BMJ Open

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|---|---|
| Journal: | *BMJ Open* |
| Manuscript ID | bmjopen-2021-053585 |
| Article Type: | Original research |
| Date Submitted by the Author: | 20-May-2021 |
| Complete List of Authors: | Elias Chitio, Jucunú J.; National Institute of Health<br>Baltazar, Cynthia; National Institute of Health<br>Langa, José Paulo; National Institute of Health<br>Baloi, Liliana Dengo; National Institute of Health<br>Manuel, José Alberto; Provincial Directorate of Health<br>Mboane, Ramos B. J.; Provincial Directorate of Health<br>Assane, Sadate; Provincial Directorate of Health<br>Omar, Alide; District Health Directorate<br>Manso, Mariana; District Health Directorate<br>Capitine, Igor; National Institute of Health<br>Luiz, Naira; National Institute of Health; International Vaccine Institute<br>Mogasale, Vittal; International Vaccine Institute, Policy and Economic Research<br>Marks, Florian ; International Vaccine Institute<br>Park, Se Eun; International Vaccine Institute; Yonsei University<br>Beck, Namseon; International Vaccine Institute; Medair Headquarters |
| Keywords: | PUBLIC HEALTH, HEALTH ECONOMICS, INFECTIOUS DISEASES, Paediatric infectious disease & immunisation < PAEDIATRICS |
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# A pre-emptive Oral Cholera Vaccine (OCV) mass vaccination campaign in Cuamba District, Niassa Province, Mozambique: feasibility, costs and vaccine coverage

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## Abstract

**Objectives:** To evaluate the feasibility and costs of vaccination and vaccine coverage of a pre-emptive Oral Cholera Vaccine (OCV) mass vaccination campaign in a rural, remote, and cholera endemic setting in Cuamba District, Mozambique, generating evidence to guide future vaccination campaigns in similar settings.

**Design:** World Health Organization (WHO) prequalified OCV (Euvichol-Plus), a killed whole-cell bivalent vaccine containing *Vibrio cholerae* O1 (classical and El Tor) and O139, administered in two-doses with a 15-day interval in August 7-11 and August 27-31, 2018. Microplanning and community sensitization conducted prior to the campaign. Vaccine coverage rates and feasibility measured through coverage survey and vaccination registry, and vaccination costs using CholTool.

**Setting:** Cuamba District located in Niassa province of Mozambique.

**Participants:** Approximately 180,000 people aged above one year living in Cuamba District targeted for vaccination. Households in vaccination target area randomly selected for vaccine coverage survey.

**Primary and secondary outcome measures:** Vaccine coverage estimates and costs of OCV mass vaccination campaign evaluated as primary outcome. Feasibility and barriers of vaccination measured as secondary outcome.

**Results:** Administrative vaccine coverage of the first and second rounds of campaign were 98.9% (194,581) and 98.8% (194,325) respectively. Coverage survey exhibited 75.9% (±2.2%) and 68.5% (±3.3%) vaccine coverages for the first and second rounds, respectively. Overall, 60.4% (±3.4%) of the target population received full two-doses of OCV. No severe adverse events following immunization

were notified. Financial cost per dose delivered was US$0.60 without vaccine cost and US$1.98 including vaccine costs.

**Conclusion:** The introduction of a pre-emptive OCV mass vaccination campaign in rural cholera endemic setting in Mozambique was technically and programmatically feasible with reasonable full-dose vaccine coverage to confer sufficient herd immunity for at least the next three to five years. The vaccination cost estimate indicates affordability of OCV vaccination campaign, comparable to Gavi's operational support for vaccination.

**Key words:** Cholera**,** OCV, pre-emptive vaccination, Cuamba, Mozambique, coverage survey, feasibility, vaccination cost

**Strengths and limitations of this study**

- This pre-emptive OCV mass vaccination campaign conducted in Cuamba District is the first and only OCV (Euvichol-Plus) vaccination conducted in the Niassa Province of Mozambique until the date of this manuscript submission, demonstrating its feasibility and acceptability in rural and remote setting in Mozambique.
- Randomized survey of households in the community documented vaccine coverage in the target population.
- Evaluation of barriers to OCV vaccination were communicated by the target population and documented through the community survey.
- Community survey identified effective communication strategies for community engagement and sensitization for each round of the OCV mass vaccination campaigns.
- Costs associated with conducting a mass vaccination campaign using a two-dose OCV (Euvichol-Plus) documented through retrospective data collection and analysis.

## Introduction

Cholera is a vaccine preventable disease that remains as a major public health concern in many parts of low- and middle-income countries (LMICs). A comprehensive policy measure is warranted to control and prevent cholera including investments in improving infrastructure and knowledge, attitude, and behavior associated with water, sanitation, and hygiene (WaSH), strengthening health system, and adequate use of oral cholera vaccine (OCV) (1). In Mozambique, cholera has been endemic since the early 1970's when the first cholera outbreak was reported in the country. Several epidemics followed since then including the outbreaks in 1997-1999 and 2012-2016 (2, 3). Cholera outbreaks are more frequent in the country's northern provinces including Nampula, Cabo Delgado, Tete, and Niassa (4). Following the reinforcement of cholera outbreak response strategies, the Ministry of Health (MOH) of Mozambique has carried out several OCV mass vaccination campaigns, as recommended by the World Health Organization (WHO) as

an integral part of a comprehensive strategy for cholera prevention and control in endemic setting along with primary interventions of WaSH measures (5): Recent cholera outbreaks in these cholera endemic and hotspot areas in December 2015 resulted in the use of global OCV emergency stockpile to vaccinate approximately 212,745 people living in six neighborhoods of Nampula city in 2016 (4); and in April 2017, another 709,077 doses from the stockpile to vaccinate approximately 354,550 people in Tete City and Moatize and Mutarara districts, in response to the cholera outbreak with over 3,592 cholera cases.

In addition to these reactive vaccination campaigns supported by the WHO International Coordinating Group (ICG) on vaccine provision for cholera, a growing need for a preventive public health intervention using a targeted vaccination approach in cholera priority areas in-country was identified. The past records of numerous episodes of cholera epidemics in Mozambique have spotted at-risk districts in the most cholera endemic provinces such as Nampula (particularly Nampula City), Niassa (Lichinga city and Cuamba and Lago Districts), and Cabo Delgado (Pemba City and Ancuabe District), and to a lesser degree, other provinces and districts with limited sanitary conditions (5). Niassa province, one of the cholera endemic regions with annual cholera outbreaks affecting largely the Lichinga City and Lago and Cuamba Districts, was identified for a planned pre-emptive vaccine introduction to prevent subsequent cholera outbreaks. Cuamba District with an estimated population of 264,572 (6), reports over 200 suspected cholera and 2,000 diarrheal cases almost every year, with an exception of 2014 and 2016 (7). Here, we describe the feasibility, costs, and coverage estimates associated with a pre-emptive OCV mass vaccination campaign conducted in Cuamba District using two-dose OCVs (Euvichol-Plus) administered to approximately 180,000 people with a 15-day interval between the doses, as well as challenges of delivering healthcare in resource limited rural setting in Mozambique.

## Methods

### *Study site and population*

The Cuamba District is located in Niassa Province with a population size of around 264,572 (6). The site was selected for a pre-emptive OCV mass vaccination campaign as the district includes the Cuamba Municipality area where cholera is found to be endemic with periodic outbreaks. The area was also highlighted by the WHO as one of the priority sites to consider for a potential OCV intervention during a needs-assessment performed in September 2015 (1). The District of Cuamba is composed of a total 36 bairros and povoados with population size of approximately 264,572 (6), which includes 21 bairros in the Cuamba Municipality area with around 137,640 residents (8). In total, approximately 180,000 individuals living in Cuamba District was targeted initially, and ultimately around 196,652 people living in Cuamba District were targeted, which included 20 Bairros in the Municipality area and 10 Povoados in the outskirts of the Municipality area (Figure 1). Selection of bairros and povoados in the outskirts of Cuamba Municipality within the District was made not only based on the high number of doses destined for the target population in the municipality area, but also the records of cholera cases during the outbreaks. Everyone above one year of age were eligible for the two-dose OCV administration.

***Vaccine delivery, storage, and handling***

Approximately 360,000 doses of WHO pre-qualified Euvichol-Plus, a killed whole-cell bivalent OCV containing *Vibrio cholerae* O1 (classical and El Tor) and O139, were procured from the manufacturer (EuBiologics) and shipped to the entry port in Pemba, Mozambique in cold-chain. Upon arrival in Mozambique, the vaccines were delivered to Lichinga by airfreight and transported to a central vaccine storage room in Cuamba project site, and kept in refrigerators with temperature maintained within range between 2-8℃ until and throughout the campaign. The vaccine vial monitor (VVM) and electronic shipping indicators (Q-Tag) were used to monitor the temperature of the vaccines during delivery, storage, and handling. During the vaccination campaign, cool boxes with dry ice maintained within 2-8℃ were used to carry the vaccines to the vaccination posts.

***Cost of vaccine delivery***

An openly available, standardized and validated Excel-based tool known as the CholTool was used for estimating vaccine delivery costs (9). This tool comprehensively estimates programmatic costs such as microplanning, communication and training materials development, sensitization/social mobilization, and personnel training, as well as costs related to vaccine delivery such as vaccine procurement, handling, storage, and transport, vaccination administration, monitoring supervision, and field support. The CholTool has the ability to estimate both financial and economic costs. Financial costs refer to the monetary costs to the payer (e.g. allowances, supplies, transport and resources used in micro-planning, training, and sensitization/social mobilization) while economic costs include financial costs along with non-monetary costs of donated goods and resources already available (e.g., health personnel time). Key informant interviews were conducted at various administrative levels before, during and after the vaccination campaign in order to identify the resources necessary for each vaccination related activity and costs of respective resources for each of the two rounds of vaccination. The resource and cost data were entered in CholTool which auto-calculates OCV delivery costs. The costs were reported in 2018 in United States Dollars (US$) based on government and payer perspective.

***Vaccination Strategy and microplanning***

A fixed-post vaccination strategy with additional mobile teams was adapted for the microplanning of the vaccination campaign. The vaccination teams for 15 fixed posts (healthcare facilities) and 33 mobile teams were identified and trained prior to the campaign. This adopted mixed vaccination strategy aimed to improve quality, accessibility, and coverage. Each post was staffed with around 5 field workers including 2 health workers and 3 community engagement workers. Five days prior to the vaccination campaign, micro-plans for each cluster were prepared with postal addresses, target populations, vaccination dates, teams, and other site-specific resources. The health workers obtained verbal informed consents from the individuals visiting the vaccination posts for the OCV administration. Pregnant women by self-report or infants below one year old were excluded from the vaccination. Vaccination cards and

vaccination registry book were developed and deployed, specific to this vaccination that included variables such as name, age, address, and vaccination date. The collected data in the vaccine registry book were entered in an excel-based database. The number of doses planned and administered were also recorded daily for each round of the vaccination campaign.

***Vaccination, adverse event monitoring, and coverage estimate***

The vaccination campaign occurred in two rounds with a 15-day interval. The first round took place during August 7-11, followed by the second round during August 27–31, 2018. Provision was made for mop-up activities after the second round for those who missed the second dose. To detect any possible adverse events following immunization (AEFI) during and after the campaign, health workers were trained to monitor and notify any adverse events encountered in inpatient and outpatient admissions at Cuamba health facilities from the first day of each round throughout the 15 days after the last day of each round. Coverage estimates were assessed in two-folds; administrative coverage and community vaccine coverage surveys. Community vaccine coverage surveys included daily monitoring of vaccine coverage in relations to vaccine dose usage, conducted during each rounds of the campaign, and a final coverage survey conducted following the completion of the second-round campaign to measure the vaccine coverage of two full doses of OCV administration.

The vaccine coverage survey was carried out by a team composed of 16 interviewers distributed across 5 teams. Each team conducted 26 interviews daily, totaling 572 instead of 650 for the 5 days of the first phase of the campaign, as some data were excluded due to inconsistency. For the second phase of the coverage survey, 714 households were visited and interviewed for the final coverage monitoring and evaluation survey. Performance of the vaccination campaign was monitored through daily surveys using questionnaires to collect daily information on vaccine coverage, barriers against OCV, and source of information on the campaign. The survey results were communicated to the vaccination campaign field teams and the local government officials in real-time, allowing them to refine the outreach strategies

during the campaign. For both the daily monitoring and final coverage surveys, a two-stage cluster random sampling was used, where each cluster (primary sampling unit) was selected from the list of villages in the Health Zones, according to the Probability Proportional to Population Size (PPS), and households (secondary sampling unit) were chosen by segmentation of the sectors resulting in maximum 15 households, followed by numbering of households and random selection to start the survey interviews. The final vaccine coverage was also calculated after converting the daily coverages to that of the final day by multiplying the ratio of the final vaccine consumption to that of each day, based on an assumption that vaccine coverage is linearly correlated with vaccine use. For each variable, the prevalence was estimated with 95% confidence interval.

***Ethics statement***

The vaccination campaign was conducted as a part of the government's public health intervention, approved by the Ministry of Health. Institutional Ethical Committee of the National Institute of Health (Ref: 116/CNBS/19) and ethical review board of the International Vaccine Institute, Seoul, Korea (IRB number 2017-006) approved the study protocol for the OCV mass vaccination campaign monitoring and coverage survey. Oral informed consent was obtained from eligible participants. For children, consents were obtained from parents/guardian and all adult participants provided their own consent. The study did not present any risk of harm to subjects. No biological samples were collected. Minimum data was collected from participants, whereby privacy and confidentiality of the data were ensured during the survey implementation and data entry and management.

***Patient and public involvement***

The participants in this study were people living in the cholera endemic and hotspot area, targeted for OCV vaccination campaign as an integral part of the government's cholera prevention efforts. The vaccination target population living in Cuamba District were sensitized and engaged, prior to and during the vaccination campaign, by the district and provincial health officials, study team that included the

Ministry of Health and National Institute of Health government officials, and local public health professionals at healthcare facilities. The participants were provided with information on the planned OCV mass vaccination such as the purpose of pre-emptive vaccination and detailed information on where and when the vaccination campaigns were to take place. The vaccination campaign was also announced through various press and social media in Mozambique for public awareness and involvement. The study was conducted in a transparent manner with open communication and information sharing in the community, and participants to the OCV vaccination and vaccine coverage survey were informed for oral consent. Stakeholder meetings were also conducted prior to, during, and after the vaccination campaign to further disseminate the campaign plan and results to the community members.

## Results

### *OCV vaccine coverage*

The administrative coverage of the first and the second rounds of the campaign were 98.9% (194,581) and 98.8% (194,325) respectively based on the available census data of vaccination target population in Cuamba Municipality and outskirts, estimated at around 196,652 (6) inhabitants (Table 1a). A total of 194,581 people over one-year-old received the first dose, out of whom 99,275 were females and 122,592 were children aged less than 15 years. For the second round, total 194,325 people were vaccinated, including 99,275 females and 120,169 children less than 15 years old. Notably, the vaccine coverage survey conducted in the target community during each round and post-vaccination exhibited an approximate coverage estimates of 75.9% (95 CI, 78,10 - 73.70%) for the first round and 68.5% (71.80 - 65.20%) for the second round. The coverage rate for the full two-doses was estimated at 60.4% (63.80 - 57.00%), whereby the coverage of children aged 1-5 years was around 64.4 % (57.10 – 71.10%) (Table 1b). No adverse events were reported during and after the vaccination activities, monitored up to 14 days post-vaccination campaign.

### *Source of Information and Acceptability*

The source of information on the OCV vaccination campaign, identified by the populations living in the vaccination target areas, showed use of megaphone as the most effective tool in disseminating information on the vaccination plan and mobilizing the community to get immunized for both rounds: 24% and 34% at the first and second rounds respectively (Table 2). Around 15% of the surveyed people in the target community indicated that they have learnt about the vaccination campaign through radio broadcast for the first round, but its communication impact reduced in the second round (4%). This was different for the community leaders, whose contribution increased from 5% in the first round to 19% in the following round, reflecting their active engagement and communication efforts in close coordination with the vaccination teams on the ground.

***Reasons for not being vaccinated***

The unavailability (absence) of the target population for vaccination and incompatibility between working hours and campaign schedule were commonly cited as barriers for vaccination in both the first (35%) and the second round (51%) (Table 3). Absence of vaccinators at the vaccination sites were also mentioned, 12% and 18% for the first and second round respectively, despite the pre-vaccination planning and programmatic organization. Notably, around 10% of the target population has indicated that they have not been informed about the vaccination campaign even in the second round, though this was a reduction compared to 18% in the first round. In order to address the most common barriers identified in the first round, the second round of the vaccination campaign was further extended for additional few days including the weekends, enabling more people to get vaccinated.

***OCV delivery costs***

The total financial cost of campaign was US$768,904 of which vaccine acquisition including vaccine shipment constituted 69% (US$533,659) (Table 4). The vaccine delivery costs including, microplanning, training, communication, and social mobilization, vaccination implementation (Round 1 & 2) constituted rest 31% (US$235,245). The total financial cost per dose delivered was US$0.60 without the vaccine cost

and US$1.98 including the vaccine costs in 2018 price. The economic cost per dose delivered excluding vaccine costs was five times higher at US$3.02. The total financial cost of delivery per fully immunized person excluding vaccine costs was US$1.21.

**Conclusion**

The OCV campaign in Cuamba District was organized without major logistical and programmatic challenges, and no adverse events were reported throughout the vaccination activities and up to 14 days after the campaign. Despite the similarity in the number of people vaccinated in the first and second rounds, the vaccine coverage survey of the second round showed lower coverage estimates than the first round. This may be due to possible cross border movement of people from untargeted districts to get vaccination during the second round. The vaccine coverage for the full two-doses was over 60% that may confer sufficient herd immunity for the following several years based on the existing literature on a cholera transmission model using the Matlab data from Bangladesh (10,11), which predicted 50% coverage with OCV in cholera endemic areas may result in 89% reduction in cholera cases in unvaccinated (12).

In our study, children aged 5-14 years exhibited the highest coverage. This may be due to the vaccination posts in both schools (fixed vaccination post) and near homes (mobile vaccination posts), which facilitated the school-aged children to access the immunization health service more easily. The female group also presented higher vaccine coverage rate compared to the male group, likely associated with their routine boundaries of livelihood near their houses or their child/children's schools as they take care of children while the male group typically work outside. This assumption is supported by the fact that the absence during the campaign was identified as a significant barrier against vaccination during both rounds of the campaign. Similar pattern was consistently prevalent in the previous OCV campaigns in Beira (13) and Nampula (4), whereby absence was the main barrier for vaccination. The second round of the campaign coincided with the period of school holidays when most households move to farming and food

production, resulting in higher absence rate in the second round (43.0%) than in first round (17.0%). Further, it is encouraging to observe more than 60% vaccine coverage rate among children aged 1-4 years, the most at-risk population age-group concerning cholera outbreaks. Considering that caregivers for these younger children are mostly women, higher vaccine coverage for these toddlers and younger children and women is as anticipated in accordance with other studies published in similar settings (14).

In order to enhance the vaccine coverage, it is paramount to better understand the effective means of communications for community sensitization and engagements, as well as barriers towards participating in a vaccination program such as this campaign. Here, we showed that the use of megaphone proved to be the most effective advocacy tool for disseminating information on the vaccination to our target community, which may have allowed the field workers to reach out to families without access to other sources of information. For those with missed opportunities to receive the OCV doses during the two rounds, a mop-up vaccination can be considered, though it is often more laborious and costly, requiring a complex management (13). Further, informing the public on the availability of a mop-up prior to or during the campaign may negatively affect their participation in the regular vaccination schedule set-up. Hence, a mop-up was not considered after the first round in our approach, but pursued after the second round in order to enhance the full two-dose vaccination and verify vaccination data records submitted during the regular program. Approximately 15.4% (32,775/212,824) of the delivered second doses were through this mop-up campaign indicative of an effective strategy.

