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Vaccine Management Knowledge and Practice of Health workers in Yemen

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Abstract

Vaccine management comprises of estimation of vaccine needs, ordering, storage, distribution, monitoring vaccines use and limiting vaccine wastage. Yemen has been in conflict situation for over 7 years and remains one of the world's worst humanitarian crises, with an estimated 23.4 million people in need of humanitarian assistance. This descriptive cross-sectional study to assess the vaccine management knowledge and practice in Yemen was carried out among health workers in 6 governorates. 536 health workers at different levels provided responses to the online questionnaire which were imported into the Statistical Package for Social Sciences (SPSS) platform for relevant descriptive and inferential analysis. Chi square test was used to determine statistical significance of observed difference in knowledge and vaccine management practice against relevant socio-demographic and work-related variables. The level of significance was set at p value <0.05. The study showed that 429(80%) had good knowledge while 63(11.8%) and 44(8.2%) had fair and poor knowledge of vaccine management respectively. More than two-thirds of respondents only receive vaccines 411(76.7%), 124(23.1%) receive and distribute vaccines. Vaccine distribution included use of refrigerated vehicles (15.2%), cold boxes (32.8%) and vaccine carrier (41.6%) both with conditioned ice packs. A total of 432(63.8%) have experienced vaccine stock-out and mostly for 1-2weeks (75.6%). Association between age and vaccine management knowledge was statistically significant with p-value of 0.006. The vaccine management knowledge and practice as shown from the findings of the study are commendable. However, there is need to address the artificial stock-out of vaccines to avoid missed opportunities.

Keywords: *Knowledge, Practice, Vaccine Management.*

Introduction

The Expanded Programme on Immunization (EPI) has proved its place as a cornerstone in the Primary Health Care (PHC) strategy. Not only is it a cost-efficient intervention that prevents common childhood diseases, but it also provides an entry-point into communities for other Reproductive and Child Health (RCH) interventions, such as vitamin A supplementation and growth promotion [1]. Vaccines have transformed public health, particularly since national programmes for immunization first became properly established and coordinated in the 1960s. In countries with high vaccine programme coverage, many of the diseases that were previously responsible for most childhood deaths have essentially disappeared [2].

Vaccines are biological products prepared from killed or attenuated (weakened) virus or bacteria or their toxins, used for vaccinating people to induce specific immunity against an

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infectious disease [3]. Vaccine management in immunization service delivery comprises of estimation of vaccine needs (vaccine forecast), ordering of vaccines, storage of vaccines, monitoring vaccine use and limiting vaccine wastage [4]. Globally, vaccine and immunization programmes are becoming increasingly more expensive with the addition of new vaccines to the National Immunization Programmes [4].

Immunization programmes depend greatly on efficient and effective supply chain systems to store, transport, and distribute these vaccines and health commodities, which ensures that the right products are available at the right place, at the right time and in the right condition in order to provide efficient health services to the communities [1]. Evidence have shown that effective vaccine supply chain system is one of the most vital elements of any immunization programme, which ensures that vaccines reach recipients in their potent form [1].

Without an adequate supply of vaccines at service delivery levels, children cannot be vaccinated against life-threatening diseases. It is no surprise, therefore, that much of the success of the Expanded Programme on Immunization (EPI) over the past 40 years can be attributed to immunization supply chain and logistics systems and the professionals who run them [5]. Their role is to guarantee as efficiently as possible the uninterrupted availability of vaccines all the way to service delivery levels, safeguarding vaccine potency from damaging heat and freezing temperatures in a cold chain system. Ensuring that international supply chain standards are met guarantees that national immunization programmes worldwide can achieve their goals of coverage and equitable access to life-saving vaccines [5].

The Effective Vaccine Management (EVM) initiative, launched in the year 2010 by World Health Organization (WHO) and United Nations Children Fund (UNICEF) is a comprehensive assessment of the vaccine supply chain system of immunization programmes in low and lower-middle income countries [5]. The focus of the initiative is to uncover the shortcomings in the performance of immunization supply chain to provide basis for improvement [5].

