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Uptake, scale up, integration of vaccine, immunization, and health supply chain management technologies and innovation into policy: experience from Tanzania

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Abstract

Background The uptake, scale-up, and integration of technologies and innovations have been the emphasis of the government of Tanzania for sustained health systems strengthening. This study sought to assess the state and factors for the uptake, scale-up, and integration of Vaccine, Immunization, and Health Supply Chain Management (VIHSCM) technologies and innovations into policy, drawing on experiences from Tanzania.

Methods An exploratory descriptive cross-sectional design with a mixed approach was conducted to assess associated factors for uptake, scale-up, and integration of VIHSCM technologies and innovative solutions for a wide coverage of the quality of vaccines. The data were collected from purposively and conveniently key informants from national, regional, district, and a health facility. A questionnaire was administered to 37 respondents at the health facility level and in-depth interviews were conducted with 104 key informants across all levels. Two Focus Group Discussions (FDGs) comprising 3 and 8 key informants were in one faith-based organization and a privately owned health facility respectively. An observational checklist and desk review were implemented to collect additional data and validation. As regards data analysis, qualitative data were thematically analyzed and quantitative data were analyzed descriptively using SPSS version 21.

Results The findings show that a range of innovations and technologies have been implemented for VIHSCM, with a primary focus on management and storage to guarantee consistent availability and caliber of vaccinations. Although the advantages of these technologies in improving availability and coverage are well acknowledged, the state of implementation indicates several challenges. Vaccine Information Management System (VIMS) has been put into practice at the council, regional, and national levels. Nevertheless, their efficacy is hampered by their continued fragmentation and lack of integration. Comparably, just 15 councils report that Tanzania Immunization Registry (TImR) has sufficient capability at the facility level. The potential influence of these technologies on VIHSCM is undermined by their incomplete scale-up and limited usefulness. Furthermore, the Remote Temperature Monitoring (RTM) tool, crucial for maintaining vaccine quality, is only operational up to the council level and suffers from inadequate integration. Consequently, many health facilities still rely on outdated methods like 30-day temperature loggers, which may compromise the integrity of temperature-sensitive vaccines.

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Conclusion The value of technologies and innovations for improving VIHSCM is highly recognized for facilitating high-quality, effective, efficient, and equitable immunization services. However, the adopted technologies and innovations have been beneficial to only a small group of the population and for a short time because of inadequate scale-up and integration. Effective integration and scale-up of technologies and innovations are critical for a sustained effective VIHSCM.

Keywords VIHSCM, Scale-up, Uptake, Technologies, Immunization

Introduction

Tanzania recognizes the adoption of technologies and innovations as critical tools for enhancing the effectiveness and efficiency of health systems processes [1–3]. In response to the existing national frameworks such as the Health Sector Strategic Plan (HSSP V) and guidelines for COVID-19 vaccination, Tanzania has recently witnessed the growing use of technologies and innovation in the health systems on Vaccines, Immunization, and Health Supply Chain Management (VIHSCM). VIHSCM technologies and Innovation strives to strengthen the health supply chains for vaccines and immunizations by utilizing cutting-edge techniques and technology. The focus is to ensure the quality, accessibility, and equity of immunization services [4, 5]. This has triggered the development of several data systems capturing similar data as reported in the review of Tanzania Health Sector Strategic Plan IV [6]. Some of these systems are programmes, projects, or institutional-based which are specifically for disease control, or government systems. Again, some data systems cover medicines and supplies (quantification, supply chain monitoring) and have valuable elements that are important for management, e.g. planning for vaccines and immunization, accounting, and procurement [7, 8].

Moreover, the use of technologies and innovations reported in the supply chain management of vaccines and immunization enabled the country to reach more than 90% of its population including children and pregnant women in hard-to-reach areas [9, 10]. Thus, the adoption of technologies like the Vaccine Information Management System (VIMS) and Tanzania Immunization Registry (TImR), alongside innovative strategies such as Reach Every District (RED) and Reach Every Community (REC), has significantly expanded the reach of immunization programmes. Nevertheless, before these advancements, some populations were not adequately reached. Additionally, adopting Remote Temperature Monitoring (RTM) enabled effective management of standard required temperature, which is a critical aspect of quality control of the vaccines. However, despite the adoption of these technologies and innovative strategies, Tanzania remains with a significant number of unimmunized and under-immunized children [3, 4]. In the same vein, despite the recognized positive effect in improving the effectiveness and efficiency of VIHSCM, some of the adopted technologies and innovations are only implemented on a small scale and project-based. For instance, the REC tool- the Immunization Equity Micro Planning tool, was implemented in only 15 low-performing districts out of the 34 districts focused on immunization that is supported by the United Nations International Children's Emergency Fund (UNICEF).