The financial costs of OCV delivery per fully immunized person in this campaign was lower than delivery costs reported in other African countries using the same CholTool (US$1.8 in Shashemene district of Ethiopia; US$2.5 in Nsanje district of Malawi; and US$3.5 in Machinga, Phalombe, and Zomba districts of Malawi per the US$ price value of 2016), but closer to that reported in Puri district of India (US$1.14 per the US$ price value of 2016) (9). One reason could be that Mozambique has experience of conducting several OCV campaigns in recent years, and hence there were already resources and expertise available

for micro-planning, communication, sensitization, trainings etc., which might have reduced the costs associated with introduction of vaccines in comparison to a vaccination programs in naïve setting. The financial cost of US$0.60 per dose delivered (excluding vaccine procurement) is comparable to the operational support ranging between US$0.30 and US$0.80 per person targeted for vaccination campaigns, recommended by the Gavi, the Vaccine Alliance (15,16). This indicates the affordability of OCV campaign in the current setting.

Overall, our study proved the feasibility of conducting a preemptive OCV mass vaccination campaign in a rural and semi-rural setting in Cuamba District and Cuamba Municipality areas respectively, with sufficient coverage rate and relatively lower delivery cost. The success of vaccination was a result of effective coordination and microplanning among stakeholders despite some field challenges. The vaccination strategy utilizing both fixed and mobile posts, as well as the daily feedback to the coordination team on the preliminary coverage survey result and data related to barriers and source of information on the vaccination campaign, proved valuable to prospectively refine the campaign and mobilization strategy every day on a real-time basis.

However, there are several limitations. First, the operational challenges concerning poor road conditions resulted in the accessibility to the target area difficult. Second, the programmatic support that required sufficient and trained human resources and budget for a sustained field monitoring activity and close on-site supervision prior to and during the vaccination campaign and coverage survey activities. Third, the differences in the coverage rates of administrative data and survey result are due to the lack of accurate up-to-date census data of local population. In addition, in order to avoid any conflict with the measles and rubella national immunization campaign that was taking place across the country at the time of this vaccination campaign, we had to delay our OCV vaccination campaign for about two months to obtain support from immunization-related stakeholders, particularly the expanded programme of immunization

(EPI) for cold chain space and logistics. Any mass vaccination campaigns should also consider seasonality and other major community activities and/or any political issues.

**Acknowledgements**

The authors are grateful to the research partners and staff who supported this Cuamba OCV mass vaccination campaign and monitoring and evaluation study on the ground. We thank Ms. Somyoung Cho for the project management and Ms. Jihyun Han and Ms. Nozipho Manjate for the project administrative support.

**Contributors**

S.E.P conceptualized the overall study design of the Mozambique Cholera Prevention and Surveillance: MOCA) project. N.S.B. conceptualized and supervised vaccination campaign and monitoring and evaluation study component. J.C., N.L, and the project field team in Cuamba and Niassa contributed to data acquisition on the community vaccine coverage survey, and interpretation of results under the supervision of N.S.B. R.B.J.M., S.A., A.O., M.M., and others in the vaccination teams of Cuamba District and Niassa Province contributed to acquisition on the administrative coverage data. J.C. drafted and edited the paper under the scientific guidance from N.S.B and S.E.P. All authors read and approved the final draft.

**Funding**

Funding for this study (grant budget code: MOCA-CHKOI02051; award/grant number not applicable) was provided by the Korea International Cooperation Agency (KOICA), government of the Republic of Korea. The findings and conclusions are our own and do not necessarily reflect positions of the KOICA.

**Competing interests**

The authors declare no competing interests.

## Data sharing statement

All data is presented in this manuscript. No additional data available.

## Figure legends

**Figure 1. Pre-emptive OCV mass vaccination site**

Location of the pre-emptive OCV vaccination campaign site in Cuamba District, Mozambique, included bairros and povoados in the municipality and district.

**Table 1. OCV vaccine coverage estimates, Cuamba District, 2018**

**a) Administrative vaccine coverage rates of OCV**

| | | Number of people vaccinated (No.) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Day 1** | **Day 2** | **Day 3** | **Day 4** | **Day 5** | **Day 6** | **Total** |
| **1st Dose** | **Age (year)** | | | | | | | |
| Individuals vaccinated per age group | 1-4 | 6,493 | 9,283 | 12,394 | 12,506 | 7,691 | - | 48,367 |
| | 5-15 | 7,050 | 16,705 | 21,590 | 17,536 | 11,344 | - | 74,225 |
| | ≥15 | 10,136 | 12,400 | 18,835 | 18,798 | 11,820 | - | 71,989 |
| Total no. of daily vaccinated | | 23,679 | 38,388 | 52,819 | 48,840 | 30,855 | - | 194,581 |
| Cumulative no. of vaccinated | | 23,679 | 62,067 | 114,886 | 163,726 | 194,581 | - | |
| **Cumulative administrative coverage** | | **12.04%** | **31.56%** | **58.42%** | **83.26%** | **98.95%** | **-** | **98.95%** |
| **2nd Dose** | | | | | | | | |
| Individuals vaccinated per age group | 1-4 | 5,479 | 6,484 | 11,117 | 9,596 | 7,760 | 7,586 | 48,022 |
| | 5-15 | 9,355 | 8,796 | 15,679 | 13,208 | 14,444 | 10,665 | 72,147 |
| | ≥15 | 9,416 | 9,275 | 14,271 | 14,265 | 14,848 | 12,081 | 74,156 |
| Total no. of daily vaccinated | | 24,250 | 24,555 | 41,067 | 37,069 | 37,052 | 30,332 | 194,325 |
| Cumulative no. of vaccinated | | 24,250 | 48,805 | 89,872 | 126,941 | 163,993 | 194,325 | |
| **Cumulative administrative coverage** | | **12.33%** | **24.82%** | **45.70%** | **64.55%** | **83.39%** | **98.82%** | **98.82%** |

**b) OCV vaccine coverage rates through coverage survey**

| | | **First Round** | **Second Round** | **Full Two Doses** |
|---|---|---|---|---|
| **Age (years old)** | 1- 4 | 81.1±4.5% | 72.2±6.9% | 64.4±7.3% |
| | 5-14 | 86.4±3.1% | 71.3±5.8% | 65.2±6.1% |
| | ≥15 | 67.6±3.3% | 65.2±4.8% | 55.7±5.0% |
| **Sex** | Male | 76.3±2.9% | 77.8±3.9% | 57.3±4.6% |
| | Female | 75.4±3.2% | 67.7±5.0% | 64.4±5.1% |
| **Total** | - | **75.9±2.2%** | **68.5±3.3%** | **60.4±3.4%** |

**Table 2. Source of information on OCV campaign, Cuamba District, 2018**

| Source of information | 1st Round[1] N= 646 n (%=n/N) | 2nd Round[2] N= 578 n (%=n/N) |
|---|---|---|
| Megaphone | 152 (24%) | 195 (34%) |
| Family | 60 (9%) | 53 (9%) |
| Radio | 96 (15%) | 23 (4%) |
| Religious leader | 82 (13%) | 25 (4%) |
| Health workers | 74 (11%) | 120 (21%) |
| Activists | 55 (9%) | 9 (2%) |
| Community leader | 33 (5%) | 108 (19%) |
| TV | 14 (2%) | 11 (2%) |
| Others[3] | 78 (12%) | 33 (6%) |

Footnote:
[1] 1st round: 646 households/or people were interviewed.
[2] 2nd round: 578 households/or people were interviewed.
[3] Others included: list other source of info if such data were collected.

**Table 3. Reasons for non-vaccination during the OCV campaign, Cuamba District, 2018**

| Reasons for non-vaccination | 1st Dose | | 2nd Dose | |
|---|---|---|---|---|
| | n=361 | % | n=222 | % |
| Unavailable | 63 | 17% | 96 | 43% |
| Incompatibility between working hours and campaign time | 53 | 15% | 18 | 8% |
| Vaccination post without vaccinator | 40 | 11% | 41 | 18% |
| Did not have information | 66 | 18% | 23 | 10% |
| Ill during the vaccination period | 30 | 8% | 10 | 5% |
| Does not believe in vaccine efficacy | 24 | 7% | 2 | 1% |
| Afraid of adverse events | 8 | 2% | 0 | 0% |
| Head of the family did not authorize | 4 | 1% | 2 | 1% |
| Religious leader forbid | 2 | 1% | 0 | 0% |
| Considered not safe for pregnant women | 1 | 0% | 2 | 1% |
| Other | 70 | 19% | 28 | 13% |

**Table 4. Costs of OCV vaccine delivery and immunization in Cuamba District**

| Vaccine Delivery Costs | Financial Cost (Mzn) | Economic Cost (Mzn) | Financial Cost (USD) | Economic Cost (USD) |
|---|---|---|---|---|
| Vaccine Acquisition | 32,179,644 | 42,081,073 | 533,659 | 697,862 |
| Microplanning | 640,415 | 7,596,625 | 10,620 | 125,981 |
| Training | 265,186 | 299,419 | 4,398 | 4,965 |
| Communication and Social Mobilization | 1,912,520 | 4,301,342 | 31,717 | 71,332 |
| Vaccination Implementation (Round 1 &2) | 11,367,160 | 58,510,806 | 188,510 | 970,328 |
| **Total** | **46,364,925** | **112,789,265** | **768,904** | **1,870,469** |
| **Immunization Costs** | **Financial Cost (Mzn)** | **Economic Cost (Mzn)** | **Financial Cost (USD)** | **Economic Cost (USD)** |
| Cost per Vaccine Administered (including vaccine) | 119 | 290 | 1.98 | 4.81 |
| Cost per Vaccine Administered (without vaccine cost) | 36 | 182 | 0.60 | 3.02 |
| Cost per Partially Immunized Person | 238 | 580 | 3.95 | 9.61 |
| Cost per Fully Immunized Person (with vaccine) | 239 | 580 | 3.96 | 9.63 |
| Cost per Fully Immunized Person (without vaccine) | 73 | 364 | 1.21 | 6.03 |

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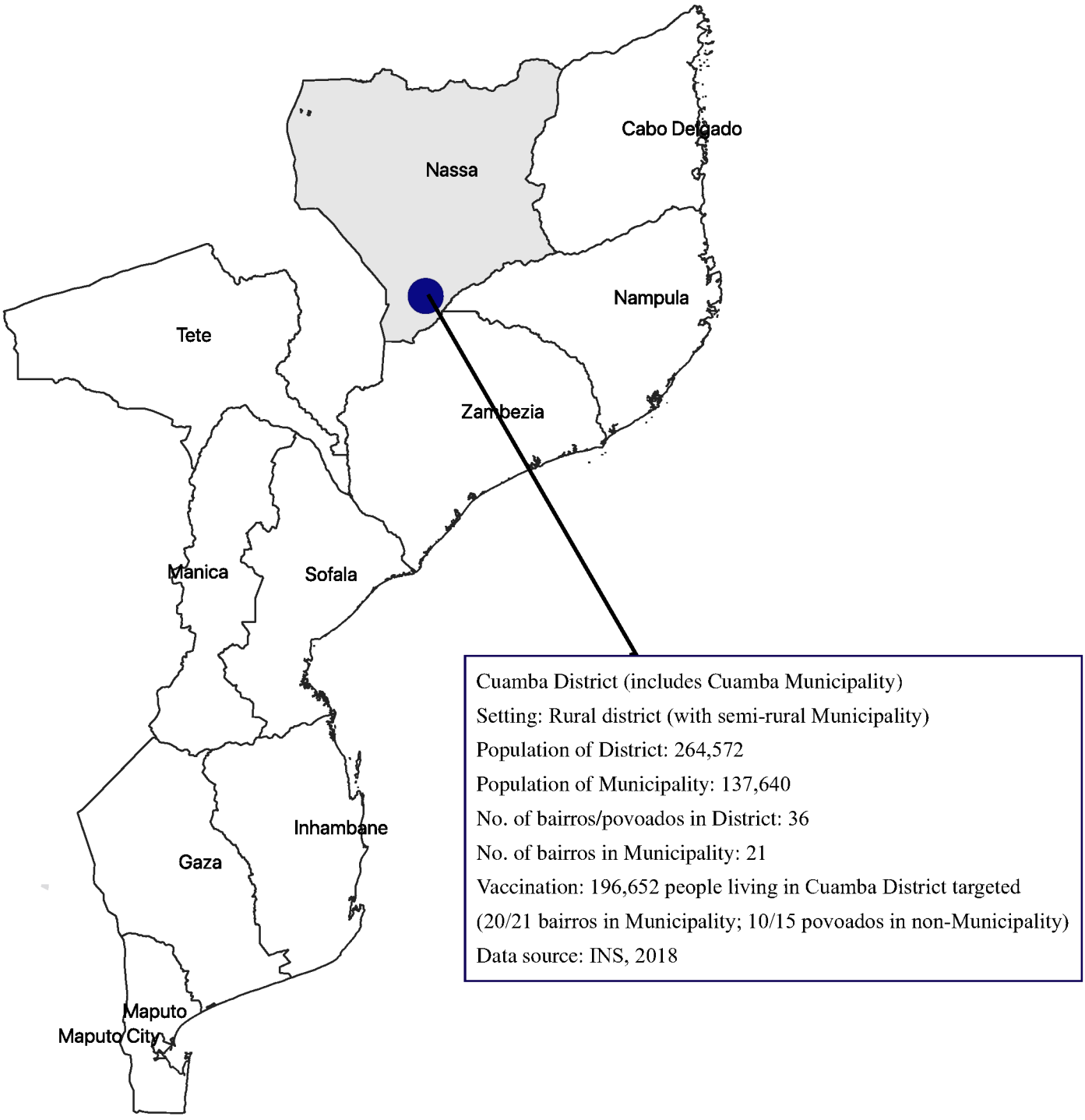


Figure 1. Pre-emptive OCV mass vaccination site

BMJ Open

# A pre-emptive Oral Cholera Vaccine (OCV) mass vaccination campaign in Cuamba District, Niassa Province, Mozambique: feasibility, costs and vaccination coverage



| | |
|---|---|
| Journal: | *BMJ Open* |
| Manuscript ID | bmjopen-2021-053585.R1 |
| Article Type: | Original research |
| Date Submitted by the Author: | 12-Feb-2022 |
| Complete List of Authors: | Elias Chitio, Jucunú J.; National Institute of Health<br>Baltazar, Cynthia; National Institute of Health<br>Langa, José Paulo; National Institute of Health<br>Baloi, Liliana Dengo; National Institute of Health<br>Manuel, José Alberto; Provincial Directorate of Health, Provincial Directorate of Health<br>Mboane, Ramos B. J.; Provincial Directorate of Health, Provincial Directorate of Health<br>Assane, Sadate; Provincial Directorate of Health, Provincial Directorate of Health<br>Omar, Alide; District Health Directorate, District Health Directorate<br>Manso, Mariana; District Health Directorate, District Health Directorate<br>Capitine, Igor; National Institute of Health<br>Van Rensburg, Craig; International Vaccine Institute<br>Luiz, Naira; National Institute of Health; International Vaccine Institute<br>Mogasale, Vittal; International Vaccine Institute, Policy and Economic Research<br>Marks, Florian ; International Vaccine Institute<br>Park, Se Eun; International Vaccine Institute; Yonsei University<br>Beck, Namseon; International Vaccine Institute; Medair Headquarters |
| Primary Subject Heading: | Global health |
| Secondary Subject Heading: | Infectious diseases, Health economics, Global health, Health policy |
| Keywords: | PUBLIC HEALTH, HEALTH ECONOMICS, INFECTIOUS DISEASES, PREVENTIVE MEDICINE, Infection control < INFECTIOUS DISEASES |
| | |

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# A pre-emptive Oral Cholera Vaccine (OCV) mass vaccination campaign in Cuamba District, Niassa Province, Mozambique: feasibility, costs and vaccination coverage

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## Abstract

**Background:** Mozambique suffers from regular floods along its principal river basins and periodic cyclones that resulted in several cholera epidemics during the last decades. Cholera outbreaks in the recent five years affected particularly the northern provinces of the country including Nampula and Niassa provinces. A pre-emptive Oral Cholera Vaccine (OCV) mass vaccination campaign was conducted in Cuamba District, Niassa Province, and the feasibility, costs, and vaccination coverage assessed.

**Method:** World Health Organization prequalified OCV (Euvichol-Plus), a killed whole-cell bivalent vaccine containing *Vibrio cholerae* O1 (classical and El Tor) and O139, was administered in two-doses with a 15-day interval during 7-31 August 2018, targeting around 180,000 people aged above one year in Cuamba District. Microplanning, community sensitization, and trainings of local public health professionals and field enumerators were conducted. Feasibility and costs of vaccination were assessed using CholTool. Vaccination coverage and barriers were assessed through community surveys.

**Findings:** The administrative coverage of the first and second rounds of the campaign were 98.9% (194,581) and 98.8% (194,325) respectively based on the available population data that estimated total 196,652 inhabitants in the target area. The vaccination coverage survey exhibited 75.9% (±2.2%) and 68.5% (±3.3%) coverages for the first and second rounds, respectively. Overall, 60.4% (±3.4%) of the target population received full two-doses of OCV. Barriers to vaccination included incompatibility between working hours and campaign time. No severe adverse events were notified. The total financial cost per dose delivered was US$0.60 without vaccine cost and US$1.98 including vaccine costs**.**

**Conclusion:** The pre-emptive OCV mass vaccination campaign in remote setting in Mozambique was feasible with reasonable full-dose vaccination coverage to confer sufficient herd immunity for at least the

next three to five years. The delivery cost estimate indicates that the OCV campaign is affordable as it is comparable to Gavi's operational support for vaccination campaigns.

**Key words:** Cholera**,** OCV, pre-emptive vaccination, Cuamba, Mozambique, vaccination coverage survey, feasibility, vaccination cost

**Strengths and limitations of this study**

- This study has successfully demonstrated the feasibility of an OCV mass vaccination campaign in a remote setting in Mozambique.
- The cost of a mass vaccination campaign for the two-dose OCV administrations has been analysed for the first time in Mozambique, which can serve as a reference cost estimate when planning for any OCV vaccination programs in a similar setting in Mozambique or other countries.
- Vaccination coverage estimates may be affected if there are people movements in and out of the study area. A sub-study on this and a focused community engagement strategy to reduce the identified barriers to vaccination should be considered in future vaccination programs.

## Introduction

Cholera is a vaccine preventable disease that remains as a major public health concern in many parts of low- and middle-income countries (LMICs). A comprehensive policy measure is warranted to control and prevent cholera including investments in improving infrastructure and knowledge, attitude, and behavior associated with water, sanitation, and hygiene (WaSH), strengthening health system, and adequate use of oral cholera vaccine (OCV) (1). In Mozambique, cholera has been endemic since the early 1970's when the first cholera outbreak was reported in the country. Several epidemics followed since then including the outbreaks in 1997-1999 and 2012-2016 (2, 3). Cholera outbreaks are more frequent in the country's northern provinces including Nampula, Cabo Delgado, Tete, and Niassa (4). Following the reinforcement of cholera outbreak response strategies, the Ministry of Health (MOH) of Mozambique has carried out several OCV mass vaccination campaigns, as recommended by the World Health Organization (WHO) as an integral part of a comprehensive strategy for cholera prevention and control in endemic setting along with primary interventions of WaSH measures (5): Recent cholera outbreaks in these cholera endemic and hotspot areas in December 2015 resulted in the use of global OCV emergency stockpile to vaccinate approximately 212,745 people living in six neighborhoods of Nampula city in 2016 (4); and in April

2017, another 709,077 doses from the stockpile to vaccinate approximately 354,550 people in Tete City and Moatize and Mutarara districts, in response to the cholera outbreak with over 3,592 cholera cases.

