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ORIGINAL ARTICLE

# Feasibility of a preventive mass vaccination campaign with two doses of oral cholera vaccine during a humanitarian emergency in South Sudan

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**Background:** As an adjunct to cholera prevention measures, WHO advises the use of oral cholera vaccine through mass vaccination campaigns in high-risk areas and for vulnerable population groups. We assessed the feasibility and acceptability of a mass vaccination campaign using 1) a predominantly fixed and 2) a mobile door-to-door strategy.

**Methods:** Vaccination included administration of two doses (given 2 weeks apart) of oral cholera vaccine to individuals older than 1 year of age, in four refugee camps: Jamam, Doro, Batil and Gendrassa, and the host population in Maban County, South Sudan, from December 2012 to February 2013.

**Results:** A total of 258 832 doses were administered to a population of 166 000 (126 000 refugees and 40 000 host population). The first round coverage for the refugees was above 84% for Doro, Jamam and Batil and 104% for Gendrassa. The second dose reached the same coverage as the first dose. For the host population, the coverage for the first dose was above 90% in Doro and Jamam and 53% in Gendrassa and Batil. For the second round, the coverage was above 79% in Doro and Jamam and above 70% in Batil and Gendrassa.

**Conclusions:** The vaccination of a large population in an emergency context proved to be feasible and acceptable and achieved high coverage. This is encouraging and is a way forward for reducing cholera related morbidity and mortality among vulnerable populations.

**Keywords:** Oral cholera vaccine, Preventive mass vaccination campaign, Refugee camps, South Sudan

## Introduction

Cholera is an acute diarrheal disease, caused by the bacteria *Vibrio cholerae*; in severe cases it can lead to death from dehydration and/or shock. In addition to appropriate clinical management for suspected cholera cases, improvements in water and sanitation facilities and community mobilization, WHO also advises the use of oral cholera vaccine (OCV) through mass vaccination campaigns (MVCs) in vulnerable population groups and in high-risk areas for cholera.[1] There are currently two WHO pre-licensed OCVs available: Dukoral (Crucell, Leiden, Netherlands) and Shanchol (Shantha Biotechnics Ltd., Basheerbagh, Hyderabad, India). Both vaccines are given as two doses (7 and 14 days apart respectively) and both require cold chain for transport. They are safe and effective for a limited period of time.[1]

Outbreaks of cholera in refugee populations can have dramatic impacts in terms of mortality and morbidity. Large-scale outbreaks have been documented among Rwandan refugees in the Democratic Republic of Congo in 1994,[2] in refugee camps in South Sudan in 2007[3] and among Somali refugees in Kenya in 2009.[4] Preventative cholera MVCs have so far been limited or restricted to small-scale interventions[5–9] and their use still debated. OCV has also been used in a preventative way in a complex emergency (Aceh, Indonesia in 2005) and in an internally displaced person camp (Darfur, Sudan, 2004).[10]

Since November 2011, Médecins Sans Frontières (MSF) have provided primary and secondary health care to an estimated 115 058 refugees and the surrounding host population (33 546 individuals) in Upper Nile State, South Sudan.[11] The population is divided over four camps: Jamam, Batil, Gendrassa and Doro (Figure 1).

Cholera is endemic in South Sudan with annual outbreaks of acute watery diarrhea reported between 2006 and 2012 in different areas of the country.[12–15] In July 2012, MSF, WHO and the Ministry of Health conducted a risk assessment for the potential impact of the introduction of cholera into the refugee camps in Maban County. It was determined that the risk was high due to a high intensity of transport of goods and traffic in the area. The