Similarly, uptake, scale-up, and integration of technologies and innovations are critical for increasing the benefit to a wider population sustainably. In the same regard, the uptake, scale-up, and integration of technologies and innovations are about sustainably extending benefits to a broader population. Specifically, scale-up entails replication and institutionalization of the effective supply chain procedures or technologies that will improve vaccine delivery and immunization outcomes. Uptake is more of the adoption and utilization by the stakeholders in the health supply chain of new technologies, processes, or innovations. However, most of the adopted technologies are inadequately scaled up, and integrated into policies and existing national systems [11, 12]. Several factors can be associated with inadequate scale-up and integrations; but the effective engagement of key stakeholders in the adoption process and alignment or context relevance are critical factors for such scale-up and integration [13, 14]. In addition, the zeal of those involved to see it is integrated into policy and scale up to a wider population is also important.

Furthermore, the government acknowledges the value of technologies and innovation in vaccines and Immunization. However, it is unclear what are the determinants for the scale-up and integration of technologies and innovations for VIHSCM in Tanzania. This study seeks to assess factors for scale-up and integration of existing technologies and innovative strategies for VIHSCM into policy. It describes the extent to which the adopted technologies and innovative strategies are scaled up and integrated as well as the associated factors. The study also recommends a model for the scale-up and integration of the adopted technologies and innovative strategies for improving VIHSCM in Tanzania.

Design and method

We employed an exploratory descriptive cross-sectional design with a convergent parallel mixed method approach to study the adopted technologies and innovations for VIHSCM, its scale-up, and integration to the existing systems and policies. This research design was adopted as it allows both qualitative and quantitative data to be collected simultaneously, analyzed separately, and later combined for interpretation to provide a comprehensive analysis of the uptake, scale up, and integration into the existing systems and policies [15].

Sample and sampling procedures

Regions and Districts Covered
Mwanza region
Ukerewe DC
Nyamagana DC
Arusha region
Meru DC
Longido DC
Mbeya region
Mbeya DC
Kyela DC
Morogoro region
Morogoro urban DC

Data collection was conducted in four purposively selected regions of mainland Tanzania namely, Arusha, Mwanza, Morogoro, and Mbeya. In each of the selected region, two districts were purposively selected. The criteria for selection of both regions and districts were the urban–rural divide and the vaccines and immunization uptake rate. The selection was based on capturing contextual variations that can influence the uptake, scale-up, and integration of adopted technologies and innovations into the existing systems and policies. Key informants were selected at all levels based on their involvement in supply chain management. At the national level, key informants were selected from the Ministry of Health (MOH), the President's Office of Regional Administration and Local Government (PORALG), government agencies, and non-governmental organizations. At the MOH, five informants from the Preventive Services Division, and two from the Policy and Planning Division were selected, and at PORALG, two officials were selected. In the government agencies, two officials were selected from the Medical Stores Department (MSD); two from the Tanzania Food and Drug Authority (TFDA), two from the pharmacy council, and one official from each of the four supply chain implementing partners. Key informants from the non-governmental institutions were the Christian Social Service Commission, the Association of Private Health Facilities in Tanzania, the Private Nurses and Midwives Association of Tanzania, and the Umbrella of the Last Mile Facilities for Mother and Child Health.

At the regional level, the key informants were purposively selected from the zonal resources center in regions where the zonal resources center was located. Again, in the selected regions and councils, two and three relevant officials were selected purposively based on the involvement in the implementation of vaccines and immunization activities. These included the Regional Medical Officer (RMO), Regional Immunization and Vaccine Officer (RIVO), District Medical Officer(DMO), District Immunization and Vaccine Officer(DIVO), and District HMIS (MTUHA) as focal persons as indicated in Table 1. Three staff were purposively selected in each health facility based on their involvement in vaccine and immunization management. These were the health facility in charge, the in-charge of the Reproductive and Child Health (RCH), and the RCH vaccine coordinator. It is important to notice that in some health facilities, the in-charge of RCH served also as the vaccine coordinator.

Furthermore, each district's selection of health facilities was guided by their involvement in vaccine and immunization management. We purposefully targeted facilities where key personnels such as health facility in-charges, RCH coordinators, and vaccine coordinators, play pivotal roles in VIHSCM activities.

