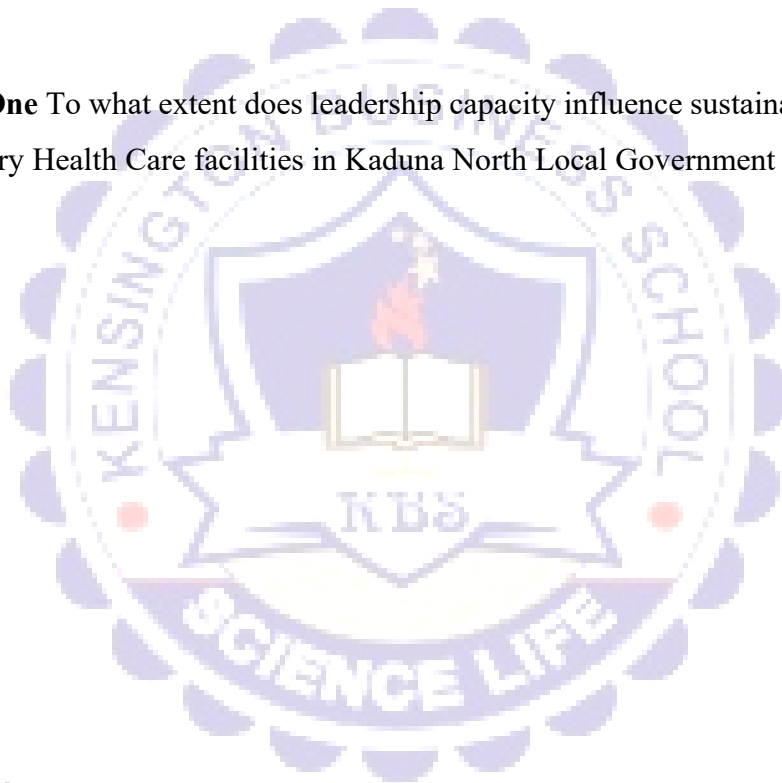


Table 4.1: Mean and Standard Deviation on the Influence of Leadership Capacity on Sustainable Vaccine Cold Chain Management (N = 150)

S/N	Leadership Capacity Variables	Mean ($\bar{X}$)	Std. Dev.	Decision
1	Strategic leadership enhances effective vaccine cold chain management.	4.45	0.61	Agreed
2	Effective supervision improves vaccine storage and handling.	4.31	0.69	Agreed
3	Leadership promotes timely maintenance of cold chain equipment.	4.40	0.58	Agreed
4	Good communication improves coordination of vaccine logistics.	4.28	0.71	Agreed
5	Leadership improves accountability in vaccine management.	4.36	0.66	Agreed
6	Competent leaders reduce vaccine wastage.	4.29	0.74	Agreed
7	Leadership ensures compliance with vaccine storage guidelines.	4.41	0.63	Agreed
8	Leadership improves staff commitment to immunization services.	4.33	0.68	Agreed
9	Leadership promotes efficient resource utilization.	4.38	0.65	Agreed
10	Leadership strengthens sustainability of vaccine cold chain management.	4.47	0.57	Agreed
	Grand Mean	4.37	0.65	High Extent

Decision Rule

Mean Range	Interpretation
4.50–5.00	Very High Extent
3.50–4.49	High Extent
2.50–3.49	Moderate Extent
1.50–2.49	Low Extent
1.00–1.49	Very Low Extent

Table 4.1 shows the respondents' perceptions of the influence of leadership capacity on sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area. The results indicate that all the questionnaire items recorded mean scores above the criterion mean of 3.00, with values ranging from 4.28 to 4.47. The overall grand mean of 4.37 and a standard deviation of 0.65 indicate that respondents generally agreed to a high extent that leadership capacity positively influences sustainable vaccine cold chain management. Specifically, respondents strongly agreed that leadership strengthens sustainability of vaccine cold chain management ($\bar{X} = 4.47$), enhances strategic leadership ($\bar{X} = 4.45$), ensures compliance with vaccine storage guidelines ($\bar{X} = 4.41$), and promotes timely maintenance of cold chain equipment ($\bar{X} = 4.40$). This finding suggests that effective leadership significantly contributes to improved vaccine preservation, reduced wastage, enhanced accountability, and better immunization service delivery within Primary Health Care facilities.