Despite the limited access to vaccines in many developing countries, a high vaccine wastage rates have been observed. This has been linked to inadequate knowledge and skills of the staff managing the scarce vaccines, particularly at the peripheral health facility level [4]. Knowledge and practice of routine immunization (RI) service providers regarding vaccine management have implications on childhood immunization. Studies have shown varying degree of gaps in vaccine management knowledge of health workers, and these have direct and indirect impact on immunization programme and control of Vaccine Preventable Diseases (VPDs) [4].

Effective vaccine management is the cornerstone for immunization program in any country. Accurate vaccine forecasting, timely procurement of vaccine, good storage practice, effective distribution of vaccine across levels ensures the readily availability of potent vaccine for immunization service delivery. Assessing the knowledge of the health workers on vaccine management will enable us to identify and address existing gap to ensure effectiveness.

Healthcare workers handling vaccines for routine immunization need to be well acquainted with the knowledge and skills required to maintain the potency of vaccines to achieve the desired results of vaccination. For instance, practices such as proper implementation of the Multi-Dose Vial Policy (MDVP) have been found to significantly reduce vaccine wastage rate particularly at service delivery level [4]. Similarly, the use of new technology like the Vaccine Vial Monitor (VVM) and the Cold Chain Monitor (CCM) have also played crucial roles not only in detecting cold chain problem but also in

reducing vaccine wastage and in preventing the administration of heat damaged vaccines [4].

Some gaps in knowledge, attitude, and practice of vaccination cold chain logistic system still exist among studied respondents, and these should be addressed by stakeholders in immunization programs [6]. A study on Knowledge, attitude, and practice of cold chain management among primary health care workers in Giwa, Northwestern Nigeria in 2018 showed that majority (71.8%) of the respondents knew the correct temperature range for which vaccines should be stored. Only 3.8% of the respondents had good knowledge of cold chain management [6]. Similar study on Knowledge, attitude and practice of vaccinators and vaccine handlers on vaccine cold chain management in public health facilities, Ethiopia showed more than half of vaccinators and vaccine handlers had satisfactory knowledge [7].

Despite the globally acknowledged critical relevance of vaccine management in immunization programming, not much have been done regarding assessing the knowledge of health workers on vaccine management in humanitarian settings. Therefore, this study was carried out to determine vaccine management knowledge and practice of health workers in Yemen in the middle east with history of humanitarian crisis going to eight years.

Materials and Methods

Description of the Study Area

This study was conducted in Yemen, a country situated at the southwestern corner of the Arabian Peninsula and shares border with Saudi Arabia and Oman. It has a total population of about 32 million people; and is subdivided into 23 governorates and 333 districts with about 4,500 health facilities providing routine immunization services with Arabic as the main language of instruction [8].

Eight years into the conflict, the country remains one of the world's worst humanitarian crises, with an estimated 23.4 million people (68% of the population) including 12.9 million children and 5.2 million women in need of humanitarian assistance [9]. The crisis has affected both the delivery of and access to essential services. Over four million people, including two million children, are internally displaced. Many are in a situation of protracted and multiple displacement, straining their resources and exacerbating vulnerabilities. The influx of large numbers of internally displaced persons (IDPs) puts an additional burden on resources in hosting communities – many of which are conflict-affected with significant humanitarian needs [9].

The country has four immunization supply chain levels including the central level with a cold store equipped with walk in Cold and freezer rooms (WICR and WIFRs) where vaccine for routine immunization and campaigns from offshores are stored and managed by the team led by vaccine and cold chain manager. This level is involved in quarterly vaccines distribution to the governorates. The governorate level equipped with WICRs for vaccines storage undertakes monthly distribution of vaccines to the districts and districts level equipped with solar direct drive (SDD) refrigerators for vaccines storage, distributes to health facilities or facilities pull vaccines from there on monthly basis. Both governorate and district cold stores are managed by the EPI focal persons. The Health Facility which is the service delivery point is equipped with SDD refrigerators and managed by the facility manager under whom the vaccinators work as focal persons for vaccine management.

