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Lessons and challenges of implementing an integrated oral cholera vaccine and WaSH response to a cholera epidemic in Hoima district, Uganda

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3 1 **Lessons and challenges of implementing an integrated oral cholera vaccine and WaSH**
4 2 **response to a cholera epidemic in Hoima district, Uganda**
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3 31 **ABSTRACT**

4 32 **Background.** Cholera is preventable and treatable through application of surveillance, case
5 33 management, water, sanitation and hygiene (WaSH) complemented by oral cholera vaccine
6 34 (OCV). Vaccine was first introduced in Uganda during an outbreak in Hoima district in May -
7 35 June 2018. Since OCV was new for Uganda, documentation of this campaign provided
8 36 important lessons for future OCV campaigns in Uganda and elsewhere.

9 37 **Methods.** Surveys conducted during and post campaign consisted of two sub-studies. Sub-
10 38 study one assessed the knowledge and practices of OCV staff who implemented the OCV
11 39 campaign. Sub study two used a two-stage cluster random sampling technique to select 31
12 40 villages (clusters) from which 4 – 7 households were randomly selected and interviewed to
13 41 assess vaccine coverage, the community's knowledge and practice of cholera prevention and
14 42 the participant's understanding of OCV.

15 43 **Results.** In sub-study 1, most staff (93%) were knowledgeable about cholera control; however,
16 44 29% did not clearly understand detecting and managing adverse events following immunization
17 45 (AEFI). In sub-study two, 209 households (1,259 individuals) were surveyed, of whom 1178
18 46 (93%) reported receiving at least one OCV dose and 986 (78%) reported receiving two doses.
19 47 Among vaccinated individuals, minor complaints were reported by 71 persons (5.6%).
20 48 Individuals with 'some' education (primary or secondary school) were more knowledgeable
21 49 regarding the required OCV doses compared to non-educated (p-value = 0.04). Factors
22 50 negatively associated with campaign implementation included community sensitisation time,
23 51 staff payment and problems with field transport. Although the campaign was carried out quickly,
24 52 the outbreak was over before the campaign started.

25 53 **Conclusion.** The campaign achieved high OCV coverage, but the surveys provided insights for
26 54 improvement. For greater vaccine coverage, more effort is needed for community sensitisation,
27 55 and additional resources for staff transportation and timely payment is required. Pre and post-
28 56 test assessment of staff training can identify and address knowledge and skill gaps.

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3 **58 Strengths and limitations of this study**
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- 5 59 • This is an evaluation of the first oral cholera vaccine (OCV) campaign in Uganda
6 60 • Coverage rates were high, indicating a successful campaign
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8 61 • Evaluation of the vaccination staff immediately following each round identified ways to
9 improve performance in the next round.
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11 63 • Communities readily accepted OCV, but some were not sure of the timing of the second
12 dose
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14 65 • Improvements were needed in the program to detect and manage potential adverse events
15 following immunization (AEFI).
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68 INTRODUCTION

69 Cholera, a preventable and treatable disease is characterized by profuse watery diarrhoea
70 caused by infection of the intestine with the bacterium *Vibrio cholerae*.^{1 2} Cholera is a major
71 cause of morbidity and mortality in several countries in sub-Saharan Africa where cholera
72 outbreaks also negatively affect development due to associated high economic burden.^{3 4}
73 Between 2010 and 2016 an average 141,918 incident cases annually were reported from sub-
74 Saharan African countries, including Uganda.⁵ In Uganda, cholera outbreaks occurred as both
75 endemic and epidemic disease. Epidemic disease occurred in northern and eastern Uganda
76 districts⁶ and are thought to be worsened by contamination of safe water due to poor
77 sanitation.⁷ Endemic cholera outbreaks occur in districts along the international borders with the
78 Democratic Republic of the Congo (DR Congo), South Sudan and Kenya and along the Great
79 lakes.^{6 8} These districts include Hoima, where cholera is endemic.^{6 9-11} The World Health
80 Organization (WHO) recommends an integrated approach to cholera prevention where water,
81 sanitation and hygiene (WaSH) interventions are complemented by vaccine campaigns which
82 provide oral cholera vaccine (OCV) to persons living in areas considered high risk.³ These
83 campaigns may be either preventive, in which the vaccine is targeted to cholera hotspots, or
84 reactive in which the campaign is implemented in response to an outbreak or a humanitarian
85 emergency.¹² There are two OCVs WHO-prequalified currently available from the global
86 stockpile: Shanchol (Shantha Biotechnics Limited, India), and Euvichol (Eubiologics Co., Ltd.,
87 Korea).³ The standard immunization schedule consists of two doses given at an interval of at
88 least two weeks to all persons in the target area above one year of age. While there is
89 increasing use of OCV to control outbreaks, preventive use is constrained due to inadequate
90 vaccine supply.¹³ Since creation of a global OCV stockpile in July, 2013, several OCV
91 campaigns had been successfully implemented^{12 13} but it is still important to document national
92 campaign experiences as well as monitoring and evaluation activities, to continually improve the
93 effectiveness and efficiency of vaccine campaigns.

