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EFFECTIVE COLD CHAIN MANAGEMENT SYSTEM AND QUALITY ASSURANCE MONITORING OF PRIMARY HEALTH CARE FACILITIES IN SAKI LOCAL GOVERNMENT AREA, OYO STATE, NIGERIA

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Abstract

The performance of cold chain systems directly affects public health outcomes especially low coverage of immunization in Saki Local Government Area (LGA), Oyo State, Nigeria, This study examine the relationship between factors influencing cold chain management, management of cold chain and quality assurance monitoring of cold chain management , in Saki local government ,area , Oyo state Nigeria. Descriptive research design was used in the study and the population comprised all health workers in the primary health care in the study area from which 209 respondents were selected using simple random sampling technique. Descriptive and inferential statistics were adopted for data analysis. Findings of the research revealed significant relationship between identified factors influencing cold chain management system and monitoring of cold chain system (F = 3.962, 0.048, p<0.05) in hypothesis one, while hypothesis two discovered no significant relationship between management of cold chain system and quality assurance monitoring in Saki Local government area of Oyo state (F = 1.584, 0.210,

Keywords: Cold chain management system, healthcare infrastructure, immunization coverage, Quality assurance, Real time Monitoring Techniques.

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p>0.05). The study concluded that cold chain management system in primary health care facilities in Saki LGA is affected by factors such as lack of infrastructural facilities and that there has not been adequate quality assurance monitoring in the study area. The study recommended that LGA PHC Board should provide strategic investment in cold chain infrastructure, particularly in power supply systems, and integrate real-time monitoring technologies to safeguard vaccine potency.

Introduction

The cold chain ensures vaccines remain effective from production to administration, involving controlled temperatures during production, transportation, storage, distribution, and delivery to end users (Zhang et al., 2018). In recent decades, the global emphasis on immunisation as a fundamental aspect of public health has been emphasized by the essential role of vaccine cold chain systems in preserving vaccine efficacy and preventing disease outbreaks (Feyisa et al., 2022). However, the integrity of these systems remains a persistent challenge, particularly in resource-limited settings such as Saki Local Government Area (LGA) in Oyo State, Nigeria (Chukwu & Adibe, 2022). This research identifies a critical problem: the inefficiency and inconsistency in the cold chain management system in primary healthcare facilities, which compromises vaccine potency and reduces immunisation coverage, which is an issue rooted in infrastructural disparities, training deficiencies, and systemic neglect (Ergetie et al., 2023).

Historically, the cold chain concept emerged as a logistical solution to preserve the quality of temperature-sensitive biological products such as vaccines during transport and storage (Khan et al., 2018). The cold chain system is a means for storing and transporting vaccines in a potent state from the manufacturer to the person being immunized. To maintain the potency of vaccines from the manufacturer to the end-users, cold chain management has, therefore, become the essential component of an effective immunization programme. It consists of a series of storage and transport links, all designed to keep vaccines within an acceptable temperature range until it reaches the users. It makes use of human, material and financial resources as well as standards at different levels (Oyefolu, et al., 2021).

Although efforts have been made to expand immunisation coverage, gaps remain (Mulatu et al., 2020). Previously conducted kinds of literature consistently points to operational shortcomings in cold chain systems, such as the lack of real-time temperature monitoring and contingency plans (Erassa et al., 2023). In Saki LGA, empirical observations show an absence of comprehensive assessments, thereby creating a research gap (Babatunde et al., 2020). This study addresses that gap by evaluating several core areas: the level of training received by healthcare personnel, the state of infrastructure

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supporting cold chain operations, the key factors that influence system performance, and the processes established for quality assurance in vaccine handling (Feyisa et al., 2022). Hence, this study fills a critical gap in the literature and practice of cold chain management in Nigeria (Ergetie et al., 2023). It provides an evidence-based foundation for improving vaccine storage and delivery systems, ultimately supporting broader public health objectives and strengthening the primary healthcare system in Saki LGA (Mulatu et al., 2020).