Table 1 Key informants

Interviewer	District	Position
1	District F	District Immunization Vaccination Officer(DIVO)
2	District B	District Immunization Vaccination Officer(DIVO)
3	District E	District Immunization Vaccination Officer(DIVO)
4	District E	District Medical Officer(DMO)
5	District B	District Immunization Vaccination Officer(DIVO)
6	District B	District Medical Officer(DMO)
7	District E	District HMIS (MTUHA
8	District D	District Medical Officer(DMO)
9	District D	District HMIS (MTUHA
10	District A	Reproductive and Child Health(RCH)
11	District A	District Medical Officer(DMO)
12	Region A	Regional Reproductive and Child Health(RRCH)
13	Region B	Regional Medical Officer(RMO)
14	Region B	Regional HMIS (MTUHA)
15	Region B	Reproductive and Child Health(RCH)
16	Region B	Regional Immunization Vaccination Officer
17	Region C	Regional HMIS (MTUHA

Data collection

This study employed a variety of approaches to data collection, including both primary and secondary sources. Semi-structured interviews and questionnaires were used to collect primary data, and document reviews were used to collect secondary data. The secondary sources provided in-depth information about the state of VIHSCM in mainland Tanzania by containing a variety of papers, including guidelines, policies, research reports, and programme evaluations. The secondary sources were published and unpublished documents, which included policies and regulations, guidelines, strategies, research and evaluation-based reports, programme reports, databases, and online records.

The documents reviewed were the health sector strategic plan(HSSP V), an expanded programme on immunization 2010—2015 comprehensive multi-year plan, guidelines on variations of registered vaccines, national immunization programme, financial sustainability plan, guidelines for surveillance of adverse events following immunization, a performance audit report on the management of immunization and vaccination project activities, and the use of digital technologies and approaches for real-time monitoring of supplementary immunization activities. The information from the documentary review was useful in mapping and analyzing all developments, innovations, and technologies associated with VIHSCM in mainland Tanzania.

We also employed semi-structured interviews with 41 key informants at national, regional, and council levels to examine the knowledge, attitudes, values, use of VIHSCM innovations and technologies, and experiences related to the use of VIHSCM technologies in Tanzania (see Addition file 1: Interview Guide). The interviews took about 10–15 min and were conducted in an office setting. The interview guide was also used to collect data from key informants in the Faith-Based Owned health facility.

Additionally, a questionnaire was administered to 37 respondents at the health facility level to find out demographic characteristics, experience, motivators, and de-motivators of using innovations and technologies of VIHSCM (see Addition file 2: Questionnaire). Focus group discussion(FDGs) was also conducted in selected health facilities to further explore specific topics or themes related to VIHSCM.On the other hand, a discussion guide was employed to collect data from FDGs in private health facilities (see Additional file 3: Discussion Guide 1).

Data processing and analysis

The data were collected in Kiswahili, transcribed, and translated into English. This is because most respondents were fluent in Kiswahili; and therefore, they were more comfortable to provide more information in Kiswahili. Additionally, the translated data were thematically analyzed with the support of the Dedoose Desktop App. This enabled similar topics to be grouped and coded. The analyzed data are presented in the form of summary narratives and verbatim illustrative quotes. This qualitative data analysis was used to explore knowledge, attitudes, values, use of all VIHSCM innovations and technologies, and experiences related to the use of VIHSCM. On the other hand, quantitative data were cleaned, processed, and analyzed using Excel 16. This was used for the demographic characteristics, experience, motivators, and de-motivators of using innovations and technologies of VIHSCM. Moreover, the data analysis only focuses on descriptive statistics (frequencies, and percentages) because of the small number of records. The descriptive statistics intended to determine the state and factors influencing the initial uptake, scale-up, and integration of VIHSCM technologies and innovations. These quantitative data were analyzed with the aid of the Statistical Package for Social Sciences (SPSS) version 21.

Ethical considerations

Ethical clearance was obtained from the National Institute for Medical Research. The research was also approved by Mzumbe University. Again, permission to conduct research in the relevant institutions was obtained from MOH and PORALG. Similarly, participants were given consent forms describing the purpose of the study and their position to participate or terminate their participation during the interview. Only consented participants were interviewed.

Results

Respondent characteristics

In this study, we found that out of the 37 participants from the regions of Arusha, Morogoro, Mbeya, and Mwanza, 22 (59.5%) worked in district hospitals, 4 (10.8%) in health facilities, and 11 (29.7%) in dispensaries. The gender distribution shows that approximately, 26(70.3%) are women and 11(29.7%) are men. Most participants fall within the 25–44 age range, comprising 12(32.4%). The second-largest age group is 45–54, accounting for 10(27.0%), followed by 55–64, representing 3(8.1%). Nursing was the most prevalent medical qualification held by participants, accounting for 51.4% of the total population. Assistant Medical Officers made up 2.7%, Clinical Officers 16.2%, and Medical Doctors 27.0%. The majority of participants 15(40.5%) held a diploma, followed by bachelor degrees 11(29.8%), certificates 9(24.3%), and advanced diplomas (24.3%). As regards job titles, the bulk is Facility Coordinators/In Charge/Nurses

(62.2%), followed by MTUHA jobs (13.5%) and Medical Officers in Charge (24.3%). These respondents' characteristics are presented in Table 2.