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95 The Ugandan Ministry of Health (MoH) had already prepared plans for OCV campaigns in the
96 areas identified as cholera hotspots starting in the western districts of Uganda (including
97 Hoima), near the border with DR Congo and close to, or adjoining Lake Albert. These hotspot
98 districts and their specified subcounties were confirmed during a national cholera workshop in
99 Kampala on 29-31 January 2018. This workshop led to the development of an application for
100 OCV to the Global Taskforce for Cholera Control (GTFCC) which was submitted on 14 February
101 2018. The application proposed providing OCV in these identified hotspots as a preventive

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3 102 strategy. However, while preparations for these campaigns were underway, an outbreak was
4 103 declared in Hoima district on 23 February 2018. The earliest cases were identified among DR
5 104 Congo refugees, but then other cases were seen among the non-refugee Ugandan population.
6 105 The MoH responded to the outbreak with multisectoral interventions, including proper case
7 106 management, promotion of access to safe water and improved sanitation (WaSH), enhanced
8 107 cholera surveillance, as well as infection control and health education. These measures were
9 108 then supplemented with plans to carry out an emergency OCV campaign. Thus, the plans for a
10 109 preventive OCV campaign were shifted to an emergency response to control the outbreak. The
11 110 first doses of vaccine arrived on 28 March and first round of vaccines started on 2 May. The
12 111 doses for the second round arrived on 29 May and the second round started on 26 June. A
13 112 door-to-door strategy was used to deliver two doses of vaccine to an estimated 360,000 people,
14 113 including pregnant women, over the age of one year residing in the four targeted subcounties.
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24 115 To carry out the campaign, the MoH organized all activities including logistics, community
25 116 mobilisation and implementation; coordinating ground activities through an assigned point
26 117 person. Many stakeholders contributed to the campaign including the Hoima district local
27 118 government, World Health Organisation, UNICEF, UNHCR and Médecins sans Frontiers'
28 119 (MSF). Prior to the campaign, the stakeholders met in order to define and coordinate their
29 120 complementary tasks.
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35 122 This was the first time OCV was deployed in Uganda, and after this initial campaign, the MoH
36 123 intended to continue with its plans for preventive campaigns in the remaining cholera hotspot
37 124 districts. Since this was the first OCV use in Uganda, and there was no prior experience to
38 125 guide responders and implementers, this study was carried out with the aim to document
39 126 campaign activities and to monitor and evaluate its procedures and outcomes that could guide
40 127 future OCV campaigns. The issues addressed during this study included the knowledge and
41 128 practices of the campaign staff, vaccine coverage in the targeted areas, and the knowledge and
42 129 practices of the community.
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49 131 **MATERIALS AND METHODS**

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52 133 *Study setting.* Hoima district is located in western Uganda, across Lake Albert from DR Congo.
53 134 It has a total area of 5735.5 square kilometres and a projected population of 630,000 persons
54 135 (2018). The district consists of 13 administrative units as follows: 10 sub counties
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3 136 (Kyabigambire, Buhimba, Kyangwali, Kabwoya, Bugambe, Kiziranfumbi, Kitoba, Kigorobyia,
4 137 Buseruka and Buhanika), a municipality (Hoima municipality) and two town council (Kigorobyia
5 138 and Buhima town councils). The major economic activities of the population in Hoima are
6 139 substance agriculture and fishing. Cholera is endemic in the district but the endemicity is
7 140 localised in some specific subcounties particularly those with fishing communities.¹⁴
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13 142 **Epidemiologic findings.** After the outbreak, an anonymous line list of cases and deaths, by
14 143 date and stated nationality was used to describe the basic epidemiological features of the
15 144 outbreak.