Statement of the Problem

The situation in Saki Local Government Area (LGA) presents a localized yet critical example of these broader national trends. Preliminary observations suggest a lack of structured assessment of cold chain systems within this area, highlighting inconsistencies in infrastructure deployment, personnel training, and adherence to WHO-recommended monitoring protocols (Chukwu & Adibe, 2022; Mulatu et al., 2020). Despite the area's strategic role in vaccine distribution, comprehensive data on cold chain performance and compliance are limited (Feyisa et al., 2022).

This study, therefore, assessed the cold chain management system within primary healthcare facilities in Saki LGA, with particular focus on four interrelated components: the training of healthcare personnel, the adequacy of infrastructure, the operational challenges encountered, and the quality assurance mechanisms in place. By identifying and analysing these dimensions, the research seeks to address the existing gap in empirical knowledge and inform policy and practice aimed at strengthening vaccine delivery systems.

Objective of the Study

i. Identify the factors influencing the management of cold chain systems in Saki Local Government Area.
ii. Determine the process of monitoring quality assurance of cold chain management in healthcare delivery in Saki Local Government Area.

Research Questions

i. What are the factors influencing the management of cold chain systems in Saki Local Government Area?
ii. How is the process of quality assurance monitored in cold chain management within healthcare delivery in Saki Local Government Area?

Research Hypothesis

H_{01}: There is no significant relationship between identified factors influencing cold chain management system (e.g., inadequate equipment, power supply issues, and lack of trained personnel) and monitoring of the cold chain system.

H_{02}: There is no significant relationship between management of cold chain system and quality assurance monitoring among healthcare Personnel.

Applications of the Theory to the Study

The Donabedian Model serves as a guiding framework for this study by offering a structured approach to evaluating cold chain management in primary healthcare facilities. Through its three interconnected dimensions, structure, process, and outcome, the model facilitates a comprehensive assessment of the systems in place for vaccine storage and distribution.

In applying the model, the study first considers the **structure** of the cold chain system, examining the physical infrastructure and organizational elements that support vaccine storage. This includes the availability and functionality of cold chain equipment such as refrigerators, cold boxes, and backup power sources, as well as the presence of trained personnel and standard operating procedures. These structural factors are foundational, as they create the conditions necessary for proper vaccine handling.

The study then moves to assess the **processes** involved in cold chain management. This involves evaluating how healthcare workers store and monitor vaccines, maintain temperature records, respond to equipment malfunctions, and implement routine quality checks. The effectiveness of these processes reflects the degree to which structural inputs are utilized to uphold vaccine integrity and ensure compliance with guidelines.

Finally, the study examines the **outcomes** resulting from these structures and processes. These outcomes are observed through indicators such as the preservation of vaccine potency, the rate of vaccine spoilage, and the overall reliability and effectiveness of immunization services delivered to the population. Poor outcomes, such as frequent spoilage or low immunization coverage, signal underlying issues in either structure or process, which the model helps to trace and analyze.

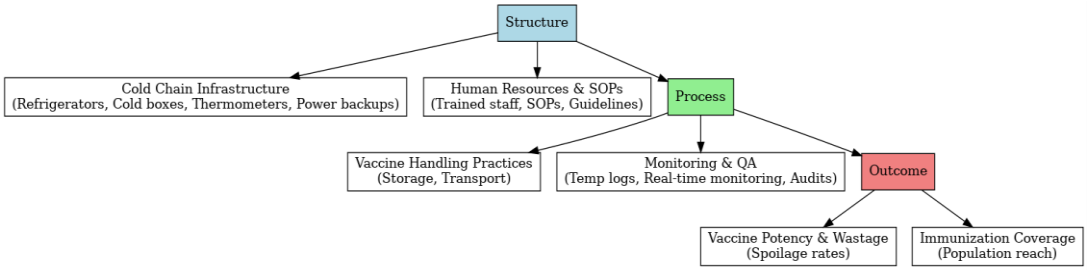


Figure 2.1: Conceptual Framework

Conceptual Review

The adoption of a cold chain storage system for products such as flowers, fresh foods, milk and dairy products, pharmaceuticals, blood and chemicals is essential to ensure the