Research Question Two What leadership competencies are required for effective and sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area?

Table 4.2: Mean and Standard Deviation on Leadership Competencies Required for Sustainable Vaccine Cold Chain Management (N = 150)

S/N	Leadership Competencies	Mean ($\bar{X}$)	Std. Dev.	Decision
1	Strategic leadership	4.46	0.60	Required
2	Financial management	4.24	0.70	Required
3	Human resource management	4.33	0.65	Required
4	Monitoring and evaluation	4.40	0.58	Required
5	Cold chain supervision	4.48	0.56	Required
6	Communication skills	4.36	0.67	Required
7	Problem-solving ability	4.29	0.69	Required
8	Risk management	4.18	0.72	Required
9	Digital health management	4.25	0.71	Required
10	Decision-making ability	4.42	0.59	Required
	Grand Mean	4.34	0.65	Required

Table 4.2 presents the leadership competencies required for effective and sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area. The findings reveal that all the identified competencies obtained mean scores above the criterion mean of 3.00, indicating that respondents considered them essential for effective vaccine cold chain management. The grand mean of 4.34 and standard deviation of **0.65** indicate a high level of agreement among respondents. Cold chain supervision recorded the highest mean score ($\bar{X} = 4.48$), followed by strategic leadership ($\bar{X} = 4.46$), decision-making ability ($\bar{X} = 4.42$), and monitoring and evaluation ($\bar{X} = 4.40$). These results suggest that healthcare managers require strong leadership, managerial, technical, and supervisory competencies to ensure proper vaccine storage, effective logistics management, efficient resource utilization, staff motivation, compliance with immunization guidelines, and long-term sustainability of vaccine cold chain systems.

Test of Hypothesis

Hypothesis One

H₀: Leadership capacity has no significant influence on sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area.

H₁: Leadership capacity has a significant influence on sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area.

Table 4.3: Simple Linear Regression Analysis Showing the Influence of Leadership Capacity on Sustainable Vaccine Cold Chain Management

Model Summary

Model	R	R ²	Adjusted R ²	Std. Error
1	0.782	0.611	0.608	0.382

ANOVA

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	64.842	1	64.842	233.51	0.000
Residual	41.112	148	0.278		
Total	105.954	149			

Coefficients

Variable	B	Std. Error	Beta	t	Sig.
Constant	1.245	0.281		4.43	0.000
Leadership Capacity	0.764	0.050	0.782	15.29	0.000

The regression analysis presented in Table 4.3 indicates a strong positive relationship between leadership capacity and sustainable vaccine cold chain management ($R = 0.782$). The coefficient of determination ($R^2 = 0.611$) shows that leadership capacity explains 61.1% of the variation in sustainable vaccine cold chain management among the selected Primary Health Care facilities, while the remaining 38.9% may be explained by other factors not included in the model. The ANOVA result reveals that the regression model is statistically significant ($F = 233.51, p = 0.000$), indicating that the model adequately predicts sustainable vaccine cold chain management. The regression coefficient for leadership capacity ($\beta = 0.782, t = 15.29, p < 0.05$) demonstrates that leadership capacity has a statistically significant positive influence on sustainable vaccine cold chain management. Therefore, the null hypothesis is rejected, while the alternative hypothesis is accepted. This implies that improvements in leadership capacity are associated with significant improvements in sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area.

DISCUSSION OF FINDINGS

The findings of this study revealed that leadership capacity exerts a substantial influence on sustainable vaccine cold chain management in Primary Health Care (PHC) facilities in Kaduna North Local Government Area. The descriptive analysis presented in Table 4.1 showed that all the questionnaire items recorded mean scores above the criterion mean of 3.00, with values ranging from 4.28 to 4.47 and an overall grand mean of 4.37. This indicates that respondents perceived leadership capacity as having a high level of influence on the sustainability of vaccine cold chain management. Specifically, respondents agreed that effective leadership strengthens vaccine cold chain sustainability, enhances strategic planning, promotes compliance with vaccine storage guidelines, ensures timely maintenance of cold chain equipment, improves accountability, minimizes vaccine wastage, and enhances overall immunization service delivery. The findings are consistent with the observations of Olutuase et al. (2022), who reported that weak governance, fragmented institutional coordination, inadequate financing, and ineffective leadership constitute major barriers to efficient vaccine supply chain management in Nigeria. Their study emphasized that strengthening leadership and governance across all levels of healthcare delivery is essential for improving vaccine availability, reducing stock-outs, minimizing vaccine wastage, and sustaining routine immunization programmes. The present study corroborates this position by demonstrating that respondents overwhelmingly perceived leadership capacity as a critical determinant of sustainable vaccine cold chain management in Primary Health Care facilities. Similarly, the findings support those of Dougherty et al.