Uptake of VIHSCM technologies and innovation

The results indicate that VIHSCM technologies and innovations are recognized for their contribution to improving the availability and quality of vaccines and immunization services. Participants in the study highly recognized the impact of technologies such as VIMS, Warehouse Management Information systems, TImR, and Storage technologies in facilitating the quality and accessibility of vaccines and immunization services. However, despite this recognition, concerns were raised regarding the adoption, design, and environmental factors supporting their scale-up. Participants noted that these technologies were often imposed by the government and thus they are top-down and do not adequately address the actual need.

"It was the directive from the government and was started as a pilot study but still we have challenges"(Interviewer 10 & 11- District A).

"The use of systems, we had received the directives from MOH since 2018" (Interviewer 5-District B).

"The establishment of the system should consider the variation in geographical location. All ICT personnel at both regional and district levels should be involved in the development and implementation of the system, especially those with healthcare-related expertise"(Interviewer 12-Region A).

The main arguments were that the government through MOH decides which vaccination and immunization system or technology to use without adequate engagement of key stakeholders or users. Also, participants pointed out that it is important to adequately involve health providers, especially in the dispensing facilities and consider the settings to make the system more useful, and responsive to the actual and user-friendliness. These issues are critical for the uptake of any technology and innovation.

Participants in districts and health facilities that have adopted the VIMS and TImR technologies respectively, expressed their recognition of the contribution of these technologies.

"Previously, we had the so-called matrix a paper-based, but for the current, we have VIMS which track the availability and ordering of the vaccines..... it is operated by responsible individuals at the facility. These technologies have simplified the tracking of availability of vaccines that was not possible to do before resulting to stock-out and thus unreliable vaccines and immunization services"(Interviewer 8-District D, interviewer 10 & 11-District A, and Interviewer 3-District E).

Tracking the vaccine inventories assures the vaccine's availability by allowing health workers to properly plan and manage distribution based on the consumptions reported in the system.

"Yes, we are using VIMS which tracks availability and usage; also, it facilitates in planning and deployment of vaccines. The software is very helpful since it guides the Vaccine Coordinator from districts and regional levels to properly plan for order-

Table 2 Socio-demographic characteristics

Variable	Frequency(n)	Percentage(%)
Sex		
Male	11	29.7
Female	26	70.3
Total	37	100
Age		
25–34	12	32.4
35–44	12	32.4
45–54	10	27.0
55–64	3	8.1
Total	37	100
Medical Qualifications		
Medical Doctors	11	27.0
Nurses	19	51.4
Clinical Officers	6	16.2
Assistant Medical Officer	1	2.7
Total	37	100
Education		
Bachelor	11	29.8
Advanced Diploma	2	5.4
Diploma	15	40.5
Certificate	9	24.3
Duration		
< 1 Years	4	10.8
1–5 Years	17	45.9
6–10 Years	10	27.0
> 11 Years	6	16.2
Total	37	100.0
Job title		
Facility Coordinator/In Charge/ Nurse	23	62.2
Medical Officer in Charge	9	24.3
MTUHA	5	13.5
Total	37	100

Table 3 Extent of use of technologies or tools planning, ordering and reporting on vaccines across council and health facilities

		Integrated Logistics Systems (ILS)	Tanzania Immunization Registry (TImR)	DHIS 2	GoTHOMIS	No software	Total
District	**Nyamagana DC**	N/A	6(85.7)	N/A	1(14.3)	N/A	7(100)
	Ukerewe DC	N/A	4(66.7)	N/A	2(33.3)	N/A	6(100)
	Meru DC	1(33.3)	1(33.3)	N/A	1(33.3)	N/A	3(100)
	Longido DC	N/A	N/A	N/A	N/A	4(100)	4(100)
	Kyela DC	N/A	N/A	N/A	1(12.5)	7(8.5)	8(100)
	Mbeya rural DC	N/A	N/A	3(50)	N/A	3(50)	6(100)
	Morogoro urban DC	N/A	2(66.7)	N/A	N/A	1(33.3)	3(100)
Total		1(2.7)	13(35.1)	3(8.1)	5(13.5)	15(40.5)	37(100)
Health Facility Level	**District Hospital**	N/A	10(45.5)	1(4.5)	4(18.2)	7(31.8)	22(100)
	Health Centre	1(25)	N/A	N/A	N/A	3(75)	4(100)
	Dispensary	N/A	3(27.3)	2(18.2)	1(9.1)	5(45.5)	11(100)
Total		1(2.7)	13(35.1)	3(.1)	5(13.5)	15(40.5)	37(100)
Health Facility Ownership	**Public**	N/A	9(32.1)	1(3.6)	5(17.9)	13(46.4)	28(100)
	Private	N/A	2(100)	N/A	N/A	N/A	2(100)
	FBO	1(14.3)	2(28.6)	2(28.6)	N/A	2(28.6)	7(100)

ing and distribution. We are using refrigerators at the facility level, freezers, and walk-in cold rooms at district and regional level while on top of that we are using VVMs, and RTMs to ensure the quality of vaccine is maintained at its standard" (Interviewer 13-Region B, Interviewer 14- Region B, Interviewer 8-District D, Interviewer 2-District B).

