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Uptake likelihood assessment of oral cholera vaccine capsules: insights from stakeholder consultations in five countries

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Abstract

Background The global resurgence of cholera, a diarrhoeal disease, has resulted in vaccine demand that exceeds the currently available supply resulting in global calls for next generation cholera vaccines. DuoChol is a novel, thermostable, low-cost oral cholera vaccine capsule currently in development which has the potential to introduce programmatic benefits and efficiencies in cholera vaccination campaigns.

Objectives This qualitative study aimed to identify country-specific challenges in handling, distributing, and storing cholera vaccines and to assess the feasibility, acceptability, and policy implications of vaccine capsules compared to current products and practices in vaccination campaigns.

Methods Using the World Health Organization's Vaccine Innovation Framework, consultations were conducted with 81 immunization programme stakeholders from Bangladesh, Ethiopia, Kenya, Mozambique and Tanzania.

Results Key barriers to cholera vaccination include challenges in disbursing funds to subnational levels and the need for surged resources, such as additional health workers and cold chain equipment, during campaigns. Stakeholders discussed attributes of the novel vaccine such as improved thermostability and presentation which could reduce or eliminate the existing barriers.

Conclusions The stakeholders highlighted that vaccine capsules are desirable for use in the general population as they have the potential to have many advantages over the current practice. However, for children who are not able to swallow the capsule, the currently available liquid oral cholera vaccine may be more desirable. To make an eventual informed decision about whether to recommend use of the vaccine capsule, national stakeholders requested the generation of evidence derived from pilot studies.

Keywords Cholera, Oral Cholera Vaccine (OCV), vaccine capsules, stakeholder perceptions, vaccine innovation, innovation uptake

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Introduction

Cholera is a severe diarrheal disease caused by *Vibrio cholerae*, a non-invasive bacterium. Since the 19th century, the disease has caused seven pandemics, the most recent of which began in 1961 and remains ongoing [1–3]. From 2015 to 2019, at least 47 countries have been affected, resulting in an estimated 2.9 million cases and 95,000 deaths per year [4, 5]. Cholera outbreaks cause not only death and human suffering, but also enormous economic burden on communities and public health systems, hindering development in impacted regions [6]. In 2023, the World Health Organization (WHO) has classified the global resurgence of cholera as a grade three emergency- the highest internal level for emergencies [7].

Primary cholera prevention and control strategies include the use of Oral Cholera Vaccines (OCVs), and improvement of water, sanitation and hygiene (WASH). With the availability of effective OCV, Gavi, the Vaccine Alliance, approved the funding for a global OCV stockpile in 2013, managed by the International Coordinating Group (ICG), to improve demand and supply dynamics and reduce the scale of outbreaks. Since its creation until February 2025, over 216 million doses of OCV were shipped to 35 countries for emergency and preventive response in vaccination campaigns [8]. However, the demand for OCV doses from the global stockpile has been exceeding the available supply, underscoring the need for new suppliers and new products [9]. In 2023, Gavi, the Vaccine Alliance, published a market shaping roadmap for improvement of the OCV market dynamics highlighting the need for improved vaccine presentation. This includes improved effectiveness in young children and improved thermostability, which is the ability of a vaccine to maintain potency despite exposure to elevated temperatures, thereby reducing cold chain requirements [10].

DuoChol is a novel, low cost, thermostable vaccine, in development, containing inactivated bacterial whole cells and cholera toxin B subunit in an enteric-coated capsule. The product is being co-developed by Holmgren (developer of the technology in DUKORAL®) and colleagues at the University of Gothenburg in collaboration with the International Vaccine Institute (IVI) [11]. This product will have similar composition and dosing as the WHO prequalified OCV DUKORAL®and is expected to share clinical performance attributes in children and adults [12, 13]. DUKORAL®, like other OCVs, is administered as two doses with a 14-day interval. Compared to DUKORAL®, which requires co-mixing of the active ingredients with a buffer resulting in higher cost, bulkier packaging and complex administration in the field, DuoChol is expected to have lower cost and significantly smaller packaging weight and volume. Another significant advantage of the novel vaccine capsule is the demonstrated higher thermostability, tolerating up to 40°C for at least 21 months. The absence of a standard cold chain requirement in storage or delivery and low weight and volume packaging could result in programmatic benefits such as more rapid outbreak response through national stockpiles, delivery to remote populations, self-administration at home, and reduced delivery costs. However, the capsule presentation might not be desirable for some younger children due to their potential inability to easily swallow it.