In addition to these reactive vaccination campaigns supported by the WHO International Coordinating Group (ICG) on vaccine provision for cholera, a growing need for a preventive public health intervention using a targeted vaccination approach in cholera priority areas in-country was identified. The past records of numerous episodes of cholera epidemics in Mozambique have spotted at-risk districts in the most cholera endemic provinces such as Nampula (particularly Nampula City), Niassa (Lichinga city and Cuamba and Lago Districts), and Cabo Delgado (Pemba City and Ancuabe District), and to a lesser degree, other provinces and districts with limited sanitary conditions (5). Niassa province, one of the cholera endemic regions with annual cholera outbreaks affecting largely the Lichinga City and Lago and Cuamba Districts, was identified for a planned pre-emptive vaccine introduction to prevent subsequent cholera outbreaks. Cuamba District with an estimated population of 264,572 (6), reports over 200 suspected cholera and 2,000 diarrheal cases almost every year, with an exception of 2014 and 2016 (7). Here, we describe the feasibility, costs, and coverage estimates associated with a pre-emptive OCV mass vaccination campaign conducted in Cuamba District using two-dose OCVs (Euvichol-Plus) administered to approximately 180,000 people with a 15-day interval between the doses, as well as challenges of delivering healthcare in resource limited rural setting in Mozambique.

## Methods

### *Study site and population*

The Cuamba District is located in Niassa Province with a population size of around 264,572 (6). The site was selected for a pre-emptive OCV mass vaccination campaign as the district includes the Cuamba Municipality area where cholera is found to be endemic with periodic outbreaks. The area was also highlighted by the WHO as one of the priority sites to consider for a potential OCV intervention during a

needs-assessment performed in September 2015 (1). The District of Cuamba is composed of a total 36 bairros and povoados with population size of approximately 264,572 (6), which includes 21 bairros in the Cuamba Municipality area with around 137,640 residents (8). In total, approximately 180,000 individuals living in Cuamba District was targeted initially, and ultimately around 196,652 people living in Cuamba District were targeted, which included 20 Bairros in the Municipality area and 10 Povoados in the outskirts of the Municipality area (Figure 1). Selection of bairros and povoados in the outskirts of Cuamba Municipality within the District was made not only based on the high number of doses destined for the target population in the municipality area, but also the records of cholera cases during the outbreaks. Everyone above one year of age were eligible for the two-dose OCV administration.

***Vaccine delivery, storage, and handling***

Approximately 360,000 doses of WHO pre-qualified Euvichol-Plus, a killed whole-cell bivalent OCV containing *Vibrio cholerae* O1 (classical and El Tor) and O139, were procured from the manufacturer (EuBiologics) and shipped to the entry port in Pemba, Mozambique in cold-chain. Upon arrival in Mozambique, the vaccines were delivered to Lichinga by airfreight and transported to a central vaccine storage room in Cuamba project site, and kept in refrigerators with temperature maintained within range between 2-8℃ until and throughout the campaign. The vaccine vial monitor (VVM) and electronic shipping indicators (Q-Tag) were used to monitor the temperature of the vaccines during delivery, storage, and handling. During the vaccination campaign, cool boxes with dry ice maintained within 2-8℃ were used to carry the vaccines to the vaccination posts.

***Cost of vaccine delivery***

An openly available, standardized and validated Excel-based tool known as the CholTool was used for estimating vaccine delivery costs (9). This tool comprehensively estimates programmatic costs such as microplanning, communication and training materials development, sensitization/social mobilization, and

personnel training, as well as costs related to vaccine delivery such as vaccine procurement, handling, storage, and transport, vaccination administration, adverse events following immunization (AEFI) management, monitoring supervision, and field support. The CholTool has the ability to estimate both financial and economic costs. Financial costs refer to the monetary costs to the payer (e.g., allowances, supplies, transport, and resources used in micro-planning, training, and sensitization/social mobilization) while economic costs include financial costs along with non-monetary costs of donated goods and resources already available (e.g., health personnel time). Key informant interviews were conducted at various administrative levels before, during and after the vaccination campaign in order to identify the resources necessary for each vaccination related activity and costs of respective resources for each of the two rounds of vaccination. The resource and cost data were entered in CholTool which auto-calculates OCV delivery costs. The costs were reported in 2018 in United States Dollars (US$) based on government and payer perspective.

***Vaccination Strategy and microplanning***

A fixed post vaccination strategy with additional mobile teams was adapted for the microplanning of the vaccination campaign. The vaccination teams for 15 fixed posts and 33 mobile teams were identified and trained prior to the campaign. The fixed posts included existing healthcare facilities such as primary health centers and secondary and referral hospital, schools, market areas where many people have easy access to. The mobile teams were deployed to households remotely located with limited access to these fixed posts. This adopted mixed vaccination strategy aimed to improve quality, accessibility, and coverage. Each post was staffed with around 5 field workers including 2 health workers and 3 community engagement workers. Five days prior to the vaccination campaign, micro-plans for each cluster were prepared with postal addresses, target populations, vaccination dates, teams, and other site-specific resources. The health workers obtained verbal informed consents from the individuals visiting the vaccination posts for the OCV administration. Pregnant women by self-report or infants below one year old were excluded from the vaccination. Vaccination cards and vaccination registry book were developed

and deployed, specific to this vaccination that included variables such as name, age, address, and vaccination date. The collected data in the vaccine registry book were entered in an excel-based database. The number of doses planned and administered were also recorded daily for each rounds of the vaccination campaign.

***Vaccination, adverse event monitoring, and coverage estimate***

The vaccination campaign occurred in two rounds with a 15-day interval. The first round took place during August 7-11, followed by the second round during August 27–31, 2018. Provision was made for mop-up activities after the second round for those who missed the second dose. To detect any possible adverse events following immunization (AEFI) during and after the campaign, health workers were trained to monitor and notify any adverse events encountered in inpatient and outpatient admissions at Cuamba health facilities from the first day of each round throughout the 15 days after the last day of each round.

The vaccination coverage estimates were assessed in two-folds; administrative coverage and coverage surveys. The administrative coverage was recorded by the local government health office in charge of the vaccination campaign by tracking the number of vaccine doses administered compared to doses that had been planned in the vaccination target areas, at the end of vaccination activities every day during the two rounds of the OCV vaccination campaign. For the vaccination coverage surveys, around 520-650 households, subject to the vaccination schedule including the mop-up vaccination, were estimated to ensure more than 550 samples for each age group (1-4 years, 5-14 years, 15 years and above) assuming 80% coverage with a design effect of 2 to achieve around 5% of prevision. Sampled households were organized per cluster; total 20-25 clusters with 26 households per cluster. The households were selected using a two-stage cluster random sampling methodology. Clusters (primary sampling unit) were selected from the list of villages in the Health Zones, according to the Probability Proportional to Population Size (PPS) and households (secondary sampling unit) were chosen randomly. For the household random

sampling, the enumerators identified the center point and boundary of the survey target area and applied random selection of households. The surveyors were recruited based on their knowledge on the local area and level of education to conduct the survey, and trained on household sampling methodology, structured survey questionnaire, and process of conducting a survey interview, including verbal informed consent and data capturing on the paper-based survey questionnaires.

Over the period of the OCV vaccination campaign, five survey teams were deployed to the predetermined clusters for daily vaccination monitoring, where randomly identified 26 households per cluster (5 clusters with total 130 households per day) were visited for 4-5 days (total 520-650 households) from the second or third day of the campaign until one day after the last vaccination day. This was applied for each round of the two-dose OCV vaccination campaigns. The information gathered through the survey on the vaccine uptake in the previous day, barriers against the vaccination, and the information source on the campaign were analyzed and fed daily to the vaccination campaign coordinators and supervisors in order to facilitate overall vaccine uptakes. After the second round, the enumerators continued the household survey for additional three days to estimate the coverage of two full doses of vaccination.

***Patient and Public Involvement***

The vaccination campaign was conducted as a part of the government's public health intervention, approved by the Ministry of Health (MOH) in Mozambique. The participants in this study were people living in the cholera endemic and hotspot area, targeted for OCV vaccination campaign as an integral part of the government's cholera prevention efforts. The vaccination target population living in Cuamba District were sensitized and engaged, prior to and during the vaccination campaign, by the district and provincial health officials, study team that included the MOH and National Institute of Health government officials, and local public health professionals at healthcare facilities. The participants were provided with information on the planned OCV mass vaccination such as the purpose of pre-emptive vaccination and detailed information on where and when the vaccination campaigns were to take place.

The vaccination campaign was also announced through various press and social media in Mozambique for public awareness and involvement. The study was conducted in a transparent manner with open communication and information sharing in the community, and participants to the OCV vaccination and vaccination coverage surveys were informed for oral consent. For children, consents were obtained from parents/guardian and all adult participants provided their own consent. The study did not present any risk of harm to subjects. No biological samples were collected. Minimum data was collected from participants, whereby privacy and confidentiality of the data were ensured during the survey implementation and data entry and management. Stakeholder meetings were conducted prior to, during, and after the vaccination campaign to further disseminate the campaign plan and results to the community members.

## Results

### *OCV vaccination coverage*

The administrative coverage of the first and the second rounds of the campaign were 98.9% (194,581) and 98.8% (194,325) respectively based on the available census data of vaccination target population in Cuamba Municipality and outskirts, estimated at around 196,652 (6) inhabitants (Table 1). A total of 194,581 people over one-year-old received the first dose, out of whom 99,275 were females and 122,592 were children aged less than 15 years. For the second round, total 194,325 people were vaccinated, including 99,275 females and 120,169 children less than 15 years old. Notably, the vaccination coverage survey conducted in the target community during each round and post-vaccination exhibited an approximate coverage estimates of 75.9% (95 CI, 78,10 - 73.70%) for the first round and 68.5% (71.80 - 65.20%) for the second round. The coverage rate for the full two-doses was estimated at 60.4% (63.80 - 57.00%), whereby the coverage of children aged 1-4 years was around 64.4 % (57.10 – 71.10%) (Table 1). The coverage rates in each round were higher in male (76.3% and 77.8%) than female (75.4% and 67.7%), but coverage rate of full doses was higher in female (64.4%) than male (57.3%). No adverse

events were reported during and after the vaccination activities, monitored up to 14 days post-vaccination campaign.

**Table 1. OCV vaccination coverage estimates, Cuamba District, 2018**

**a) Administrative vaccination coverage rates**

| | | Number of people vaccinated (No.) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Day 1** | **Day 2** | **Day 3** | **Day 4** | **Day 5** | **Day 6** | **Total** |
| **1st Dose** | **Age (year)** | | | | | | | |
| Individuals vaccinated per age group | 1-4 | 6,493 | 9,283 | 12,394 | 12,506 | 7,691 | - | 48,367 |
| | 5-15 | 7,050 | 16,705 | 21,590 | 17,536 | 11,344 | - | 74,225 |
| | ≥15 | 10,136 | 12,400 | 18,835 | 18,798 | 11,820 | - | 71,989 |
| Total no. of daily vaccinated | | 23,679 | 38,388 | 52,819 | 48,840 | 30,855 | - | 194,581 |
| Cumulative no. of vaccinated | | 23,679 | 62,067 | 114,886 | 163,726 | 194,581 | - | |
| **Cumulative administrative coverage** | | **12.04%** | **31.56%** | **58.42%** | **83.26%** | **98.95%** | **-** | **98.95%** |
| **2nd Dose** | | | | | | | | |
| Individuals vaccinated per age group | 1-4 | 5,479 | 6,484 | 11,117 | 9,596 | 7,760 | 7,586 | 48,022 |
| | 5-15 | 9,355 | 8,796 | 15,679 | 13,208 | 14,444 | 10,665 | 72,147 |
| | ≥15 | 9,416 | 9,275 | 14,271 | 14,265 | 14,848 | 12,081 | 74,156 |
| Total no. of daily vaccinated | | 24,250 | 24,555 | 41,067 | 37,069 | 37,052 | 30,332 | 194,325 |
| Cumulative no. of vaccinated | | 24,250 | 48,805 | 89,872 | 126,941 | 163,993 | 194,325 | |
| **Cumulative administrative coverage** | | **12.33%** | **24.82%** | **45.70%** | **64.55%** | **83.39%** | **98.82%** | **98.82%** |

**b) Vaccination coverage rates through coverage surveys**

| | | **First Round** | **Second Round** | **Full Two Doses** |
|---|---|---|---|---|
| **Age (years old)** | 1- 4 | 81.1±4.5% | 72.2±6.9% | 64.4±7.3% |
| | 5-14 | 86.4±3.1% | 71.3±5.8% | 65.2±6.1% |
| | ≥15 | 67.6±3.3% | 65.2±4.8% | 55.7±5.0% |
| **Sex** | Male | 76.3±2.9% | 77.8±3.9% | 57.3±4.6% |
| | Female | 75.4±3.2% | 67.7±5.0% | 64.4±5.1% |
| **Total** | **-** | **75.9±2.2%** | **68.5±3.3%** | **60.4±3.4%** |

***Source of Information and Acceptability***

The source of information on the OCV vaccination campaign, identified by the populations living in the vaccination target areas, showed use of megaphone as the most effective tool in disseminating information on the vaccination plan and mobilizing the community to get immunized for both rounds: 24% and 34% at the first and second rounds respectively (Table 2). Around 15% of the surveyed people in the target community indicated that they have learnt about the vaccination campaign through radio broadcast for the first round, but its communication impact reduced in the second round (4%). This was different for the community leaders, whose contribution increased from 5% in the first round to 19% in the following round, reflecting their active engagement and communication efforts in close coordination with the vaccination teams on the ground.

**Table 2. Source of information on OCV campaign, Cuamba District, 2018**

| Source of information | 1st Round[1] N= 646 n (%=n/N) | 2nd Round[2] N= 578 n (%=n/N) |
|---|---|---|
| Megaphone | 152 (24%) | 195 (34%) |
| Family | 60 (9%) | 53 (9%) |
| Radio | 96 (15%) | 23 (4%) |
| Religious leader | 82 (13%) | 25 (4%) |
| Health workers | 74 (11%) | 120 (21%) |
| Activists | 55 (9%) | 9 (2%) |
| Community leader | 33 (5%) | 108 (19%) |
| TV | 14 (2%) | 11 (2%) |
| Others[3] | 78 (12%) | 33 (6%) |

Footnote:
[1] 1st round: 646 households/or people were interviewed.
[2] 2nd round: 578 households/or people were interviewed.
[3] Others included: list other source of info if such data were collected.

***Reasons for not being vaccinated***

The unavailability (absence) of the target population for vaccination and incompatibility between working hours and campaign schedule were commonly cited as barriers for vaccination in both the first (35%) and the second round (51%) (Table 3). Absence of vaccinators at the vaccination sites were also mentioned, 12% and 18% for the first and second round respectively, despite the pre-vaccination planning and programmatic organization. Notably, around 10% of the target population has indicated that they have not been informed about the vaccination campaign even in the second round, though this was a reduction compared to 18% in the first round. In order to address the most common barriers identified in the first round, the second round of the vaccination campaign was further extended for additional few days including the weekends, enabling more people to get vaccinated.

**Table 3. Reasons for non-vaccination during the OCV campaign, Cuamba District, 2018**

| Reasons for non-vaccination | 1st Dose | | 2nd Dose | |
|---|---|---|---|---|
| | n=361 | % | n=222 | % |
| Unavailable | 63 | 17% | 96 | 43% |
| Incompatibility between working hours and campaign time | 53 | 15% | 18 | 8% |
| Vaccination post without vaccinator | 40 | 11% | 41 | 18% |
| Did not have information | 66 | 18% | 23 | 10% |
| Ill during the vaccination period | 30 | 8% | 10 | 5% |
| Does not believe in vaccine efficacy | 24 | 7% | 2 | 1% |
| Afraid of adverse events | 8 | 2% | 0 | 0% |
| Head of the family did not authorize | 4 | 1% | 2 | 1% |
| Religious leader forbid | 2 | 1% | 0 | 0% |
| Considered not safe for pregnant women | 1 | 0% | 2 | 1% |
| Other | 70 | 19% | 28 | 13% |

***OCV delivery costs***

The total financial cost of campaign was US$768,904 of which vaccine acquisition including vaccine shipment constituted 69% (US$533,659) (Table 4). The vaccine delivery costs including, microplanning, training, communication, and social mobilization, vaccination implementation (Round 1 & 2) constituted rest 31% (US$235,245). The total financial cost per dose delivered was US$0.60 without the vaccine cost and US$1.98 including the vaccine costs in 2018 price. The economic cost per dose delivered excluding vaccine costs was five times higher at US$3.02. The total financial cost of delivery per fully immunized person excluding vaccine costs was US$1.21.

**Table 4. Costs of OCV vaccine delivery and immunization in Cuamba District**

| Vaccine Delivery Costs | Financial Cost (Mzn) | Economic Cost (Mzn) | Financial Cost (USD) | Economic Cost (USD) |
|---|---|---|---|---|
| Vaccine Acquisition | 32,179,644 | 42,081,073 | 533,659 | 697,862 |
| Microplanning | 640,415 | 7,596,625 | 10,620 | 125,981 |
| Training | 265,186 | 299,419 | 4,398 | 4,965 |
| Communication and Social Mobilization | 1,912,520 | 4,301,342 | 31,717 | 71,332 |
| Vaccination Implementation (Round 1 &2) | 11,367,160 | 58,510,806 | 188,510 | 970,328 |
| **Total** | **46,364,925** | **112,789,265** | **768,904** | **1,870,469** |
| **Immunization Costs** | **Financial Cost (Mzn)** | **Economic Cost (Mzn)** | **Financial Cost (USD)** | **Economic Cost (USD)** |
| Cost per Vaccine Administered (including vaccine) | 119 | 290 | 1.98 | 4.81 |
| Cost per Vaccine Administered (without vaccine cost) | 36 | 182 | 0.60 | 3.02 |
| Cost per Partially Immunized Person | 238 | 580 | 3.95 | 9.61 |
| Cost per Fully Immunized Person (with vaccine) | 239 | 580 | 3.96 | 9.63 |
| Cost per Fully Immunized Person (without vaccine) | 73 | 364 | 1.21 | 6.03 |

## Discussion

The OCV campaign in Cuamba District was organized without major logistical and programmatic challenges, and no adverse events were reported throughout the vaccination activities and up to 14 days after the campaign. Despite the similarity in the number of people vaccinated in the first and second rounds, the vaccination coverage survey of the second round showed lower coverage estimates than the first round. This may be due to possible cross border movement of people from untargeted districts to get vaccination during the second round. The vaccination coverage for the full two-doses was over 60% that may confer sufficient herd immunity for the following several years based on the existing literature on a cholera transmission model using the Matlab data from Bangladesh (10,11), which predicted 50% coverage with OCV in cholera endemic areas may result in 89% reduction in cholera cases in unvaccinated (12).

In our study, children aged 5-14 years exhibited the highest coverage. This may be due to the vaccination posts in both schools (fixed vaccination post) and near homes (mobile vaccination posts), which facilitated the school-aged children to access the immunization health service more easily. The female group also presented higher full vaccination coverage rate compared to the male group, who showed higher drop-out after first dose, likely associated with their routine boundaries of livelihood near their houses or their child/children's schools as they take care of children while the male group typically work outside. This assumption is supported by the fact that the absence during the campaign was identified as a significant barrier against vaccination during both rounds of the campaign. Similar pattern was consistently prevalent in the previous OCV campaigns in Beira (13) and Nampula (4), whereby absence was the main barrier for vaccination. The second round of the campaign coincided with the period of school holidays when most households move to farming and food production, resulting in higher absence rate in the second round (43.0%) than in first round (17.0%). Further, it is encouraging to observe more than 60% vaccination coverage rate among children aged 1-4 years, the most at-risk population age-group concerning cholera outbreaks. Considering that caregivers for these younger children are mostly women,

higher vaccination coverage for these toddlers and younger children and women is as anticipated in accordance with other studies published in similar settings (14).