quality and safety of the goods, as they are perishable and temperature-sensitive (Feyisa et al., 2021; Khan et al., 2018; Zhang et al., 2018). This was also supported by Ergetie et al. (2023) that the efficacy and safety of medications depend on the proper upkeep of the drugs (Ergetie et al., 2023). In the past few years, the World Health Organisation (WHO) has laid emphasis on cold chain management for the preservation and distribution of some pharmaceuticals at the Primary Health Centre (PHC) in order to maintain the quality and ensure its safety (Rahmat et al., 2023; Zhang et al., 2018). The pharmaceutical products include ergometrine, insulin, oxytocin, vaccines and some diagnostic reagents (Feyisa et al., 2021). Thus, Vaccines must be placed in a cold chain system within the World Health Organization's recommended requirements (cold box and vaccine carriers containing coolants), temperature charts, shake test, and choice of temperature (typically +2°C to +8°C for refrigerator vaccines and -15°C to -25°C for deep freezer vaccines) as they are sensitive to light, freezing and thermo-sensitive and can loss its shelf life of potency as time passes (Adebimpe & Adeoye, 2021; Bogale et al., 2019; Ergetie et al., 2023; Feyisa et al., 2022; Kasahun et al., 2023; Pradeep et al., 2022). Similar to this are the NAFDAC requirements for cold chain management. The requirements include cold boxes, water packs that can be used to line the inside of the cold boxes, temperature monitoring devices, and freezers or refrigerators, all accompanied by an approved Standard Operating Procedure (SOP) from the manufacturer (NAFDAC, 2019).

Factors Influencing Cold Chain Management

In the provision of quality services in healthcare, despite the significant role played by the cold chain system, some factors hinder the operative adoption of the system in underdeveloped and developing countries, leading to some noticeable weaknesses such as inadequate storage methods, quality of refrigerators, faulty equipment, and power interruption (Bogale et al., 2019; Erassa et al., 2023; Feyisa et al., 2021; Khan et al., 2018). The factors include irregular power supply, which poses the greatest risk (Bogale et al., 2019), inadequate infrastructural facilities, lack of well-trained personnel, knowledge of cold-chain management and handling, lack of well-developed cold-chain facilities and equipment, out-of-date technologies, shortage of competent workforce, substandard waste management, and inadequate logistics for transportation (Erassa et al., 2023; Ergetie et al., 2023; Kasahun et al., 2023; Khan et al., 2018; Rahmat et al., 2023). Inadequate knowledge among health workers on cold chain procedures is a prominent factor contributing to a reduction in the quality of vaccines, thereby causing Vaccine-Preventable Diseases (VPD) (Adebimpe & Adeoye, 2021). In addition, huge capital and distinct treatment have been a factor inhibiting the normal logistics system in the cold chain (Zhang et al., 2018).

In summary, various factors influence the effectiveness of cold chain management:

Training and Knowledge: Adequate training and knowledge of cold chain handlers are essential for maintaining vaccine efficacy and ensuring proper handling and storage practices (Adebimpe & Adeoye, 2021; Feyisa et al., 2022; Kumar & Gupta, 2020).
Infrastructure and Equipment: The quality and reliability of some infrastructure, such as freezers, refrigerators, and temperature monitoring devices, are essential to maintain the cold chain (Bogale et al., 2019; Feyisa, 2021).
Environmental Conditions: Factors such as climate and power supply stability can impact cold chain effectiveness, especially in tropical regions where temperature and power supply are not constant (Kasahun et al., 2023).
Logistics and Transportation: Efficient logistics systems are necessary to ensure timely transportation and distribution of vaccines while maintaining the required temperature ranges (Bogale et al., 2019; Mulatu et al., 2020).
Supervision and Monitoring: Regular supervision and adherence to guidelines help maintain the integrity of the cold chain. Ensuring that all health facilities follow WHO recommendations for vaccine storage and temperature monitoring is crucial (Feyisa et al., 2022; Asamoah et al., 2021; Bogale et al., 2019).