This descriptive cross-sectional study was carried out among health workers working at the four levels of governance / health care system. Fisher formula was used to determine minimum sample size [10]. A total of 536 health workers were recruited for the study between February and May 2022. Out of the 23 governorates in the country, six governorates Aden, Lahj, Hajjah, Sanaa, Amran and Dhamar

were randomly selected by balloting. For a better coverage and responses, the health workers at the different levels of service including central, governorate, districts, and health facilities in the selected six (6) districts were reached with the online research tool to harvest their responses.

A structured questionnaire adapted from World Health Organization (WHO) document on vaccine management documents [11] was used to elicit information on knowledge and vaccine management practice among the respondents. The questionnaire was developed in English and translated to Arabic for ease of understanding of the respondents because the official language in Yemen is Arabic. The questionnaire thus had questions in both English and Arabic languages so that respondents had option of responding in either language convenient for them. A set of 20 questions was used to determine knowledge and each is assigned a score of one point for correct or appropriate response. The scores were aggregated to form a total score of 20. The overall knowledge was categorized into poor (with score of <10), fair (with score of 10 - 12) and good (with score of >12).

The questionnaire was pre-tested among health workers in Raymah governorate which was not part of the study areas. The pre-testing helped identify ambiguity and gaps which after corrections led to improve the tool. Questionnaire was distributed online to health workers. Participant information and guide was provided alongside of the questionnaire.

The online responses were compiled and imported into the Statistical Package for Social Sciences (SPSS) platform for relevant descriptive and inferential analysis. Chi square test was used to determine statistical significance of observed difference in knowledge and vaccine management practice against relevant socio-demographic and work-related variables. The level of significance was set at p value <0.05.

The main challenges encountered was delayed in the response of the participants. This was addressed by sending a reminder to the participants to ensure timely completion of the online questionnaire.

Results

The age of the respondents ranged from 24 to 59 years with a mean and standard deviation of 29 and 2.6 years respectively. Majority of the respondents were female 296(55.2%) and only 100(18.6%) have work experience of over 15 years. Most the respondents 426(79.5%) are working are the health facilities with very few working at central level (2.8%) and Governorate level (2.4%). Four hundred and thirty (80.2%) were vaccinator by designation while 329(61.4%) were nurse by profession. Most the respondents 463(86.4%) had training on vaccine management within the last 5 years.

Table 1. Socio-demographic Characteristics of the Respondents (N=536)

Variables	**Frequency**	**Percentage (%)**
Age group (Years)	N=536	
20-40	422	78.7
>40	114	21.3
Sex		
Male	240	44.8
Female	296	55.2
Working experience in Years		
0-5	214	39.9
6-10	125	23.3
11-15	97	18.1

16-20	50	9.3
>20	50	9.3
Level of work		
Central	15	2.8
Governorate	13	2.4
District	82	15.3
Health Facility	426	79.5
Designation		
Vaccinator	430	80.2
EPI focal person	54	10.1
Cold chain & vaccine management officer	29	5.4
Storekeeper	23	4.3
Highest qualification		
High school certificate	27	5.0
Diploma	424	79.1
Bachelor's degree	81	15.1
Master's degree	4	.7
Professional background		
Nursing	329	61.4
Midwifery	105	19.6
Pharmacy	37	6.9
Medicine	10	1.9
Last training on vaccine management		
0-5 years	463	86.4
6-10years	60	11.2
>10years	13	2.4

Less than a half of the respondents correctly knew that vaccine forecast is the first step in vaccine management 234(43.7%). However, most of them knew the correct temperature for storage of vaccine at facility level (including Rota, MR, Penta, PCV and BCG vaccines). Also, majority knew that conditioned ice packs are required for vaccine transportation and distribution 321(59.9%). Over three quarters of the respondents had corrected knowledge of tool showing vaccine exposure to heat (79.3%), discard point of VVM stages (81.7%) good knowledge of test used for suspected frozen vaccines (94.6%). The overall vaccine management knowledge grading showed that 429(80%) had good knowledge while 44(8.2%) had poor knowledge.