Country-level perspectives are essential in determining the programmatic suitability and desirability of innovative vaccine products in cholera outbreak preparedness and response. We have conducted consultations with national immunization programme stakeholders from five cholera-prone countries to understand country-specific immunization challenges that may be relevant to the handling, distribution and storage of cholera vaccines and evaluate the feasibility and acceptability, and policy implications of DuoChol capsules in comparison to current products and practices. The findings inform the utility profile of OCV capsules and offer insights into their likelihood of uptake in countries, as well as how they might enable a more rapid and efficient outbreak response and last-mile outreach. This paper presents the findings from those consultations.

Methods

The consultations were conducted through two workshops with distinct scopes. The first, held in October 2023 in Bangladesh, focused exclusively on the national context, bringing together stakeholders from various sub-national levels and regions within the country. The second workshop, held in February 2024 in Tanzania, had a broader, multi-country focus from across the East and Southern Africa sub-region. It included designated delegations from Tanzania (mainland and Zanzibar), Ethiopia, Kenya, and Mozambique. These countries, all endemic for cholera, and representing a variety of cholera-prone settings and contexts, were selected to capture a range of experiences with cholera vaccination, differences in access to water and sanitation, and variation in cholera case fatality rates.

The respective Ministries of Health from each country were asked to nominate relevant participants corresponding to the following general profiles: programmatic decision-makers from within the Ministry of Health, policy makers from the National Immunization Technical Advisory Group (NITAG), logisticians and/or service delivery professionals involved in cholera vaccination activities, and members of relevant academic/research institutions. A total of 81 stakeholders involved in national immunization programmes participated in the two workshops (Bangladesh ($n = 52$), Ethiopia ($n = 5$),

Kenya ($n=6$), Mozambique ($n=6$), Tanzania (mainland ($n=5$), Zanzibar ($n=7$)), representing Ministries of Health, Centers for Disease Control, Institutes for Public Health, the International Federation of Red Cross and Red Crescent Societies, NITAGs, WHO and UNICEF country offices.

The WHO Vaccine Innovation Framework was used to guide the workshop discussion [14]. The framework enables consultations to be structured systematically, allowing for reproducibility, consistency across countries and comparison of results. It guides evidence-based discussions based on country input through a credible and transparent consensus-building process that is fully documented. The framework has previously been used for other innovations such as Measles and Rubella Microarray Patches and thermostable vaccines [15, 16].

Figure 1 outlines the 4 steps of the Innovation Framework. In collaboration with experts from the WHO headquarters and regional offices and the IVI, the 4-step process of the Innovation Framework workshops was adapted to address questions specific to OCV capsules.

An initial desk review was carried out in advance of the workshops resulting in a long list of barriers to achieving high cholera vaccine coverage and equity. During the workshop, in Step 1, stakeholders in break-out groups prioritized these barriers across various subnational contexts, including urban, rural and hard-to-reach populations. After the group reached consensus on the list of prioritized barriers across settings, stakeholders were asked to determine the effect that each of the DuoChol vaccine attributes could have on the barriers. The attributes can have various impacts on the barrier: they may have no effect, directly reduce or increase it, or indirectly influence it. Indirect effects occur when changes in the immunization system (e.g. elimination in another related barrier) increase system efficiencies. Following a consultation with experts, cost was excluded from the list of attributes. At this stage of early development, there is no clear evidence available on the exact cost and given that countries are currently ordering OCV through the global stockpile, it would be challenging to find a baseline comparator for a hypothetical qualitative discussion. Step 3 involved discussions on the desirability and feasibility of four potential vaccine use cases: for populations able to swallow a capsule (presumed to be older than six years); able to swallow a capsule, but there is no access to clean water; unable to swallow a capsule (presumed to be younger than six years); mixed delivery with other oral cholera vaccines (e.g. Euvichol-P). The use cases were based on the assumptions of key product attributes. For example, at this stage of development it is not yet known if children will be unable to swallow the capsule, as its final size has not been determined. However, it was essential to explore such scenario to assess its impact on stakeholders' desirability of the capsule. Finally, in Step 4, stakeholders discussed decision-making processes and pathways for using OCV capsules. The discussions were facilitated by stakeholders from IVI and WHO, who also documented the discussions in an Excel workbook. All facilitators were trained on data collection through several pre-workshop, online trainings, they were provided with facilitators' guide with instruction for each session and a reporting template for the discussion. Data were analysed descriptively. All participants were able to see the documented discussion and propose changes if necessary.