Process of Monitoring Quality Assurance of Cold Chain Management in Healthcare Delivery

The effectiveness of cold chain management in healthcare delivery is critically dependent on strong quality assurance (QA) and monitoring mechanisms. A consistent theme across previously conducted research is the importance of real-time temperature monitoring, adherence to standard operating procedures (SOPs), staff training, and contingency planning to safeguard vaccine potency (Asamoah et al., 2021; Feyisa et al., 2022; Chukwu & Adibe, 2022). These elements are essential in maintaining the integrity of vaccines from storage to administration, especially in resource-constrained settings where system lapses are more likely to compromise immunisation outcomes (Babatunde et al., 2020; Erassa et al., 2023**).**

Temperature Monitoring and Documentation Practices

Temperature monitoring remains a cornerstone of cold chain QA. Studies have shown that maintaining vaccines within the recommended temperature range (2°C–8°C) is crucial to preserving their efficacy. However, adherence to twice-daily temperature recordings is not consistent across all facilities. For instance, Feyisa et al. (2022) observed that nearly half of the primary healthcare facilities in Ethiopia demonstrated poor adherence to the WHO's vaccine storage codes, which include regular temperature checks. Similarly, Asamoah et al. (2021) found that although a majority of Ghanaian facilities had basic monitoring devices like fridge tags and vaccine vial monitors, these were not effectively used due to inadequate staff engagement and oversight.

Contingency Planning and Emergency Response

Finally, the ability to respond effectively to power outages or equipment failures is central to quality assurance. Unfortunately, contingency planning remains a major gap in many facilities. Asamoah et al. (2021) reported a complete absence of contingency plans in all surveyed facilities in Ghana. This lack of preparedness increases the risk of vaccine spoilage during emergencies and reflects broader system-level deficiencies that require immediate redress.

Effects of Cold Chain Management on Health Care Delivery

Cold chain management is an important aspect in storing medications and related products. If not well managed, the system might cause some adverse effects on the delivery of healthcare globally. The errors might cause harm to the population at risk, such as unknown disease vulnerability, leading to costly revaccination (Feyisa et al., 2021). Erassa et al. (2023) reported that there are about 29% of under-five mortalities globally due to poor vaccine cold chain management (Erassa et al., 2023).

In contrast, there are advantages attached to the adoption of the system, such as low cost of overhead and gives room for a differentiated marketing strategy (Zhang et al., 2018). In addition, proper management and utilisation of the cold chain system cannot be neglected as it helps to reduce wastages, maintains immunological action of the vaccines, and affects vaccine coverage (Asamoah et al., 2021; Bogale et al., 2019; Kasahun et al., 2023; Mulatu et al., 2020).

Generally, there has been a wide range of implications of cold chain management for healthcare delivery. It includes:

Vaccine Coverage and Uptake: Reliable cold chain systems enhance vaccine coverage and uptake by ensuring vaccines are available and effective at the point of use. This is particularly important in achieving high immunisation rates and preventing outbreaks (Mulatu et al., 2020; Asamoah et al., 2021; Kasahun et al., 2023).

Vaccine Potency and Efficacy: Maintaining the correct temperatures ensures that vaccines remain potent and effective, providing the intended immunological protection. This is critical for preventing vaccine-preventable diseases and ensuring public health safety (Feyisa et al., 2022; Mulatu et al., 2020; Bogale et al., 2019).

Economic Impact: Efficient cold chain management prevents vaccine wastage and the associated costs of revaccination and disease outbreaks, contributing to overall healthcare cost savings. This is particularly important in resource-limited settings where financial constraints are significant (Feyisa et al., 2022; Mulatu et al., 2020; Adebimpe & Adeoye, 2020).

Confidence in Immunisation Programs: Consistent and effective cold chain practices build public trust in immunisation programs, encouraging higher participation rates. This is

crucial for achieving herd immunity and protecting vulnerable populations (Feyisa et al., 2022; Bogale et al., 2019; Kasahun et al., 2023).

Public Health Outcomes: Proper cold chain management reduces the incidence of vaccine-preventable diseases, thereby decreasing morbidity and mortality rates. Effective cold chain practices are essential for the success of public health initiatives and immunisation programs (Feyisa et al., 2022; Bogale et al., 2019; Asamoah et al., 2021).