Table 2. Knowledge of Vaccine Management N= 536

knowledge of Vaccine Management	**Frequency (%)**
Knew correctly that First step in vaccine management is vaccine forecasting	234(43.7%)
Knew correctly Rota vaccine storage temperature	515(96.1%)
Knew Correctly MR vaccine storage temperature at HF	415(77.4%)
Knew correctly Pentavalent vaccine storage temperature	521(97.2%)
Knew correctly BCG vaccine storage temperature at HF	413(77.1%)
Knew Correctly PCV vaccine storage temperature	521(97.2%)
Aware that MR & BCG can be stored in freezer if need be	466(86.9%)

Knew that conditioned ice packs are required for vaccine transportation and distribution	321(59.9%)
Knew that EEFO is used for Vaccine stock management at all levels	208(38.8%)
Correct knowledge of tool showing Vaccine exposure heat	425(79.3%)
Correct knowledge of Discard point of VVM Stage	438(81.7%)
Correct knowledge of test used for suspected frozen vaccines	507(94.6%)
Knowledge of Vaccine management (N=536)	
Poor	44 (8.2%)
Fair	63 (11.8%)
Good	429 (80%)

With regards to the respondents' role in vaccine management, more than two-thirds only receive vaccines 411(76.7%), 124(23.1%) receive and distribute vaccines while only one (0.2%) distribute vaccine. Among those who receive vaccines, the frequency is mostly on monthly basis 364(68.4%) while the frequency of vaccine distribution is mostly on weekly basis (78.4%). About half of those who receive vaccines said the vaccines are supplied using cold boxes conditioned with ice packs 272(50.7%) while only few 15(2.8%) received vaccine with vaccine carrier without conditioned ice packs. The mode of vaccine distribution included use of refrigerated trucks (15.2%), cold boxes conditioned with ice packs (32.8%) and vaccine carrier with conditioned ice packs (41.6%). Majority of the total respondents have experienced vaccine stock out 432(63.8%), and the duration of vaccine stock out was mostly 1-2weeks (75.6%). Of those who had experienced vaccine stock out, over two-thirds claimed they had emergency plan in place to address stock out 343(79.4%).

Table 3. Vaccine Management Practice

Variables	**Frequency (%)**
Role in vaccine supply chain N=536	
Receive vaccines only	411(76.7%)
Distribute vaccines only	1 (0.2%)
Receive and distribute vaccines to other level	124 (23.1%)
Frequency of receiving vaccine n=535	
Weekly	114 (21. 3%)
Monthly	364 (68.4%)
Quarterly	57 (10.7%)
Frequency of vaccine distribution n=125	
Weekly	98 (78.4%)
Monthly	15 (12%)
Quarterly	12 (9.6%)
Mechanism of receiving vaccine n=536	
Supplied by Refrigerated truck	25 (4.7%)
Supplied using Cold boxes conditioned with icepack	272 (50.7%)
Supplied using Vaccine carrier with conditioned icepacks	224 (41.8%)
Supplied using Vaccine carrier without conditioned icepacks	15 (2.8%)
Mechanism of vaccine distribution n=125	
Use of Refrigerated truck	19 (15.2%)
Use of cold boxes conditioned with icepack	41 (32.8%)

Use of Vaccine carrier with conditioned icepacks	52 (41.6%)
Use of Vaccine carrier without conditioned icepacks	13 (10.4%)
Ever experienced stock out n=536	
Yes	432 (63.8%)
No	194 (36.2%)
Duration of vaccine stock out n=432	
1-2 weeks	327 (75.6%)
3 weeks	21 (4.9%)
One month	52 (12.1%)
More than one month	32 (7.4%)
Presence of emergency plan to address vaccine stock out n=432	
Yes	343 (79.4%)
No	89 (20.6%)

Vaccine stock management tool mostly used is manual vaccine ledger 520(97%) while only 3% used electronic VSSM. Physical vaccines stock count is practiced by most of the respondents (85.4%), 528(98.5%) submit vaccine consumption data from RI facility to appropriate designated level or place, 79.1% had updated cold chain inventory while over 90% carried out temperature monitoring check/ charts on refrigerator twice a day.