In order to enhance the vaccination coverage, it is paramount to better understand the effective means of communications for community sensitization and engagements, as well as barriers towards participating in a vaccination program such as this campaign. Here, we showed that the use of megaphone proved to be the most effective advocacy tool for disseminating information on the vaccination to our target community, which may have allowed the field workers to reach out to families without access to other sources of information. This may also indicate the need to better understand the inter-personnel communication and community mobilization approach for future vaccination campaigns. For those with missed opportunities to receive the OCV doses during the two rounds, a mop-up vaccination can be considered, though it is often more laborious and costly, requiring a complex management (13). Further, informing the public on the availability of a mop-up prior to or during the campaign may negatively affect their participation in the regular vaccination schedule set-up. Hence, a mop-up was not considered after the first round in our approach but pursued after the second round in order to enhance the full two-dose vaccination and verify vaccination data records submitted during the regular program. Approximately 15.4% (32,775/212,824) of the delivered second doses were through this mop-up campaign indicative of an effective strategy.

The financial costs of OCV delivery per fully immunized person in this campaign was lower than delivery costs reported in other African countries using the same CholTool (US$1.8 in Shashemene district of Ethiopia; US$2.5 in Nsanje district of Malawi; and US$3.5 in Machinga, Phalombe, and Zomba districts of Malawi per the US$ price value of 2016), but closer to that reported in Puri district of India (US$1.14 per the US$ price value of 2016) (9). One reason could be that Mozambique has experience of conducting several OCV campaigns in recent years, and hence there were already resources and expertise available for micro-planning, communication, sensitization, trainings etc., which might have reduced the costs

associated with introduction of vaccines in comparison to a vaccination program in naïve setting. The financial cost of US$0.60 per dose delivered (excluding vaccine procurement) is comparable to the operational support ranging between US$0.30 and US$0.80 per person targeted for vaccination campaigns, recommended by the Gavi, the Vaccine Alliance (15,16). This indicates the affordability of OCV campaign in the current setting. To economize the healthcare provider time and efforts and incentivize beneficiaries for greater uptake of vaccines, delivery of multiple products at vaccination posts or on household visits may potentially synergize the delivery cost associated with vaccination campaigns.

Overall, our study proved the feasibility of conducting a preemptive OCV mass vaccination campaign in a rural and semi-rural setting in Cuamba District and Cuamba Municipality areas respectively, with sufficient coverage rate and relatively lower delivery cost. The success of vaccination was a result of effective coordination and microplanning among stakeholders despite some field challenges. The vaccination strategy utilizing both fixed and mobile posts, as well as the daily feedback to the coordination team on the preliminary coverage survey result and data related to barriers and source of information on the vaccination campaign, proved valuable to prospectively refine the campaign and mobilization strategy every day on a real-time basis.

However, there are several limitations. First, the operational challenges concerning poor road conditions resulted in the accessibility to the target area difficult. Second, the programmatic support that required sufficient and trained human resources and budget for a sustained field monitoring activity and close on-site supervision prior to and during the vaccination campaign and coverage survey activities. Third, the differences in the coverage rates of administrative data and survey result is due to the lack of accurate up-to-date census data of local population. In addition, in order to avoid any conflict with the measles and rubella national immunization campaign that was taking place across the country at the time of this vaccination campaign, we had to delay our OCV vaccination campaign for about two months to obtain support from immunization-related stakeholders, particularly the expanded programme of immunization

(EPI) for cold chain space and logistics. Any mass vaccination campaigns should also consider seasonality and other major community activities and/or any political issues.

**Acknowledgement**

The authors acknowledge the local government officials and healthcare professionals in Cuamba District, Niassa Province for engaging the community on the OCV vaccination program throughout the planning and implementation period. Thanks are also extended to the people who consented and took part in the coverage survey. We thank our research partners and staff at the MOCA sentinel site networks in Mozambique, and Ms. Somyoung Cho for the project management and Ms. Jihyun Han and Ms. Nozipho Manjate for the project administrative support.

**Contributorship**

S.E.P conceptualized the overall study design of the Mozambique Cholera Prevention and Surveillance (MOCA) project. C.S.B. supervised the MOCA project in Mozambique. N.S.B. supervised the overall vaccination campaign and monitoring and evaluation. All authors participated in the vaccination campaign. J.C., N.L, L.D.B., J.P.L., N.S.B., S.E.P., S.A., A.O., M.M., and the project field team in Cuamba and Niassa contributed to data acquisition on the community vaccination coverage surveys, and interpretation of results under the supervision of N.S.B. R.B.J.M., J.A.M., S.A., A.O., M.M., and others in the vaccination teams of Cuamba District and Niassa Province contributed to acquisition, review, and report of the administrative coverage data. I.C. contributed to data acquisition and analysis on vaccination costs; and V.M. and C.V.R. reviewed the cost analysis. J.C. drafted and edited the paper under the scientific guidance from N.S.B. and S.E.P. All authors read and approved the final draft.

**Funding Statement**

This study was supported by the Korea International Cooperation Agency (KOICA), government of the Republic of Korea. The findings and conclusions are our own and do not necessarily reflect positions of

the KOICA. The International Vaccine Institute acknowledges its donors, including the Government of Republic of Korea and the Swedish International Development Cooperation Agency (SIDA).

**Competing of Interests**

The authors declare no competing interests.

**Ethics approval**

Institutional Ethical Committee of the National Institute of Health (Ref: 116/CNBS/19) and ethical review board of the International Vaccine Institute, Seoul, Korea (IRB number 2017-006) approved the study protocol for the OCV mass vaccination campaign monitoring and coverage survey.

**Data sharing**

All data relevant to the study are included in the article.

**Figure legends**

**Figure 1. Pre-emptive OCV mass vaccination site**

Location of the pre-emptive OCV vaccination campaign site in Cuamba District, Mozambique, included bairros and povoados in the municipality and district.

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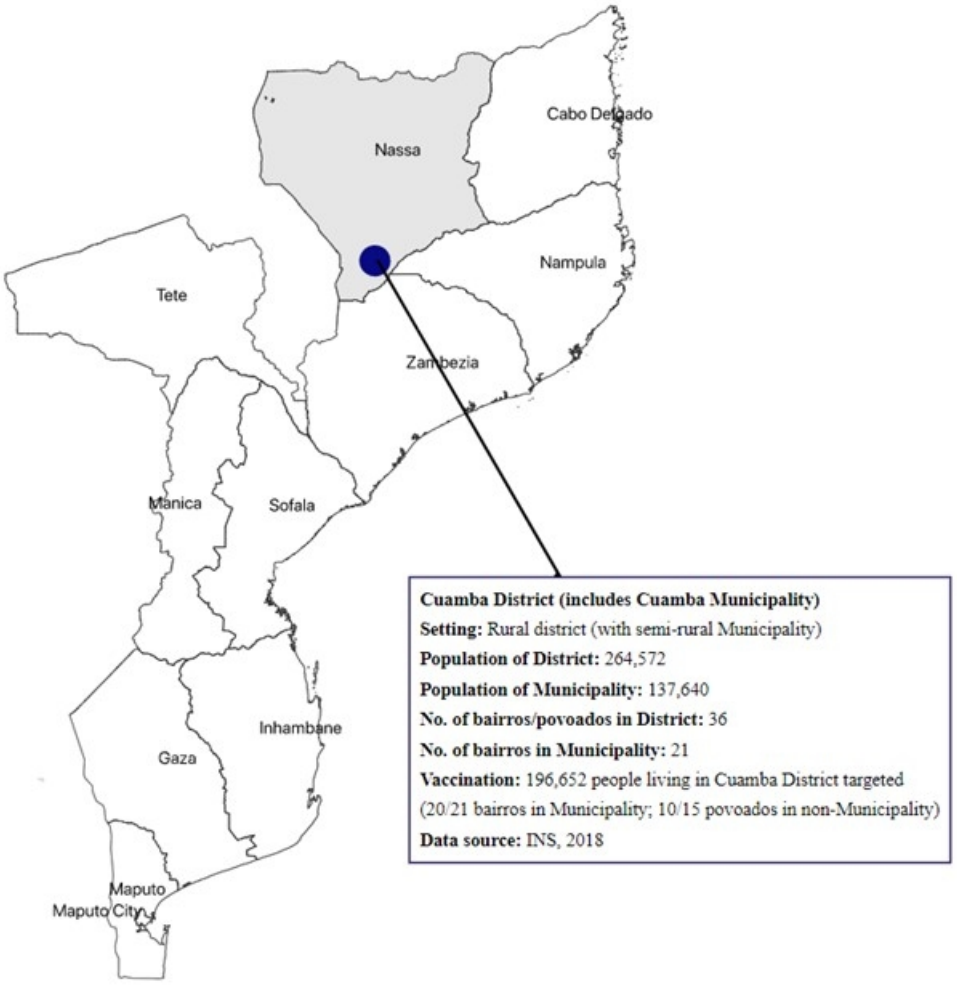


**Figure 1. Pre-emptive OCV mass vaccination site**

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Location of the pre-emptive OCV vaccination campaign site in Cuamba District, Mozambique, included bairros and povoados in the municipality and district.

165x181mm (96 x 96 DPI)

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# A pre-emptive Oral Cholera Vaccine (OCV) mass vaccination campaign in Cuamba District, Niassa Province, Mozambique: feasibility, vaccination coverage, and delivery costs using CholTool

| | |
|---|---|
| Journal: | *BMJ Open* |
| Manuscript ID | bmjopen-2021-053585.R2 |
| Article Type: | Original research |
| Date Submitted by the Author: | 08-Apr-2022 |
| Complete List of Authors: | Elias Chitio, Jucunú J.; National Institute of Health<br>Baltazar, Cynthia; National Institute of Health<br>Langa, José Paulo; National Institute of Health<br>Baloi, Liliana Dengo; National Institute of Health<br>Mboane, Ramos B. J.; Provincial Directorate of Health, Provincial Directorate of Health<br>Manuel, José Alberto; Provincial Directorate of Health, Provincial Directorate of Health<br>Assane, Sadate; Provincial Directorate of Health, Provincial Directorate of Health<br>Omar, Alide; District Health Directorate, District Health Directorate<br>Manso, Mariana; District Health Directorate, District Health Directorate<br>Capitine, Igor; National Institute of Health<br>Van Rensburg, Craig; International Vaccine Institute<br>Luiz, Naira; National Institute of Health; International Vaccine Institute<br>Mogasale, Vittal; International Vaccine Institute, Policy and Economic Research<br>Marks, Florian ; International Vaccine Institute<br>Park, Se Eun; International Vaccine Institute; Yonsei University<br>Beck, Namseon; International Vaccine Institute; Medair Headquarters |
| Primary Subject Heading: | Global health |
| Secondary Subject Heading: | Infectious diseases, Health economics, Global health, Health policy |
| Keywords: | PUBLIC HEALTH, HEALTH ECONOMICS, INFECTIOUS DISEASES, PREVENTIVE MEDICINE, Infection control < INFECTIOUS DISEASES |
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# A pre-emptive Oral Cholera Vaccine (OCV) mass vaccination campaign in Cuamba District, Niassa Province, Mozambique: feasibility, vaccination coverage, and delivery costs using CholTool

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## Abstract

**Introduction:** Mozambique suffers from regular floods along its principal river basins and periodic cyclones that resulted in several cholera epidemics during the last decades. Cholera outbreaks in the recent five years affected particularly the northern provinces of the country including Nampula and Niassa provinces. A pre-emptive Oral Cholera Vaccine (OCV) mass vaccination campaign was conducted in Cuamba District, Niassa Province, and the feasibility, costs, and vaccination coverage assessed.

**Methods:** World Health Organization prequalified OCV (Euvichol-Plus), a killed whole-cell bivalent vaccine containing *Vibrio cholerae* O1 (classical and El Tor) and O139, was administered in two-doses with a 15-day interval during 7-31 August 2018, targeting around 180,000 people aged above one year in Cuamba District. Microplanning, community sensitization, and trainings of local public health professionals and field enumerators were conducted. Feasibility and costs of vaccination were assessed using CholTool. Vaccination coverage and barriers were assessed through community surveys.

**Results:** The administrative coverage of the first and second rounds of the campaign were 98.9% (194,581) and 98.8% (194,325) respectively based on the available population data that estimated total 196,652 inhabitants in the target area. The vaccination coverage survey exhibited 75.9% (±2.2%) and 68.5% (±3.3%) coverages for the first and second rounds, respectively. Overall, 60.4% (±3.4%) of the target population received full two-doses of OCV. Barriers to vaccination included incompatibility between working hours and campaign time. No severe adverse events were notified. The total financial cost per dose delivered was US$0.60 without vaccine cost and US$1.98 including vaccine costs**.**

**Conclusion:** The pre-emptive OCV mass vaccination campaign in remote setting in Mozambique was feasible with reasonable full-dose vaccination coverage to confer sufficient herd immunity for at least the

next three to five years. The delivery cost estimate indicates that the OCV campaign is affordable as it is comparable to Gavi's operational support for vaccination campaigns.

**Key words:** Cholera**,** OCV, pre-emptive vaccination, Cuamba, Mozambique, vaccination coverage survey, feasibility, vaccination cost

**Strengths and limitations of this study**

- This study has successfully demonstrated the feasibility of an OCV mass vaccination campaign in a remote setting in Mozambique.
- The cost of a mass vaccination campaign for the two-dose OCV administrations has been analysed for the first time in Mozambique, which can serve as a reference cost estimate when planning for any OCV vaccination programs in a similar setting in Mozambique or other countries.
- Vaccination coverage estimates may be affected if there are people movements in and out of the study area. A sub-study on this and a focused community engagement strategy to reduce the identified barriers to vaccination should be considered in future vaccination programs.
- Newly introduced vaccination monitoring/coverage survey engaging the same survey team enabled quick availability of the vaccination coverage during or immediately after the campaign, but at the same time the team could be overburdened.

## Introduction

Cholera is a vaccine preventable disease that remains as a major public health concern in many parts of low- and middle-income countries (LMICs). A comprehensive policy measure is warranted to control and prevent cholera including investments in improving infrastructure and knowledge, attitude, and behavior associated with water, sanitation, and hygiene (WaSH), strengthening health system, and adequate use of oral cholera vaccine (OCV) (1). In Mozambique, cholera has been endemic since the early 1970's when the first cholera outbreak was reported in the country. Several epidemics followed since then including the outbreaks in 1997-1999 and 2012-2016 (2, 3). Cholera outbreaks are more frequent in the country's northern provinces including Nampula, Cabo Delgado, Tete, and Niassa (4). Following the reinforcement of cholera outbreak response strategies, the Ministry of Health (MOH) of Mozambique has carried out several OCV mass vaccination campaigns, as recommended by the World Health Organization (WHO) as an integral part of a comprehensive strategy for cholera prevention and control in endemic setting along

with primary interventions of WaSH measures (5): Recent cholera outbreaks in these cholera endemic and hotspot areas in December 2015 resulted in the use of global OCV emergency stockpile to vaccinate approximately 212,745 people living in six neighborhoods of Nampula city in 2016 (4); and in April 2017, another 709,077 doses from the stockpile to vaccinate approximately 354,550 people in Tete City and Moatize and Mutarara districts, in response to the cholera outbreak with over 3,592 cholera cases.

In addition to these reactive vaccination campaigns supported by the WHO International Coordinating Group (ICG) on vaccine provision for cholera, a growing need for a preventive public health intervention using a targeted vaccination approach in cholera priority areas in-country was identified. The past records of numerous episodes of cholera epidemics in Mozambique have spotted at-risk districts in the most cholera endemic provinces such as Nampula (particularly Nampula City), Niassa (Lichinga city and Cuamba and Lago Districts), and Cabo Delgado (Pemba City and Ancuabe District), and to a lesser degree, other provinces and districts with limited sanitary conditions (5). Niassa province, one of the cholera endemic regions with annual cholera outbreaks affecting largely the Lichinga City and Lago and Cuamba Districts, was identified for a planned pre-emptive vaccine introduction to prevent subsequent cholera outbreaks. Cuamba District with an estimated population of 264,572 (6), reports over 200 suspected cholera and 2,000 diarrheal cases almost every year, with an exception of 2014 and 2016 (7). Here, we describe the feasibility, costs, and coverage estimates associated with a pre-emptive OCV mass vaccination campaign conducted in Cuamba District using two-dose OCVs (Euvichol-Plus) administered to approximately 180,000 people with a 15-day interval between the doses, as well as challenges of delivering healthcare in resource limited rural setting in Mozambique.

## Methods

### *Study site and population*

The Cuamba District is located in Niassa Province with a population size of around 264,572 (6). The site was selected for a pre-emptive OCV mass vaccination campaign as the district includes the Cuamba Municipality area where cholera is found to be endemic with periodic outbreaks. The area was also highlighted by the WHO as one of the priority sites to consider for a potential OCV intervention during a needs-assessment performed in September 2015 (1). The District of Cuamba is composed of a total 36 bairros and povoados with population size of approximately 264,572 (6), which includes 21 bairros in the Cuamba Municipality area with around 137,640 residents (8). In total, approximately 180,000 individuals living in Cuamba District was targeted initially, and ultimately around 196,652 people living in Cuamba District were targeted, which included 20 Bairros in the Municipality area and 10 Povoados in the outskirts of the Municipality area (Figure 1). Selection of bairros and povoados in the outskirts of Cuamba Municipality within the District was made not only based on the high number of doses destined for the target population in the municipality area, but also the records of cholera cases during the outbreaks. Everyone above one year of age were eligible for the two-dose OCV administration.

***Vaccine delivery, storage, and handling***

Approximately 360,000 doses of WHO pre-qualified Euvichol-Plus, a killed whole-cell bivalent OCV containing *Vibrio cholerae* O1 (classical and El Tor) and O139, were procured from the manufacturer (EuBiologics) and shipped to the entry port in Pemba, Mozambique in cold-chain. Upon arrival in Mozambique, the vaccines were delivered to Lichinga by airfreight and transported to a central vaccine storage room in Cuamba project site, and kept in refrigerators with temperature maintained within range between 2-8℃ until and throughout the campaign. The vaccine vial monitor (VVM) and electronic shipping indicators (Q-Tag) were used to monitor the temperature of the vaccines during delivery, storage, and handling. During the vaccination campaign, cool boxes with dry ice maintained within 2-8℃ were used to carry the vaccines to the vaccination posts.

***Cost of vaccine delivery***

An openly available, standardized and validated Excel-based tool known as the CholTool was used for estimating vaccine delivery costs (9). This tool comprehensively estimates programmatic costs such as microplanning, communication and training materials development, sensitization/social mobilization, and personnel training, as well as costs related to vaccine delivery such as vaccine procurement, handling, storage, and transport, vaccination administration, adverse events following immunization (AEFI) management, monitoring supervision, and field support. The CholTool has the ability to estimate both financial and economic costs. Financial costs refer to the monetary costs to the payer (e.g., allowances, supplies, transport, and resources used in micro-planning, training, and sensitization/social mobilization) while economic costs include financial costs along with non-monetary costs of donated goods and resources already available (e.g., health personnel time). Key informant interviews were conducted at various administrative levels before, during and after the vaccination campaign in order to identify the resources necessary for each vaccination related activity and costs of respective resources for each of the two rounds of vaccination. The resource and cost data were entered in CholTool which auto-calculates OCV delivery costs. The costs were reported in 2018 in United States Dollars (US$) based on government and payer perspective.