Empirical Review

Factors Influencing the Management of **Cold Chain Systems**

Prosser et al. (2023), in their work titled "Thinking Outside of the [Cold] Box: Implementing a Human-cantered Design Approach to Understand Barriers and Craft Solutions to Cold Chain Equipment Maintenance in Niger," explored the challenges in maintaining cold chain equipment in rural healthcare settings. The study adopted a qualitative human-centred design approach, gathering data from healthcare workers and maintenance personnel. Findings revealed that logistical constraints, lack of trained technicians, and inconsistent funding for maintenance were key barriers. The study recommended government-led interventions, including workforce development and predictive maintenance strategies. This research is significant to the present study as it identifies practical barriers to effective cold chain management and offers potential solutions.

Shahzad et al. (2024), in their work titled "Economic, Social, and Administrative Barriers to Achieving the Sustainable Development Goal of Good Health and Well-Being," investigated the barriers affecting the Expanded Programme on Immunisation (EPI) in Pakistan. Using a mixed-methods approach, the study identified key challenges, including vaccine mismanagement, cold chain failures, and inadequate human resources. The findings revealed that vaccine storage issues, lack of trained personnel, and inadequate legislation hindered effective immunisation service delivery. The study concluded that coordinated government and community efforts are essential to overcoming these barriers. This research is relevant as it provides insights into systemic challenges affecting cold chain management in primary healthcare facilities.

Das (2021), in their work titled "COVID-19 Vaccine and the Cold Chain Implications for Global Adoption," explored the logistical challenges of distributing COVID-19 vaccines, particularly those requiring ultra-cold storage. The study highlighted the limitations of existing cold chain systems in developing countries, which often experience temperature excursions due to unreliable electricity and inadequate transportation infrastructure. The research emphasized the need for capacity-building, innovative cold storage solutions, and policy interventions to enhance vaccine distribution. This study is relevant as it

provides insights into the transportation and storage challenges faced in maintaining an effective cold chain system.

Processes for Monitoring Quality Assurance in Cold Chain Management

Gupta and Srivastava (2024), in their work titled "The Optimization of the Regional Distribution of COVID-19 Vaccinations, Taking into Account Logistical and Quality Concerns," examined the logistical and quality assurance challenges in vaccine distribution. The study utilized optimization models to balance efficiency with maintaining cold chain integrity. Findings indicated that real-time temperature monitoring and strategic location of distribution hubs were crucial for quality assurance. The research concluded that incorporating technology-driven tracking systems can enhance vaccine potency and reduce wastage. This study is relevant to the present research as it underscores the importance of structured quality assurance processes in maintaining an effective cold chain system.

Zamani and Wembridge (2022), in their work titled "Evaluating an Automated Temperature-Monitoring System in Medicine and Vaccine Storage Facilities of a Hospital Network," assessed the effectiveness of an automated system in detecting temperature fluctuations in vaccine storage. The study compared temperature excursion rates before and after the system's implementation. Findings indicated that post-implementation, the number of detected temperature deviations significantly increased, allowing for timely interventions to maintain vaccine integrity. The study concluded that integrating automated monitoring systems enhances quality assurance in cold chain management. This research is relevant to the present study as it underscores the importance of real-time monitoring in maintaining vaccine potency.

Qin et al. (2021), in their work titled "Design of a Vaccine Storage and Transportation System in Remote Areas Based on Raspberry Pi," proposed an intelligent vaccine storage and transportation system to address logistical issues in remote areas. The study integrated IoT-enabled temperature monitoring, storage traceability, and automated alerts for deviations. The findings revealed that the system significantly improved storage conditions and reduced temperature excursions during transit. The study concluded that deploying smart logistics solutions can enhance vaccine delivery efficiency in hard-to-reach areas. This study is relevant to the present research as it explores innovative solutions for improving vaccine transportation and storage in primary healthcare settings.

Research Methodology

The descriptive cross-sectional design has been widely used in cold chain management studies (Feyisa et al., 2021; Asamoah et al., 2021). It is particularly useful for assessment, infrastructure, and influencing factors in healthcare settings.