Table 4. Vaccine Management Data Tool N=536

Variables	**Frequency**
Vaccine stock out management tool used	
Manual vaccine ledger	520 (97.0%)
Electronic VSSM	16 (3.0%)
Frequency of physical vaccine stock count	
Monthly	458 (85.4%)
Quarterly	28 (5.2%)
Yearly	45 (8.4%)
Not usually done	5 (0.9%)
Frequency of submission of vaccine consumption data from RI facility	
Monthly	528 (98.5%)
Quarterly	4 (0.7%)
Yearly	4 (0.7%)
Status of cold chain equipment inventory data	
No cold chain inventory	61 (11.4%)
Inventory not updated	51 (9.5%)
Inventory updated	424 (79.1%)
Frequency of temperature monitoring chart on refrigerator	
Once a day	29 (5.4%)
Morning and evening	497 (92.7%)
No temperature chart	6 (1.1%)
Temperature chart not updated	4 (0.7%)

More of the respondents age above 40 years had good knowledge compared to those age 40 and below and this is statistically significant (P value = 0.0060) but respondents' gender has no significant difference on vaccine management knowledge (P value = 0.5257). Also, years of

working experience did not show any significant difference in knowledge among them (P value = 0.8451).

Table 5. Respondents' Age, Sex, and Years of Working Experience in Relation to their Knowledge of Vaccine Management

Age group (years)	**Poor knowledge**	**Fair Knowledge**	**Good knowledge**	**Total**	**Chi-square**
20 - 40	7	86	329	422	P value = 0.00605
>40	1	9	104	114	X^2 = 10.2154
Total	**8**	**95**	**433**	**536**	**-**
Sex					
Male	2	43	195	240	P value = 0.5257
Female	6	52	238	296	X^2= 1.2861.
Total	**8**	**95**	**433**	**536**	**-**
Working Experience in years					
0 - 5	3	45	166	214	P value = 0.8451
6 - 10	2	22	101	125	X^2= 4.1304
11 - 15	2	13	82	97	-
16 - 20	0	9	41	50	-
>20	1	6	43	50	-
Total	**8**	**95**	**433**	**536**	**-**

There is no significant difference in knowledge based on level of work among the respondents (P value = 0.5275). Similarly, there is no difference in knowledge among the respondents based on their designations and professional background with P value of 0.05181 and 0.5897 respectively. Table 6. A higher proportion of those who receive and distribute vaccine had good knowledge of vaccine management compared to others and this is statistically significant (P value = 0.0012).

Table 6. Respondents Level at Work, Designation, and Professional Background in Relation to their Knowledge of Vaccine Management

Level of work	**Poor knowledge**	**Fair Knowledge**	**Good Knowledge**	**Total**	**Chi-square**
Central	0	6	9	15	P value = 0.5275
Governorate	0	4	9	13	X^2= 12.4444
District	1	15	66	82	-
Health facility	7	70	349	426	-
Total	**8**	**95**	**433**	**536**	**-**
Respondent's Designation					
Vaccinator	7	77	346	430	P value= 0.05181
EPI focal person	0	3	51	54	-
Cold chain/vaccine management officer	0	8	21	29	X^2= 12. 6921
Storekeeper	1	7	15	23	-
Total	**8**	**95**	**433**	**536**	**-**
Professional background					

Nursing	5	56	268	329	P value = 0.5897
Midwifery	1	20	84	105	X^2 = 6.5151
Pharmacy	1	9	27	37	-
Medicine	0	1	9	10	-
Laboratory science	1	9	45	55	-
Total	**8**	**95**	**433**	**536**	**-**

The vaccine Management Knowledge among respondents who had emergency plan to address vaccine stockout was better than those without emergency plan. However, this is not statistically significant (P value = 0.6648). Health workers who had vaccine Management training in the last 5 years had good knowledge of vaccine management compared to those whose last training was 6 or more years. This is statistically significant (P value = 0.04735).