***Vaccination Strategy and microplanning***

A fixed post vaccination strategy with additional mobile teams was adapted for the microplanning of the vaccination campaign. The vaccination teams for 15 fixed posts and 33 mobile teams were identified and trained prior to the campaign. The fixed posts included existing healthcare facilities such as primary health centers and secondary and referral hospital, schools, market areas where many people have easy access to. The mobile teams were deployed to households remotely located with limited access to these fixed posts. This adopted mixed vaccination strategy aimed to improve quality, accessibility, and coverage. Each post was staffed with around 5 field workers including 2 health workers and 3 community engagement workers. Five days prior to the vaccination campaign, micro-plans for each cluster were

prepared with postal addresses, target populations, vaccination dates, teams, and other site-specific resources. The health workers obtained verbal informed consents from the individuals visiting the vaccination posts for the OCV administration. Pregnant women by self-report or infants below one year old were excluded from the vaccination. Vaccination cards and vaccination registry book were developed and deployed, specific to this vaccination that included variables such as name, age, address, and vaccination date. The collected data in the vaccine registry book were entered in an excel-based database. The number of doses planned and administered were also recorded daily for each rounds of the vaccination campaign.

***Vaccination, adverse event monitoring, and coverage estimate***

The vaccination campaign occurred in two rounds with a 15-day interval. The first round took place during August 7-11, followed by the second round during August 27–31, 2018. Provision was made for mop-up activities after the second round for those who missed the second dose. To detect any possible adverse events following immunization (AEFI) during and after the campaign, health workers were trained to monitor and notify any adverse events encountered in inpatient and outpatient admissions at Cuamba health facilities from the first day of each round throughout the 15 days after the last day of each round.

The vaccination coverage estimates were assessed in two-folds; administrative coverage and coverage surveys. The administrative coverage was recorded by the local government health office in charge of the vaccination campaign by tracking the number of vaccine doses administered compared to doses that had been planned in the vaccination target areas, at the end of vaccination activities every day during the two rounds of the OCV vaccination campaign. For the vaccination coverage surveys, around 520-650 households, subject to the vaccination schedule including the mop-up vaccination, were estimated to ensure more than 550 samples for each age group (1-4 years, 5-14 years, 15 years and above) assuming 80% coverage with a design effect of 2 to achieve around 5% of prevision. Sampled households were

organized per cluster; total 20-25 clusters with 26 households per cluster. The households were selected using a two-stage cluster random sampling methodology. Clusters (primary sampling unit) were selected from the list of villages in the Health Zones, according to the Probability Proportional to Population Size (PPS) and households (secondary sampling unit) were chosen randomly. For the household random sampling, the enumerators identified the center point and boundary of the survey target area and applied random selection of households. The surveyors were recruited based on their knowledge on the local area and level of education to conduct the survey, and trained on household sampling methodology, structured survey questionnaire, and process of conducting a survey interview, including verbal informed consent and data capturing on the paper-based survey questionnaires.

Over the period of the OCV vaccination campaign, five survey teams were deployed to the predetermined clusters for daily vaccination monitoring, where randomly identified 26 households per cluster (5 clusters with total 130 households per day) were visited for 4-5 days (total 520-650 households) from the second or third day of the campaign until one day after the last vaccination day. This was applied for each round of the two-dose OCV vaccination campaigns. The information gathered through the survey on the vaccine uptake in the previous day, barriers against the vaccination, and the information source on the campaign were analyzed and fed daily to the vaccination campaign coordinators and supervisors in order to facilitate overall vaccine uptakes. During the second round of campaign, the survey team collected data for the first round coverage using the same questionnaire for monitoring, which enabled the first-round vaccine coverage available before the completion of the second round. After the second round, the enumerators continued the household survey for additional three days (total four days, including the last survey day for monitoring of the second round, which was one day after the mop-up campaign) to estimate the coverage for the second round and two full doses of vaccination.

***Patient and Public Involvement***

The vaccination campaign was conducted as a part of the government's public health intervention, approved by the Ministry of Health (MOH) in Mozambique. The participants in this study were people living in the cholera endemic and hotspot area, targeted for OCV vaccination campaign as an integral part of the government's cholera prevention efforts. The vaccination target population living in Cuamba District were sensitized and engaged, prior to and during the vaccination campaign, by the district and provincial health officials, study team that included the MOH and National Institute of Health government officials, and local public health professionals at healthcare facilities. The participants were provided with information on the planned OCV mass vaccination such as the purpose of pre-emptive vaccination and detailed information on where and when the vaccination campaigns were to take place. The vaccination campaign was also announced through various press and social media in Mozambique for public awareness and involvement. The study was conducted in a transparent manner with open communication and information sharing in the community, and participants to the OCV vaccination and vaccination coverage surveys were informed for oral consent. For children, consents were obtained from parents/guardian and all adult participants provided their own consent. The study did not present any risk of harm to subjects. No biological samples were collected. Minimum data was collected from participants, whereby privacy and confidentiality of the data were ensured during the survey implementation and data entry and management. Stakeholder meetings were conducted prior to, during, and after the vaccination campaign to further disseminate the campaign plan and results to the community members.

## Results

### *OCV vaccination coverage*

The administrative coverage of the first and the second rounds of the campaign were 98.9% (194,581) and 98.8% (194,325) respectively based on the available census data of vaccination target population in Cuamba Municipality and outskirts, estimated at around 196,652 (6) inhabitants (Table 1). A total of 194,581 people over one-year-old received the first dose, out of whom 99,275 were females and 122,592

were children aged less than 15 years. For the second round, total 194,325 people were vaccinated, including 99,275 females and 120,169 children less than 15 years old. Notably, the vaccination coverage survey conducted in the target community during each round and post-vaccination exhibited an approximate coverage estimates of 75.9% (95 CI, 78,10 - 73.70%) for the first round and 68.5% (71.80 - 65.20%) for the second round. The coverage rate for the full two-doses was estimated at 60.4% (63.80 - 57.00%), whereby the coverage of children aged 1-4 years was around 64.4 % (57.10 – 71.10%) (Table 1). The coverage rates in each round were higher in male (76.3% and 77.8%) than female (75.4% and 67.7%), but coverage rate of full doses was higher in female (64.4%) than male (57.3%). No adverse events were reported during and after the vaccination activities, monitored up to 14 days post-vaccination campaign.

**Table 1. OCV vaccination coverage estimates, Cuamba District, 2018**

**a) Administrative vaccination coverage rates**

| | | Number of people vaccinated (No.) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Day 1** | **Day 2** | **Day 3** | **Day 4** | **Day 5** | **Day 6** | **Total** |
| **1st Dose** | **Age (year)** | | | | | | | |
| Individuals vaccinated per age group | 1-4 | 6,493 | 9,283 | 12,394 | 12,506 | 7,691 | - | 48,367 |
| | 5-15 | 7,050 | 16,705 | 21,590 | 17,536 | 11,344 | - | 74,225 |
| | ≥15 | 10,136 | 12,400 | 18,835 | 18,798 | 11,820 | - | 71,989 |
| Total no. of daily vaccinated | | 23,679 | 38,388 | 52,819 | 48,840 | 30,855 | - | 194,581 |
| Cumulative no. of vaccinated | | 23,679 | 62,067 | 114,886 | 163,726 | 194,581 | - | |
| **Cumulative administrative coverage** | | **12.04%** | **31.56%** | **58.42%** | **83.26%** | **98.95%** | **-** | **98.95%** |
| **2nd Dose** | | | | | | | | |
| Individuals vaccinated per age group | 1-4 | 5,479 | 6,484 | 11,117 | 9,596 | 7,760 | 7,586 | 48,022 |
| | 5-15 | 9,355 | 8,796 | 15,679 | 13,208 | 14,444 | 10,665 | 72,147 |
| | ≥15 | 9,416 | 9,275 | 14,271 | 14,265 | 14,848 | 12,081 | 74,156 |
| Total no. of daily vaccinated | | 24,250 | 24,555 | 41,067 | 37,069 | 37,052 | 30,332 | 194,325 |
| Cumulative no. of vaccinated | | 24,250 | 48,805 | 89,872 | 126,941 | 163,993 | 194,325 | |
| **Cumulative administrative coverage** | | **12.33%** | **24.82%** | **45.70%** | **64.55%** | **83.39%** | **98.82%** | **98.82%** |

**b) Vaccination coverage rates through coverage surveys**

| | | **First Round** | **Second Round** | **Full Two Doses** |
|---|---|---|---|---|
| **Age (years old)** | 1- 4 | 81.1±4.5% | 72.2±6.9% | 64.4±7.3% |
| | 5-14 | 86.4±3.1% | 71.3±5.8% | 65.2±6.1% |
| | ≥15 | 67.6±3.3% | 65.2±4.8% | 55.7±5.0% |
| **Sex** | Male | 76.3±2.9% | 77.8±3.9% | 57.3±4.6% |
| | Female | 75.4±3.2% | 67.7±5.0% | 64.4±5.1% |
| **Total** | - | **75.9±2.2%** | **68.5±3.3%** | **60.4±3.4%** |

***Source of Information and Acceptability***

The source of information on the OCV vaccination campaign, identified by the populations living in the vaccination target areas, showed use of megaphone as the most effective tool in disseminating information on the vaccination plan and mobilizing the community to get immunized for both rounds: 24% and 34% at the first and second rounds respectively (Table 2). Around 15% of the surveyed people in the target community indicated that they have learnt about the vaccination campaign through radio broadcast for the first round, but its communication impact reduced in the second round (4%). This was different for the community leaders, whose contribution increased from 5% in the first round to 19% in the following round, reflecting their active engagement and communication efforts in close coordination with the vaccination teams on the ground.

**Table 2. Source of information on OCV campaign, Cuamba District, 2018**

| Source of information | 1st Round[1] N= 646 n (%=n/N) | 2nd Round[2] N= 578 n (%=n/N) |
|---|---|---|
| Megaphone | 152 (24%) | 195 (34%) |
| Family | 60 (9%) | 53 (9%) |
| Radio | 96 (15%) | 23 (4%) |
| Religious leader | 82 (13%) | 25 (4%) |
| Health workers | 74 (11%) | 120 (21%) |
| Activists | 55 (9%) | 9 (2%) |
| Community leader | 33 (5%) | 108 (19%) |
| TV | 14 (2%) | 11 (2%) |
| Others[3] | 78 (12%) | 33 (6%) |

Footnote:
[1] 1st round: 646 households/or people were interviewed.
[2] 2nd round: 578 households/or people were interviewed.
[3] Others included: list other source of info if such data were collected.

***Reasons for not being vaccinated***

The unavailability (absence) of the target population for vaccination and incompatibility between working hours and campaign schedule were commonly cited as barriers for vaccination in both the first (35%) and the second round (51%) (Table 3). Absence of vaccinators at the vaccination sites were also mentioned, 12% and 18% for the first and second round respectively, despite the pre-vaccination planning and programmatic organization. Notably, around 10% of the target population has indicated that they have not been informed about the vaccination campaign even in the second round, though this was a reduction compared to 18% in the first round. In order to address the most common barriers identified in the first round, the second round of the vaccination campaign was further extended for additional few days including the weekends, enabling more people to get vaccinated.

**Table 3. Reasons for non-vaccination during the OCV campaign, Cuamba District, 2018**

| Reasons for non-vaccination | 1st Dose | | 2nd Dose | |
|---|---|---|---|---|
| | n=361 | % | n=222 | % |
| Unavailable | 63 | 17% | 96 | 43% |
| Incompatibility between working hours and campaign time | 53 | 15% | 18 | 8% |
| Vaccination post without vaccinator | 40 | 11% | 41 | 18% |
| Did not have information | 66 | 18% | 23 | 10% |
| Ill during the vaccination period | 30 | 8% | 10 | 5% |
| Does not believe in vaccine efficacy | 24 | 7% | 2 | 1% |
| Afraid of adverse events | 8 | 2% | 0 | 0% |
| Head of the family did not authorize | 4 | 1% | 2 | 1% |
| Religious leader forbid | 2 | 1% | 0 | 0% |
| Considered not safe for pregnant women | 1 | 0% | 2 | 1% |
| Other | 70 | 19% | 28 | 13% |

***OCV delivery costs***

The total financial cost of campaign was US$768,904 of which vaccine acquisition including vaccine shipment constituted 69% (US$533,659) (Table 4). The vaccine delivery costs including, microplanning, training, communication, and social mobilization, vaccination implementation (Round 1 & 2) constituted rest 31% (US$235,245). The total financial cost per dose delivered was US$0.60 without the vaccine cost and US$1.98 including the vaccine costs in 2018 price. The economic cost per dose delivered excluding vaccine costs was five times higher at US$3.02. The total financial cost of delivery per fully immunized person excluding vaccine costs was US$1.21.

**Table 4. Costs of OCV vaccine delivery and immunization in Cuamba District**

| Vaccine Delivery Costs | Financial Cost (Mzn) | Economic Cost (Mzn) | Financial Cost (USD) | Economic Cost (USD) |
|---|---|---|---|---|
| Vaccine Acquisition | 32,179,644 | 42,081,073 | 533,659 | 697,862 |
| Microplanning | 640,415 | 7,596,625 | 10,620 | 125,981 |
| Training | 265,186 | 299,419 | 4,398 | 4,965 |
| Communication and Social Mobilization | 1,912,520 | 4,301,342 | 31,717 | 71,332 |
| Vaccination Implementation (Round 1 &2) | 11,367,160 | 58,510,806 | 188,510 | 970,328 |
| **Total** | **46,364,925** | **112,789,265** | **768,904** | **1,870,469** |
| **Immunization Costs** | **Financial Cost (Mzn)** | **Economic Cost (Mzn)** | **Financial Cost (USD)** | **Economic Cost (USD)** |
| Cost per Vaccine Administered (including vaccine) | 119 | 290 | 1.98 | 4.81 |
| Cost per Vaccine Administered (without vaccine cost) | 36 | 182 | 0.60 | 3.02 |
| Cost per Partially Immunized Person | 238 | 580 | 3.95 | 9.61 |
| Cost per Fully Immunized Person (with vaccine) | 239 | 580 | 3.96 | 9.63 |
| Cost per Fully Immunized Person (without vaccine) | 73 | 364 | 1.21 | 6.03 |

## Discussion

The OCV campaign in Cuamba District was organized without major logistical and programmatic challenges, and no adverse events were reported throughout the vaccination activities and up to 14 days after the campaign. Despite the similarity in the number of people vaccinated in the first and second rounds, the vaccination coverage survey of the second round showed lower coverage estimates than the first round. This may be due to possible cross border movement of people from untargeted districts to get vaccination during the second round. The vaccination coverage for the full two-doses was over 60% that may confer sufficient herd immunity for the following several years based on the existing literature on a cholera transmission model using the Matlab data from Bangladesh (10,11), which predicted 50% coverage with OCV in cholera endemic areas may result in 89% reduction in cholera cases in unvaccinated (12).

In our study, children aged 5-14 years exhibited the highest coverage. This may be due to the vaccination posts in both schools (fixed vaccination post) and near homes (mobile vaccination posts), which facilitated the school-aged children to access the immunization health service more easily. The female group also presented higher full vaccination coverage rate compared to the male group, who showed higher drop-out after first dose, likely associated with their routine boundaries of livelihood near their houses or their child/children's schools as they take care of children while the male group typically work outside. This assumption is supported by the fact that the absence during the campaign was identified as a significant barrier against vaccination during both rounds of the campaign. Similar pattern was consistently prevalent in the previous OCV campaigns in Beira (13) and Nampula (4), whereby absence was the main barrier for vaccination. The second round of the campaign coincided with the period of school holidays when most households move to farming and food production, resulting in higher absence rate in the second round (43.0%) than in first round (17.0%). Further, it is encouraging to observe more than 60% vaccination coverage rate among children aged 1-4 years, the most at-risk population age-group concerning cholera outbreaks. Considering that caregivers for these younger children are mostly women,

higher vaccination coverage for these toddlers and younger children and women is as anticipated in accordance with other studies published in similar settings (14).

For the monitoring of the campaign, the researchers used representative sampling with the same questionnaire for coverage, which resulted in representative daily coverage. The representative sampling enabled the first-round coverage available before completion of the second round and fed to the coordination team to fine-tune the mop-up campaign. Again, the second and full dose vaccination coverage were estimated within a week after the campaign by extension of the survey days by three more days. However, the survey extension and additional questions for the final coverages (the first, second and full) made some survey team members exhausted, which might have affected survey quality.

In order to enhance the vaccination coverage, it is paramount to better understand the effective means of communications for community sensitization and engagements, as well as barriers towards participating in a vaccination program such as this campaign. Here, we showed that the use of megaphone proved to be the most effective advocacy tool for disseminating information on the vaccination to our target community, which may have allowed the field workers to reach out to families without access to other sources of information. This may also indicate the need to better understand the inter-personnel communication and community mobilization approach for future vaccination campaigns. For those with missed opportunities to receive the OCV doses during the two rounds, a mop-up vaccination can be considered, though it is often more laborious and costly, requiring a complex management (13). Further, informing the public on the availability of a mop-up prior to or during the campaign may negatively affect their participation in the regular vaccination schedule set-up. Hence, a mop-up was not considered after the first round in our approach but pursued after the second round in order to enhance the full two-dose vaccination and verify vaccination data records submitted during the regular program. Approximately 15.4% (32,775/212,824) of the delivered second doses were through this mop-up campaign indicative of an effective strategy.

The financial costs of OCV delivery per fully immunized person in this campaign was lower than delivery costs reported in other African countries using the same CholTool (US$1.8 in Shashemene district of Ethiopia; US$2.5 in Nsanje district of Malawi; and US$3.5 in Machinga, Phalombe, and Zomba districts of Malawi per the US$ price value of 2016), but closer to that reported in Puri district of India (US$1.14 per the US$ price value of 2016) (9). One reason could be that Mozambique has experience of conducting several OCV campaigns in recent years, and hence there were already resources and expertise available for micro-planning, communication, sensitization, trainings etc., which might have reduced the costs associated with introduction of vaccines in comparison to a vaccination program in naïve setting. The financial cost of US$0.60 per dose delivered (excluding vaccine procurement) is comparable to the operational support ranging between US$0.30 and US$0.80 per person targeted for vaccination campaigns, recommended by the Gavi, the Vaccine Alliance (15,16). This indicates the affordability of OCV campaign in the current setting. To economize the healthcare provider time and efforts and incentivize beneficiaries for greater uptake of vaccines, delivery of multiple products at vaccination posts or on household visits may potentially synergize the delivery cost associated with vaccination campaigns.

Overall, our study proved the feasibility of conducting a preemptive OCV mass vaccination campaign in a rural and semi-rural setting in Cuamba District and Cuamba Municipality areas respectively, with sufficient coverage rate and relatively lower delivery cost. The success of vaccination was a result of effective coordination and microplanning among stakeholders despite some field challenges. The vaccination strategy utilizing both fixed and mobile posts, as well as the daily feedback to the coordination team on the preliminary coverage survey result and data related to barriers and source of information on the vaccination campaign, proved valuable to prospectively refine the campaign and mobilization strategy every day on a real-time basis.

However, there are several limitations. First, the operational challenges concerning poor road conditions resulted in the accessibility to the target area difficult. Second, the programmatic support that required sufficient and trained human resources and budget for a sustained field monitoring activity and close on-site supervision prior to and during the vaccination campaign and coverage survey activities. Third, the differences in the coverage rates of administrative data and survey result is due to the lack of accurate up-to-date census data of local population. In addition, in order to avoid any conflict with the measles and rubella national immunization campaign that was taking place across the country at the time of this vaccination campaign, we had to delay our OCV vaccination campaign for about two months to obtain support from immunization-related stakeholders, particularly the expanded programme of immunization (EPI) for cold chain space and logistics. Any mass vaccination campaigns should also consider seasonality and other major community activities and/or any political issues.

**Acknowledgement**

The authors acknowledge the local government officials and healthcare professionals in Cuamba District, Niassa Province for engaging the community on the OCV vaccination program throughout the planning and implementation period. Thanks are also extended to the people who consented and took part in the coverage survey. We thank our research partners and staff at the MOCA sentinel site networks in Mozambique, and Ms. Somyoung Cho for the project management and Ms. Jihyun Han and Ms. Nozipho Manjate for the project administrative support.