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17 145 *Population and design for the Monitoring and Evaluation of the Vaccination Campaign.* A cross-
18 146 sectional study was conducted between May and June 2018 in Hoima districts in the
19 147 subcounties where the OCV campaign was conducted. This included four sub-counties:
20 148 Buseruka, Kabwoya, Kangwali, and Kigorobyia which together constitute the six administrative
21 149 units of Kyangwali, Kigorobyia, Kabwoya Buseruka, Kigorobyia town council and Kyangwali
22 150 refugee settlement (Old and New) as shown in Figure 1. The study consisted of two sub-
23 151 studies. Sub-study 1 assessed the knowledge and practices of staff who participated in and
24 152 contributed to the OCV campaign. Sub-study 2 was a cluster randomised community survey
25 153 that assessed vaccine coverage, detection of adverse events following immunization (AEFI),
26 154 and indicators of community knowledge regarding cholera.
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35 156 *Sub-study 1, staff assessment.* Staff were assessed on their level of knowledge on the cause of
36 157 cholera, the importance of safe water in cholera prevention, the target age group for cholera
37 158 vaccination, and knowledge about AEFI and the procedures for care should subjects experience
38 159 an AEFI. Staff were surveyed twice with each survey taking place within two weeks after
39 160 administration of the first and second OCV rounds, respectively. All staff who participated
40 161 directly by administering the vaccines or indirectly through supervisory roles and who were
41 162 present at the workstation during the study period were enrolled in the survey. For the staff
42 163 survey, structured questions were administered on paper questionnaires that allowed for adding
43 164 text to explain the answers (open-ended questions). There was no list of all workers in the
44 165 campaign and many of the workers who participated in the second round had left prior to
45 166 administering the questionnaire; thus, there were fewer respondents in the second round and
46 167 the proportion of all workers who participated could not be determined precisely.
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3 169 *Sub-study 2, cluster surveys.* Sub-study 2 was carried out with the intention of obtaining
4 170 information from a representative sample of families in the target area. The study population
5 171 included each person > one year of age who was living in the OCV targeted area at the time of
6 172 the vaccination campaign. This sample consisted of 31 household clusters with 4-7 households
7 173 per cluster. We assumed a household size of five persons. A standard formula for cluster
8 174 sampling was used to derive the sample size.¹⁵ The sample was increased in order to increase
9 175 the analytical power and precision of the surveys, using the formula $n = (z^2pq)/d^2$, where 'n' is
10 176 the number of people desired for the survey, 'd' is the precision of the result, 'z' is the
11 177 confidence limit, and 'p' and 'q' correspond to the proportion of persons in the population who
12 178 are immunised and not immunised, respectively. To identify the clusters, a list of villages was
13 179 obtained from each of the four subcounties targeted for vaccination. From these lists, Excel
14 180 random number generator (=RANDBETWEENBOTTOM, TOP) was used to select the 31
15 181 villages from which households were selected. From each selected village a list of households
16 182 was obtained from village administrative leader (Local Council (LC) – 1: is the smallest
17 183 recognised administrative unit in Uganda. It is headed an elected leader called LC-1) and used
18 184 to identify the household by random selection similar to that used to select the villages or
19 185 clusters. The subcounty population was obtained from the district planning unit and used to
20 186 compute the number of households for each sub county as indicated in Table 1.
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34 **Table 1. Age and Sex Breakdown of the**
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36 **Participants in the Cluster Survey**

Age Group (years)	Male	Female	Total
1 to 4	99	93	192
5 to 14	236	207	443
15 to 44	210	285	495
45+	80	65	145
Total	625	650	1275

