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Research Article

Assessment of Vaccine Handlers' Knowledge and Cold Chain Management in Primary Health Care Facilities in Tripoli, Libya

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ABSTRACT

Vaccination is one of the most effective public health interventions for preventing infectious diseases. In Libya, particularly in Tripoli, challenges related to infrastructure, training, and supervision may affect the effectiveness of vaccine storage and handling practices. The Knowledge, Attitudes, and Practices (KAP) assessment framework provides a structured approach to evaluating provider-level performance in immunization services, yet limited evidence exists from primary health care facilities in Tripoli. A descriptive cross-sectional study was conducted in August 2024 across 65 primary health care vaccination sites in six municipalities of Tripoli, Libya. Using a total population sampling approach, all 65 vaccination providers were assessed. Data were collected using structured questionnaires and observational checklists adapted from WHO Effective Vaccine Management (EVM) guidelines. Standardized categorical scoring thresholds were applied to evaluate provider knowledge, attitude, and practice, alongside overall facility performance. Most facilities possessed functional cold chains with adequate refrigeration (96.9%) and temperature monitoring (98.5%), though operational gaps remained in guideline availability and emergency alarms. While providers overwhelmingly demonstrated positive attitudes (98.5%), good practices (96.9%), and moderate-to-good overall knowledge (93.8%), specific deficiencies were identified regarding mild illness contraindications, vaccine distinctions, batch number recording, and post-vaccination observation times. The study concluded that despite functional cold chains and experienced staff, operational gaps in training, documentation, and emergency preparedness threaten vaccine quality in Tripoli. Addressing these through continuous training, supportive supervision, and enhanced monitoring is essential for safe immunization.

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1. Introduction

Vaccination is one of the most cost-effective public health interventions and has significantly reduced morbidity and mortality worldwide. The Expanded Programme on Immunization (EPI), established in 1974, has substantially improved global immunization coverage; however, the full potential of vaccines can only be realized when their potency is preserved throughout the supply chain [1,2].

Vaccines are temperature-sensitive biological products that must be stored within a strict range of 2-8°C. Exposure to inappropriate temperatures may irreversibly reduce vaccine potency and effectiveness, leading to inadequate immune responses and potentially leaving vaccinated individuals unprotected against vaccine-preventable diseases (VPDs) [3,4]. The cold chain system—a series of storage and transport links designed to keep vaccines within acceptable temperature ranges from manufacture to administration—is therefore fundamental to the success of any immunization program [5,6].

The KAP (Knowledge, Attitudes, and Practices) assessment framework is a well-established methodology used in public health to evaluate healthcare provider performance. In the context of vaccine management, KAP studies assess whether providers possess adequate knowledge of storage requirements and cold chain procedures, hold supportive attitudes toward immunization, and translate this knowledge into consistent daily practice [7]. Prior KAP studies from Ethiopia, Nigeria, Malaysia, and Uganda have consistently documented knowledge gaps—particularly around vaccine contraindications, VVM interpretation, and temperature monitoring—as well as practice weaknesses in documentation and post-vaccination observation [8-11].

Cold chain failures are common in many low- and middle-income countries, including those in the Middle East and North Africa (MENA) region, and are driven by inadequate infrastructure, power instability, lack of training, and weak supervision [12,13]. In Libya, the national vaccination program immunizes against 17 infectious diseases and represents a major public health achievement; however, the program faces contextual challenges including infrastructure limitations and health system fragmentation [14]. Previous studies from Benghazi and Sabha have documented cold chain management gaps, but evidence from Tripoli—Libya's capital and most populous city—remains limited [15,16].

The rationale for conducting a KAP and cold chain assessment in Tripoli is therefore well grounded: the selection of a cross-sectional descriptive study design was appropriate given the need to simultaneously characterize provider-level knowledge, attitudes, and practices alongside facility-level infrastructure conditions. This design enables the identification of current gaps and the generation of evidence for targeted interventions, while recognizing its inherent limitation in establishing causal relationships [17].

This study aimed to: (1) assess the knowledge, attitudes, and practices of vaccination providers regarding vaccine handling and cold chain management; (2) evaluate the status of the cold chain system in primary health care facilities across six municipalities of Tripoli; and (3) identify operational gaps to inform evidence-based improvements in immunization service quality.that it is innovative, it is used in the section "Research Method" to describe the step of research and used in the section "Results and Discussion" to support the analysis of the results.