(2024), who concluded that sustainable improvements in routine immunization programmes require effective institutional leadership, collaborative governance, continuous supervision, political commitment, and coordinated resource mobilization. The current findings reinforce this argument by showing that healthcare workers in Kaduna North Local Government Area considered leadership capacity indispensable for maintaining efficient vaccine cold chain systems.

The findings of the study further revealed that several leadership competencies are essential for achieving effective and sustainable vaccine cold chain management in Primary Health Care facilities. Table 4.2 indicated that all the identified competencies recorded mean scores above the criterion mean of 3.00, with an overall grand mean of 4.34, indicating a high level of agreement among respondents. Among the identified competencies, cold chain supervision, strategic leadership, decision-making ability, monitoring and evaluation, communication skills, human resource management, financial management, risk management, and digital health management were considered critical for sustaining vaccine cold chain systems. The findings are consistent with Suleiman et al. (2021), who found that although Primary Health Care facilities in Kaduna State generally had trained personnel and vaccine availability, significant weaknesses remained in cold chain management practices, equipment maintenance, and supportive supervision. Their study concluded that stronger managerial leadership and effective supervision are necessary for improving routine immunization performance. Ifezulike et al. (2026) demonstrated that workforce development, equipment maintenance, supportive supervision, and leadership commitment significantly improved vaccine preservation and strengthened immunization service delivery in Nasarawa State. These studies reinforce the current finding that sustainable vaccine cold chain management depends on competent leaders capable of effectively managing healthcare personnel, infrastructure, logistics systems, and technological innovations.

The regression analysis conducted to test the study hypothesis established that leadership capacity has a statistically significant positive influence on sustainable vaccine cold chain management in Primary Health Care facilities in Kaduna North Local Government Area. The results showed a strong positive relationship between leadership capacity and sustainable vaccine cold chain management ($R = 0.782$). Furthermore, the coefficient of determination ($R^2 = 0.611$) indicated that leadership capacity accounted for 61.1% of the observed variation in sustainable vaccine cold chain management, while the remaining 38.9% could be attributed to other organizational and environmental factors not included in the study model. The regression model was statistically significant ($F = 233.51$, $p < 0.05$), while the regression coefficient ($\beta = 0.782$, $t = 15.29$, $p < 0.05$) confirmed that leadership capacity significantly predicts sustainable vaccine cold chain management. Consequently, the null hypothesis was rejected, while the alternative hypothesis was

accepted. This finding demonstrates that improvements in leadership capacity are likely to produce corresponding improvements in vaccine preservation, equipment maintenance, inventory management, supportive supervision, accountability, logistics coordination, and immunization service delivery. It also indicates that leadership capacity is one of the strongest organizational factors influencing the sustainability of vaccine cold chain management in Primary Health Care facilities. The findings are equally consistent with Olutuase et al. (2022), who emphasized that strengthening institutional leadership and governance significantly improves vaccine supply chain efficiency and immunization outcomes in Nigeria. Similarly, Galadima (2026) found that effective managerial oversight and digital logistics monitoring strengthened vaccine stock management and reduced vaccine wastage in Kaduna State. Ifezulike et al. (2026) also reported that leadership commitment, continuous supportive supervision, equipment maintenance, and workforce development significantly enhanced vaccine cold chain performance in Nasarawa State. In the same vein, World Health Organization (2024) maintained that countries with strong health system leadership consistently record better immunization coverage, lower vaccine wastage, improved logistics performance, and stronger health system resilience. The convergence of these findings with the present study provides robust empirical evidence that strengthening leadership capacity should remain a strategic priority for policymakers, healthcare administrators, and development partners seeking to improve routine immunization services and sustain vaccine cold chain management in Nigeria.