**Contributorship**

S.E.P conceptualized the overall study design of the Mozambique Cholera Prevention and Surveillance (MOCA) project. C.S.B. supervised the MOCA project in Mozambique. N.S.B. supervised the overall vaccination campaign and monitoring and evaluation. All authors participated in the vaccination campaign. J.C., N.L, L.D.B., J.P.L., N.S.B., S.E.P., S.A., A.O., M.M., and the project field team in Cuamba and Niassa contributed to data acquisition on the community vaccination coverage surveys, and

interpretation of results under the supervision of N.S.B. R.B.J.M., J.A.M., S.A., A.O., M.M., and others in the vaccination teams of Cuamba District and Niassa Province contributed to acquisition, review, and report of the administrative coverage data. I.C. contributed to data acquisition and analysis on vaccination costs; and V.M. and C.V.R. reviewed the cost analysis. J.C. drafted and edited the paper under the scientific guidance from N.S.B. and S.E.P. All authors read and approved the final draft.

**Funding Statement**

This study was supported by the Korea International Cooperation Agency (KOICA), government of the Republic of Korea. The findings and conclusions are our own and do not necessarily reflect positions of the KOICA. The International Vaccine Institute acknowledges its donors, including the Government of Republic of Korea and the Swedish International Development Cooperation Agency (SIDA).

**Competing of Interests**

The authors declare no competing interests.

**Ethics approval**

Institutional Ethical Committee of the National Institute of Health (Ref: 116/CNBS/19) and ethical review board of the International Vaccine Institute, Seoul, Korea (IRB number 2017-006) approved the study protocol for the OCV mass vaccination campaign monitoring and coverage survey.

**Data sharing**

All data relevant to the study are included in the article.

**Figure legends**

**Figure 1. Pre-emptive OCV mass vaccination site**

Location of the pre-emptive OCV vaccination campaign site in Cuamba District, Mozambique, included bairros and povoados in the municipality and district.

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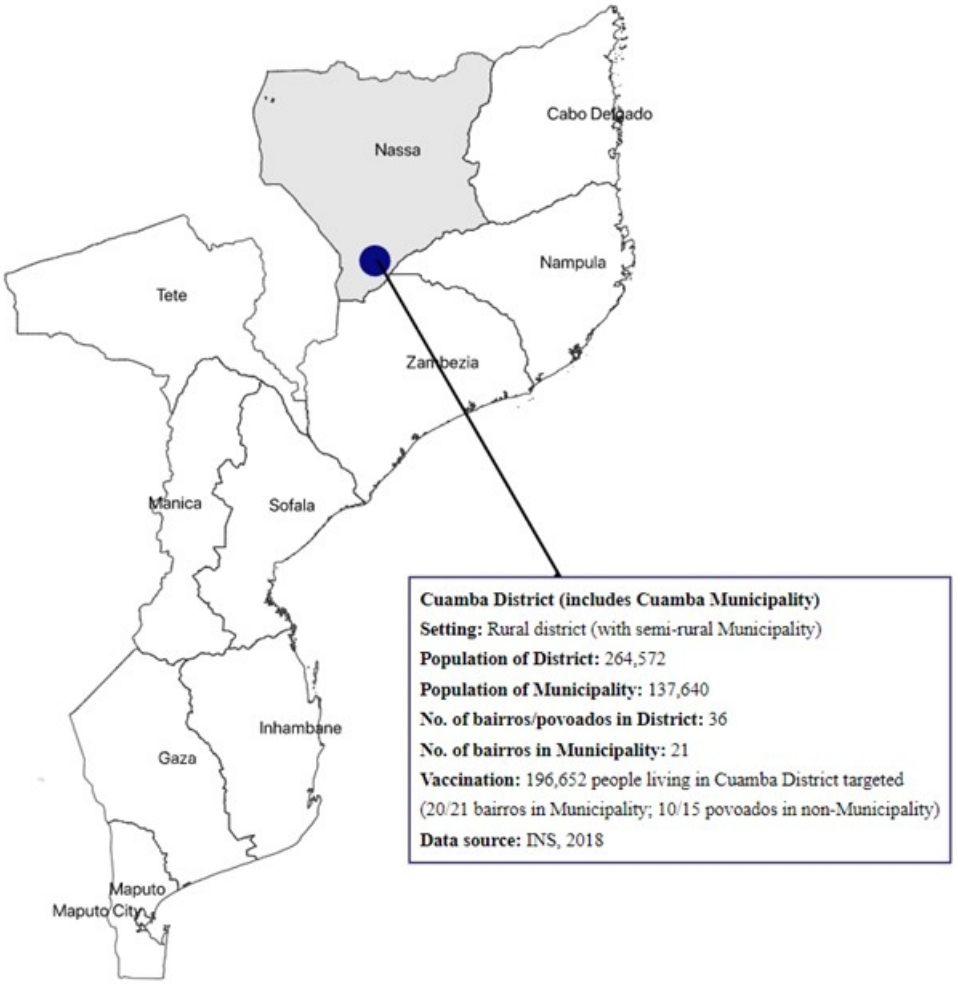


Figure 1. Pre-emptive OCV mass vaccination site

Location of the pre-emptive OCV vaccination campaign site in Cuamba District, Mozambique, included bairros and povoados in the municipality and district.

165x181mm (96 x 96 DPI)

# The Final Vaccine Coverage Estimation by Five Series of Quick Household Surveys for Monitoring of the Preventive Vaccination Campaign in Cuamba


Seoul, Korea
June 11, 2018

**Table of Contents**

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**Abbreviations**

| | |
|---|---|
| AE | Adverse Event |
| AEFI | Adverse Event Following Immunization |
| CFR | Case Fatality Rate |
| DRC | Democratic Republic of Congo |
| INS | Instituto Nacional de Saúde |
| IVI | the International Vaccine Institute |
| M&E | Monitoring and Evaluation |
| MOH | Ministry of Health |
| OCHA | the United Nations Office for the Coordination of Humanitarian Affairs |
| OCV | Oral Cholera Vaccine |
| PAHO | Pan American Health Organization |
| PPS | Probability Proportional to Population Size |
| PSU | Primary Sampling Unit |
| SAE | Serious Adverse Event (SAE). |
| SSU | Secondary Sampling Unit |

## 2 Introduction

Mozambique suffers from regular floods along its principal rivers, especially the Zambezi and Limpopo river basins, and also cyclones almost annually. An outbreak of cholera was first reported in Mozambique in the early 1970s, followed by several epidemics in 1997-1999 and 2012-2014. [1] In December 2014, another cholera outbreak was reported in the country, with an official outbreak declaration by the government in January 2015. The situation worsened with extensive flooding, which led to over 8,835 cholera cases including 65 deaths in five months. [2] International humanitarian organizations and UN agencies responded with emergency cholera treatments and care service in the affected areas, but the need to address the gap in preparedness and response activities were identified by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA).

In October 2016, a large scale OCV campaign was conducted in Nampula and neighborhoods regularly affected by cholera outbreaks. .

In 2017, the rainy season has been characterized by less frequent but heavier rains including the recent tropical cyclone, Dineo. Response to the cyclone together with other emergencies as well as a financial crisis has led to a dearth of human resources for response. Risk factors fueling cholera transmission include shortage of potable water, contamination of house water in cyclone-affected areas, and recurrent risk of flooding in high density populated areas, particularly in the most deprived areas. Between week 1 and 11, a total of 1,622 suspect cases and 3 deaths (CFR 0.2%) have been reported. Seventy fiver percent of cases came from Nampula and Tete provinces with 653 cases (40%) from Tete city during weeks 10 and 11 [3].

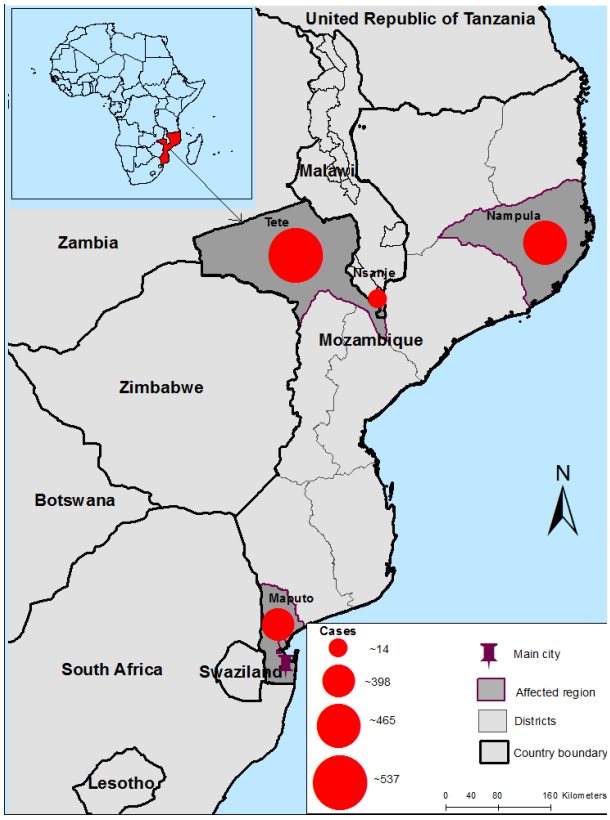
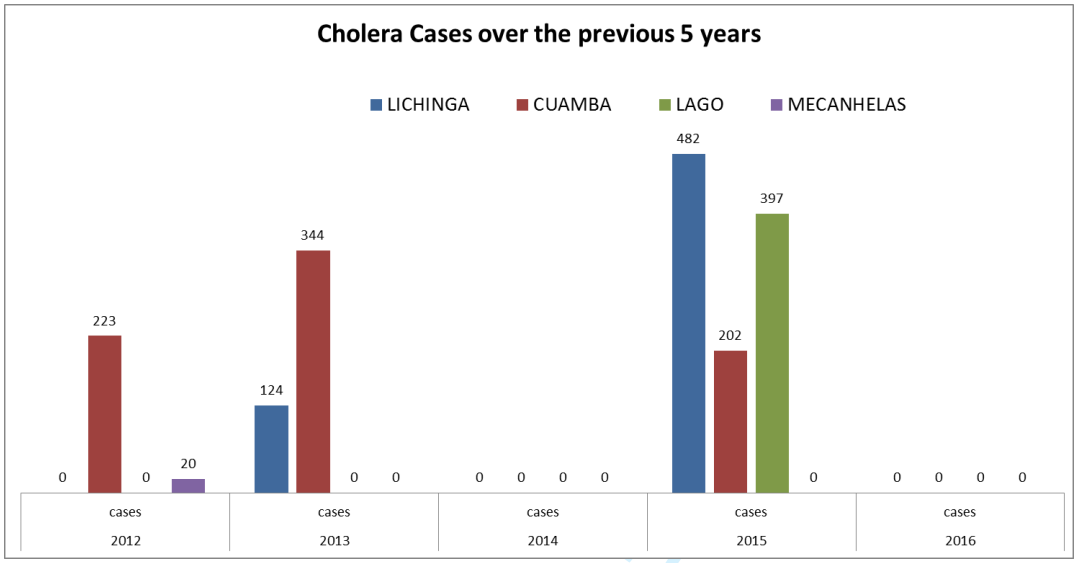



Figure 1. Geographical distribution of Cholera cases in Mozambique, 01 January - 15 March 2017 [4]

Coping with the outbreaks, the first round of reactive OCV campaign has been successfully conducted in Tete in June, 2017, which will be followed by the second dose immunization scheduled in Decembre.

Cuamba, an adjacent district to Nampula with an estimated population of over 300,000 inhabitants is considered as a cholera hot spot. As the district regularly experiences more than 200 suspect cholera cases per year except 2014 and 2016 the district will be targeted by IVI for a mass cholera vaccination campaign with supported by KOICA, followed by a cholera and diarrheal surveillance. With 180,000 individuals over the age of one year in the at-risk communities in the target area will benefit from receiving OCV (Euvichol®) hopefully before the rainy season.




The Rapid Coverage Monitoring strategy was designed by PAHO to provide local authorities with a quick impression of the completeness of vaccination [5,6]. Modifying the monitoring tool, Save the Children has invented a new monitoring tool which enables to estimate not only daily vaccination coverage and vaccination barriers, but also the final coverage. And its usefulness was proved during the period of preemptive 2016 yellow fever vaccination campaign in DRC [7].

## 3 Objectives

### *3.1 General Objective*

1) To provide support to MOH Mozambique to ensure successful and quality national OCV campaign

### *3.2 Specific Objectives*

- Evaluate the OCV vaccination campaign by estimation of final-day and post vaccination coverage
- Validate quick monitoring survey for estimation of final coverage
- Provide technical support to MOH Mozambique to ensure successful OCV campaign and quality data collection
- Build M&E capacity of MOH Mozambique ensuring quality vaccination campaign

- Increase vaccine coverage by feeding the vaccination team with daily vaccine coverage and barriers against cholera vaccination

## 4 Design

### *4.1 M&E activities during the Vaccination Campaign*

During the vaccination campaigns, daily vaccine coverage and barriers against vaccination will be closely monitored employing a close monitoring tool described in the implementation section. The monitoring results will be fed to the vaccination team to address any identified challenges on real time bases. The final vaccine coverage will be estimated at the last day of the campaign for the three age groups including 'aged between 1 and 4 years', '5 to 14 years' and 'more than 15 years' using 'measurement error approach' [Annex 2] by analyzing the monitoring and administrative data. Mop-up vaccination shall be considered in case where the coverage rate indicates too low.

## 5 Sample Size Estimation

### *5.1 M&E activities for the vaccination campaign*

In order to get the final vaccine coverage rate with reasonable precision (5%), we will conduct five series of independent assessment in the Cuamba district during the mass vaccination campaign day 1 to 5. Based on a confidence level of 95%, assuming 80% coverage and accounting for a design effect of 2, sample size requirements have been determined as follows in the table 1 for each of the three age groups: 1-4, 5-14 and 15+ years of age.

Sample size = $\frac{t^2 P(1-P) d_{eff}}{d^2}$

, where denotes t = t score, p = prevalence (or coverage), d = precision, and $d_{eff}$ =design effect

Table 1. the number of households reached for each age group*

| Age group | average household size | precision | Estimated coverage | Required sample size | Proportion among total population* | Average # of people / HH | required household | Household to be reached |
|---|---|---|---|---|---|---|---|---|
| 1-4 years | 6 | 0.05 | 0.8 | 535 | 14.0% | 0.8 | 637 | 650 |
| 5-14 years | 6 | 0.05 | 0.8 | 535 | 26.9% | 1.6 | 332 | 650 |
| 15 years or more | 6 | 0.05 | 0.8 | 535 | 55.9% | 3.4 | 160 | 650 |

In conclusion, total 650 households will be reached to get 550 children aged between 1-4 years. However for the age group for 5-14 years and 15+, who are available more than 1 for average household, the enumerators will identify only one for the specific age group from each household for survey by randomization. Upon failure of acquisition of survey consent, the enumerators are advised to skip the household but continue to the nearest next household until reach all 26 households per cluster.

## 6 Consent Process

* UNICEF country profile 2016

Data for the coverage survey will be obtained from an adult in the household, where adult is defined as the person aged +18 years or the parents (aged 15 years or more) of a child(ren). As the study is low risk, there will be no need for witness unless otherwise required by Institutional Review Board (IRB). Consent for the vaccination survey will take place at the home of individuals living in the target areas of the vaccination campaign before each survey. Residing in a target area for vaccination will make an individual eligible for each survey. The age at the vaccination campaign is considered for the eligibility for the survey by each age group. The consent and survey answers will be obtained from the household heads or the adult who is most knowledgeable about the household members' health whenever possible.

## 7 Study Implementation

**M&E activities for the vaccination campaign**

7.1.1 Daily monitoring of vaccine coverage and barriers

During the vaccination campaign, daily vaccine coverage, acceptability and barriers against the campaign will be closely monitored employing a close monitoring tool described below. The monitoring results will be fed to vaccination team to address any identified challenges on real time bases. The final vaccine coverage will be estimated at the last day of the campaign using 'measurement error approach' (Annex 2) by analyzing the monitoring and administrative data. Mop-up vaccination shall be considered in case where the coverage rate indicates too low.

7.1.1.1 Daily Vaccine Coverage with precision of ~10%, and Barriers against vaccination:

From Day 1 through Day 5, five community assessment teams are sent to the 5 clusters for each vaccination group, where each team randomly identify 26 households and collect data for 'daily vaccine coverage' and 'barriers' reaching daily total 130 households from 5 clusters households involving more than 110 individuals for each of two age groups: 1-4, 5-14 and 15+ years. Based on the collected data, the survey supervisor will estimate daily vaccine coverage rate and barriers from D1 through 5 and share the results with the vaccination team and stakeholders to improve vaccine coverage.

Data Collection:

Data for the community survey will be collected by trained surveyors and supervisors by direct interview with a questionnaire (Annex 1). A pilot will be conducted to test the questionnaire before the survey. Each questionnaire will collect information on a cluster of around 130 individuals for each age group. The aim of the questionnaire is to obtain information on the vaccination status of individuals, on the reasons for non-vaccination and on demographic characteristics that can be associated with vaccination.

Sampling Method for quick monitoring assessment:

The sampling method will be two stage cluster sampling to select localities (primary sampling units or PSUs) and households (secondary sampling units or SSUs). In each district 25 localities (villages or neighborhoods) will be selected, in which clusters of 26 households will be accessed. PSUs will be selected from the list of the villages in the districts (with information on the size of the target population) according to probability proportional to population size (PPS). Each day for the monitoring survey, 5 clusters are selected randomly out of the total 25 clusters identified by PPS so

as not to reach the same cluster/household during the vaccination campaign. In this way the number of clusters assigned to each locality will be based on the demographic weight of the village. The first household (SSU) in each cluster will be selected according to geographic random sampling: we will draft a map of the locality, divide it into smaller sectors according to existing divisions (streets, rivers, etc), and select one sector according to simple random sampling (SRS). We will continue dividing the selected sector until obtaining a sector with less than 20 households. In the finally selected sector, we will number each household and selected one randomly to start the survey. Once the interview will be completed in the household, we will move to the nearest the household to select the subsequent households. Out of the eligible persons in the household surveyed the enumerators are trained to select only one for each age group from each household by randomization, and an adult will be identified for assess the barriers.

If the survey subjects (children aged 1-4 years, 5-14 years or 15 or more) are not available, the enumerators are advised to move to the next households until reach 26 households.

The questionnaire is composed by three sections (Annex 1, survey questionnaire):

- Questions about vaccination status
  - How many eligible individuals (aged over one year) live in the household
  - Vaccinated: Yes/No for each eligible individuals
  - Vaccination card is available: Yes/No
  - Length of journey to the nearest health center:
- Questions about reasons for non-vaccination: pre-coded multiple choice
- Questions about the awareness of the campaign

Reason for non-vaccination:
Using the questionnaire the investigator will identify the major barriers against the mass vaccination campaign and its delivery and administration strategies, and feed the result to the vaccination coordination team.

7.1.1.2 Final Vaccine Coverage using monitoring and administrative data:

With the data of the daily vaccine coverage rate and cumulative vaccine consumption for each day, the final vaccination coverage is estimated using 'measurement error approach' as described in Annex 2 on assumption that the vaccine coverage rate is linearly correlated with the cumulative number of vaccine consumption.

7.1.2 Post vaccination coverage survey

The post vaccination survey will employ the same sampling method and questionnaire used for the daily monitoring while the post-vaccination survey will be conducted after the vaccination.

After the vaccination campaign has been completed, interview teams will be mobilized to visit homes in the target areas. Two interviewers make up a team and administer the surveys with the same questionnaire as used for daily monitoring survey. If the family is not home at the time when the interview team approaches a selected house, the team would attempt to re-visit that house later in the day.

A two-stage cluster sampling methods will be used to reach 650 households in which the clusters are selected first using PPS, and in a second stage, households are selected from within those clusters, which is used for the daily monitoring. Based on the collected data, the coverage rate is estimated by disaggregation by age: 1-4 years, 5 years or more.