Results

Prioritized cholera immunization barriers

During the desk review, the lines of enquiry were classified across the seven categories of the Essential Programme on Immunization (EPI). Cholera vaccination during reactive or preemptive campaigns requires rapid delivery of large number of doses over a short period of time, targeting a wide age range (all >1 year old). Successful campaigns depend on advance planning and mobilization of resources. This surge in resources and capacity helps overcome barriers that typically affect routine immunization programmes. As a result, these barriers appear less prominent during campaigns, making them less likely to be systematically documented.

The number of identified barriers based on existing information sources varied across workshops. In Bangladesh, 30 barriers in total were identified, and in the

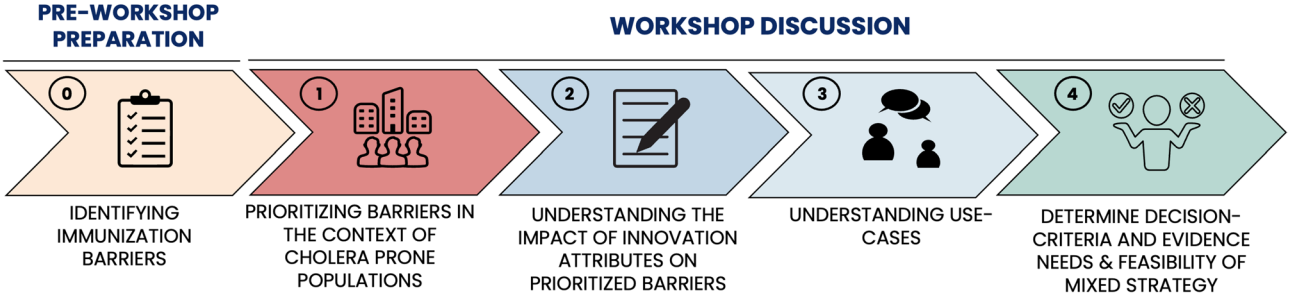

Fig. 1 Methodology of the Innovation Framework

African countries (AFR) workshop 36 barriers. Each country determined the importance of the identified barriers across three different settings: urban, rural and hard-to-reach populations. The definition of hard-to-reach populations varied across countries; for instance, in Bangladesh those populations included populations living in the Chittagong Hill Tracts, while in Ethiopia those included pastoralist communities. To determine the importance of each barrier to the identified settings, stakeholders focused their discussions on relevance of the barrier to the setting, impact on coverage and equity of cholera vaccination in the setting and whether the barrier can be addressed through technological innovations. The outcome of the prioritization of barriers was 16 high importance barriers identified by stakeholders in Bangladesh, and 25 high importance barriers in the African Region.

Table 1 shows the percentage of identified barriers classified as high importance per EPI category and per setting. For example, in category one, *Programme Management and Financing*, the desk review revealed five barriers in Bangladesh. During the discussions, stakeholders determined that out of those 60% (three barriers) were high importance in urban settings, 80% (four barriers) were high importance in rural settings, and 40% (two barriers) were high importance for high to reach populations. In comparison for the AFR workshop four barriers were identified in this category. Stakeholders from Ethiopia and Mozambique classified 50% (two barriers) as high importance, while stakeholders from Kenya considered 75% (three barriers) high importance in Kenya.

While prioritization of barriers varied between countries and sub-national settings, there were clear patterns that have emerged during the discussions. Stakeholders identified inadequate subnational budgeting and challenges with disbursement of funds to subnational levels as an important barrier that delayed logistics provision and the start of vaccination campaigns. In terms of human resource management, mobilization of adequate number of vaccinators and other health personnel to reach the

Table 1 Percentage of identified barriers classified as high importance per EPI category and per setting