2. Methodology

2.1. Study Design and Setting

A descriptive cross-sectional study was conducted in August 2024 in the peripheral vaccination units of primary health care (PHC) facilities across six municipalities of Tripoli, Libya: Souq Aljuma, Ain Zara, Tajoura, Tripoli Center, Hay Al-Andalus, and Abu Salim. These municipalities were selected because they represent all administrative subdivisions of Tripoli and collectively encompass the full range of urban and peri-urban facility types in the capital. The six municipalities serve a

combined population of approximately 1.2 million residents, with facility densities varying from high-density urban centers (Tripoli Center) to more dispersed peri-urban areas (Ain Zara, Tajoura).

2.2. Study Population and Sampling

This study focused on the peripheral level of the cold chain system, including all functional vaccination storage sites and all vaccination providers. A total population sampling (census) approach was used, as the target population of vaccine handlers was relatively small, well-defined, and accessible in its entirety. All 65 functional vaccination facilities within the six municipalities were included in the facility assessment. All 65 vaccination providers working in these facilities and present during the August 2024 data collection period were invited to participate.

Inclusion criteria: functional vaccination storage units within the selected municipalities; healthcare workers directly involved in vaccination, storage, and cold chain management; providers present and actively working during data collection; and individuals who provided informed consent. Exclusion criteria: non-functional or closed facilities at the time of data collection; providers absent during data collection; healthcare workers not involved in vaccination or cold chain activities; and those who declined to participate.

2.3. Data Collection Tools

Data were collected using two instruments adapted from WHO Effective Vaccine Management (EVM) guidelines [18]: (1) a structured self-administered questionnaire assessing provider KAP, and (2) a facility-level observational checklist assessing cold chain infrastructure and conditions.

The KAP questionnaire comprised four sections: (i) socio-demographic characteristics (age, sex, education, profession, years of experience, municipality, training status); (ii) 15 knowledge questions with dichotomous correct/incorrect responses covering vaccine storage temperatures, VVM interpretation, contraindications, and vaccine-disease relationships; (iii) 7 attitude statements scored on a 3-point Likert scale (Agree=3, Neutral=0, Disagree=1), with a maximum score of 21 points; and (iv) 14 practice questions with Yes/No responses assessing temperature monitoring, documentation, safe administration, and post-vaccination procedures.

The observational checklist assessed cold chain infrastructure across domains including vaccine supply management, guideline availability, physical environment, record-keeping, refrigerator conditions, temperature monitoring, vaccine storage practices, transport equipment, emergency preparedness, and infection prevention.

Content validity was established by expert review from community medicine and public health specialists, and face validity was confirmed through pilot testing on a small group of providers not included in the final study.

2.4. Scoring System

Knowledge scores (out of 15): Good ≥12 points; Moderate 9-11 points; Poor <9 points. For the combined moderate-to-good category reported in results, a score ≥9 was used. Attitude scores (out of 21): Positive ≥15 points; Negative/Neutral <15 points. Practice scores (out of 14): Good ≥11 points; Poor <11 points. Facility-level performance: Very Good/Good ≥80%; Satisfactory 60-79%; Moderate 50-59%; Poor <50%.

2.5 Data Collection Procedures

Data collection was conducted in August 2024 by the principal investigator (M.A.E.), a trained community medicine physician, with the assistance of two field coordinators who received standardized training prior to data collection. Questionnaires were administered individually to each provider in the vaccination room or an adjacent private area. The facility assessment was conducted simultaneously through direct observation using the standardized checklist. Data entry was performed by the principal investigator using SPSS version 25.

2.6. Statistical Analysis

Descriptive statistics were computed for all variables. Frequencies and percentages were reported for categorical variables; mean ± standard deviation (SD) for continuous variables (age, years of experience, knowledge score, attitude score, practice score). Inferential analysis using independent t-tests (two groups,

e.g., sex) and one-way ANOVA (three or more groups, e.g., educational level) was applied to assess differences in mean KAP scores between demographic subgroups. A p-value <0.05 was considered statistically significant.