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53 189 For the household interviews, data were collected through standardized questionnaires during
54 190 face-to-face interviews conducted by trained research assistants using the local language.
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56 191 Within a selected household the questionnaires were administered to the key respondents
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3 192 (head of the HHs), who represented the entire household. If the HH was absent, additional visits
4 193 were scheduled. In two households, a person could not be located, and the household was
5 194 dropped. For each vaccinated person, the research assistants assessed cholera immunization
6 195 status through oral reporting (history) and by reviewing vaccination cards. None of the residents
7 196 who were approached refused to answer the survey.
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12 198 *Adverse Events Following Immunization (AEFI)*. The occurrence of AEFIs were assessed by
13 199 asking for occurrence of symptoms following vaccination. As part of the campaign itself, a
14 200 routine system for AEFI detection was established in which the vaccine team members advised
15 201 vaccinees to report to a health worker or to seek care at a health facility if they experienced
16 202 symptoms following immunization. By contrast, the AEFI surveillance in this study asked the
17 203 participants who participated in the cluster survey about symptoms they may have experienced.
18 204 This AEFI sub-study was thus, designed to enhance our understanding of potential AEFIs which
19 205 may not have been reported through the routine AEFI surveillance.
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27 207 AEFIs were categorised for each individual member of the household who received a dose of
28 208 OCV as follows. They were considered mild if the symptoms did not interfere with normal
29 209 activities; moderate if they interfered somewhat; and severe if the symptoms prevented the
30 210 individual from continuing normal activities. Persons who reported to be having ongoing
31 211 symptoms > 72 hours were advised to visit the nearest health facility for more care.
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36 213 *Data collection and analysis*. Data from the community surveys were collected by tablet
37 214 computers using *Kobo Collect* , <https://www.kobotoolbox.org/> installed to record the responses
38 215 in the field. Data were cleaned, coded and stored in Stata Version 14. Data were analysed to
39 216 generate frequencies, percentages or proportions and means. Comparisons between groups,
40 217 such as sub-counties or age strata was done using Chi Square or 2 x X tables with the
41 218 calculation of odds ratios and 95% confidence intervals. Multivariate analysis was done using
42 219 conditional logistic regression, or Poisson regression for analysis of uncommon events.
43 220 Continuous variables were analysed and compared using Student's T test or analysis of
44 221 variance (ANOVA). The results of analysis were presented in the form of graphs, tables, charts
45 222 and means and were included in interim and end of campaign reports.
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53 224 *Quality Assurance*. Research assistants were trained on data collection methods and were able
54 225 to consult field supervisors and the principal investigator on any issue not clear to them. For
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226 quality assurance, the survey supervisors revisited about 10% of the households, not to collect
227 the data again, but to ensure that they were not skipped by the interviewers for eligible
228 respondents. The surveys were conducted within two weeks of completion of the second round
229 of the vaccination campaign to minimize recall bias.

230 *Ethical Considerations.* This study was conducted as part of the routine MoH operational
231 research for improvement of health services; however ethical issues were considered and
232 addressed. The proposal was approved by the Makerere University School of Public Health
233 Institutional Review Board (MaKSPH IRB) and Uganda National Council of Science and
234 Technology. Written informed consent was obtained from all participants, including for both the
235 staff and community surveys. Participation in the study was voluntary and respondents were
236 free to opt out at any stage of the interviews.

237 Confidentiality was observed at all stages of the study. No names or personal identifiers were
238 included on the questionnaires. The research assistants underwent training on interview
239 techniques, neutrality and research ethics. The benefits of the study to the staff included the
240 ability to express themselves, provide feedback and observations that in turn might lead to
241 improvements in supportive services for their training and work.

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243 *Patient and Public Involvement.* This research was done without research subject
244 involvement. There was not enough time to involve the subjects prior to the vaccine campaign.
245 They were also not invited to contribute to the writing or editing of this document for readability
246 or accuracy. However, the findings of the study were disseminated to the Hoima district
247 administration, MoH and other policymakers to use them to strengthen health service
248 interventions and future OCV campaigns.

250 RESULTS

251 *The epidemic curve.* As shown on Figure 2, the epidemic was declared on the 8th week of
252 2018. A total of 2,122 cases with 44 deaths (case fatality rate, 2.1%) was reported during the
253 outbreak. Sixty seven percent (1,410) and 64% (28) of the deaths occurred during the first two
254 weeks of the outbreak. Many of the cases and deaths (1276 and 32, or 60% and 73%,
255 respectively) occurred among persons who were from DR Congo, nearly all refugees who
256 developed cholera symptoms soon after arrival in Uganda. Among the 44 deaths reported, 25
257 (57%) occurred in the community, not in the health facility. Nineteen of the fatal cases were
258 treated at the health facility; the CFR for facility-treated patients was 0.9%. The vaccination

259 campaign, originally planned as a preventive OCV campaign, was changed to an emergency
260 response intended to control the outbreak. Because the outbreak was so sudden and was
261 short-lived, the campaign could only be initiated after the outbreak had already declined.