"We are using TImR and VIMS and MTUHA though in the previous, we were using DHIS2 but we have now transformed into paperless" (Interviewer 3-District E).

The findings in Table 3 confirm that health workers are using technologies which have been useful in facilitating the reliable availability of vaccines. Most are transitioning from paperwork to paperless in ordering, administering, and reporting. These are done using tools for administering vaccines that resemble immunization information management ways. As indicated in the table, most have not experienced stock-out for a while and only reported experiencing stock-out once a year. The quality of vaccines has been managed through the effective use of refrigerators and Remote Temperature Monitoring technology. This technology was reported by respondents to be useful in ensuring adherence to managing the temperature at the required range and maintaining its condition for safety use (cold chain system). The use of the technology has also enabled feedback from vaccinated individuals and their locations which has been useful in developing strategies to reach more population in case of under-vaccination reports.

The adoption of technologies, as indicated in Fig. 1 in project- or small-scale interventions, represents the initial steps in addressing issues with vaccination administration and distribution. Nonetheless, effective integration and scale-up have the most significant effect on enhancing vaccine accessibility and quality throughout healthcare facilities.

Scale up of VIHSCM technologies and innovations

Also, we found that the scale-up of VIHSCM technologies and Innovation remains a challenge. As indicated in Table 4, the column of ILS (integrated logistic system) is reported as zero because the target respondents (i.e. RCH in-charge, dispensing nurse, MTUHA focal person) are not using that system in their routine services and the vaccines are separated from pharmaceuticals. TImR is reported to some facilities because this system is not scaled up countrywide. It is only rolled in 3736 health facilities in 15 (57.7%) regions. In the studied regions, TImR was only rolled out in Arusha, Morogoro, and Mwanza. It was not yet rolled out in Mbeya. It was also learned that in Meru and Longido district councils, there was a good number of broken tablets that led to the stoppage of use of the TIMR system. Moreover, as indicated in Table 2, TIMR is used in both public and private health facilities. However, Government of Tanzania Health Operation Management Information System (GoTHOMS) is only used at district hospital levels. It has not yet been rolled out athealth centers and dispensaries.

Conversely, the data on vaccines and immunization are still filled out manually and electronically, indicating that

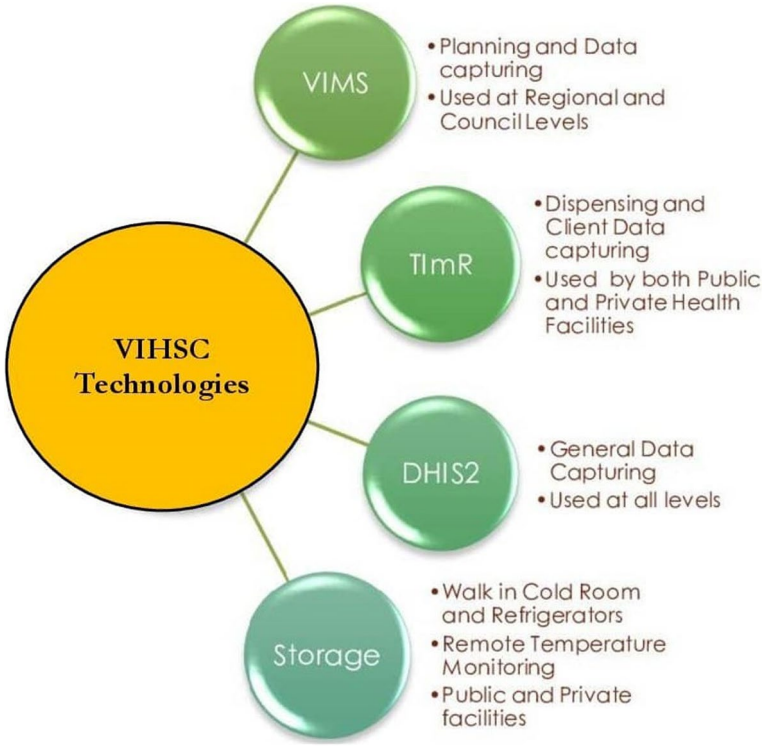

Fig. 1 Technologies adopted to facilitate access to vaccines and immunization

Table 4 Status of technology uptakes across primary-level health facilities in 2023

Characteristics	Status	Health Facility Level ($n=37$)			
		District Hospital	Health Centre	Dispensary	Total
Frequent of Vaccines Receipt	Monthly	22(59.5)	4(10.8)	11 (29.7)	37
Reporting of the Used Vaccines	Software	3(75)	1(25)	N/A	4
	Form	9(50)	1(5.6)	8(44.4)	18
	Both software and form	10(66.7)	2(13.3)	3(20)	15
Frequency of Out of Stock	Once a year	9(50)	2(11.1)	7(38.9)	18
	Never experienced stock-out	13(68.4)	2(10.5)	4(21.1)	19
Tool for Administering Vaccine	Electronic software	2(40)	1(20)	2(40)	5
	Form	10(55.6)	2(11.1)	6(33.3)	18
	Both electronic software and form	10(71.4)	1(7.1)	3(21.4)	14
Technology used for vaccines and immunization storage	Refrigerator	22(59.5)	4(10.8)	11(29.7)	37

the technology is still not fully integrated. Although all studied health facilities reported the availability of functional refrigerators, the RTM technology is only used at the national, regional, and council levels. Given most respondents, the RTM is a most useful technology that needs to be scaled up to health facility levels.