CONCLUSION

This study examined the influence of leadership capacity on sustainable vaccine cold chain management in Primary Health Care (PHC) facilities in Kaduna North Local Government Area, Kaduna State. The findings revealed that leadership capacity significantly influences the sustainability of vaccine cold chain management by enhancing strategic planning, supportive supervision, communication, accountability, equipment maintenance, and compliance with vaccine storage protocols. Effective leadership was found to contribute to improved vaccine preservation, reduced vaccine wastage, efficient resource utilization, and uninterrupted immunization services.

The study further identified key leadership competencies required for effective vaccine cold chain management, including strategic leadership, financial management, human resource management, monitoring and evaluation, communication, decision-making, risk management, and digital health management. These competencies enable healthcare managers to address operational challenges and

improve overall system performance. Regression analysis confirmed that leadership capacity has a statistically significant positive influence on sustainable vaccine cold chain management. The findings therefore establish leadership capacity as a critical predictor of vaccine cold chain sustainability and an essential factor in strengthening routine immunization programmes. The study also supports the assumptions of Transformational Leadership Theory and Systems Theory by demonstrating that effective leadership facilitates coordination, accountability, and integration of resources necessary for sustainable vaccine cold chain management. Consequently, strengthening leadership capacity remains vital for improving immunization outcomes and enhancing Primary Health Care service delivery.

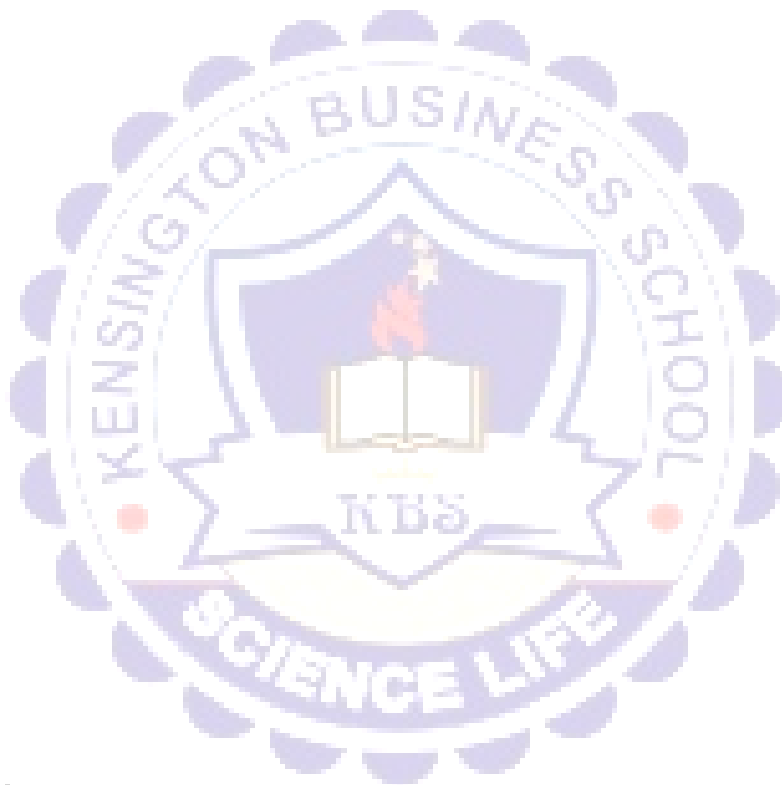
RECOMMENDATIONS

Based on the findings and conclusions of this study, the following recommendations are made:

1. The Kaduna State Primary Health Care Board and the National Primary Health Care Development Agency (NPHCDA) should institutionalize continuous leadership development programmes for Primary Health Care managers, Cold Chain Officers, Routine Immunization Officers, and facility heads. These programmes should focus on strategic leadership, supportive supervision, communication, decision-making, financial management, monitoring and evaluation, and digital health management to improve vaccine cold chain performance.
2. Government at the federal, state, and local levels should strengthen supportive supervision systems by ensuring regular supervisory visits to Primary Health Care facilities. Effective supportive supervision will improve compliance with vaccine storage guidelines, enhance accountability, identify operational challenges early, and improve the maintenance of cold chain equipment.
3. Primary Health Care managers should receive regular capacity-building training on vaccine logistics management, cold chain supervision, inventory management, preventive maintenance, risk management, and emergency preparedness. Continuous professional development will enhance managerial competence and improve the sustainability of vaccine cold chain systems.
4. The Kaduna State Government should provide adequate financial resources for the maintenance, replacement, and upgrading of vaccine cold chain equipment, including solar-powered refrigerators, temperature monitoring devices, cold boxes, vaccine carriers, and standby power systems. Adequate funding will minimize equipment failures and ensure uninterrupted vaccine preservation.
5. Digital Logistics Management Information Systems (eLMIS/OpenLMIS) should be expanded and fully integrated into all Primary Health Care facilities in Kaduna North Local Government Area. The use of digital technologies will improve vaccine forecasting, inventory control, temperature