EPI Category (no. of barriers identified)	*Setting*	*Country*				
		Bangladesh	**Ethiopia**	**Kenya**	**Mozambique**	**Tanzania**
Programme Management & Financing *(BAN n=5; AFR n=4)*	**Urban**	60%	50%	75%	50%	25%
	Rural	80%	50%	75%	50%	50%
	Hard-to-reach	40%	50%	75%	50%	50%
Human Resources Management *(BAN n=5; AFR n=3)*	**Urban**	20%	33%	100%	33%	100%
	Rural	20%	67%	100%	33%	100%
	Hard-to-reach	20%	67%	100%	33%	100%
Vaccine supply, quality & logistics *(BAN n=7; AFR n=10)*	**Urban**	14%	30%	60%	30%	70%
	Rural	57%	50%	70%	40%	70%
	Hard-to-reach	50%	50%	70%	30%	70%
Service Delivery *(BAN n=4; AFR n=6)*	**Urban**	50%	17%	33%	67%	33%
	Rural	50%	83%	83%	83%	50%
	Hard-to-reach	50%	83%	83%	50%	67%
Immunization Coverage & AEFI monitoring *(BAN n=3; AFR n=3)*	**Urban**	0%	33%	33%	0%	100%
	Rural	33%	33%	33%	0%	100%
	Hard-to-reach	33%	33%	33%	0%	100%
Disease Surveillance *(BAN n=2; AFR n=4)*	**Urban**	50%	50%	75%	75%	50%
	Rural	100%	75%	100%	75%	50%
	Hard-to-reach	75%	75%	100%	75%	50%
Demand Generation *(BAN n=4; AFR n=6)*	**Urban**	25%	17%	100%	0%	17%
	Rural	0%	17%	100%	0%	17%
	Hard-to-reach	38%	17%	100%	0%	17%

*BAN: Bangladesh workshop; AFR: African countries workshop; AEFI: Adverse Events Following Immunization.

sizeable target populations was identified as a challenge. This is largely perceived as being due to a chronic shortage of health staff in health systems, suboptimal supervision, and inadequate training. Furthermore, campaigns put pressure on the existing supply and cold chain due to the large number of vaccine doses that should be stored in the cold chain during campaigns. This results in an inadequate number of functioning cold chain equipment in health facilities, as well as during the last-mile delivery. Lack of adequate number of transport vehicle makes service delivery challenging, particularly for hard-to-reach populations, requiring intensified outreach efforts. Moreover, already fragile waste management systems can become overburdened during campaigns.

Inherent challenges with data, such as difficulties in estimating accurate denominators, hamper adequate microplanning for campaigns. Stakeholders discussed how weaknesses in the disease surveillance system and the adverse events following immunization (AEFI) monitoring system, limit data availability and timelines for evidence-based planning, compounding challenges in hard-to-reach areas. Lastly, demand generation efforts are seldomly impacted by vaccine hesitancy rooted in non-evidence-based beliefs. In Kenya this barrier is particularly relevant to all three settings. Meanwhile, in Bangladesh lack of confidence in vaccines is of high relevance to hard-to-reach populations, to a lower extent to the other settings. Inadequate processes to promote vaccination further impact demand generation.

Innovation attributes affecting the prioritized barriers

The high priority barriers were discussed in the context of innovation attributes. Stakeholders determined the effect of the potential vaccine attributes of Duo-Chol capsules on each of the barriers. Figure 2 shows the attributes that would counter or alleviate most high importance barriers. The three attributes that were most frequently selected as having the potential to favourably reduce the identified barriers were the storage temperature (due to higher thermostability), the packaging, and the ease of administration.

Stakeholders argued that improved thermostability has the potential to reduce the highest number of barriers to cholera vaccination. Its positive impact does not