2.7 Ethical Considerations

Ethical approval was obtained from the Libyan Board of Medical Specialties and relevant health authorities prior to data collection. Official permission was secured from municipal health offices and facility management. Informed consent was obtained from all participants. Confidentiality and anonymity were maintained throughout; no identifying personal information was recorded. All data were used solely for research purposes.

3. Results

3.1. Demographic Characteristics of Study Participants and Facilities

A total of 65 vaccination providers and 65 facilities were included. The demographic profile of participants is summarized in Table 1. The workforce was predominantly male (98.5%; n=64), and largely composed of nurses (73.8%; n=48). Secondary education was the most common educational level (70.8%; n=46). Nearly two-thirds of participants (64.6%; n=42) had 16 to 37 years of employment experience, indicating a highly experienced workforce. Importantly, all participants (100%; n=65) reported having received immunization-related training. Facilities were distributed across the six municipalities, with Abu Salim contributing the largest proportion (23.1%; n=15).

3.2. Cold Chain Infrastructure Assessment

Results of the facility-level cold chain assessment are summarized in Table 2. All facilities had a designated vaccination coordinator (100%) and ordered vaccines monthly. Vaccine needs estimation relied predominantly on previous consumption (93.8%) rather than target population forecasting. Regarding guidelines, only 47.7% of facilities had storage and handling protocols available, while 50.8% of providers were uncertain of their availability; vaccination schedules were prominently displayed in 78.5% of facilities.

Physical conditions were generally satisfactory: vaccination rooms were clean in all facilities (100%), air-conditioned in 95.4%, and secured with locked storage in 96.9%. However, 56.9% of facilities combined vaccination and storage rooms rather than maintaining separate spaces. Record-keeping was strong, with vaccination registers present in 92.3% and legible entries in 93.8%; however, vaccination cards were not consistently issued to all recipients (69.2%).

Refrigerator conditions were among the strongest findings: 96.9% used ice-lined refrigerators, 98.5% had temperature monitoring devices, and 100% maintained vaccines at appropriate positions with adequate spacing and FEFO (First-Expiry, First-Out) arrangement. Notable gaps included: warning signs ('Do Not Unplug') absent in 67.7% of facilities; coil and motor cleanliness unknown in 47.7% of cases; and expired vaccines found in 13.8% of facilities.

Emergency preparedness showed significant weaknesses: alarm systems were available in only 32.3% of facilities and verified as functional in 30.8%; emergency drugs (adrenaline, antihistamines, hydrocortisone) were available in fewer than 17% of facilities. Standby generators were present in 84.6%, though only 61.5% operated automatically.

3.3. Knowledge Assessment

Table 3 presents the distribution of correct answers to individual knowledge questions. Strong performance was observed for: flu vaccine safety in pregnancy (96.9%), HBV administration technique (93.8%), HPV vaccine protection against cancer (92.3%), and HPV recommended doses (92.3%). Moderate performance was observed for: HBV recommended doses (67.7%) and who should receive HPV vaccine (98.5%). Notably poor performance was observed for: fever/mild illness as a reason to postpone vaccination (35.4% correct); BCG vaccine and TB transmission prevention (36.9% correct); pneumonia vaccine and influenza protection

Table 1. Demographic and Employment Characteristics of Study Participants (n=65)

Characteristic	Category	n	%
Sex	Male	1	98.5
	Female	64	1.5
Education	Primary	3	4.6
	Secondary	46	70.8
	University	13	20.0
	Postgraduate	1	1.5
Profession	Nurse	48	73.8
	Public Health	11	16.9
	Community Health	4	6.2
	Doctor	1	1.5
	Nurse Assistant	1	1.5
Employment Years	4-15 years	23	35.4
	16-37 years	42	64.6
Training Received	Yes	65	100.0
Municipality	Abu Salim	15	23.1
	Center Tripoli	10	15.4
	Hayy Al-Andalus	11	16.9
	Tajura	11	16.9
	Ain Zara	9	13.8
	Souq Aljuma	9	13.8

Table 2. Summary of Key Cold Chain Infrastructure Indicators in Primary Health Care Facilities (n=65)