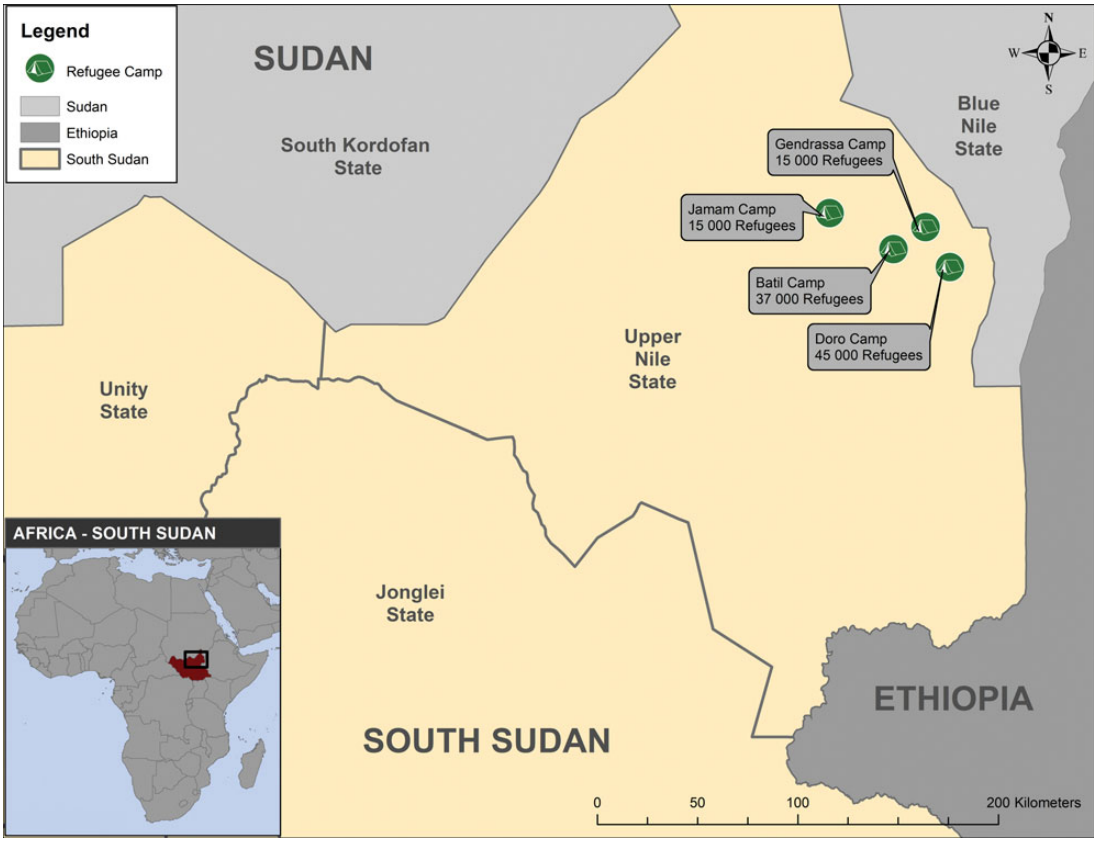


**Figure 1.** Map of the four refugee camps in the oral cholera vaccine (OCV) vaccination campaign, Maban County, South Sudan, December 2012 to February 2013. This figure is available in black and white in print and in colour at Transactions online.

population was also found to be highly vulnerable to cholera due to their fragile health status and the inadequate water and sanitation conditions in the camps. This high perceived risk for a cholera outbreak in Maban County led to an agreement with the Ministry of Health in September 2012 to conduct a mass vaccination campaign with OCV (Shanchol) in the four refugee camps and their surrounding host populations.

Here, we report on the modus operandi of this MVC which, to date, is the largest preventative OVC campaign implemented during a humanitarian emergency. We also describe the logistic and resource requirements related to two different vaccine delivery strategies used during the campaign: 1) predominantly fixed and 2) mobile/door-to-door.

## Methods

The vaccination campaign started on 27 December 2012 and ended on 7 February 2013. The campaign was conducted in two rounds in order to administer two doses to recipients.

### Target population and exclusion criteria

We targeted the refugee population living in the four refugee camps and their surrounding host communities. The criteria to include the host population were related to their proximity and intense contact with the refugee camps' population or their presence in the main markets. The total population in Maban County at the time of vaccination was estimated to be 149 104 individuals. As OCV is developed for all individuals >12 months of age, 96.2% (143 438/149 104) of the total population was included as the target population.

