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Influence of Storage Practices on Vaccines Availability in Public Health Facilities in Kisii County, Kenya

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ABSTRACT

Vaccine stock outs remain a significant challenge in public health systems, especially in low- and middle-income countries, where fragile health infrastructure and logistical inefficiencies undermine routine immunization programs. These stock outs disrupt vaccination schedules, expose populations, especially children—to vaccine-preventable diseases, and ultimately compromise health outcomes. In Kenya, repeated vaccine shortages have been reported across counties, often linked to poor cold chain management, insufficient maintenance of storage equipment, and inadequate inventory practices. This study aimed to assess the influence of storage practices on vaccines availability in public health facilities in Kisii County, Kenya. A descriptive cross-sectional design was employed, targeting 131 healthcare workers from all 131 public health facilities offering immunization services in the county. A census approach with purposive sampling was used to identify vaccine handlers. Data were collected using researcher-administered questionnaires and an observation checklist, and analyzed using SPSS version 26.0. Descriptive statistics summarized storage practices, while linear regression assessed the relationship between storage practices and vaccine availability, with statistical significance set at $p < 0.05$. The findings showed that while functional refrigerators were available in 90.6% of the facilities, availability of freezers (15.4%) and cold boxes (29.1%) was limited. Monthly physical counts were routinely done (mean = 3.57), but many facilities lacked routine maintenance plans and trained cold chain personnel (means = 2.90 and 2.71 respectively). Regression analysis revealed a strong positive relationship between storage practices and vaccines availability ($R = 0.734$, $\beta = 0.734$, $p < 0.001$), with 53.8% of the variability in availability explained by storage practices ($R^2 = 0.538$). The study concludes that strengthening cold chain infrastructure, training staff, and implementing structured maintenance plans are essential to improving vaccine storage and preventing stock outs. It recommends budget allocation for cold chain improvements and adoption of standard operating procedures to enhance vaccine availability and health system responsiveness in immunization delivery.

Key Terms: Vaccine Availability, Storage Practices, Cold Chain Management, Public Health Facilities, Immunization Services, Health Systems, Kisii County, Kenya

INTRODUCTION

Health systems comprise six critical areas: leadership and governance; health information systems; health workforce; access to medicines, vaccines, and technologies; health service delivery; and health system financing (WHO, 2007). In a properly functioning healthcare system, these components operate cohesively to ensure services are of high quality, safe, affordable, and timely.

Vaccines have been used successfully to prevent infectious diseases, which remain a leading cause of both morbidity and mortality worldwide. In 2018, approximately 700,000 children under the age of five, mostly from low- and middle-income countries, died of vaccine-preventable diseases (Res & 2020, n.d.). The World Health Organization estimates that vaccinations can prevent 2 to 3 million deaths annually (WHO, 2018). However, achieving these outcomes requires an uninterrupted and efficient vaccine supply chain.

The Global Vaccine Action Plan 2011–2020 provided a coordinated framework to guide immunization programs toward universal access (WHO, 2020). Nonetheless, vaccine stockouts persist globally and locally

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due to disruptions in the supply chain (Sarigol et al., 2023). These interruptions lead to missed vaccinations, lower immunization coverage, and heightened risk of disease outbreaks. (Gavi, 2022)emphasizes that strengthening immunization supply chains is essential for vaccine potency and availability, particularly in LMICs like Kenya.

In Kenya, frequent vaccine stockouts have been documented in public health facilities. In Nairobi County, stockouts of tetanus, measles, and oral polio vaccines affected up to 88% of facilities(Kanja et al., 2021). Similarly, (Onyango, 2024)attributes persistent stockouts during COVID-19 to poor coordination, insufficient stock visibility, and logistical gaps. In Tana River County, stockouts were linked to vaccine rationing, transportation issues, and faulty cold chain equipment (Mkamba et al., 2023). Studies by (Wanyonyi et al., 2024)and (Ayako, 2023) further highlight the lack of cold chain knowledge and inadequate forecasting tools as significant contributors to vaccine unavailability.

Moreover, (Olutuase et al., 2022)reported that poor data systems and lack of real-time decision-making tools hinder vaccine availability in Kenyan counties. (Iwu et al., 2020)similarly noted that at the facility level in the WHO African Region, inventory mismanagement and irregular stock audits contribute to vaccine shortages. While some counties have invested in WHO-compliant equipment, gaps in temperature monitoring and contingency planning remain widespread. For instance, in Turkana County, only 80% of fridges had functional monitoring devices, and in Nairobi, 40% of facilities lacked equipment failure plans(Kanja et al., 2021).