Table 7. Respondent's Knowledge of Vaccine Management in Relation to their Vaccine Management Practice

Role in vaccine management	**Poor knowledge**	**Fair Knowledge**	**Good knowledge**	**Total**	**Chi-square**
Receive vaccine only	7	76	328	411	P value = 0.0012
Distribute vaccine only	0	0	1	1	X^2= 23.0695
Receive and distribute vaccine	1	19	104	124	-
Total	**8**	**95**	**433**	**536**	**-**
Presence of emergency plan for vaccine stock out					
Yes	5	73	265	343	P value = 0.6648
No	2	22	65	89	X^2 = 0.8164
Total	**7**	**95**	**330**	**432**	**-**
Last training on vaccine management in years					
≤5	7	74	382	463	P value = 0.0473
6 -10	1	17	42	60	X^2 = 9.6194
>10	0	4	9	13	-
Total	**8**	**95**	**433**	**536**	**-**

Majority of the respondents at facility and district levels had vaccine Management training within the last 5 years compared to staff at other levels of work. This is statistically significant (P value = 0.002962). Also, a high proportion of respondents who are storekeepers had last vaccine Management training more than 10 years ago compared to other categories of staff and this is statistically significant (P value = 0.0073). However, the professional background of the respondents did not show significant differences on duration of last training on vaccine Management. (P value = 0.0557).

Table 8. Respondent's Work Level, Designation, and Professional Background in Relation to Last Training on Vaccine Management

Level of work	**Last training on vaccine management in years**				**Chi-square**
	≤5 years	**6 - 10 years**	**>10 years**	**Total**	
Central	13	1	1	15	-
Governorate	7	4	2	13	P value = 0.0029
District	72	9	1	82	X^2 = 19.8359
Health facility	371	46	9	426	-
Total	**463**	**60**	**13**	**536**	**-**

Designation					
Vaccinator	374	46	10	430	P value = 0.0073
EPI focal person	47	7	0	54	X^2= 17.5889
Cold chain / vaccine management officer	28	1	0	29	-
Storekeeper	14	6	3	23	-
Total	**463**	**60**	**13**	**536**	**-**
Professional background					
Nursing	281	38	10	329	P value = 0.0557
Midwifery	97	6	2	105	X^2 = 15.1787
Pharmacy	35	2	0	37	-
Medicine	6	3	1	10	-
Laboratory science	44	11	0	55	-
Total	**463**	**60**	**13**	**536**	**-**

Discussion

Vaccine cold chain handlers are the most crucial personnel at a cold chain point as their correct knowledge and cold chain practices, vaccine management, and handling are immensely vital for the success of the Universal Immunization Programme [12]. In this study, 80% of the health workers had good knowledge of vaccine management and 43.7% knew that vaccine forecasting is the first step in vaccine management. This finding may be connected to the annual vaccine forecast exercise which is strongly encouraged mostly at the central and first subnational level [13]. Also, most of the health workers (96.8%) knew the recommended temperature range for storage of routine vaccines (like Penta, Rota and PCV) at the health facility. These findings are consistent with the results of the studies conducted in Oromia, Ethiopia (96.9%) [7], Malaysia (95.5%) [14] and Tigray Ethiopia (80%) [15]. However, the results are higher than those reported in studies done in Bale and Gurage zone, Ethiopia (67.8% and 71.1%) [16,17], Cameroon (68.5%) [18], Mozambique (52%) [19] and Nigeria (52%) [20].