Evidence gathered in this study shows that the availability of agencies to facilitate troubleshooting and repair limits the use of TImR. It was reported in three health facilities in Longido district council, four in Meru, and two in Morogoro municipality that they are not using the TImR system because the tablet is not working and they could not repair it. This indicates that necessary preparation is critical to create systems that can support and sustain the adopted technology. In Arusha, for example, it was learned that "private, faith-based, and public health

facilities have engaged with one service provider to help them get support when needed. One of the respondents commented that "we have a contractual agreement with the service provider that includes the provision of technical support and troubleshooting; so all health providers use the same systems for vaccines provision and when experience challenges with the systems the provider is required to assist" (Interviewer 9-Region B).

Interviews with key informants show how it is important to scale up the adopted technologies and innovations that proved to be useful in addressing vaccines and immunization needs. According to some of the key informants:

> *"Scale-up of VIHSCM technologies is highly needed….The system has enabled reaching the facilities available within the region as it could be very difficult to reach all facilities through physical visits. It enables the timely request or ordering of vaccines by tracking the stock availability. Also, the technology has improved the storage of vaccines hence the increase of uptake (interviewer 13 & 14-Region B, Interviewer 8-District D).*

> *"For instance, VIMS gives alert for stock availability and ordering system" (Interviewer 10 & 11-District A)*

> *"Vaccines are stored in freezers and fridges where there is MTR which monitors the temperature in the required standard and it gives alert whenever changes occurred". (Interviewer 1-District F), (Interviewer 5- District B).*

Integration of the VIHSCM technologies and innovations

This study revealed that Scaling up and sustaining the adopted technologies and innovations that proved to be relevant and useful is a primary goal of most project-based small-scale interventions. The resources used for the adoption of technologies and innovations will be wasted if the benefits generated end up at a pilot stage or project life cycle. One of the strategies for the scale-up of technologies and innovations is the integration into policy. The buy-in by key stakeholders including government officials facilitate integration into national policy and ultimately scale up and sustainability.

Most of VIHSCM were yet to be integrated into policies and some are likely to be bypassed by events before they are integrated. The integration into policy not only facilitates scale-up but also continuous improvement of the adopted technologies and innovations in response to the new demands of the time. Most respondents revealed that the study technologies were started on a small scale and were later rolled out. However, during this study, the respondents commented that:

> *"Now, we are thinking of integrating TImR systems at the facility level. GOTMIS is from PO-RALG, it was introduced 5 years ago, used for collecting health service provision data at the facility level and but only 40% of the facilities are using it. Now, they are the MOH is working on integrating it with DHIS2 and VIMS" (Interviewer 13-Region B, Interviewer 9-District D, Interviewer 4-District E, Interviewer 17-Region C).*

Also, the findings demonstrate that unintegrated technologies and innovations are likely to lack continuity. *"The tablets to support VIMS were introduced with the support from PATH Tanzania and were mostly used by the RCH in-charge, the DIVO, and the RIVO it"* (Interviewer 18-District D). The fact that the cost to sustain these tablets through repair and replacement was not integrated into the Comprehensive Council Health Plans, it is less likely to be operational after the support from implementing partners ends.

The involvement of key stakeholders including users and top government officials from the start of the adoption of technology and innovation, is an important factor for the integration of a relevant and useful technology. Most of the users commented that:

> *"…….. I believe different stakeholders were involved in the development of these technologies" (Interviewer 10- District A).*

When asked if they were involved, they said:

> *Yes, we have been involved in the development of the guideline of any kind, but not from the early stages and I think the stakeholders at council and region level especially ICT should be involved or included" (Interviewer 16- Region B, Interviewer 6- District B).*

Although users acknowledge their involvement with the assumption that other key stakeholders have been involved in the adoption of VIHSCM technologies and innovations, the commitment to scale up seems to be very little. However, the existing digital health strategy, emphasizes technology adoption and use to address health problems, and the reluctance from key government stakeholders to push it to happen was more dominant. The question that remains is whether the involvement of key stakeholders was inadequate to promote the integration of adopted VIHSCM technologies and nnovations. One explanation can be motivations decrease proportionally with a decrease in resources from implementing partners.