The exclusion criteria for vaccination were children <12 months and individuals who were visibly ill at the time of vaccination or who were excluded on the basis of medical advice. In these latter cases, excluded individuals were given the opportunity to receive the vaccination at a later stage at any of MSF's healthcare facilities. Pregnant women were included in the vaccination campaign.[16]

### Vaccine procurement

As two doses of OCV should be administered, 350 650 doses were ordered (=2×143 438 target population+10% additional buffer). The vaccines arrived in insulated boxes weighing 140 kg per box, each containing 12 600 vaccines. Each vaccine vial was equivalent to one dose and had a volume of 16.8cm$^3$. Vaccines were ordered directly from the manufacturer Shantha Biotechnics Ltd. (Basheerbagh, Hyderabad, India). All vaccines were air freighted into Maban County due to the remoteness of this location in South Sudan.

## Cold chain management

The Shanchol vaccine is determined to be medium stable for heat exposure and has a Vaccine Vial Monitor (VVM) 14, meaning that it can be kept for a period of 14 days at 37°C. The vaccines were transported in cold boxes and stored in refrigerators (2–8°C). Temperature control monitors were implemented in all the refrigerators in order to maintain the cold chain. On the day of vaccination, controlled temperature chain (CTC) was applied. In Jamam, Gendrassa and Batil all vials required for one round of vaccination were stored in cold boxes without ice-packs inside. In Doro, all vials were stored in normal buckets without ice packs. These were replenished twice a day with vaccines. Finally all VVMs on vials were checked before administration to ensure the stability of the vaccine.

## Vaccination strategies and teams

We employed two vaccination strategies: 1) a predominantly fixed strategy with outreach points in markets and in the periphery of the camps and 2) a mobile door-to-door strategy. These are summarized in Table 1. In both strategies, the teams were composed of community members (community workers and volunteers from other NGOs). Each team received theoretical and practical training with a session on how to conduct the vaccination.

The predominantly fixed strategy was used in Gendrassa, Jamam and Batil. In each camp we established nine vaccination teams at fixed points. The most suitable location was decided together with the community leaders and the health authorities. Outreach vaccination activities (with smaller mobile teams) were organized to reach peripheral populations, the main markets and individuals unable to walk to the fixed vaccination points (e.g. the elderly). A vaccination card, which was issued during the first round, had to be presented by each person when seeking the second dose of vaccine. With this card there was an additional voucher for soap distribution after the administration of the second dose. The host population was vaccinated using the mobile door-to-door strategy.

The mobile door-to-door strategy was used in Doro for both the refugee and host population. As there were no fixed vaccination sites, the number of teams was decided based upon the size of the target population. In total, 57 teams of three people were deployed during the vaccination campaign. No vaccination cards were used in this strategy based on previous experience showing that cards are often lost during, between or after the vaccination campaign. Furthermore, we believed that their use would reduce the simplicity and speed of the mobile door-to-door strategy. In this strategy, the refugee population did not receive soap with the administration of the second dose as these were already included in the weekly kit distributed for camp residents. Vaccine recipients from the host community received a bar of soap after each dose.

## Social communication and mobilization

Social mobilization started 1 week before the first round and a small reminder was distributed several days before the second round (Table 1). Contacts with the community leaders as well with other NGOs and health authorities were established in order to use all possible communication channels. The information shared included the rationale behind the vaccination, basic information about cholera and standard precautions such as hygiene practices, as well as information about the vaccine, the target group, the importance of the two doses regime and the vaccination card, the immunization strategy and the side effects.

**Table 1.** Logistics and resource requirements related to a predominantly fixed and mobile strategy for mass oral cholera vaccination for refugees, Maban County, South Sudan, December 2012 to February 2013

| | Predominantly fixed strategy | Mobile strategy: door-to-door |
|---|---|---|
| Vaccination locations | Jamam, Batil, Gendrassa | Doro |
| Population type | Refugee and host | Refugee and host |
| Vaccination points | Fixed sites plus mobile outreach | Mobile |
| Vaccination card | Yes | No |
| Soap voucher | Yes | Only for host population |
| No. of vaccination sites | 9 per location | NA |
| No. of vaccination teams | 9 per location | 57 |
| No. of vaccinators | 184 (92 per location)[a] | 386[b] |
| Supervision | One medical supervisor per team | One supervisor for each 3–4 teams |
| Team composition | NGO staff and community health workers | NGO staff and community health workers |
| Cold chain (CTC) | Cold boxes, no ice packs | Regular buckets, no ice packs |
| Social mobilization | T-shirts, banners, verbal messages | Verbal messages |

CTC: controlled temperature chain; NA: not applicable.
[a] Part of the fixed team was performing outreach activities.
[b] Different team composition according to the location to vaccinate.