### 7.1.3 Monitoring of AEFI (Adverse Events Following Immunization)

Passive AEFI surveillance system will be set up for monitoring of adverse events following immunization at the health facilities up to 14 days after the vaccination campaign. However at the same time for the women with overt pregnant sign in their 2nd and 3rd trimester, and those reporting pregnancy during the vaccination period, the contact details (phone number) will be collected to reach them for active monitoring of adverse events both for the women and possible pregnancy outcomes up to 14 days after the campaign.

## 8 Ethical considerations

For household survey, data will be treated confidentially and no personal identifiers (names) will be collected from the interviewees. Verbal informed consent will be asked from the responsible adults in the household before starting the survey. Considering that the household survey described in this proposal is a programmatic activity undertaken in the frame of the already advised guideline by international community as a package of mass vaccination program, only verbal consent will be obtained for the data collection from the households surveyed.

If only children are available in the household selected, the questionnaires will not be administered and the household will be revisited or excluded.
For monitoring of AEFI, a verbal consent will be obtained from the pregnant women before acquisition of the contact details (Inform Consent Form) as well. While obtaining verbal consent the team will explain the purpose of the survey and AEFI surveillance to the parents or guardians of potential participants, and pregnant women and answer any questions that may arise. Considering illiteracy, the team uses a witness for the information by word of mouth. The adults or guardians of potential participants, or pregnant women will be provided the opportunity to ask questions prior to offer verbal consent. Before providing the verbal consent, parents or guardians of potential participants, or pregnant women will be asked to undergo an informed consent process validation to ensure that they fully understand the purpose of the study, procedures, AEFI surveillance and their rights. They are also informed to withdraw consent at any time.

## 9 Data management Plan

All source of documents and electronic records of participants in this study will be paper-based and double-entered into the study database by dedicated data entry staff. All data will be secured in locked cabinets at the INS office. The electronic database will be password protected and study computers will be locked. The database will automatically be backed up onto local hard disks and external drives. Access to the electronic database and hard-copy data will be restricted to authorized senior study personnel only. Data entry and cleaning will be conducted at local sites.

If resources allow, a digital platform for collection of study information on portable tablets may be developed and utilized in this study. Data will be uploaded from all devices at the end of each day to the central database and backed-up to compensate instability of electricity supply together with keeping paper based data until completion of all data installation. Paper-based data collection will be continued until the quality of digital collection is well established.

## 10 Potential Risk and Mitigation Plan

While there are no direct individual risks from participation in the study, information will be collected that could be used to identify the patient. Although the study takes care to keep this

information confidential, there is a risk that information could be stolen or accidently released. All data related to the study will be kept on password-locked computers and only specified study staff will have access to the database where the information is stored.

The vaccination campaign might be delayed owing to slowness in acquisition of import permit, registration, procurement, transportation of the vaccine as well as seasonal challenges. To mitigate the expected challenges, the project team will work closely with the government officials with MOH and WHO country and HQ IHM teams as well as Joint Cholera Initiative for Southern Africa for expediting the vaccine registration and permission of utilization process. Also before commencement of the project, IVI will work closely with the manufacture of the vaccine and monitor the vaccine production and shipment.

## 11 Benefits of the study

Participation in the study will benefit the study population by being vaccinated against the V. cholerae which effects will last at least three years with reasonable efficacy. However the results of this study will benefit all populations at risk of cholera infection by improving the scientific understanding of the protection offered by vaccination and directing both preventative and reactive vaccine strategies. The pregnant women who provides contact details will be reached for monitoring of adverse events and guided for appropriate care at nearest health facility for any potential adverse events.

## 12 Fund

This M&E is a part of the MOCA project.

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# A pre-emptive Oral Cholera Vaccine (OCV) mass vaccination campaign in Cuamba District, Niassa Province, Mozambique: feasibility, vaccination coverage, and delivery costs using CholTool

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|---|---|
| Journal: | *BMJ Open* |
| Manuscript ID | bmjopen-2021-053585.R3 |
| Article Type: | Original research |
| Date Submitted by the Author: | 27-Apr-2022 |
| Complete List of Authors: | Elias Chitio, Jucunú J.; National Institute of Health<br>Baltazar, Cynthia; National Institute of Health<br>Langa, José Paulo; National Institute of Health<br>Baloi, Liliana Dengo; National Institute of Health<br>Mboane, Ramos B. J.; Provincial Directorate of Health, Provincial Directorate of Health<br>Manuel, José Alberto; Provincial Directorate of Health, Provincial Directorate of Health<br>Assane, Sadate; Provincial Directorate of Health, Provincial Directorate of Health<br>Omar, Alide; District Health Directorate, District Health Directorate<br>Manso, Mariana; District Health Directorate, District Health Directorate<br>Capitine, Igor; National Institute of Health<br>Van Rensburg, Craig; International Vaccine Institute<br>Luiz, Naira; National Institute of Health; International Vaccine Institute<br>Mogasale, Vittal; International Vaccine Institute, Policy and Economic Research<br>Marks, Florian ; International Vaccine Institute<br>Park, Se Eun; International Vaccine Institute; Yonsei University<br>Beck, Namseon; International Vaccine Institute; Medair Headquarters |
| Primary Subject Heading: | Global health |
| Secondary Subject Heading: | Infectious diseases, Health economics, Global health, Health policy |
| Keywords: | PUBLIC HEALTH, HEALTH ECONOMICS, INFECTIOUS DISEASES, PREVENTIVE MEDICINE, Infection control < INFECTIOUS DISEASES |
| | |

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# A pre-emptive Oral Cholera Vaccine (OCV) mass vaccination campaign in Cuamba District, Niassa Province, Mozambique: feasibility, vaccination coverage, and delivery costs using CholTool

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## Abstract

**Introduction:** Mozambique suffers from regular floods along its principal river basins and periodic cyclones that resulted in several cholera epidemics during the last decades. Cholera outbreaks in the recent five years affected particularly the northern provinces of the country including Nampula and Niassa provinces. A pre-emptive Oral Cholera Vaccine (OCV) mass vaccination campaign was conducted in Cuamba District, Niassa Province, and the feasibility, costs, and vaccination coverage assessed.

**Methods:** World Health Organization prequalified OCV (Euvichol-Plus), a killed whole-cell bivalent vaccine containing *Vibrio cholerae* O1 (classical and El Tor) and O139, was administered in two-doses with a 15-day interval during 7-31 August 2018, targeting around 180,000 people aged above one year in Cuamba District. Microplanning, community sensitization, and trainings of local public health professionals and field enumerators were conducted. Feasibility and costs of vaccination were assessed using CholTool. Vaccination coverage and barriers were assessed through community surveys.

**Results:** The administrative coverage of the first and second rounds of the campaign were 98.9% (194,581) and 98.8% (194,325) respectively based on the available population data that estimated total 196,652 inhabitants in the target area. The vaccination coverage survey exhibited 75.9% (±2.2%) and 68.5% (±3.3%) coverages for the first and second rounds, respectively. Overall, 60.4% (±3.4%) of the target population received full two-doses of OCV. Barriers to vaccination included incompatibility between working hours and campaign time. No severe adverse events were notified. The total financial cost per dose delivered was US$0.60 without vaccine cost and US$1.98 including vaccine costs**.**

**Conclusion:** The pre-emptive OCV mass vaccination campaign in remote setting in Mozambique was feasible with reasonable full-dose vaccination coverage to confer sufficient herd immunity for at least the

next three to five years. The delivery cost estimate indicates that the OCV campaign is affordable as it is comparable to Gavi's operational support for vaccination campaigns.

**Key words:** Cholera**,** OCV, pre-emptive vaccination, Cuamba, Mozambique, vaccination coverage survey, feasibility, vaccination cost

**Strengths and limitations of this study**

- This study has successfully demonstrated the feasibility of an OCV mass vaccination campaign in a remote setting in Mozambique.
- The cost of a mass vaccination campaign for the two-dose OCV administrations has been analysed for the first time in Mozambique, which can serve as a reference cost estimate when planning for any OCV vaccination programs in a similar setting in Mozambique or other countries.
- Vaccination coverage estimates may be affected if there are people movements in and out of the study area. A sub-study on this and a focused community engagement strategy to reduce the identified barriers to vaccination should be considered in future vaccination programs.
- Newly introduced vaccination monitoring/coverage survey engaging the same survey team enabled quick availability of the vaccination coverage during or immediately after the campaign, but at the same time the team could be overburdened.

## Introduction

Cholera is a vaccine preventable disease that remains as a major public health concern in many parts of low- and middle-income countries (LMICs). A comprehensive policy measure is warranted to control and prevent cholera including investments in improving infrastructure and knowledge, attitude, and behavior associated with water, sanitation, and hygiene (WaSH), strengthening health system, and adequate use of oral cholera vaccine (OCV) (1). In Mozambique, cholera has been endemic since the early 1970's when the first cholera outbreak was reported in the country. Several epidemics followed since then including the outbreaks in 1997-1999 and 2012-2016 (2, 3). Cholera outbreaks are more frequent in the country's northern provinces including Nampula, Cabo Delgado, Tete, and Niassa (4). Following the reinforcement of cholera outbreak response strategies, the Ministry of Health (MOH) of Mozambique has carried out several OCV mass vaccination campaigns, as recommended by the World Health Organization (WHO) as an integral part of a comprehensive strategy for cholera prevention and control in endemic setting along

with primary interventions of WaSH measures (5): Recent cholera outbreaks in these cholera endemic and hotspot areas in December 2015 resulted in the use of global OCV emergency stockpile to vaccinate approximately 212,745 people living in six neighborhoods of Nampula city in 2016 (4); and in April 2017, another 709,077 doses from the stockpile to vaccinate approximately 354,550 people in Tete City and Moatize and Mutarara districts, in response to the cholera outbreak with over 3,592 cholera cases.

In addition to these reactive vaccination campaigns supported by the WHO International Coordinating Group (ICG) on vaccine provision for cholera, a growing need for a preventive public health intervention using a targeted vaccination approach in cholera priority areas in-country was identified. The past records of numerous episodes of cholera epidemics in Mozambique have spotted at-risk districts in the most cholera endemic provinces such as Nampula (particularly Nampula City), Niassa (Lichinga city and Cuamba and Lago Districts), and Cabo Delgado (Pemba City and Ancuabe District), and to a lesser degree, other provinces and districts with limited sanitary conditions (5). Niassa province, one of the cholera endemic regions with annual cholera outbreaks affecting largely the Lichinga City and Lago and Cuamba Districts, was identified for a planned pre-emptive vaccine introduction to prevent subsequent cholera outbreaks. Cuamba District with an estimated population of 264,572 (6), reports over 200 suspected cholera and 2,000 diarrheal cases almost every year, with an exception of 2014 and 2016 (7). Here, we describe the feasibility, costs, and coverage estimates associated with a pre-emptive OCV mass vaccination campaign conducted in Cuamba District using two-dose OCVs (Euvichol-Plus) administered to approximately 180,000 people with a 15-day interval between the doses, as well as challenges of delivering healthcare in resource limited rural setting in Mozambique.

## Methods

### *Study site and population*

The Cuamba District is located in Niassa Province with a population size of around 264,572 (6). The site was selected for a pre-emptive OCV mass vaccination campaign as the district includes the Cuamba Municipality area where cholera is found to be endemic with periodic outbreaks. The area was also highlighted by the WHO as one of the priority sites to consider for a potential OCV intervention during a needs-assessment performed in September 2015 (1). The District of Cuamba is composed of a total 36 bairros and povoados with population size of approximately 264,572 (6), which includes 21 bairros in the Cuamba Municipality area with around 137,640 residents (8). In total, approximately 180,000 individuals living in Cuamba District was targeted initially, and ultimately around 196,652 people living in Cuamba District were targeted, which included 20 Bairros in the Municipality area and 10 Povoados in the outskirts of the Municipality area (Figure 1). Selection of bairros and povoados in the outskirts of Cuamba Municipality within the District was made not only based on the high number of doses destined for the target population in the municipality area, but also the records of cholera cases during the outbreaks. Everyone above one year of age were eligible for the two-dose OCV administration.

***Vaccine delivery, storage, and handling***

Approximately 360,000 doses of WHO pre-qualified Euvichol-Plus, a killed whole-cell bivalent OCV containing *Vibrio cholerae* O1 (classical and El Tor) and O139, were procured from the manufacturer (EuBiologics) and shipped to the entry port in Pemba, Mozambique in cold-chain. Upon arrival in Mozambique, the vaccines were delivered to Lichinga by airfreight and transported to a central vaccine storage room in Cuamba project site, and kept in refrigerators with temperature maintained within range between 2-8℃ until and throughout the campaign. The vaccine vial monitor (VVM) and electronic shipping indicators (Q-Tag) were used to monitor the temperature of the vaccines during delivery, storage, and handling. During the vaccination campaign, cool boxes with dry ice maintained within 2-8℃ were used to carry the vaccines to the vaccination posts.

***Cost of vaccine delivery***

An openly available, standardized and validated Excel-based tool known as the CholTool was used for estimating vaccine delivery costs (9). This tool comprehensively estimates programmatic costs such as microplanning, communication and training materials development, sensitization/social mobilization, and personnel training, as well as costs related to vaccine delivery such as vaccine procurement, handling, storage, and transport, vaccination administration, adverse events following immunization (AEFI) management, monitoring supervision, and field support. The CholTool has the ability to estimate both financial and economic costs. Financial costs refer to the monetary costs to the payer (e.g., allowances, supplies, transport, and resources used in micro-planning, training, and sensitization/social mobilization) while economic costs include financial costs along with non-monetary costs of donated goods and resources already available (e.g., health personnel time). Key informant interviews were conducted at various administrative levels before, during and after the vaccination campaign in order to identify the resources necessary for each vaccination related activity and costs of respective resources for each of the two rounds of vaccination. The resource and cost data were entered in CholTool which auto-calculates OCV delivery costs. The costs were reported in 2018 in United States Dollars (US$) based on government and payer perspective.

***Vaccination Strategy and microplanning***

A fixed post vaccination strategy with additional mobile teams was adapted for the microplanning of the vaccination campaign. The vaccination teams for 15 fixed posts and 33 mobile teams were identified and trained prior to the campaign. The fixed posts included existing healthcare facilities such as primary health centers and secondary and referral hospital, schools, market areas where many people have easy access to. The mobile teams were deployed to households remotely located with limited access to these fixed posts. This adopted mixed vaccination strategy aimed to improve quality, accessibility, and coverage. Each post was staffed with around 5 field workers including 2 health workers and 3 community engagement workers. Five days prior to the vaccination campaign, micro-plans for each cluster were

prepared with postal addresses, target populations, vaccination dates, teams, and other site-specific resources. The health workers obtained verbal informed consents from the individuals visiting the vaccination posts for the OCV administration. Pregnant women by self-report or infants below one year old were excluded from the vaccination. Vaccination cards and vaccination registry book were developed and deployed, specific to this vaccination that included variables such as name, age, address, and vaccination date. The collected data in the vaccine registry book were entered in an excel-based database. The number of doses planned and administered were also recorded daily for each rounds of the vaccination campaign.

***Vaccination, adverse event monitoring, and coverage estimate***

The vaccination campaign occurred in two rounds with a 15-day interval. The first round took place during August 7-11, followed by the second round during August 27–31, 2018. Provision was made for mop-up activities after the second round for those who missed the second dose. To detect any possible adverse events following immunization (AEFI) during and after the campaign, health workers were trained to monitor and notify any adverse events encountered in inpatient and outpatient admissions at Cuamba health facilities from the first day of each round throughout the 15 days after the last day of each round.

The vaccination coverage estimates were assessed in two-folds; administrative coverage and coverage surveys. The administrative coverage was recorded by the local government health office in charge of the vaccination campaign by tracking the number of vaccine doses administered compared to doses that had been planned in the vaccination target areas, at the end of vaccination activities every day during the two rounds of the OCV vaccination campaign. For the vaccination coverage surveys, around 520-650 households, subject to the vaccination schedule including the mop-up vaccination, were estimated to ensure more than 550 samples for each age group (1-4 years, 5-14 years, 15 years and above) assuming 80% coverage with a design effect of 2 to achieve around 5% of prevision. Sampled households were

organized per cluster; total 20-25 clusters with 26 households per cluster. The households were selected using a two-stage cluster random sampling methodology. Clusters (primary sampling unit) were selected from the list of villages in the Health Zones, according to the Probability Proportional to Population Size (PPS) and households (secondary sampling unit) were chosen randomly. For the household random sampling, the enumerators identified the center point and boundary of the survey target area and applied random selection of households. The surveyors were recruited based on their knowledge on the local area and level of education to conduct the survey, and trained on household sampling methodology, structured survey questionnaire, and process of conducting a survey interview, including verbal informed consent and data capturing on the paper-based survey questionnaires.

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Five survey teams were deployed to the predetermined clusters for daily vaccination monitoring, where randomly identified 26 households per cluster (5 clusters with total 130 households per day) were visited for 4-5 days (total 520-650 households) from the second or third day of the campaign until one day after the last vaccination day. This was applied for each round of the two-dose OCV vaccination campaigns. The information gathered through the survey on the vaccine uptake in the previous day, barriers against the vaccination, and the information source on the campaign were analyzed and fed daily to the vaccination campaign coordinators and supervisors in order to facilitate overall vaccine uptakes. During the second-round of campaign, the survey team collected data for the first-round coverage using the same questionnaire for monitoring, which enabled the first-round vaccine coverage available before the completion of the second round. After the second round, the enumerators continued the household survey for additional three days (total four days, including the last survey day for monitoring of the second round, which was one day after the mop-up campaign) to estimate the coverage for the second round and two full doses of vaccination.

***Patient and Public Involvement***

The vaccination campaign was conducted as a part of the government's public health intervention, approved by the Ministry of Health (MOH) in Mozambique. The participants in this study were people living in the cholera endemic and hotspot area, targeted for OCV vaccination campaign as an integral part of the government's cholera prevention efforts. The vaccination target population living in Cuamba District were sensitized and engaged, prior to and during the vaccination campaign, by the district and provincial health officials, study team that included the MOH and National Institute of Health government officials, and local public health professionals at healthcare facilities. The participants were provided with information on the planned OCV mass vaccination such as the purpose of pre-emptive vaccination and detailed information on where and when the vaccination campaigns were to take place. The vaccination campaign was also announced through various press and social media in Mozambique for public awareness and involvement. The study was conducted in a transparent manner with open communication and information sharing in the community, and participants to the OCV vaccination and vaccination coverage surveys were informed for oral consent. For children, consents were obtained from parents/guardian and all adult participants provided their own consent. The study did not present any risk of harm to subjects. No biological samples were collected. Minimum data was collected from participants, whereby privacy and confidentiality of the data were ensured during the survey implementation and data entry and management. Stakeholder meetings were conducted prior to, during, and after the vaccination campaign to further disseminate the campaign plan and results to the community members.

## Results

### *OCV vaccination coverage*

The administrative coverage of the first and the second rounds of the campaign were 98.9% (194,581) and 98.8% (194,325) respectively based on the available census data of vaccination target population in Cuamba Municipality and outskirts, estimated at around 196,652 (6) inhabitants (Table 1). A total of 194,581 people over one-year-old received the first dose, out of whom 99,275 were females and 122,592

were children aged less than 15 years. For the second round, total 194,325 people were vaccinated, including 99,275 females and 120,169 children less than 15 years old. Notably, the vaccination coverage survey conducted in the target community during each round and post-vaccination exhibited an approximate coverage estimates of 75.9% (95 CI, 78,10 - 73.70%) for the first round and 68.5% (71.80 - 65.20%) for the second round. The coverage rate for the full two-doses was estimated at 60.4% (63.80 - 57.00%), whereby the coverage of children aged 1-4 years was around 64.4 % (57.10 – 71.10%) (Table 1). The coverage rates in each round were higher in male (76.3% and 77.8%) than female (75.4% and 67.7%), but coverage rate of full doses was higher in female (64.4%) than male (57.3%). No adverse events were reported during and after the vaccination activities, monitored up to 14 days post-vaccination campaign.