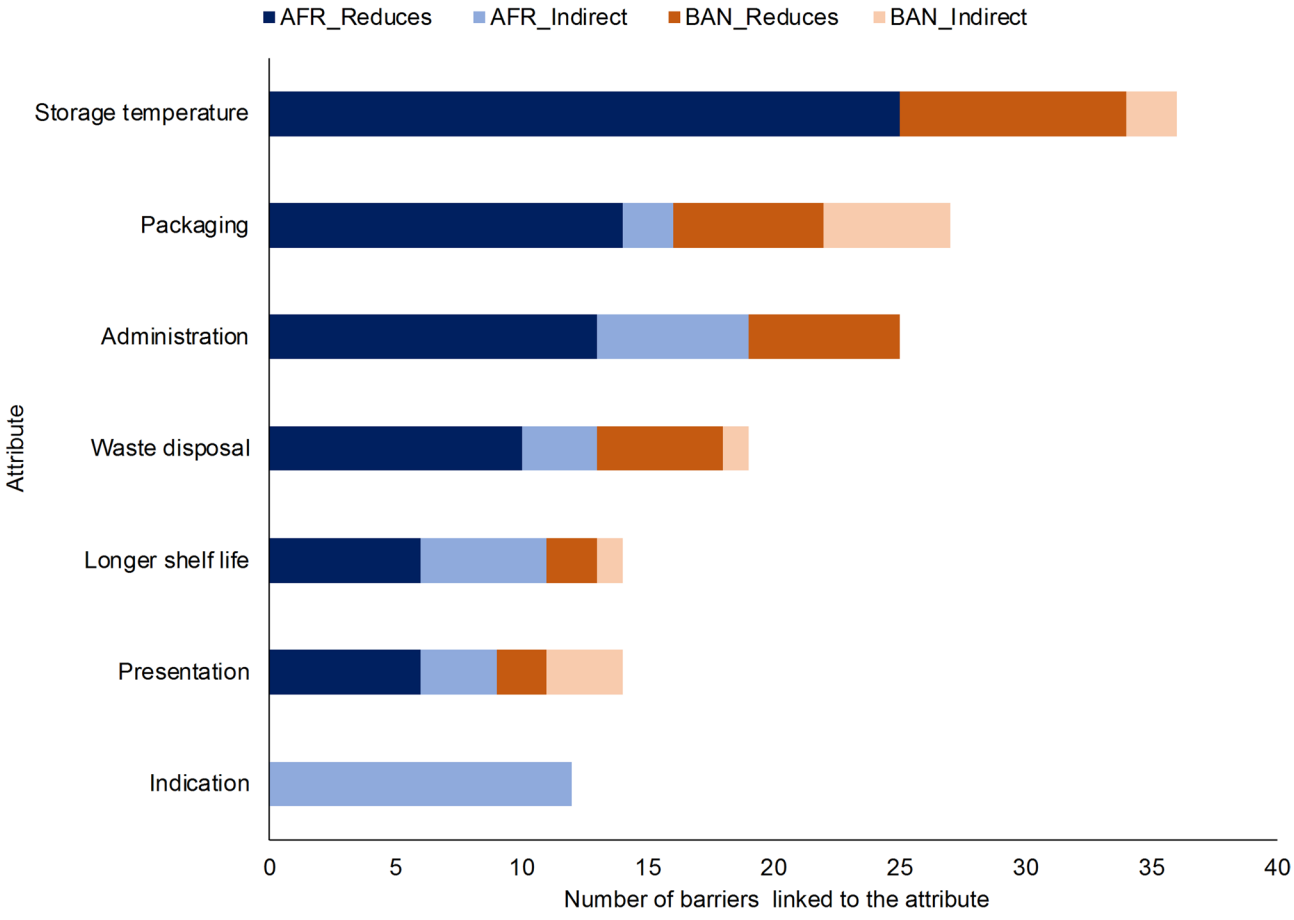

Fig. 2 Product attributes that could directly or indirectly reduce the identified barriers. *Note: More than one attribute can be linked to a barrier. In Bangladesh (BAN) 16 barriers were prioritized, in the African Region (AFR) 25 barriers were prioritized. The full list of attributes evaluated is available in Annex 1*

	Legend:	Yes	Maybe	No
	UC1	**UC2**	**UC3**	**UC4**
Bangladesh				
Ethiopia				
Kenya				
Mozambique				
Tanzania				
Summary explanation	Advantages of using vaccine capsule compared to current practice: • No cold chain required • No smell compared to existing OCV • Lower operational costs • Less waste • Easier transport and storage	• Similar advantages as UC1. • Countries with challenges around access to clean water are less likely to adopt this case. Anticipated challenges with microplanning & securing additional resource to provide clean water. • Argued that cost of logistics for providing clean water anticipated to be lower compared to cost of logistics for maintaining cold chain.	• Ethiopia and Tanzania argued that to consider adopting this UC, specific guidelines how to administer the vaccine to those who cannot swallow are required, as well as clear manufacturer labelling on how to dissolve the vaccine without the risk of loss of efficacy. • The other 3 countries argued that the additional challenges of this UC could be easily ameliorated.	• Preferred use case for children who cannot swallow the capsule. • Concerns around mixed delivery as it might introduce additional logistical complexities and confusion. • These complexities can be eliminated if clear standard operating procedures exist. • Additional training around management and microplanning would be required.

Fig. 3 Desirability and likelihood of adoption of use-cases for OCV capsules

derive only from the reduction of barriers related to cold chain and vaccine logistics, but also to simplifying barriers related to implementation of strategic and operational plans, especially for hard-to-reach populations. For example, by reducing the need for maintaining continuous cold-chain, service delivery logistics would be simplified as there would be no need to procure additional ice packs or vaccine carriers. Moreover, stakeholders argued that there would be an indirect benefit in reducing the barriers related to inadequate number of health staff, as health workers will be able to carry and administer more doses in the allocated time due to not needing to maintain the cold chain.