monitoring, reporting accuracy, and evidence-based decision-making while reducing vaccine stock-outs and wastage.

6. Routine preventive maintenance schedules should be established and strictly implemented for all vaccine cold chain equipment. Qualified biomedical engineers and cold chain technicians should conduct regular inspections, repairs, calibration, and servicing of equipment to minimize breakdowns and prolong equipment lifespan.



References

- Adewale, A. O., & Ibrahim, M. A. (2023). Leadership competencies and primary healthcare service delivery in Nigeria. *African Journal of Health Systems*, 15(2), 45–60.
- Adewuyi, T. O., Bello, A. M., & Yusuf, H. A. (2025). Leadership effectiveness and health system resilience in Nigeria's primary healthcare facilities. *Nigerian Journal of Health Administration*, 12(1), 81–98.
- Aina, O. A., Okeke, C. C., & Hassan, M. I. (2024). Cold chain management practices and vaccine logistics performance in Nigerian primary healthcare centres. *African Journal of Public Health*, 18(1), 92–109.
- Bass, B. M. (1985). *Leadership and performance beyond expectations*. Free Press.
- Bertalanffy, L. von. (1968). *General system theory: Foundations, development, and applications*. George Braziller.
- Burns, J. M. (1978). *Leadership*. Harper & Row.
- Dougherty, L., et al. (2024). Strengthening routine immunization systems through collaborative leadership in northern Nigeria. *Global Health: Science and Practice*, 12(1), e2300456.
- Eze, P. N., Mohammed, A. S., & Bello, M. Y. (2025). Leadership development and managerial effectiveness among primary healthcare managers in Nigeria. *International Journal of Health Planning and Management*, 40(2), 356–372.
- Galadima, A. S. (2026). Digital supply chain monitoring on vaccine logistics performance in Zaria Local Government Area. *International Journal of Premium Advanced Educational Research*, 2(3), 122–133.
- Ifezulike, M. A., Ishaleku, D., Ugwu, D. C., Abdullahi, Y. Y., & Dogo, D. P. (2026). Health system determinants of vaccine cold chain performance at the primary healthcare facilities in Nasarawa State, Nigeria: A mixed-methods study. *International Journal of Community Medicine and Public Health*.
- Moshood, A. A., & Okafor, C. C. (2025). Determinants of vaccine cold chain performance in Primary Health Care facilities in Oyo State, Nigeria. *Nigerian Journal of Health Systems Research*, 11(2), 88–104.

National Primary Health Care Development Agency. (2023). *National routine immunization strategic plan 2023–2028*. National Primary Health Care Development Agency.

National Primary Health Care Development Agency. (2024). *Annual primary healthcare performance report*. National Primary Health Care Development Agency.

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.

Suleiman, A. G., Olorukooba, A. A., Babandi, Z. S., Umar, S. S., & Umar, U. M. (2021). Assessing the capacity of primary health care centres to provide routine immunization services amidst COVID-19 lockdown in Kaduna State, Nigeria. *International Journal of Community Medicine and Public Health*, 8(8), 3731–3736.

UNICEF Nigeria. (2023). *Improving immunization supply chain and cold chain systems in Nigeria*. UNICEF Nigeria.

UNICEF Nigeria. (2024). *Strengthening primary healthcare and routine immunization in Nigeria: Annual report*. UNICEF Nigeria.

World Health Organization. (2023). *Everybody's business: Strengthening health systems to improve health outcomes*. World Health Organization.

World Health Organization. (2024). *Immunization agenda 2030: Progress report*. World Health Organization.