Finally, (Olutuase et al., 2022)found that challenges in vaccine supply chains such as lack of accountability mechanisms, weak human resources, and donor dependency are widespread across sub-Saharan Africa. Addressing these challenges calls for a strengthened, evidence-based approach to cold chain infrastructure, stock management, and supply chain governance. This study contributes to that effort by examining how storage practices influence vaccine availability in public health facilities in Kisii County, Kenya.

METHODOLOGY

This study used a descriptive cross-sectional survey design, which was well suited to assess the current state of vaccine storage practices and how they affect vaccine availability in public health facilities across Kisii County. The design allowed the researchers to gather quantitative data at a single point in time, making it possible to identify patterns and relationships between how vaccines are stored and whether they are consistently available. The research took place in Kisii County, Kenya, a region made up of nine sub-counties and a wide network of public health facilities that provide routine immunization services under the Kenya Expanded Programme on Immunization (KEPI). The county operates a decentralized health system, where vaccines are first delivered to regional depots and then sent to sub-county stores. From there, individual health facilities collect their monthly vaccine supplies.

The study targeted 131 healthcare workers, mainly nurses, who are directly involved in vaccine handling and administration in each of the 131 public health facilities that offer immunization services in the county. These individuals were chosen because of their hands-on experience and deep understanding of both storage practices and the day-to-day realities of vaccine availability in their respective facilities. A census approach was used to include all 131 public health facilities, with one vaccine handler selected per facility. This method ensured comprehensive data collection and increased the representativeness of the findings. Purposive sampling was applied to select respondents directly involved in vaccine management, including nurses and cold chain focal persons.

Data were collected using two structured instruments: a researcher-administered questionnaire designed to collect information on storage practices, facility infrastructure, human resource capacity, and perceptions of vaccine availability; and an observation checklist used to independently assess cold chain equipment, temperature monitoring practices, and physical vaccine stock status. Both tools were developed based on World Health Organization (WHO) standards and validated survey instruments from previous related studies.

The instruments were subjected to pre-testing in three public health facilities not included in the final sample to ensure face validity, clarity, and consistency. Feedback from the pre-test led to modifications of question

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wording and response options. Reliability testing was done using Cronbach's alpha coefficient, with a benchmark of 0.7 used to determine internal consistency for Likert scale items.

Data collection was conducted over a period of four weeks. Trained research assistants visited each facility, administered questionnaires to the designated vaccine handlers, and completed the observation checklist with consent from facility in-charges. Ethical conduct and confidentiality were maintained throughout the process.

Data were coded, cleaned, and analyzed using Statistical Package for Social Sciences (SPSS) version 26.0. Descriptive statistics including means, frequencies, percentages, and standard deviations were used to summarize respondents' characteristics and facility-level storage practices. A simple linear regression analysis was conducted to determine the strength and significance of the relationship between storage practices and vaccine availability. Significance was set at $p < 0.05$. Results were presented in tables, charts, and graphs to facilitate easy interpretation.

Approval to conduct the study was obtained from Kenya Methodist University (KEMU) Ethical Review Committee, the National Commission for Science, Technology and Innovation (NACOSTI), and the Kisii County Health Department. Informed written consent was obtained from all participants. Respondents were assured of the confidentiality and voluntary nature of participation, and no personal identifiers were collected.

RESULTS AND DISCUSSION

The study sought to assess storage practices in public health facilities in Kisii County, Kenya. It focused on evaluating the conditions under which vaccines were stored, including infrastructure, inventory management, and adherence to safety standards. The findings aimed to identify gaps in storage practices that could affect vaccines availability and consequently affect service delivery.