The presentation and packaging of capsules in a container or a blister pack is a desired characteristic by stakeholders. It has the potential to improve vaccine delivery to hard-to-reach populations, as well as fragile and conflict settings, since a higher number of vaccines can be delivered in a single trip. Initially, this novel presentation might impose challenges associated with additional training of health workers on handling and administration, since it is a change to the current practice. However, in the long term, this challenge was considered negligible. The novel presentation could also simplify and reduce waste disposal, introducing efficiencies and alleviating the burden on existing waste disposal mechanisms.

Water is required to swallow the vaccine capsule. However, stakeholders did not perceive this as a significant challenge for vaccine delivery. In Bangladesh, stakeholders argued that water is readily available in all households. In the African region, stakeholders agreed that although water might not be available, the logistics of securing water are simpler and less costly than maintaining a cold chain; thus, by having a thermostable vaccine, such costs would be offset, and efficiencies would be introduced.

Use cases

Following the discussion on the desirability of attributes, the stakeholders discussed four potential use cases of the DuoChol OCV capsule vaccine. Those were: use case (UC) 1 for populations able to swallow a capsule (presumed to be older than six years); UC2 for populations able to swallow a capsule, but there is no access to clean water; UC3 for populations unable to swallow a capsule (presumed to be younger than six years) and UC4 mixed delivery with other oral cholera vaccines (e.g. Euvichol-P). There was a consensus that for the population above the age of 6 years, the use of vaccine capsule would be more advantageous compared to the current liquid oral vaccine. The advantages include easier transport and storage, lower operational costs, less waste and no smell or taste compared to the current liquid type OCV (Fig. 3). This answer persisted even for settings without access to clean water, except for Tanzania, Ethiopia and Mozambique where the stakeholders argued that in those settings, they would prefer the current practice. Stakeholders from Mozambique specified that this scenario is not preferred over the current practice, as the current OCV can also be used outside of the cold chain, although for shorter period, thus the advantage of using thermostable capsules do not offset the required changes

in logistics. Similarly, stakeholders from Ethiopia argued that although it will not be favoured over the current OCV in this scenario, it could potentially be used for house-to-house strategies provided funding is available to address logistical complexities associated with additional distribution of water.

For populations that could not easily swallow the capsule, presumed to be under the age of six years or the elderly, the responses varied across the countries. Stakeholders from Bangladesh, Kenya and Mozambique argued that the vaccine can be used for those populations if the contents are dissolved in water. This would require clear standard operating procedures and observation by trained health staff. Stakeholders highlighted that they would welcome guidance from technical organizations, such as the WHO. They would not prefer the vaccine to be sprinkled on food as there would be an expectation to provide food, while the vaccine should not be given at home because of the small powder quantity which might be lost, and the full dose might not be administered. For the other countries, UC3 was not a desirable use case, and for those populations they would prefer the liquid vaccine. Finally, all countries agreed that it is feasible to use two vaccine presentations in the programme, for example capsules and the current liquid oral vaccine for those who cannot swallow a capsule, but this would require significant preparations in terms of microplanning, training and community engagement, as there is a potential for programmatic errors and documentation challenges. However, many countries had experience successfully managing delivery of several vaccine products (e.g. different COVID-19 vaccines).

Stakeholders were asked whether they would consider self-administration of the vaccine, meaning the beneficiary or the caregiver of the beneficiary would administer the vaccine. The answers varied between countries and setting. For settings where service delivery is more challenging (e.g., hard-to-reach populations), stakeholders are more likely to accept self-administration scenarios. Generally, they would prefer the first dose to be administered by a trained vaccinator, while the second dose of the vaccine to be given to the beneficiary with instructions on how to administer it. However, there was a preference for observation during administration, due to fears of incorrectly capturing coverage and AEFI monitoring. For example, a community health worker would monitor numerous people and record whether the vaccine has been taken. Other potential challenges to self-administration relate to low literacy rates and sociocultural barriers among communities that have lower trust in the health system.

Understanding the decision-making pathway for vaccine introduction

The key national entities involved in the decision-making processes include the Ministry of Health, NITAG and other ministries, such as those for water and sanitation. Close collaboration with the media, the community and religious leaders would play an important role post introduction to support vaccine uptake. The WHO prequalification is an important criterion, alongside safety, efficacy, vaccine availability, waste management and operational costs when considering trade-offs compared to the current practice. Given that currently, OCV is mainly accessed through a global stockpile that does not require countries to cover the cost of procuring and shipping the vaccine, product cost considerations were not discussed. To make an informed decision, stakeholders would like to see evidence from introduction pilots in countries with similar characteristics, efficacy and effectiveness studies, and cost-effectiveness studies.