Cold Chain Indicator	N	%
Vaccination coordinator present	65	100.0
Guidelines/protocol available	31	47.7
Guidelines availability unknown	33	50.8
Vaccination schedules prominently displayed	51	78.5
Separate vaccine storage room	28	43.1
Ice-lined refrigerator in use	63	96.9
Temperature monitoring device present	64	98.5
Temperature chart present and checked	65	100.0
'Do Not Unplug' warning sign present	21	32.3
Expired vaccines found	9	13.8
Alarm system available	21	32.3
Standby generator present	55	84.6
Generator operates automatically	40	61.5
Emergency drugs available (adrenaline)	10	15.4
Vaccination card issued to all recipients	45	69.2

Table 3. Distribution of Correct Answers to Knowledge Questions Among Participants (n=65)

Knowledge Question	Correct (n)	Correct (%)
Flu vaccine safe for pregnant women	63	96.9
How to administer the hexa vaccine	62	95.4
Who should receive the HPV vaccine?	64	98.5
HBV administration technique	61	93.8
HPV vaccine protects against cancer	60	92.3
Recommended doses of HPV vaccine	60	92.3
Who should receive the HBV vaccine?	52	80.0
HBV vaccine recommended number of doses	44	67.7
Oral vs. inactivated polio in supply shortages	43	66.2
Chickenpox vaccine vs. measles protection	37	56.9
Vaccines protect against some cancers (general)	34	52.3
Pneumonia vaccine protects against flu (misconception)	29	44.6
BCG vaccine prevents TB transmission	24	36.9
Fever/mild illness warrants postponement	23	35.4

a misconception question—(44.6% correct); and whether vaccines protect against some cancers (52.3%).

Overall knowledge classification: 41.5% (n=27) demonstrated Good knowledge, 52.3% (n=34) Moderate knowledge, and 6.2% (n=4) Poor knowledge. Combined moderate-to-good knowledge was observed in 93.8%.

3.4. Attitude Assessment

Attitude levels were overwhelmingly positive. Agreement rates exceeded 96% for six of seven attitude statements, including the importance of vaccinating healthcare workers against HBV (98.5%), vaccinating children during national campaigns (98.5%), effectiveness of HPV vaccine against cervical cancer (98.5%), and recommending the varicella vaccine for children (98.5%). The statement regarding HBV vaccine effectiveness in preventing liver cancer received slightly lower agreement (87.7%). Overall, 98.5% of participants (n=64) were classified as having a Positive attitude; only 1 participant (1.5%) was classified as Negative.

3.5. Practice Assessment

Practice performance was generally strong. All responding participants (n=64) reported washing hands between each child, checking vaccine type, dose, and expiry date before administration, identifying the correct injection site, informing parents about side effects, and checking the safety of syringe handling. Batch number recording on vaccination cards was done by only 73.4% of participants. Critically, only 26.6% (n=17) reported advising children to wait 15-20 minutes post-vaccination, representing the most significant practice gap identified. Overall, 96.9% of participants were classified as demonstrating Good practice.

Table 4. Distribution of Responses to Vaccination Practice Questions Among Participants (n=64 responding)

Practice Item	Yes (n)	Yes (%)
Wash hands between each child	65	100.0
Check vaccine type, dose before administration	64	100.0
Check expiry date of the vial	64	100.0
Identify correct injection site	64	100.0
Inform parents about possible side effects	64	100.0
Check vaccination card before giving vaccine	62	95.4
Date of next visit noted on card	61	95.3
Received hepatitis B vaccine (self-vaccination)	58	89.2
Dispose of tools in correct container	63	98.4
Clean the skin before injection	63	96.9
Batch number recorded on vaccination card	47	73.4
Advise 15-20 min post-vaccination wait	17	26.6

4. Discussion

This study provides a comprehensive assessment of cold chain management and vaccine handlers' KAP across primary health care facilities in Tripoli, Libya. The findings reveal a generally functional system with experienced, positively oriented staff, but persistent operational gaps that merit targeted intervention.

4.1. Cold Chain Infrastructure

Cold chain infrastructure in Tripoli was generally strong. Nearly all facilities used ice-lined refrigerators (96.9%) with temperature monitoring devices (98.5%), and all maintained temperature charts with reported daily checks. These findings compare favorably with assessments from Ethiopia and Nigeria, where refrigerator malfunction, absent temperature charts, and inadequate monitoring were documented [8,10]. However, important operational gaps were identified that align with findings from comparable settings.