The population of the study is all healthcare workers such as Doctors, Nurses, Community Health Extension Workers (CHEW), Community Health Officers (CHO), and Facility Managers who are working in the Primary healthcare facilities within the Local Government area. Sample size was 219 respondents selected on the basis of simple random technique. To ensure reliability of the research instrument, pilot study was conducted on 21 questionnaire and the result yielded cronbach alpha coefficient of 75% indicating that the instrument is reliable.

Descriptive statistics involving frequencies and percentage was used while regression and correlation was used in the test of hypotheses.

Data Analysis and Interpretation of Result

Table 1: Types of Equipment Available for Cold Chain Management System

Equipment Type	Available	Functional	Nonfunctional
Refrigerators	160	120 (75.00%)	40 (25.00%)
Freezers	172	130 (75.58%)	42 (24.42%)
Cold boxes	167	127 (76.05%)	40 (23.95%)
Vaccine carriers	164	129 (78.66%)	35 (21.34%)
Icepacks	174	133 (76.44%)	41 (23.56%)
Temperature loggers	166	136 (81.93%)	30 (18.07%)
Thermometers	172	131 (76.16%)	41 (23.84%)

Source: Researcher's field Study (2025)

Table 1 indicate that the most commonly available equipment includes Refrigerators (160 units), Freezers (172 units), and Icepacks (174 units). Cold boxes, vaccine carriers, temperature loggers, and thermometers were also reported, though in slightly lower numbers. Functionality assessment shows that the majority of equipment is functional, with operational rates ranging from 75% to 81.93%. However, a significant portion remains non-functional, especially among cold boxes and vaccine carriers. The presence of non-functional equipment suggests that while healthcare facilities are equipped with cold chain management tools, maintenance and repair issues may hinder optimal performance. The availability of functional cold chain equipment is essential for maintaining the potency of vaccines and ensuring that immunisation efforts remain effective.

Table 2: Cold Chain Equipment Maintenance

Maintenance Type	Regular	Often	Seldom	Never
Cleaning	88 (52.15%)	46 (27.27%)	26 (15.31%)	9 (5.26%)
Defrosting	82 (48.33%)	58 (34.45%)	20 (11.96%)	9 (5.26%)

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Maintenance Type	Regular	Often	Seldom	Never
Safety Engineering	72 (42.60%)	48 (28.40%)	39 (23.08%)	10 (5.92%)

Source: Researcher's field Study (2025)

Table 2 shows that cleaning is conducted regularly in 52.15% of facilities, while 27.27% perform it often. However, 14.83% clean their equipment seldom, and 5.26% never conduct cleaning at all. This indicates that while cleaning practices are fairly well established, a small percentage of healthcare facilities neglect proper hygiene practices for cold chain equipment. Similarly, defrosting is performed regularly in 48.33% of the facilities, with 30.62% doing it often. However, 15.79% seldom defrost their equipment, and 5.26% never engage in this activity. The lack of regular defrosting can lead to ice build-up, which affects temperature regulation and the overall efficiency of cold storage units. Regarding safety engineering checks, only 42.58% of respondents reported performing them regularly, while 28.23% conducted them often, and 22.97% seldom carried out safety checks. 6.22% of facilities never perform safety engineering maintenance, indicating potential risks of equipment failure. The findings suggest that while most facilities follow some form of maintenance routine, more consistent safety engineering checks are needed to ensure long-term functionality.

Table 3: Factors Influencing Cold Chain Management

Variable	Category	Frequency	Percentage (%)
Challenges Faced	Inadequate equipment	47	22.49
	Power supply	46	22.01
	Insufficient funding	45	21.53
	Lack of trained personnel	23	11.00
	Poor infrastructure	18	8.61
	Equipment breakage	17	8.13
	Transportation issue	13	6.22
Measures in Place	Yes	152	72.73
	No	57	27.27
Types of Measures Taken	Use of generators	45	29.67
	Alternative storage facility	39	25.84
	Solar power	36	23.44
	Regular maintenance schedules	22	14.35
	Others	10	6.70

Source: Researcher's field Study (2025)

Table 3 reveals that inadequate equipment (22.49%) and power supply issues (22.01%) were the most commonly reported factors influencing the cold chain management system, while transportation issues (6.22%) and equipment breakage (8.13%) were the least reported. The presence of measures to address these challenges was also assessed, with 72.73% of respondents confirming that they had measures in place. Among these measures, use of generators (29.67%) and alternative storage facilities (25.84%) were the most commonly employed solutions.