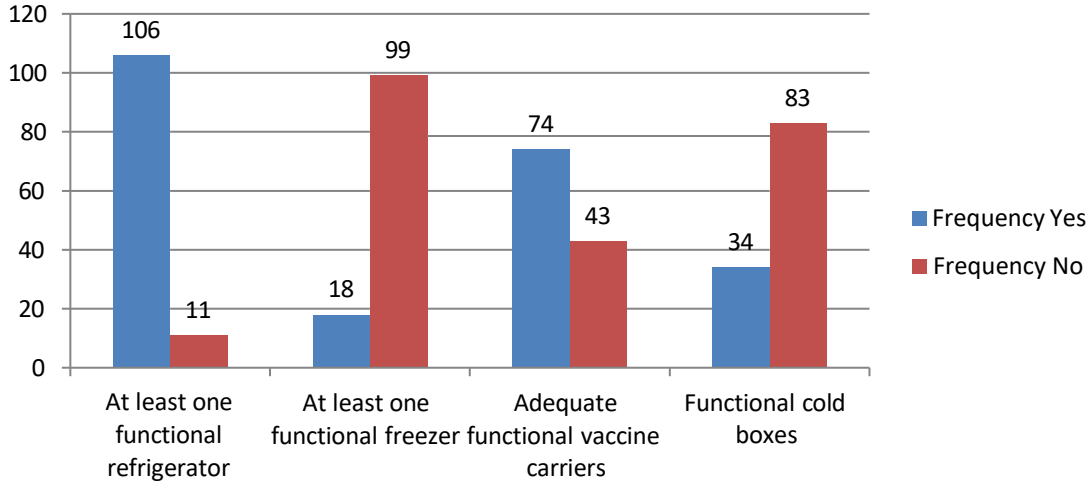

Figure 1: Availability and functionality of cold chain equipment

The data highlighted notable disparities in the availability and functionality of cold chain equipment at the facility. While functional refrigerators were widely available (90.6%), ensuring stable vaccine storage, the availability of freezers was significantly low, with only 18 out of 117 facilities (15.4%) having at least one operational unit. Vaccine carriers showed better functionality, with 63.2% of facilities possessing adequate equipment. However, functional cold boxes remained limited (29.1%). These findings emphasize the need to strengthen cold chain infrastructure, particularly by addressing the shortage of freezers and cold boxes, to enhance vaccine storage and distribution efficiency.

The data provided offers insight into perceptions of storage practices in health facilities, particularly in relation to vaccine management and cold chain systems. The analysis of each item based on the descriptive statistics (mean and standard deviation) and a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) is as follows:

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Table 1: Descriptive Analysis on Storage practices

Statements	N	Min	Max	Mean	Std. Dev
Cold chain equipment has adequate storage capacity of vaccines	117	1	5	2.62	1.120
Availability of correctly and completely filled vaccine ledger books	117	1	5	3.07	1.081
Monthly vaccine physical count is conducted	117	1	5	3.57	1.155
Vaccines usually tally with what is documented in the ledger book at all times	117	1	5	2.83	1.116
Availability of a routine maintenance plan for cold chain equipment at the facility	117	1	5	2.90	1.199
Availability of a trained person responsible for cold chain equipment routine maintenance	117	1	5	2.71	1.300

Item 1 cold chain equipment has adequate storage capacity of vaccines: With a mean score of 2.62 and a standard deviation of 1.120, the responses indicate a general disagreement with the adequacy of cold chain storage capacity. Most respondents lean toward the view that storage capacity may be insufficient, though the relatively wide spread suggests variation in perceptions across facilities. Availability of correctly and completely filled vaccine ledger books: The mean score of 3.07 indicates a neutral to slightly positive perception, suggesting that, on average, respondents are somewhat satisfied with the accuracy and completeness of vaccine ledger books. However, the moderate standard deviation (1.081) implies a range of responses, with some facilities likely performing better than others in this regard. Monthly vaccine physical count is conducted: This item scored a mean of 3.57, the highest among all, with a standard deviation of 1.155. This suggests a general agreement that monthly physical counts are conducted. While there is a positive perception, the moderate variability shows that this practice is not universally applied or perceived the same across all settings.

Vaccines usually tally with what is documented in the ledger book at all times: A mean of 2.83 indicates disagreement to neutrality, implying some inconsistencies between physical stock and recorded data. This point to potential issues in record-keeping or inventory management with a standard deviation (1.116) again reflects diverse experiences among respondents. Availability of a routine maintenance plan for cold chain equipment at the facility: The mean score of 2.90 reflects a neutral stance, bordering on disagreement, about the existence of routine maintenance plans. This suggests that many facilities may lack structured, consistent maintenance procedures, which can impact cold chain reliability. The relatively higher standard deviation (1.199) supports the idea of inconsistency in maintenance practices across facilities.

Availability of a trained person responsible for cold chain equipment routine maintenance: With a mean of 2.71 and the highest standard deviation (1.300), there is a general disagreement regarding the availability of trained personnel for maintenance. This finding underscores a critical gap in human resource capacity, with considerable variation between facilities in terms of staffing for cold chain equipment upkeep. Overall, the data suggest that while some foundational practices like monthly physical counts are moderately well-established, significant challenges remain in areas such as cold chain capacity, maintenance planning, and the availability of trained personnel. These gaps point to areas that require policy and operational attention to strengthen vaccine storage and management systems.