The high proportion of providers uncertain about guideline availability (50.8%) and the absence of warning signs on refrigerators (67.7%) are concerning, as these represent basic system requirements. Studies from Cameroon and Uganda similarly documented limited availability of standard operating procedures and job aids [9,13]. Preventive maintenance awareness was low, with approximately half of facilities reporting clean coils and motors, and nearly half being unable to verify this, mirroring patterns described by Gebretnsae et al. [8] and Atwiine et al. [13].

Emergency preparedness was the weakest domain: alarm systems were present in only 32.3% of facilities, and emergency medications for managing anaphylaxis (adrenaline, antihistamines, hydrocortisone) were available in fewer than 17%. These findings represent a significant patient safety risk and contrast with WHO recommendations for post-vaccination management capacity. The 'Unknown' response rate for guideline availability (50.8%) is itself a substantive finding suggesting inadequate dissemination of reference materials at the facility level.

4.2. Knowledge

Knowledge levels in this study (93.8% moderate-to-good) were substantially higher than those reported in Ethiopia (Gebretnsae et

al.), Malaysia (Najwa et al.), and Nigeria (Adebimpe), where moderate-to-good knowledge proportions ranged from approximately 50% to 84% [8,10,11]. These differences may reflect several contextual factors specific to the Tripoli sample: universal training coverage (100%), a workforce composed predominantly of nurses—a cadre associated with stronger cold chain performance—and nearly two-thirds having over 16 years of professional experience [8,10].

Despite these strengths, specific misconceptions persisted. Only 35.4% correctly identified that mild illness or fever does not warrant vaccination postponement, 36.9% correctly understood the BCG vaccine's limited role in preventing TB transmission, and 44.6% correctly answered that pneumococcal vaccine does not protect against influenza. These patterns mirror knowledge gaps documented in Ethiopia and Nigeria [8,10], suggesting that clinical judgment-related concepts and nuanced vaccine-disease relationships require more targeted, ongoing education regardless of overall training coverage.

4.3. Attitudes

Attitude levels were exceptionally positive (98.5%), exceeding those reported across comparable studies [8,10,11]. This strong attitudinal profile likely reflects the long professional tenure of the workforce, the cultural value placed on childhood vaccination in Libyan society, and sustained participation in national immunization campaigns. Consistent with findings from Malaysia (Najwa et al.), high attitude levels in this sample appeared to correlate with high knowledge levels, suggesting a reinforcing relationship between competence and professional conviction [11].

4.4. Practices

Practice levels were strong overall (96.9% Good), with consistent adherence to critical safety procedures including hand hygiene, vaccine verification, and safe disposal. However, two important gaps were identified. First, only 73.4% consistently recorded batch numbers on vaccination cards—a WHO-required traceability measure essential for adverse event investigation and vaccine recall procedures. Second, only 26.6% consistently advised the recommended 15-20 minute post-vaccination observation period, a critical precaution for early identification and management of immediate hypersensitivity reactions [18,19].

These gaps are particularly notable because all participants reported receiving training, suggesting that the failures reflect implementation and reinforcement issues rather than lack of awareness. Studies from Ethiopia and Kenya documented similar post-vaccination practice deficiencies and incomplete documentation despite adequate training, emphasizing that knowledge alone does not guarantee practice compliance and that ongoing supervision is essential [8,12].

5. Conclusions

This study demonstrates that primary health care facilities in Tripoli maintain a generally functional cold chain infrastructure and employ an experienced, highly motivated workforce with positive attitudes toward immunization. However, significant operational gaps remain in areas critical to vaccine safety and service quality: guideline availability and dissemination, emergency preparedness including alarm systems and anaphylaxis management supplies, preventive maintenance practices, documentation of batch numbers, and post-vaccination observation compliance.

The findings suggest that Libya's immunization program in Tripoli has achieved strong structural foundations but requires investment in system-level controls and consistent supervisory oversight to reach WHO best-practice standards. Addressing these gaps through targeted refresher training, improved supervision, enhanced documentation systems, and infrastructure investment in monitoring and emergency preparedness is essential to ensure safe, effective, and sustainable immunization services and to protect the quality of Libya's national vaccination program.

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Conflict of Interest

The authors declare no conflict of interest.

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