Hypothesis One

Research Objective 1:

Identify the factors influencing the management of cold chain systems in Saki Local Government Area.

Research Question 1

What are the factors influencing the management of cold chain systems in Saki Local Government Area?

Research Hypothesis 1

H_{03}: There is no significant relationship between the identified factors influencing cold chain management system and monitoring of the cold chain system in Saki Local Government Area.

Table 4: Hypothesis Testing 1 (factors influencing the cold chain management system and Monitoring of Cold Chain)

factors influencing the cold chain management system and Monitoring of Cold Chain				
Regression				
Variable	**Coeff.**	**SE**	**t-test**	**Sig**
R	0.139[a]			
R^2	0.19			
Adjusted R^2	0.14	1.04044		
Constant	1.840	0.114	16.153	0.000
FIC	0.065	0.033	F= 3.962	0.048[b]

Dependent Variable: Monitoring of cold chain
Source: Researcher's field Study (2025)

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The results in **Table 4** investigates the relationship between identified factors influencing the cold chain management system and the monitoring of the cold chain system in Saki Local Government Area.

R which indicates the strength and direction of linear relationship between identified factors influencing the cold chain management system and monitoring of cold chain system (0.139) indicates a positive but weak relationship between identified factors influencing the cold chain management system and monitoring of cold chain system in Saki West Local government area. This implies that the identified factors influencing cold chain management system affects monitoring of cold chain management system, that is, the more those factors identified, the more there will be monitoring of cold chain management system.

R^2 which is the coefficient of determination, explains the proportion of identified factor influencing cold chain management system that influence the level of monitoring the cold chain management system. $R^2 = 0.19$ indicates a better fit of the model result since it is positive. This implies that monitoring of cold chain management system accounts for 19% of the variation in the identified factors influencing cold chain management system. The remaining 81% is explained by variables not covered by the study.

The adjusted R^2 which is a modified version of the standard R-squared accounted for only 14% of the predictor (identified factors influencing cold chain management system) in the model, and thus penalized for adding unnecessary predictors to the model.

The *F – Stat (3.962, 0.048)* which measures the overall significance of the model, indicates that 0.048 < 0.05 which implies that the overall model is significant. This tells how the model as a whole provides a better fit to the data than a model without a predictor value. On this note, the null hypothesis that, 'There is no significant relationship between the identified factors influencing cold chain management system and monitoring of the cold chain system in Saki Local Government Area' is rejected while the alternate hypothesis that 'There is significant relationship between the identified factors influencing cold chain management system and monitoring of the cold chain system in Saki Local Government Area' is accepted.

Research Objective 2:

Determine the process of monitoring quality assurance of cold chain management in healthcare delivery in Saki Local Government Area.

Research Question 2

How is the process of quality assurance monitored in cold chain management within healthcare delivery in Saki Local Government Area?

Research Hypothesis 2

H_{04}: There is no significant relationship between management of cold chain system and quality assurance monitoring in healthcare delivery in Saki Local Government Area.

Table 5: Hypothesis Testing 2 (Management of cold chain system and quality assurance monitoring in healthcare delivery in Saki Local Government Area)

Management of cold chain system and quality assurance monitoring in healthcare delivery in Saki Local Government Area				
Regression				
Variable	Coeff.	SE	t-test	Sig
R	0.91[a]			
R^2	0.8			
Adjusted R^2	0.3	1.01372		
Constant	1.906	0.238	7.995	0.000
MCCS	0.244	0.194	F= 1.584	0.210[b]

Dependent Variable: Quality Assurance Monitoring of cold chain

Source: Researcher's field Study (2025)

The results in **Table 5** examines the relationship between management of cold chain system and quality assurance monitoring in healthcare delivery in Saki Local Government Area**.**

R which indicates the strength and direction of linear relationship between management of cold chain system and quality assurance monitoring in healthcare delivery (0.91) indicates a positive and strong relationship between management of cold chain system and quality assurance monitoring in healthcare delivery in Saki West Local government area. This implies that management of cold chain system impacts quality assurance monitoring of cold chain management system, that is, the more there is quality assurance monitoring in healthcare delivery, the better the management of cold chain system in Saki West Local government area.