Stakeholders discussed the feasibility of mixed strategy of delivering with other oral cholera vaccines, meaning cholera vaccine capsules and OCV are given during the same session. For such scenario, regulatory approval, NITAG approval and interagency coordination group agreement would be needed. Policy changes, relating to how to measure coverage, would be required if the vaccine is self-administered. Further programmatic considerations include guidance on microplanning for two vaccine presentations, community engagement and provision of training for beneficiaries on how to administer the vaccine.

Discussion

Stakeholders from Bangladesh, Ethiopia, Kenya, Mozambique and Tanzania have indicated that thermostable cholera vaccine capsules have the potential to be a promising advancement in the fight against cholera. They suggested that the novel vaccine capsules have the potential to alleviate existing barriers to immunization and improve efficiencies within the systems used for delivery of cholera vaccines.

Unmet cold chain requirements have been recognized as an important challenge in cholera vaccination [17]. The challenge is multifaceted and country specific; it could range from inadequate number of refrigerators to inability to maintain the cold chain in humanitarian settings. Logistical challenges could be further exacerbated by other concurrent outbreaks [18]. Thus, unsurprisingly thermostability emerged as the attribute that could potentially address the highest number of barriers. However, preferences were not uniform across all use cases. In contexts where clean water is not readily available, stakeholders from Ethiopia, Mozambique, and Tanzania expressed a preference for the current liquid OCV as a

practical trade-off, suggesting greater confidence and familiarity with existing mechanisms to manage cold chain constraints compared to new arrangements and resources that may be required to ensure safe water.

While the cholera vaccine capsules are desirable for the general population, use of the capsules for populations who cannot swallow them (e.g. children), requires detailed programmatic preparation. However, currently, at an early stage of development, the size of the capsule is not known yet. Younger children are able to swallow tablets, although the ease with which they can swallow them and the amount of water required varies depending on the size of the tablet [18]. Therefore, guidance on administration among those populations or guidance for use of more than one vaccine presentation should be prepared when the product is available. Stakeholders suggested to conduct pilot studies in countries before wide scale uses. The pilot studies would allow to explore the strengths and challenges for implementation, and those findings would serve as an evidence base for development of standard operating procedures and guidelines within the country.

The potential for self-administration of the vaccine prompted extensive discussion among stakeholders. There was an agreement that if a second dose is required, it could be desirable for it to be self-administered. However, this would require adequate arrangements for post-vaccination observation and clear procedures for documenting coverage and compliance. Evidence from the current liquid OCV suggests that when given clear instructions on storage and administration, drop-out rates among vaccine recipients were relatively low [19]. Moreover, hard-to-reach communities considered self-administration practical, provided clear training was offered to prevent loss of vaccine and incorrect administration [20, 21]. Thus, when the vaccine capsule becomes available, policy makers should engage with local communities to identify preferred ways to support safe and effective self-administration. Insights from these consultations can inform evidence-based decisions on whether and how to adopt this use case.

This stakeholder consultation provides an assessment of the possible future cholera vaccine capsule to confirm the potential utility and guide its development. To create an enabling environment for vaccine product innovations, country perspectives and priorities need to be central to the entire product-development to country uptake continuum [22]. The findings from these consultations inform both product developers and the policy makers. Product developers should keep the considerations raised by national stakeholders at the forefront of product development, ensuring the novel product has the desirable attributes which would lead to reduction of barriers to immunization. At the later stages of the development continuum, both developers and policy makers should ensure the reservations that have emerged from these discussions are addressed prior to introduction of the product in the countries. Desired future directions include continued development along the regulatory pathways, and as indicated by the stakeholders, evaluation of potential methods for administering the vaccine to young children. Once the vaccine is available, there is a need for effectiveness and cost-effectiveness studies to inform policy and decision-makers. Engagement with the local communities is essential to ensure development of context sensitive strategies and ultimately uptake of the vaccine.