### Coverage data, adverse effect reporting and financial estimates

In both strategies, data was collected on a daily basis using vaccination site tally sheets. These sheet listed information on the number of individuals vaccinated by age group and gender. This data was entered daily into an Excel spreadsheet (Microsoft Excel 2010, Microsoft Corporation, Redmond, WA, USA) in order to calculate daily administrative coverage numbers based on available population data. Using the daily statistics, the delivery strategies and the team allocations were reviewed to better target the areas reporting unsatisfactory vaccination coverage. For the predominantly fixed strategy, the data from round one was also used to change the planning for the second round, such as increasing team's capacity at the busiest vaccination sites from round one or the re-prioritization of resources to certain larger villages.

In order to monitor adverse effects, each vaccination team was able to record any observed adverse effects in recently vaccinated individuals. Additionally, we established reporting of adverse effects from vaccination at all health facilities in Maban County.

Following the campaign we tried to estimate the costs per vaccinated individual by calculating the cumulative costs of vaccines and human and logistical resources. The total expenses were divided by the total number of vaccinated individuals in the campaign.

## Results

### Vaccination coverage

Across all four refugee camps, 130 560 individuals were vaccinated during the first round of vaccination and 128 365 individuals were vaccinated during the second round (Supplementary data). Taking into account the available population data, this translated to a first round vaccination coverage for the refugee population of above 84% in Doro, Jamam and Batil and 104% in Gendrassa. The second dose achieved the same coverage as the first dose. For the host population, the vaccination coverage for the first dose was above 90% in Doro and Jamam and 53% in Gendrassa and Batil. For the second round, the coverage was above 79% in Doro and Jamam and above 70% in Batil and Gendrassa (Figure 2). The results of the vaccination coverage survey will be communicated elsewhere.

### Logistic and human resource requirements for both vaccination strategies

Each team in the mobile door-to-door strategy vaccinated between 500–700 individuals per day, while in the predominantly fixed strategy an average of 250 individuals per hour received OCV at each vaccination site. The mobile door-to-door strategy required a higher number of people for implementation (386 individuals) compared to the predominantly fixed strategy which required 184 individuals. However in the mobile door-to-door strategy the teams worked 12 days (6 days each round) compared to the teams in the predominantly fixed strategy who worked approximately 29 days for the two rounds.

The average cost per dose administered ranged from €3.32 for the mobile door-to-door strategy to €4.68 for the predominantly fixed strategy. These cost estimates exclude the costs for international staff. The main costs were attributed to the purchase of the vaccines (€1.5/dose), the transport to difficult to access areas of Maban County (air freight for the majority of supplies) and the cold chain hardware. The cost per person vaccinated varies from €7–€9. The difference in cost estimates between strategies might be due to the existing availability of cold chain materials for the mobile door-to-door strategy, as well as the reduced transportation costs in this strategy as the target population was lower (therefore less vaccines needed to be transported).

In the predominantly fixed strategy, the choice was made to use a card in order to confirm the vaccination status during the coverage survey. Vaccination cards did not include the individual's name, only their age and gender, therefore during the second round matching cards to the correct individuals was a challenge. Also several individuals lost their cards between rounds and there were misunderstandings about what the vaccination card was and what the soap voucher was. In the mobile door-to-door strategy the vaccination card was not used resulting in less logistical burden on the mobile teams. The risk of double counting was limited as the tally sheet reporting how many people were vaccinated in a tent during the first round was used during the second round matching the number of individuals per tent.

### Reported adverse effects of OCV

Adverse effects were reported by 471/258 832 (0.18%) individuals, mainly during the first round. All the adverse effects were of a minor nature such as nausea, vomiting, abdominal pain and diarrhea. Thirty-five percent of individuals reporting adverse effects sought care in the health centers and two people required hospitalization for dehydration. The majority of the adverse effects occurred in women (71.3%, 102/143) and in the age group of 15–49 years old (47.1%, 67/142).