R^2 which is the coefficient of determination, explains the proportion of management of cold chain system that influence the quality assurance monitoring in healthcare delivery. $R^2 = 0.8$ indicates a better fit of the model result since it is positive. This implies that quality assurance monitoring of cold chain system accounts for 80% of the variation in the management of cold chain management system. The remaining 20% is explained by variables not covered in the study.

The adjusted R^2 which is a modified version of the standard R-squared accounted for only 30% of the predictor (management of cold chain system) in the model, and thus penalized for adding unnecessary predictors to the model.

The *F – Stat (1.584, 0.210)* which measures the overall significance of the model, indicates that 0.210 > 0.05 which implies that the overall model is not significant. This tells how the model as a whole provides a better fit to the data than a model without a predictor value. On this note, the null hypothesis that, 'There is no significant relationship between management of cold chain system and quality assurance monitoring in healthcare delivery in Saki Local Government Area' is accepted while the alternate hypothesis that 'There is significant relationship between management of cold chain system and quality assurance monitoring in healthcare delivery in Saki Local Government Area' is rejected.

Discussion of Findings

The functionality rates of cold chain equipment ranged from 75% to 81.93%, indicating that some facilities have nonfunctional equipment. This aligns with findings by Pambudi et al. (2021), who reported that equipment failures in Nigerian healthcare centres often result from irregular maintenance and poor funding.

The study confirmed that power supply issues (22.01%), inadequate equipment (22.49%), and insufficient funding (21.53%) were the most significant barriers. Unlike the initial results, the revised hypothesis test for challenges ($\chi^2 = 44.14$, $p = 0.000$) revealed a statistically significant relationship between challenges and cold chain effectiveness.

This finding supports Kasahun et al. (2023), who reported that healthcare facilities without stable electricity and adequate storage equipment experience higher vaccine wastage. The significant association suggests that addressing these barriers through sustainable energy solutions, equipment procurement, and better funding will lead to improved vaccine storage outcomes.

The study also evaluated quality assurance mechanisms in cold chain management. While 62.20% of facilities had SOPs and 41.63% conducted monthly audits, 10.05% of facilities never conducted audits. This finding is concerning, as irregular quality assurance can lead to vaccine degradation.

Moreover, while 79.43% of respondents reported no vaccine spoilage incidents, the absence of real-time monitoring systems in many facilities (62.68%) suggests that spoilage could be underreported. Research by Zamani & Wembridge (2022) highlights that real-time monitoring significantly reduces vaccine wastage and should be adopted more widely.

Summary of Findings

The result of hypothesis three testing confirmed significant relationship between identified factors influencing cold chain management system and monitoring of cold

chain system (*F = 3.962, 0.048, p<0.05*). Hypothesis four also discovered no significant relationship between management of cold chain system and quality assurance monitoring in Saki Local government area of Oyo state (*F = 1.584, 0.210, p>0.05*).

The study concluded that while most facilities reported having cold chain systems and backup power, the irregularity in emergency preparedness plans and the presence of non-functional equipment remain problematic. The absence of significant relationship between infrastructure and cold chain effectiveness suggests that investment in physical resources could be a high-yield strategy for improving performance. Equipment maintenance, including cleaning, defrosting, and safety engineering, also varied across facilities, with some failing to implement regular checks.

Recommendation

The followings were recommended:

i. There should be development and enforcement of Standard Operating Procedures (SOPs) to ensure uniformity in vaccine storage, distribution and handling.
ii. Conduction of periodical research and evaluation to assess the effectiveness of interventions in cold chain management.

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