262 *Sub-study I, staff survey.* A total of 242 and 125 staff were interviewed in the first and second
263 knowledge and practice (KP) surveys (KP1 and KP2). Most respondents were vaccination team
264 members (89% and 87% in rounds 1 and 2, respectively). Almost all the respondents were
265 knowledgeable about the cause of cholera, the importance of safe water in cholera prevention
266 and the vaccine target group, but were less knowledgeable regarding potential adverse events
267 following administration (AEFI) or how to advise vaccinees with 29% and 16% being less
268 informed about AEFI during the first and second surveys.

269 When staff were asked to suggest areas that needed improvement in future OCV campaigns,
270 more than 10% suggested more timely payment of allowances, more time to sensitize and
271 inform the communities on the benefits of the vaccine, and better transportation and facilitation
272 allowances (payments to health workers to cover the cost they incurred when administering the
273 vaccines or conducting activities related to the OCV campaign). Other suggestions included
274 use of both static and mobile vaccination points, provision of gumboots, umbrellas, and more
275 areas for vaccine storage in subcounties where vaccine would be more accessible, more
276 workers for hard to reach areas, and an increase in the number of vaccine days.

277 *Sub-study II, community survey results.* The community surveys were carried out in four sub-
278 counties of Buseruka, Kabwoya, Kyangwali and Kigorobya as shown in Figure 1 and Table 1. A
279 total of 209 households, including 1,259 individuals, were surveyed. Most (96%) of the
280 respondents were household heads or their spouses. All respondents confirmed that they were
281 living in the targeted OCV area at the time of the campaign. 51% of the respondents had
282 primary education, 17% had secondary education, 1% had tertiary education, and the remaining
283 31% had no education. The respondents were aged 18 – 89 years with a mean age of 40 years.
284 Both sexes were present, with no statistically significant difference.

285 By verbal reports, 93% of the residents received at least one dose and 78% received two doses
286 of OCV. Based on the vaccination card to confirm the vaccination status, the two-dose coverage
287 was 62% (95%CI: 59.4-64.9). 91% of residents received vaccine during the first round and 80%
288 received vaccine during the second round. Coverage rates are shown on Table 2.

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290 **Table 2: Vaccination coverage post OCV campaign, Hoima District, Uganda, 2018.**

	Round 1	Round 2	Received only one dose	Received two doses	Received at least one dose	Total surveyed
Reported number (%)	1,164 (91.2)	1,027 (80.5)	195 (15.3)	998 (78.3)	1193 (93.6)	1275
95% CI	89.7-92.8	78.3-82.7	13.4-17.4	76.0-80.6	92.2-94.9	
Confirmed by availability of the vaccination card (%)	1,065 (83.5)	823 (64.5)	304 (23.8)	792 (62.1)	1096 (86.0)	
95% CI	81.5-85.6	62.0-67.2	21.6-26.3	59.5-64.8	84.1-87.9	

291
292 Among those who did not receive a dose of vaccine, over half of these missed doses (255
293 missed doses during the two rounds) were because the person was not at home at the time of
294 vaccination or was out of town. In a few cases, the vaccine team missed the household,
295 accounting for 53 missed doses. Refusing to take vaccine was not reported.

296
297 *Reported AEFIs.* Overall, 71 individuals of 1,259 respondents (5.6%) reported an AEFI (Table
298 3).