The use of conditioned ice packs has long been recommended by the World Health Organization (WHO) to avoid freezing vaccines (preventing freezing [21]. Finding from this study revealed that 321(59.9%) of the respondents knew conditioned icepacks are required for vaccine transportation and distribution. Poor understanding of the dangers of vaccine freezing contributes to the weakness of the existing cold chain in many countries. Emphasis has long been placed on keeping vaccines cold, with less attention devoted to the prevention of vaccine damage from freezing. Freezing of vaccines in the cold chain is commonplace, potentially resulting in the widespread delivery of vaccines whose potency has been compromised [12].

Earlier Expiry First Out (EEFO) principle is the method of vaccine management which involves issuing products with the earliest expiry date first, regardless of the order in which they are received) to reduce vaccine wastage [15,22]. In this study, only 38.8% of the health workers knew that EEFO principle should be applied for vaccine stock management at all levels of immunization supply chain. This result is lower compared to a study conducted in Tigray Northern Ethiopia (66%) [15]. and East Gojam in Ahmara region where 43.3% of the respondent applied the principle [22]. The finding is collaborated by the report of the Yemen EVM assessment in 2013 which showed central, governorate and district level applied EEFO principle but health facility do not because they usually receive one batch of vaccines [23] which may have accounted for the low knowledge.

The introduction of the vaccine vial monitor (VVM), a time-temperature sensitive indicator that accumulates information on the exposure of a given vaccine vial to heat and temperature, has allowed vaccinators to use vaccines with confidence as to their potency [24]. About 22% of the estimated 344 million doses used for routine immunization in the Western Pacific region carry VVMs compared to developing countries where vaccines with VVMs is about 30% [24]. In the Eastern Mediterranean region, the figure is about 82%, in the Southeast Asian region 56%, and in the Africa region 84% [24]. The findings from the study revealed that 79.3% had correct knowledge of the tool (vaccine vial monitor) that shows vaccine exposure to heat and 81.7% knew the discard points of the VVM stages. These results were found to be higher than those reported in other studies conducted in Tigray region, northern Ethiopia (64%) [15], Gojam zone, Ethiopia (58.3%) [22], Nigeria (45.3%) [20] and Ghana (38.1%) [1].

When a vaccine is damaged by freezing, the potency lost can never be restored because the damage is permanent [25]. The shake test is designed to determine whether adsorbed vaccines have been affected by freezing [25]. In this study, 94.6% of the respondents demonstrated good knowledge of shake test for suspected frozen vaccines. This result is by far higher than those reported in similar studies in Ethiopia ranging from (36.2% to 53.3%) [7,16,22], India (40%) [26] and Nigeria (51.6%) [20] and Dalocha District of Silt'e Zone, Ethiopia (56.4%) [12].

Age of the respondents and having had vaccine management training in the last 5 years is significantly associated with good knowledge of vaccine management. Respondents above 40 years had good knowledge indicating the older the health worker, the more likely the exposure to frequent trainings on vaccine management. Also, respondents trained in the last five years who may have been exposed to recent developments in vaccine management had good knowledge compared to those trained six years and above.

This study also showed that a high proportion (76.7%) respondents only receive vaccines while 23.1% receives and distribute vaccine to other level. Of those that receive vaccine, 68.4% do so on monthly basis. The high number is an indication that most of these respondents are operating at the health facility level which is the last mile for vaccine delivery in immunization services. The finding of regular distribution practice agrees with the report of timely and regular supply of vaccines to all levels as strength in vaccine security and logistics that keeps immunization running despite the complex emergency in Yemen [8]. This also showed a strong relationship between those involved in both receiving and distribution of vaccine and vaccine management knowledge which implies health workers who are regularly involved in vaccine management related activities are likely to have good knowledge of vaccine management.