### Logistic constraints

Some cold chain ruptures were reported due to freezing and therefore 7350 vials were lost. One batch of vaccine doses arrived in styrofoam trays and some vials in this tray demonstrated an unusual change of VVM; the Shanchol vaccine has a VVM 14. This means that the vaccine has a medium stability for heat exposure: it can be kept for a period of 14 days at 47°C and 90 days at a temperature of 25°C. VVM at level 1 is the starting point: the vaccine is useable if the expiry date has not passed. It turns from level 1 to level 2 when the vaccine is exposed to heat but it can be used. The VVM turns from level 1 to level 4 when the endpoint is exceeded and the vaccine cannot be used anymore. The VVM changed to level 4 in the part of the vial that was outside the Styrofoam tray while the bottom part of the VVM remained at level 2. Due to the unusual change in the VVM and the indication of the level 4 which means that the vials reached their end point, these vaccines were not used. All vaccines displaying this VVM composition were discarded and destroyed.

The existing OCV vial has a metallic cap which is not user friendly to open. It requires the use of scissors and during the vaccination campaign this slowed down the process. To make the

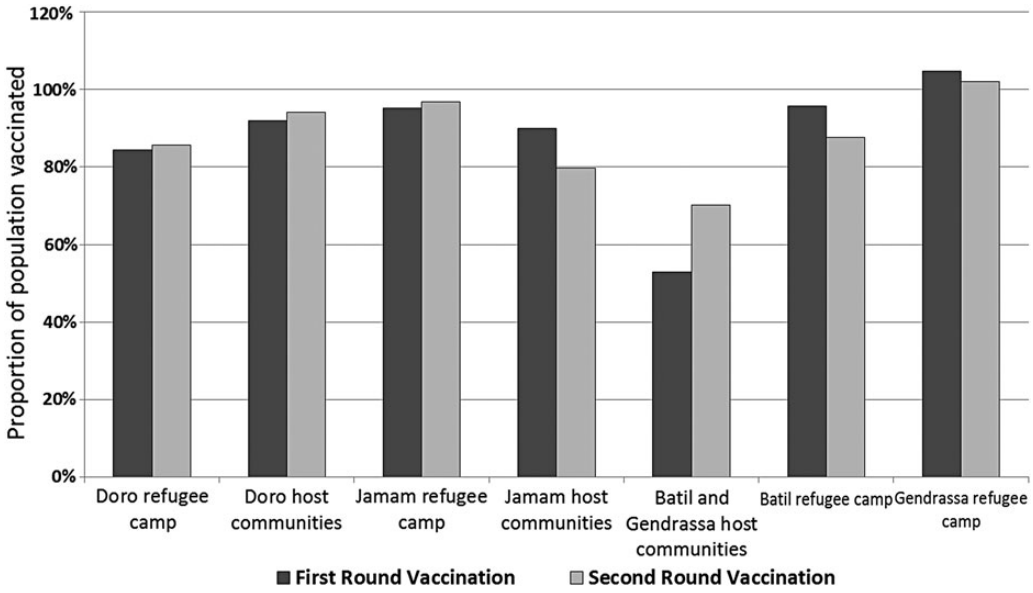


**Figure 2.** Administrative coverage of refugee camps and host populations during the oral cholera vaccine (OCV) vaccination campaign in Maban county, South Sudan, December 2012 to February 2013.

vaccination process smooth and fast, one person in each team was in charge of opening the vials. In addition, the single dose vial occupies a large storage volume in the cold chain. This results in the need for high storage capacity (with cold chain) for mass vaccination campaigns which is not always achievable in humanitarian emergency settings.

## Discussion

This vaccination campaign demonstrated that a MVC with two doses of OCV is feasible in closed settings at high risk of cholera introduction. Since the vaccination campaign was conducted, no suspected cases of cholera have been reported in the refugee and host populations in Maban County. This in itself is not evidence that the vaccination campaign has been effective in preventing cholera introduction.