Finally, it is necessary to explore the limitations of this study. First, the vaccine capsules are still in development and are not available on the market yet, so the discussion was based on the target product profile for this product. Thus, the views of the stakeholders are based on an assumption for optimal attributes of the product. If the novel product has attributes that do not meet the optimal specifications the applicability of these findings might be limited. Moreover, given the early stage of development, we did not delve into the specific logistical and operational pathways for feasibility of uptake (e.g., exact costs of logistics for securing water, or operating procedures for dissolvement of capsules), instead we accepted the stakeholders' assessment based on their experiences. Once the product is available future feasibility studies should be conducted to ascertain the details. Second, the results represent the perspectives of the stakeholders involved, and the perceived desirability of the novel product may differ among other stakeholders. These views do not indicate any commitment from the countries to adopt the product in the future. Third, due to logistical limitations each workshop had a limited number of participants, thus other perspectives from the health systems might not have been captured, and the nomination process may have introduced selection bias. In addition, variation in cholera endemicity across the five study countries could influence stakeholder views and may limit the generalizability of findings. The structured methodology used in these discussions ensures systematic and robust documentation, making the process reproducible with different stakeholder groups. To explore additional perspectives the Innovation Framework methodology could be adapted and similar stakeholder discussions could address any remaining questions along the product development continuum.

Conclusion

National stakeholders from Bangladesh, Ethiopia, Kenya, Mozambique, and Tanzania, confirmed that, if DuoChol achieves the specified target product attributes, innovative OCV capsules could address multiple immunization barriers and introduce efficiencies in vaccination

programmes and last mile outreach. Key factors which would influence uptake include accessibility, perceived efficacy and public awareness. The presentation and improved thermostability were viewed as especially valuable features to improve service delivery, while vaccination of young children unable to swallow capsules would likely continue to require liquid OCV formulations.

To inform policy and programmatic decision-making, stakeholders emphasized the eventual need to conduct pilot studies and engage with communities to assess feasibility, acceptability, and effectiveness of capsules across diverse contexts, including among children. Once an OCV capsule product is available, additional research on cost-effectiveness and real-world impact will be required, as will implementation research to inform programmatic guidance on use and distribution, including mixed delivery with liquid OCVs, protocols for self-administration, and strategies for effective training and community engagement that build trust and awareness. Finally, coordination between relevant partner organizations, policymakers and implementers will be critical to ensuring optimized uptake of OCV capsules which can translate to increased cholera vaccination coverage and equity.

Appendix

List of evaluated attributes.

1. *Indication:* Higher short-term efficacy against cholera incl. in children under 5 years.
2. *Indication:* Protection against ETEC diarrhea in persons > 2years.
3. *Presentation:* Capsules in container or blister pack.
4. *Packaging:* Reduced volume and weight per dose.
5. *Storage temperature:* Greater thermostability, does not require cold storage.
6. *Storage temperature:* Number of vaccines carried per vaccinator increases.
7. *Storage temperature:* Transportation from storage to vaccines is more efficient (time & quantity of doses).
8. *Administration:* Can be self-administered at home.
9. *Administration:* Requires water for swallowing capsule.
10. *Administration:* For those unable to swallow, contents to be dissolved in buffer/water.
11. Longer shelf life (3 years).
12. Reduced waste disposal post-campaign.

Abbreviations

AEFI	Adverse Events Following Immunization
AFR	African Region
BAN	Bangladesh
EPI	Essential Programme on Immunization
ICG	International Coordinating Group
IVI	International Vaccine Institute
NITAG	National Immunization Technical Advisory Group
OCV	Oral Cholera Vaccine
UC	Use Case
UNICEF	United Nation's Children Fund
WASH	Water, sanitation and hygiene
WHO	World Health Organization

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Authors' contributions

DS, ALK, MB, NADC, JL, SEP, and JL conceptualised and designed the study; DS, ALK, MB, NADC, JL, SEP, and JL collected the data; DS and ALK performed the data analysis; DS wrote the first draft. DS, ALK, MB, NADC, JL, SEP, and JL contributed to the interpretation of data, reviewing and revising the manuscript. The authors' views do not necessarily represent the decisions, policy and views of the World Health Organization or their institutions. All authors read and approved the final manuscript.

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Data availability

The findings have previously been presented during a global webinar which is available on the following link https://www.youtube.com/watch?v=BzyFDJk0kvc&t=1377s and at the Annual Meeting of the American Society for Hygiene and Tropical Medicine 2024 in New Orleans, USA. All data supporting the conclusions of this study are included in the article, though a more detailed record of the workshop discussion outcomes (Excel workbook) is available from the corresponding author upon reasonable request, subject to institutional approval from WHO and IVI.

Declarations

Ethics approval and consent to participate

The generic study protocol detailing the approach used for the workshops has been exempted by the WHO Research Ethics Review Committee (ERC) from requiring ethical review and clearance on the basis of the participating public officials being interviewed in their official, professional capacity on issues that are in the public domain.

Consent for publication

Not applicable

Competing interests

The authors declare no competing interests.

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