300 **Table 3: Treatment and resolution of Adverse Events Following Immunization in**
301 **Hoima District, Uganda, 2018.**

Symptoms	Treatment		Status		
	No treatment (%)	Treated (%)	Recovered (%)	Ongoing (%)	Improved, not to baseline (%)
Mild	24(80.0)	6(20.0)	29(96.7)	1(3.3)	0(0.0)
Moderate	11(39.3)	17(60.7)	23(82.1)	3(10.7)	2(7.1)

Severe	8(61.5)	5(38.5)	10(76.9)	0(0.0)	3(23.1)
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 303 Most of these were considered mild or moderate, but 8 (0.6%) persons reported an AEFI as
 304 severe. Most (60%) of the persons reporting an AEFI did not seek treatment including 60% of
 305 those reporting a severe AEFI. 29.6% of the reported adverse events occurred in the first round,
 306 40.9% in the second round and 29.6% in both rounds. The most common symptoms were
 307 abdominal pain (15), diarrhoea, (9), fever, nausea and headache (each 6) reports. Table 4
 308 provides additional information on the AEFIs.

Table 4. Onset and frequency of symptoms reported as adverse events

	<6 hours	6-12 hours	12-24 hours	1-2 days	3-7 days	8-14 days	Total
Diarrhoea	3	2	2	1	1	0	9
Vomiting	3	0	0	0	2	0	5
Nausea	6	0	0	0	0	0	6
Abdominal pain	15	0	0	0	0	0	15
Stomach gurgling	0	3	0	1	0	0	4
Mouth ulcers	0	0	0	0	0	1	1
cough	1	1	0	2	1	1	6
Felt feverish	1	1	0	0	6	1	9
Poor appetite	1	0	0	0	0	0	1
Dizziness	0	3	0	0	0	0	3
Fainted	0	1	0	0	0	0	1
Itching	0	0	0	0	0	1	1
Weakness	0	0	0	0	1	0	1
Headache	3	0	2	1	0	0	6
Other	1	0	0	2	0	0	3
Total	34	11	4	7	11	4	71

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3 311 *Community knowledge.* Most respondents knew the major signs and symptoms of cholera, that
4 312 it was related to contaminated water or food, the importance of drinking safe water and hand
5 313 washing. Following the campaign, they also understood that vaccine was also a way to prevent
6 314 cholera. There was a statistically significant association between education level and knowledge
7 315 about OCV, with those having at least a primary school education being two and a half times as
8 316 likely to know the number of required doses as compared to those with no education (RO 2.46,
9 317 95% CI 1.09, 5.59 [P = 0.023].

14 318 **DISCUSSION**

16 319 Our findings suggest that the OCV campaign in Hoima successfully provided vaccine to a very
17 320 large proportion of the target population in these four subcounties in western Uganda. 93%
18 321 reported receiving at least one dose and 78% reported receiving two doses among residents.
19 322 Given the mobile and transient nature of this population, this was noteworthy, and suggests that
20 323 even better coverage may be possible for more settled populations in Uganda. Refusal to take
21 324 vaccine was not a constraint to the campaign, but not finding people at home did result in many
22 325 missed vaccinations. High coverage is especially important when one is attempting to achieve
23 326 herd protection. Since it is estimated that herd protection can be achieved with a coverage
24 327 even lower than 90%;¹⁶ the high coverage achieved in this campaign would be expected to
25 328 induce significant protection among even those who did not receive vaccine.

26 329
27 330 It was noted in the administrative report from the MoH and during a stakeholder's meeting that
28 331 one of the reasons for the reduction in the coverage during the second OCV dose was the
29 332 unpredictable campaign dates for the second round. The vaccine for the second round had to
30 333 be shipped and cleared through customs, and the timing for this was not certain. To avoid this
31 334 problem in the future, a mechanism needs to be established to provide a better timeline for
32 335 receipt of the vaccine shipments.

33 336
34 337 Inclusion of staff KP survey contributed to the success by identifying gaps amongst the staff
35 338 knowledge and performance. After the first staff KP survey, these gaps were communicated to
36 339 the MoH and the stakeholders responded with appropriate actions to ensure that these gaps
37 340 were addressed prior to the second round.