There was a high vaccination acceptance among the refugee population and they were eager to reach the fixed sites to receive the vaccine. In contrast, in the host population the door-to-door (mobile strategy) approach was better adapted to the context. The two different strategies did not show significant differences in terms of coverage and speed. The predominantly fixed strategy took longer to complete the vaccination campaign because it was applied in three camps consecutively (not simultaneously) while the mobile door-to-door strategy was used in one camp. Generally, the speed used to vaccinate one camp using the predominantly fixed strategy is the same as that reported for the mobile door-to-door strategy. In future campaigns in closed settings a mixed strategy, which employs fixed points and mobile teams, would be likely to be the most effective.

The strategies employed for this OCV campaign did not significantly differ from other MVCs conducted in closed settings for other vaccine antigens. The predominantly fixed strategy enabled vaccination of a higher number of people in a shorter period of time and employed fewer human resources, but it had a geographical limit. The advantage of the mobile door-to-door strategy was the ease with which we reached the whole target population. It did, however, require large amounts of people to reach every house in a reasonable period of time.

The single dose vaccine vial requires a high storage volume, but was manageable because the campaign was done over a 2-month period allowing a phased storage and release of vaccine vials. The vaccine was supplied for one vaccination round at a time. However better adapted packaging could simplify the vaccination process and expand the use of OCV. At present two doses are needed to reach an acceptable level of protection in the individual. A single dose vaccine would facilitate the logistics and administration of OCV in MVCs substantially. Moreover, it would improve adherence to vaccination by the target population, probably increase coverage levels in all target groups and allow OCV to be given concomitantly with other vaccine antigens during the same campaign. Studies in Kolkata, India, have shown that a single dose of OCV stimulates a partial immunity response but it still has to be demonstrated whether this response is sufficient to protect against the disease.[17]

The high thermostability of Shanchol allowed the use of CTC at field level and consequently reduced the cold chain needs. Studies on efficacy and long term ambient temperature stability are needed to guarantee that CTC can continue to be used in future campaigns. More studies on vaccine efficacy under ambient temperature and single dose long term protection are needed to increase the use of OCV on a larger scale.

Also, the use of the vaccination card is frequently debated during mass vaccination campaigns. Its use has an added value during post-MVC surveys. In the case of Maban, the evidence of vaccination for the coverage survey was absent in the Doro refugee and host populations and, therefore, might need to be considered for use in future.

Social mobilization has been essential to inform the population about vaccination. The use of the community health workers who already knew the camp proved to be a crucial positive aspect of the campaign.

We must acknowledge that this OCV campaign was set up as a means to prevent the introduction of cholera into an existing vulnerable population in South Sudan. The systems established, therefore, for monitoring and evaluation were targeted specifically at ensuring that the campaign reached its target population. We did not envision the MVC as a study and as such our documented experience of this campaign with OCV has remained descriptive in nature. In future campaigns it would be of use to have, for example, more detailed financial recording systems to be able to better document differences in cost estimates per person vaccinated.

### Conclusion

In a large refugee population in South Sudan, mass vaccination with OCV was feasible, accepted by the population and achieved very high coverage. This outcome is very encouraging as using the cholera vaccine during humanitarian emergencies, as an added measure for reducing cholera related morbidity in vulnerable populations, such as refugees and internally displaced persons, has now become increasingly achievable.

## Supplementary data

Supplementary data are available at Transactions Online (http://trstmh.oxfordjournals.org/).

**Authors' contributions:** MIP, AL, RC, MJF, SDW, RS conceived the study and designed the study protocol; RS and MJF carried out the vaccination campaign; MIP, AL, RC, SDW, RS analyzed and interpreted the data. MIP and AL drafted the manuscript. RC, SDW, RS, MJF, MVH and RZ critically revised the manuscript for intellectual content. All authors read and approved the final manuscript. MIP, AL, RZ are guarantors for the paper.

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**Competing interests:** None declared.

**Ethical approval:** As OCV is a novel vaccine to be used in the context of emergency settings such as in South Sudan, we felt it was important to examine the feasibility of the implementation of a mass vaccination campaign in a closed refugee camp setting so that other healthcare workers might learn from our experience. As such, the description of the feasibility and the data collection used to document the mass vaccination campaign were not designed as a typical study. As we implemented the vaccination campaign in collaboration with the Minister of Health and the WHO, and the feasibility documentation was part of our usual monitoring and evaluation procedure, no ethical approval was sought.

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