**Table 1. OCV vaccination coverage estimates, Cuamba District, 2018**

**a) Administrative vaccination coverage rates**

| | | Number of people vaccinated (No.) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Day 1** | **Day 2** | **Day 3** | **Day 4** | **Day 5** | **Day 6** | **Total** |
| **1st Dose** | **Age (year)** | | | | | | | |
| Individuals vaccinated per age group | 1-4 | 6,493 | 9,283 | 12,394 | 12,506 | 7,691 | - | 48,367 |
| | 5-15 | 7,050 | 16,705 | 21,590 | 17,536 | 11,344 | - | 74,225 |
| | ≥15 | 10,136 | 12,400 | 18,835 | 18,798 | 11,820 | - | 71,989 |
| Total no. of daily vaccinated | | 23,679 | 38,388 | 52,819 | 48,840 | 30,855 | - | 194,581 |
| Cumulative no. of vaccinated | | 23,679 | 62,067 | 114,886 | 163,726 | 194,581 | - | |
| **Cumulative administrative coverage** | | **12.04%** | **31.56%** | **58.42%** | **83.26%** | **98.95%** | **-** | **98.95%** |
| **2nd Dose** | | | | | | | | |
| Individuals vaccinated per age group | 1-4 | 5,479 | 6,484 | 11,117 | 9,596 | 7,760 | 7,586 | 48,022 |
| | 5-15 | 9,355 | 8,796 | 15,679 | 13,208 | 14,444 | 10,665 | 72,147 |
| | ≥15 | 9,416 | 9,275 | 14,271 | 14,265 | 14,848 | 12,081 | 74,156 |
| Total no. of daily vaccinated | | 24,250 | 24,555 | 41,067 | 37,069 | 37,052 | 30,332 | 194,325 |
| Cumulative no. of vaccinated | | 24,250 | 48,805 | 89,872 | 126,941 | 163,993 | 194,325 | |
| **Cumulative administrative coverage** | | **12.33%** | **24.82%** | **45.70%** | **64.55%** | **83.39%** | **98.82%** | **98.82%** |

**b) Vaccination coverage rates through coverage surveys**

| | | **First Round** | **Second Round** | **Full Two Doses** |
|---|---|---|---|---|
| **Age (years old)** | 1- 4 | 81.1±4.5% | 72.2±6.9% | 64.4±7.3% |
| | 5-14 | 86.4±3.1% | 71.3±5.8% | 65.2±6.1% |
| | ≥15 | 67.6±3.3% | 65.2±4.8% | 55.7±5.0% |
| **Sex** | Male | 76.3±2.9% | 77.8±3.9% | 57.3±4.6% |
| | Female | 75.4±3.2% | 67.7±5.0% | 64.4±5.1% |
| **Total** | - | **75.9±2.2%** | **68.5±3.3%** | **60.4±3.4%** |

***Source of Information and Acceptability***

The source of information on the OCV vaccination campaign, identified by the populations living in the vaccination target areas, showed use of megaphone as the most effective tool in disseminating information on the vaccination plan and mobilizing the community to get immunized for both rounds: 24% and 34% at the first and second rounds respectively (Table 2). Around 15% of the surveyed people in the target community indicated that they have learnt about the vaccination campaign through radio broadcast for the first round, but its communication impact reduced in the second round (4%). This was different for the community leaders, whose contribution increased from 5% in the first round to 19% in the following round, reflecting their active engagement and communication efforts in close coordination with the vaccination teams on the ground.

**Table 2. Source of information on OCV campaign, Cuamba District, 2018**

| Source of information | 1st Round[1] N= 646 n (%=n/N) | 2nd Round[2] N= 578 n (%=n/N) |
|---|---|---|
| Megaphone | 152 (24%) | 195 (34%) |
| Family | 60 (9%) | 53 (9%) |
| Radio | 96 (15%) | 23 (4%) |
| Religious leader | 82 (13%) | 25 (4%) |
| Health workers | 74 (11%) | 120 (21%) |
| Activists | 55 (9%) | 9 (2%) |
| Community leader | 33 (5%) | 108 (19%) |
| TV | 14 (2%) | 11 (2%) |
| Others[3] | 78 (12%) | 33 (6%) |

Footnote:
[1] 1st round: 646 households/or people were interviewed.
[2] 2nd round: 578 households/or people were interviewed.
[3] Others included: list other source of info if such data were collected.

***Reasons for not being vaccinated***

The unavailability (absence) of the target population for vaccination and incompatibility between working hours and campaign schedule were commonly cited as barriers for vaccination in both the first (35%) and the second round (51%) (Table 3). Absence of vaccinators at the vaccination sites were also mentioned, 12% and 18% for the first and second round respectively, despite the pre-vaccination planning and programmatic organization. Notably, around 10% of the target population has indicated that they have not been informed about the vaccination campaign even in the second round, though this was a reduction compared to 18% in the first round. In order to address the most common barriers identified in the first round, the second round of the vaccination campaign was further extended for additional few days including the weekends, enabling more people to get vaccinated.

**Table 3. Reasons for non-vaccination during the OCV campaign, Cuamba District, 2018**

| Reasons for non-vaccination | 1st Dose | | 2nd Dose | |
|---|---|---|---|---|
| | n=361 | % | n=222 | % |
| Unavailable | 63 | 17% | 96 | 43% |
| Incompatibility between working hours and campaign time | 53 | 15% | 18 | 8% |
| Vaccination post without vaccinator | 40 | 11% | 41 | 18% |
| Did not have information | 66 | 18% | 23 | 10% |
| Ill during the vaccination period | 30 | 8% | 10 | 5% |
| Does not believe in vaccine efficacy | 24 | 7% | 2 | 1% |
| Afraid of adverse events | 8 | 2% | 0 | 0% |
| Head of the family did not authorize | 4 | 1% | 2 | 1% |
| Religious leader forbid | 2 | 1% | 0 | 0% |
| Considered not safe for pregnant women | 1 | 0% | 2 | 1% |
| Other | 70 | 19% | 28 | 13% |

***OCV delivery costs***

The total financial cost of campaign was US$768,904 of which vaccine acquisition including vaccine shipment constituted 69% (US$533,659) (Table 4). The vaccine delivery costs including, microplanning, training, communication, and social mobilization, vaccination implementation (Round 1 & 2) constituted rest 31% (US$235,245). The total financial cost per dose delivered was US$0.60 without the vaccine cost and US$1.98 including the vaccine costs in 2018 price. The economic cost per dose delivered excluding vaccine costs was five times higher at US$3.02. The total financial cost of delivery per fully immunized person excluding vaccine costs was US$1.21.

**Table 4. Costs of OCV vaccine delivery and immunization in Cuamba District**

| Vaccine Delivery Costs | Financial Cost (Mzn) | Economic Cost (Mzn) | Financial Cost (USD) | Economic Cost (USD) |
|---|---|---|---|---|
| Vaccine Acquisition | 32,179,644 | 42,081,073 | 533,659 | 697,862 |
| Microplanning | 640,415 | 7,596,625 | 10,620 | 125,981 |
| Training | 265,186 | 299,419 | 4,398 | 4,965 |
| Communication and Social Mobilization | 1,912,520 | 4,301,342 | 31,717 | 71,332 |
| Vaccination Implementation (Round 1 &2) | 11,367,160 | 58,510,806 | 188,510 | 970,328 |
| **Total** | **46,364,925** | **112,789,265** | **768,904** | **1,870,469** |
| **Immunization Costs** | **Financial Cost (Mzn)** | **Economic Cost (Mzn)** | **Financial Cost (USD)** | **Economic Cost (USD)** |
| Cost per Vaccine Administered (including vaccine) | 119 | 290 | 1.98 | 4.81 |
| Cost per Vaccine Administered (without vaccine cost) | 36 | 182 | 0.60 | 3.02 |
| Cost per Partially Immunized Person | 238 | 580 | 3.95 | 9.61 |
| Cost per Fully Immunized Person (with vaccine) | 239 | 580 | 3.96 | 9.63 |
| Cost per Fully Immunized Person (without vaccine) | 73 | 364 | 1.21 | 6.03 |

## Discussion

The OCV campaign in Cuamba District was organized without major logistical and programmatic challenges, and no adverse events were reported throughout the vaccination activities and up to 14 days after the campaign. Despite the similarity in the number of people vaccinated in the first and second rounds, the vaccination coverage survey of the second round showed lower coverage estimates than the first round. This may be due to possible cross border movement of people from untargeted districts to get vaccination during the second round. The vaccination coverage for the full two-doses was over 60% that may confer sufficient herd immunity for the following several years based on the existing literature on a cholera transmission model using the Matlab data from Bangladesh (10,11), which predicted 50% coverage with OCV in cholera endemic areas may result in 89% reduction in cholera cases in unvaccinated (12).

In our study, children aged 5-14 years exhibited the highest coverage. This may be due to the vaccination posts in both schools (fixed vaccination post) and near homes (mobile vaccination posts), which facilitated the school-aged children to access the immunization health service more easily. The female group also presented higher full vaccination coverage rate compared to the male group, who showed higher drop-out after first dose, likely associated with their routine boundaries of livelihood near their houses or their child/children's schools as they take care of children while the male group typically work outside. This assumption is supported by the fact that the absence during the campaign was identified as a significant barrier against vaccination during both rounds of the campaign. Similar pattern was consistently prevalent in the previous OCV campaigns in Beira (13) and Nampula (4), whereby absence was the main barrier for vaccination. The second round of the campaign coincided with the period of school holidays when most households move to farming and food production, resulting in higher absence rate in the second round (43.0%) than in first round (17.0%). Further, it is encouraging to observe more than 60% vaccination coverage rate among children aged 1-4 years, the most at-risk population age-group concerning cholera outbreaks. Considering that caregivers for these younger children are mostly women,

higher vaccination coverage for these toddlers and younger children and women is as anticipated in accordance with other studies published in similar settings (14).

For real time monitoring of the OCV vaccination campaign, the researchers have employed a representative sampling (two stage cluster sampling) instead of conventional convenient sampling, where the new approach assessed only 1/5 of the predetermined households and demanding five days reaching full households for optimal precision. This new approach has several advantages including 1) availability of representative daily coverage, and barriers, which were fed to the coordination team on a real time bases despite limited precision, 2) the first round vaccine coverage became available before the end of the second round, and finally 3) the vaccine coverage was available immediately after each round without a separate post vaccination coverage survey using 'measurement error approach (15)' (the details have not been discussed here, but in a separate article currently under development). Again, the second and full dose vaccine coverage were estimated within a week after the campaign by extension of the survey days by three more days. However, the survey extension and additional questions for the final coverages (the first, second and full) made some survey team members exhausted, which might have affected survey quality.

In order to enhance the vaccination coverage, it is paramount to better understand the effective means of communications for community sensitization and engagements, as well as barriers towards participating in a vaccination program such as this campaign. Here, we showed that the use of megaphone proved to be the most effective advocacy tool for disseminating information on the vaccination to our target community, which may have allowed the field workers to reach out to families without access to other sources of information. This may also indicate the need to better understand the inter-personnel communication and community mobilization approach for future vaccination campaigns. For those with missed opportunities to receive the OCV doses during the two rounds, a mop-up vaccination can be considered, though it is often more laborious and costly, requiring a complex management (13). Further,

informing the public on the availability of a mop-up prior to or during the campaign may negatively affect their participation in the regular vaccination schedule set-up. Hence, a mop-up was not considered after the first round in our approach but pursued after the second round in order to enhance the full two-dose vaccination and verify vaccination data records submitted during the regular program. Approximately 15.4% (32,775/212,824) of the delivered second doses were through this mop-up campaign indicative of an effective strategy.

The financial costs of OCV delivery per fully immunized person in this campaign was lower than delivery costs reported in other African countries using the same CholTool (US$1.8 in Shashemene district of Ethiopia; US$2.5 in Nsanje district of Malawi; and US$3.5 in Machinga, Phalombe, and Zomba districts of Malawi per the US$ price value of 2016), but closer to that reported in Puri district of India (US$1.14 per the US$ price value of 2016) (9). One reason could be that Mozambique has experience of conducting several OCV campaigns in recent years, and hence there were already resources and expertise available for micro-planning, communication, sensitization, trainings etc., which might have reduced the costs associated with introduction of vaccines in comparison to a vaccination program in naïve setting. The financial cost of US$0.60 per dose delivered (excluding vaccine procurement) is comparable to the operational support ranging between US$0.30 and US$0.80 per person targeted for vaccination campaigns, recommended by the Gavi, the Vaccine Alliance (16,17). This indicates the affordability of OCV campaign in the current setting. To economize the healthcare provider time and efforts and incentivize beneficiaries for greater uptake of vaccines, delivery of multiple products at vaccination posts or on household visits may potentially synergize the delivery cost associated with vaccination campaigns.

Overall, our study proved the feasibility of conducting a preemptive OCV mass vaccination campaign in a rural and semi-rural setting in Cuamba District and Cuamba Municipality areas respectively, with sufficient coverage rate and relatively lower delivery cost. The success of vaccination was a result of effective coordination and microplanning among stakeholders despite some field challenges. The

vaccination strategy utilizing both fixed and mobile posts, as well as the daily feedback to the coordination team on the preliminary coverage survey result and data related to barriers and source of information on the vaccination campaign, proved valuable to prospectively refine the campaign and mobilization strategy every day on a real-time basis.

However, there are several limitations. First, the operational challenges concerning poor road conditions resulted in the accessibility to the target area difficult. Second, the programmatic support that required sufficient and trained human resources and budget for a sustained field monitoring activity and close on-site supervision prior to and during the vaccination campaign and coverage survey activities. Third, the differences in the coverage rates of administrative data and survey result is due to the lack of accurate up-to-date census data of local population. In addition, in order to avoid any conflict with the measles and rubella national immunization campaign that was taking place across the country at the time of this vaccination campaign, we had to delay our OCV vaccination campaign for about two months to obtain support from immunization-related stakeholders, particularly the expanded programme of immunization (EPI) for cold chain space and logistics. Any mass vaccination campaigns should also consider seasonality and other major community activities and/or any political issues.

**Acknowledgement**

The authors acknowledge the local government officials and healthcare professionals in Cuamba District, Niassa Province for engaging the community on the OCV vaccination program throughout the planning and implementation period. Thanks are also extended to the people who consented and took part in the coverage survey. We thank our research partners and staff at the MOCA sentinel site networks in Mozambique, and Ms. Somyoung Cho for the project management and Ms. Jihyun Han and Ms. Nozipho Manjate for the project administrative support.

**Contributorship**

S.E.P conceptualized the overall study design of the Mozambique Cholera Prevention and Surveillance (MOCA) project. C.S.B. supervised the MOCA project in Mozambique. N.S.B. supervised the overall vaccination campaign and monitoring and evaluation. All authors participated in the vaccination campaign. J.C., N.L, L.D.B., J.P.L., N.S.B., S.E.P., S.A., A.O., M.M., and the project field team in Cuamba and Niassa contributed to data acquisition on the community vaccination coverage surveys, and interpretation of results under the supervision of N.S.B. R.B.J.M., J.A.M., S.A., A.O., M.M., and others in the vaccination teams of Cuamba District and Niassa Province contributed to acquisition, review, and report of the administrative coverage data. I.C. contributed to data acquisition and analysis on vaccination costs; and V.M. and C.V.R. reviewed the cost analysis. J.C. drafted and edited the paper under the scientific guidance from N.S.B. and S.E.P. All authors read and approved the final draft.

**Funding Statement**

This study was supported by the Korea International Cooperation Agency (KOICA), government of the Republic of Korea. The findings and conclusions are our own and do not necessarily reflect positions of the KOICA. The International Vaccine Institute acknowledges its donors, including the Government of Republic of Korea and the Swedish International Development Cooperation Agency (SIDA).

**Competing of Interests**

The authors declare no competing interests.

**Ethics approval**

Institutional Ethical Committee of the National Institute of Health (Ref: 116/CNBS/19) and ethical review board of the International Vaccine Institute, Seoul, Korea (IRB number 2017-006) approved the study protocol for the OCV mass vaccination campaign monitoring and coverage survey.

**Data sharing**

All data relevant to the study are included in the article.

**Figure legends**

**Figure 1. Pre-emptive OCV mass vaccination site**

Location of the pre-emptive OCV vaccination campaign site in Cuamba District, Mozambique, included bairros and povoados in the municipality and district.

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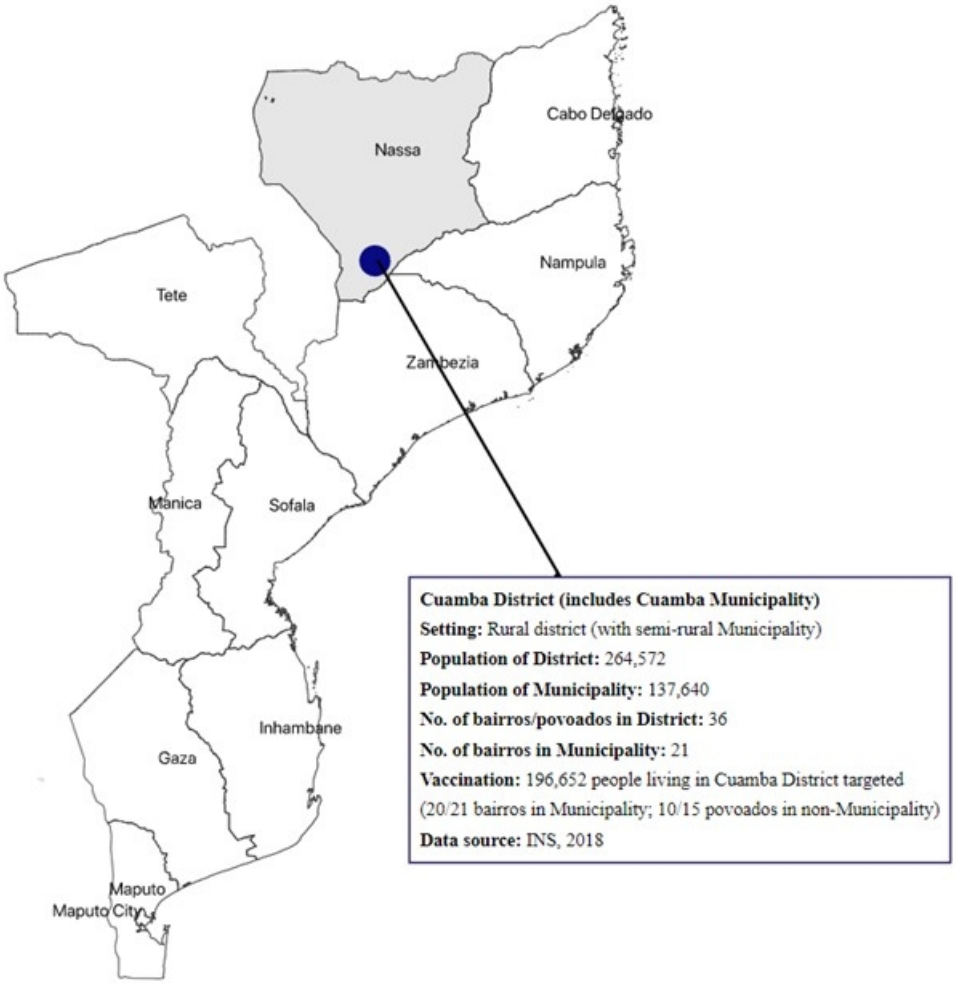


**Figure 1. Pre-emptive OCV mass vaccination site**

Figure 1. Pre-emptive OCV mass vaccination site

Location of the pre-emptive OCV vaccination campaign site in Cuamba District, Mozambique, included bairros and povoados in the municipality and district.

165x181mm (96 x 96 DPI)