Regression analysis

The study sought to evaluate the linear relationship between storage practices and vaccines availability. As part of this assessment, the storage process was examined as a critical component influencing the timely and efficient distribution of vaccines. Proper storage ensures vaccine potency and minimizes wastage, thereby

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supporting sustained availability. Vaccines availability, in turn, reflects the health system's capacity to meet immunization demands, which is essential for disease prevention and public health outcomes.

Table 2: ANOVA for Storage Practices and Vaccines Availability

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.465	1	13.465	134.129	.000[b]
	Residual	11.545	115	.100		
	Total	25.010	116			
a. Dependent Variable: Vaccines Availability						
b. Predictors: (Constant), Storage Practices						

The ANOVA results in Table 2 confirm the statistical significance of the regression model evaluating the impact of storage practices on vaccines availability. The F-statistic (134.129) is notably high, indicating a strong explanatory power of storage practices in predicting vaccines availability. The p-value (.000) further validates this significance at conventional thresholds ($p < 0.05$), confirming that storage practices play a crucial role in determining vaccine availability. The regression sum of squares (13.465) accounts for a substantial proportion of the total variance, demonstrating the importance of effective storage strategies, while the residual sum of squares (11.545) represents unexplained variance. These findings emphasize the necessity of optimizing vaccine storage systems to enhance reliability and distribution efficiency.

Table 3: Model Summary for Storage Practices and Vaccines Availability

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.734[a]	.538	.534	.31684	2.148
a. Predictors: (Constant), Storage Practices					
b. Dependent Variable: Vaccines Availability					

The model summary in Table 3 demonstrates a strong positive correlation ($R = 0.734$) between storage practices and vaccines availability, indicating that enhanced storage management significantly contributes to vaccines availability. The R Square value (0.538) shows that 53.8% of the variation in vaccines availability is explained by storage practices, while the Adjusted R Square (0.534) refines this estimate, accounting for model complexity. The standard error of the estimate (0.31684) suggests relatively low variability in predicted values, indicating a well-fitted model. Additionally, the Durbin-Watson statistic (2.148) falls within the acceptable range (1.5–2.5), confirming minimal autocorrelation in residuals and reinforcing the reliability of the model's conclusions. These results highlight the crucial role of effective storage strategies in ensuring the consistent and stable availability of vaccines.

Table 4: Coefficients for Storage Practices and Vaccines Availability

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.261	.084		26.764	.000

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	Storage Practices	.311	.027	.734	11.581	.000
a. Dependent Variable: Vaccines Availability						

The regression coefficients in Table 4 highlight the significant influence of storage practices on vaccines availability. The unstandardized coefficient (B = 0.311) suggests that for every unit increase in storage practices, vaccine availability improves by 0.311 units, assuming other variables remain constant. The standardized coefficient (Beta = 0.734) indicates a strong positive effect, emphasizing that storage practices play a crucial role compared to other predictors. The t-value (11.581) is considerably high, demonstrating the robustness of this relationship, while the p-value (.000) confirms its statistical significance ($p < 0.05$). These findings underscore the critical role of proper storage management in ensuring consistent vaccines availability, highlighting the need for optimized storage systems to enhance healthcare supply chain efficiency.

CONCLUSION AND RECOMMENDATIONS

The findings of this study reveal a clear and meaningful link between how vaccines are stored and their consistent availability in public health facilities across Kisii County. When storage practices are done well, such as having reliable cold chain equipment, keeping accurate stock records, and conducting regular physical counts, vaccines are more likely to be available when and where they are needed. However, the study also uncovered some serious gaps. Many facilities lacked freezers and cold boxes, did not have regular maintenance plans in place, and had too few trained staff to oversee cold chain equipment. These challenges can lead to vaccine spoilage, missed immunizations, and ultimately put community health at risk.

To address these issues, several practical steps are recommended. First, the Kisii County Government, working closely with the Ministry of Health, should prioritize improving and expanding cold chain infrastructure in all public health facilities. This means investing in modern equipment like refrigerators, freezers, cold boxes, and vaccine carriers that offer enough storage space and reliable performance. Second, each facility should establish a routine maintenance plan to keep this equipment functional and avoid breakdowns. Third, clear policies should ensure that every facility has a trained person responsible for maintaining cold chain systems and managing vaccine storage. This should be supported with regular training and certification programs to give staff the necessary skills and knowledge. In addition, facilities should put in place and consistently follow written procedures that guide how vaccines are stored, how stock is monitored, how equipment is maintained, and how records are reported. Finally, the county government should allocate specific funds within the health budget to cover essential costs such as equipment maintenance, vaccine transport, and staff capacity building. These actions are essential for achieving reliable vaccine availability and strengthening the health system's ability to deliver timely and effective immunization services.

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