Discussion

Uptake of VIHSCM technologies and innovation

In this study, we identified that uptake serves as the cornerstone in determining the value and effectiveness of technological innovations. In the context of Tanzania's healthcare system, the implementation of VIHSC technologies and innovations commenced on a small-scale project basis, to expand their reach. The success of this expansion, or scale-up, hinges upon several factors, including uptake, integration into existing policies, and sustained support. Despite positive initial reception and uptake of VIHSCM technologies, particularly VIMS, TImR, and Storage, there were significant challenges in achieving widespread adoption. This is supported by previous research on the challenges that affect the effectiveness of the web-based vaccination information system [16]. Although national strategic frameworks emphasize technology adoption, inadequate resource allocation undermines long-term sustainability, leading to wasted investments when donor support diminishes.

Surprisingly, the interests of involved key stakeholders including national-level officials to facilitate scale-up and integration sometimes decrease and finally disappear as the funds from donors gradually decrease and come to an end. This situation leaves most of the resources invested and innovative technologies that have proved to be useful to be wasted. Strong uptake from policymakers at the very initiation stages of technology adoption and proper alignment with existing policies and frameworks remain critical, though it is not certain to guarantee uptake and integration- as it is sometimes influenced by frequent changes of officials in positions. Efficient adoption and integration of technological innovations of vaccines and immunizations in healthcare systems require sustained support from stakeholders [17].

Despite reported little engagement in the design and development of technologies and innovations, the usefulness of technology and innovation was echoed by those who use them. The concern of users on technology and innovations was that they do not compressively address the actual needs despite good capacities demonstrated by these technologies and innovative solutions. As a result, it leads to reluctance to use them. In the same line, prior research has expressed similar concerns regarding the gap in technology solutions between professionals, and people's true needs in covid-19 vaccines [18].

Users see it as something imposed from the top down; and therefore lack ownership and inadequate reflection of their real-life situation. This situation leads to a gradual uptake and in a situation where there is no adequate enforcement, people tend to ignore and keep their ways of doing things. Even in a situation where they acknowledge the relevance and usefulness of the technology and innovation, they tend to associate with factors that would not have stopped them from using it if there was ownership. For instance, some technologies require maintenance and internet connectivity that can be sorted out by councils or relevant health facilities. Because ownership is low, they tend to leave it for those who brought it to address. Thus, engagement of users in the design process and proper adoption plan remain a critical factor for the uptake of technologies and innovative solutions. The same findings have been drawn from earlier research, which stressed the significance of user engagement in the design and adoption phases to guarantee successful implementation [19].

The findings suggest that inadequate engagement of key stakeholders and lack of a proper plan on the scale-up and integration of adopted technologies and innovative strategies leaves useful interventions at pilot stages. Only a few cross to scale up stage and integration into the existing policies and guidelines. For instance, all three VIHSCMs were at the pilot stages with their cycles already completed and ready for scale-up and integration. These technologies and innovations were adopted in the form of the project and once the project life cycle ended, little was done. It appeared that the key stakeholders at the national level also lost interest when the project life cycle ended. This provides the lessons that effective strategies of engaging policymakers at the design and development stage as well as making sure that the take-off for scale-up and integration take place during the project or pilot stages is critical. The other study by [20] emphasized that the persistent challenge of transferring effective interventions from pilot programmes to more widely used technology and smooth integration with current procedures and regulations.

That will ensure that adopted technologies and innovations are effectively scaled up and integrated into existing policies and guidelines. Without such integration, most of the resources used in the adoption of useful technologies and innovations will be enjoyed on a very small scale and in a short time. The integrations are likely to guarantee scale-up and sustainability as resources will be allocated through government planning processes. The VIHSCM technologies and innovations, therefore require another push to review it to adequately address the actual needs, integrate it into policies and guidelines, and scale up.

Adopted VIHSCM technologies and innovations

The findings revealed that access to vaccines and immunization has been a priority of many countries including Tanzania. Several strategies and technologies were adopted in Tanzania- to facilitate access to vaccines and immunization for everyone who needs it. Some of

the strategies were the Expanded Program on Immunization (EPI), RED, and REC. The underlying assumption by the government and other key stakeholders is that strong immunization systems to deliver vaccines to those who need them most will play a significant role in achieving the health, equity, and economic aspects of the 2030 components of the Sustainable Development Goals (SDGs) [21].

Evidence shows that these strategies and programmes have played a key role in successfully increasing immunization coverage. For instance, given [21], the RED approach has contributed to increasing DPT3 coverage in Africa from 57 to 80% between 2000 and 2014. In Tanzania, the strategies were reported to contribute to plateauing and maintaining immunization coverage to 90 percent in the past 13 years since its adoption in 2009. The focus was on low-performing 15 districts supported by UNICEF [22]. Despite its significant contribution, there is no clear road map on how these strategies can be scaled up and integrated into policy or planning processes.