The practice of using refrigerated vehicle for vaccine distribution was shown in this study by a total of 19(15.2%) of respondents that are involved in vaccine distribution and 25(4.7%) responsible for receiving vaccine. 272(50.7%) and 224(41.8%) of the respondents receiving vaccines do so with cold boxes and vaccine carriers with conditioned icepacks while 41(32.8%) and 52(41.6%) that supply vaccines do with cold boxes and vaccine carrier with conditioned icepacks. The demonstration of best practice by a good number of respondents is not a reflection of the knowledge of the respondents with 59.9% who had correct knowledge. There may be need for this to be part of any vaccine management training for practice to match the knowledge of health workers.

The finding of this study showed an unacceptable number of respondents 432(63.8%) that had experienced vaccine stock-out and 327(63.8%) of them for a period of 1-2 weeks. However, there was a commendable

practice of emergency plan to address stock-out shown by 343(79.4%) of these respondents. The finding is consistent with that of the study in OR Tambo District of South Africa with 77% of health facilities reported at least one stock-out for at least one vaccine [27]. In 2014, vaccine stock outs were reported in about one-third 31% of low and lower-middle-income countries at the national level and in 26% at the district level leading to "missed" opportunities and inequitable access to life saving vaccines [1]. Apart from national shortage of BCG due to global shortage in 2014 [23] and reported stock-out of Rota virus vaccine and Pneumococcal Conjugate vaccine (PCV) at national level during the last quarter of 2018 [28], there has not been any reported stock-out of any vaccine at the national store level during the last three years in Yemen [29,30] despite the complex emergency in the country**.** Thus, the finding of this study regarding vaccine stock-out suggests artificial situation caused by human error, occurring either at district or facility level due to poor estimation or delayed supply. With the rising number of zero dose and under vaccinated children which Yemen tops in the Middle East and North Africa (MENA) region [31], there is need for concerted efforts to minimize stock-out at service delivery points to reduce missed opportunities.

In this study, 97.0% of health workers still uses manual system for vaccine stock management and only 16(3%) using the electronic vaccination supplies stock management (VSSM) tool. This finding is collaborated by the report of 2013 EVM in Yemen that found all health facilities and districts using manual system and only central cold store and some governorates using the VSSM [23]. There is need to scale up the electronic stock management system at least to all governorates. Physical stock count reportedly conducted by 458(85.4%) and 28(5.2%) of the respondents on monthly and quarterly basis. The quarterly stock-take is collaborated by the compiled quarterly report from districts, governorate, and central level in 2020 and 2021 [32,33]. The study showed submission of vaccine consumption data by 528(98.5%) on monthly basis. However, these consumption data were not reflected in the routine immunization data at national level [34,35,36]. With the roll out of the District Health Information System (DHIS2) in Yemen, there should be visibility for vaccine consumption data to inform decision at all levels of immunization supply chain.

Temperatures in vaccine refrigerators should be read and recorded twice a day. The WHO recommendations were effective for self-monitoring to prevent breaking the cold chain that can reduce the potency of vaccines and contribute to primary vaccine failure [37]. The finding from this current study showed 92.7% had morning and evening frequency of temperature monitoring with chart on the refrigerator. This finding is consistent with similar study in India (95%) [38] and higher than that of Thailand (66.1%) [27].

In this study, majority of those trained in the last five years were those at health facility and district level which was statistically significant (P value =0.002) This may be explained by the fact that frequent capacity buildings is usually focused on those levels close to vaccine administration sites. However, a high proportion of respondents who are storekeepers received training well over 10 years ago. This is an indication for a capacity building need assessment to determine vaccine management training need and its periodicity at each level of immunization supply chain.

Conclusion

In conclusion, given the complex humanitarian context of Yemen with the conflict into its 8th year, the vaccine management knowledge and practice as shown from the findings of the study are commendable. However, there is need to address the artificial stock-out of vaccines to avoid missed opportunities and plan vaccine

management training for levels that have not been trained for a long time.

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Declaration of Conflicting Interest

The Author(s) declare(s) that there is no conflict of interest.

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