In recent years, Tanzania adopted VIHSCM technologies and innovation to facilitate coverage of vaccines and immunization services [6]. This is to ensure that "everyone is protected from vaccine-preventable diseases throughout the life-course with high quality, effective, efficient and equitable immunization services; and ensure an effective, efficient, and resilient immunization program as an integral part of the primary health care system" [3]. The availability of a supply chain that delivers a reliable, continuous supply of vaccines and immunization commodities [6, 21] to its customers wherever they are is critical for the attainment of the goal. Among the adopted technologies were: VIMS, Warehouse Management Information Systems (Part of the VIMS Module), and TImR. Overall, the health sector information is generated through District Health Information Systems 2 (DHIS2), and therefore, it plays a key role in informing VIHSCM interventions.

Scale-up and integration of VIHSCM technologies and innovations into policy

As in many other countries, the adoption of technologies and innovations started on a small scale. It was done in the form of pilot or implementation science. The main intent was to determine its additional value to the health systems before a large number of resources are committed to spreading it to a large scale and institutionalization through integration into policy. Scale-up and integration into policy are critical in spreading the benefit of the adopted technology and innovation to a wider population and in sustaining it. However, various literatures have indicated the greatest challenge to scale up and institutionalize proven interventions [23, 24]. This leads to most proven interventions or adopted technologies not making adequate impacts as they should have been as indicated by evidence generated during pilot or implementation science. The question that remains is how and to what extent we integrate the existing model of scale-up and integration into the adoption of technologies or designed intervention. The implementing best practices as indicated in [25], provide an important framework for fostering scale-up of proven technology or intervention in the health sector. Such frameworks with several others consider design, environmental factors that foster adoption, and infrastructure required to support scale-up as critical factors for the scale-up of the ideas [26].

Therefore, there have been varied experiences on the uptake, scale-up, and integration of ideas be it technology or interventions into policy [21, 26]. Most of the adopted technologies or proven intervention end up at the pilot stage or implementation of scientific research even if it has proven to be useful and effective in improving the access, quality, and delivery of health services.

Study limitations

First, the use of purposive sampling is not representative of diversity across regions, districts, and health facilities; hence, generalization of results is limited. The reliance on self-reported information by the key informants raises several potential biases, such as social desirability bias and recall bias, which negatively impact data accuracy, especially the challenges faced in implementing the VIHSCM technologies. Third, the conclusions cannot be strong since small samples of both qualitative and quantitative data may not represent the full array of experiences of interest in the population among health workers. Fourth, the current study investigated the status of the technology adoption, but did not go into details of the long-term sustainability and challenges for scaling up and integrating the VIHSCM technologies into the national policy. Further research will be needed, for instance, in monitoring the trend of VIHSCM adoption and its longer-term impacts.

Conclusion

The government recognizes the adoption of technologies and innovation as an important strategy for effective VIHSCM. In the same vein, stakeholders acknowledge the relevance and usefulness of the adopted technologies and innovations in increasing access, utilization, and ensuring the quality of vaccines and immunization in the country. However, there is no clear strategy to determine uptake, inform scale, and guarantee integration to useful and impactful technologies and innovations. The three technologies namely; VIMS, TImR, and storage were

not scaled up or integrated into the existing operational guidelines despite the emphasis on key strategic frameworks such as Health Policy, HSSPs, and Tanzania's Digital Health Strategy. The uptake of VIHSCM technologies and innovations was not adequately documented and disseminated for scale-up and integrations. As a result, uptake has been undermined by limited use of policy enabling factors, inadequate integration of the adopted technologies and innovations into the existing systems, and insufficient supportive services for technical troubleshooting, training, and data use at lower health facilities. The integration of technology and innovation into policy has been slow and sometimes does not happen at all due to inadequate documentation, translation into policy statements, and dissemination.

Abbreviations

RCH	Reproductive and Child Health
RTM	Remote Temperature Monitoring
TImR	Electronic Immunization Registry
VIHSCM	Vaccines, Immunization, and Health Supply Chain Management
VIMS	Vaccine Information Management System
UNICEF	United Nations International Children's Emergency Fund

Supplementary Information

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Additional file 1.

Additional file 2.

Additional file 3.

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Authors' contributions
Henry A. Mollel, Lawrencia D. Mushi, and Richard V. Nkwera have contributed to data collection, data analysis, and preparation of the manuscript. All authors commented on previous versions of the manuscript, read and approved the final manuscript.

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Data availability
The data sets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
Ethical clearance was obtained from the National Institute for Medical Research. The research was also approved by Mzumbe University. Permission to conduct research in the relevant institutions was obtained from the MOH and the PORALG. Participants were given an informed consent form describing the purpose of the study and their position to participate or terminate their participation during the interview. Only consented participants were interviewed.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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