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39 342 As with previous OCV campaigns very few AEFI were reported.^{17 18} Most of adverse events
40 343 were considered mild or moderate and were self-limited. Despite the low prevalence of AEFI,

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3 344 the survey exposed the need to better inform the community about seeking treatment for more
4 345 severe adverse events or for those that do not quickly resolve. This was especially true for
5 346 those for families with little education who were less likely to seek medical attention for severe
6 347 AEFI (data not shown).
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10 348
11 349 Most other OCV campaigns have also reported high coverage rates. These have included
12 350 reports from Bangladesh^{19 20}, Malawi^{21 22}, Mozambique¹⁷, Democratic Republic of Congo ²³,
13 351 Zambia ²⁴, South Sudan ^{25 26}, Iraq²⁷, Haiti²⁸, and Guinea ²⁹. Clearly, OCV is well accepted
14 352 among these very diverse population groups where the vaccine campaigns have been carried
15 353 out.
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19 354
20 355 Important limitations of this study included only one series of surveys for the community, rather
21 356 than one following each vaccination round. Learning from the community prior to the campaign
22 357 as well as immediately after the first dose might have provided feedback to the teams that would
23 358 have improved the coverage for the second round and would have further increased two dose
24 359 coverage rates. Similarly, more direct observation of the training and coordination meetings
25 360 would have been useful to independently assess the efficiency and effectiveness of these
26 361 training and coordination meetings.
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30 362
31 363 The community KP survey did not include questions on attitudes regarding cholera; it was not a
32 364 KAP survey. Since the survey had to be carried out very quickly following the campaign, and
33 365 since the survey was targeted to identify issues that would be immediately relevant to campaign
34 366 performance, it was felt that understanding attitudes regarding cholera, even though important,
35 367 would have required other qualitative methods requiring more time than was available.
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41 368
42 369 In this outbreak 2,122 cholera cases and 44 deaths were reported, nearly all before the OCV
43 370 campaign and over half occurred in the first two weeks of the outbreak. Of note, the outbreak
44 371 started in February 2018 at about the same time the application for preventive use of OCV was
45 372 being submitted. The original application proposed a series of preventive campaigns over
46 373 the next year, and Hoima, as well as neighbouring districts in western Uganda, were targeted
47 374 for vaccination in the first round of these preventive campaigns. However, when the outbreak
48 375 was identified, plans were quickly shifted so that an emergency campaign could be
49 376 implemented to control the outbreak. Even though this emergency response was planned as
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3 377 quickly as possible, in fact, the outbreak was nearly over before the vaccine campaign could
4 378 start.

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8 380 Furthermore, though the outbreak started with the influx of the refugees from DRC into Uganda,
9 381 it quickly spread to the refugee host communities in Hoima. Therefore, to prevent rapid spread,
10 382 improvement of cholera prevention measures for both the refugees and the host communities is
11 383 paramount during resettlement.

12 384

13 385

14 386 **CONCLUSION**

15 387 This study suggests that the integrated OCV campaign in Hoima district to prevent cholera was
16 388 successful and achieved a high level of coverage in this population that was targeted to be at
17 389 risk. However, there was a need to devote more effort on community sensitisation on the
18 390 benefits of vaccination, as well as improving some logistic support during the campaign.

19 391

20 392 While a rapid response to this outbreak was appropriate, in fact, even with a rapidly organized
21 393 campaign, the outbreak was largely over before the vaccine could be given; thus, the vaccine
22 394 likely had little impact on this outbreak. Nevertheless, this area had already been identified as a
23 395 hotspot, and it would have been targeted if the planned preventive campaign had proceeded as
24 396 originally planned. Planners must realize that an area identified as a hotspot might experience
25 397 an outbreak while preparations are underway for a preventive campaign and take this into
26 398 account when allocating vaccine for preventive vs emergency campaigns. Since these are
27 399 areas where cholera risk is high, outbreaks are likely to occur in these areas if there are delays
28 400 in implementing preventive campaigns.

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30 402

31 403 **LEGENDS**

32 404

33 405 **Figure 1: Map of Hoima District, showing sub-counties that received OCV and**
34 406 **households where interviews were conducted (red dots)**

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3 408 **Figure 2. Epicurve of the Hoima Outbreak, 2018 with events identified in**
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5 **response to the outbreak**
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30 424 **Footnotes**

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32
33 425 **Contributors:** Conceived and designed the study: GB, MR, WAB, ABS, CGO, DAS.

34 426 Discussed, critically revised and approved the study protocol: GB, MR, WAB, CGO, DAS.

35 427 Performed the research: GB, MR, WAB, AO, FR, IA. Analysed the data: GB, MR, WAB, AO,
36 428 DAS. Wrote the first draft: GB, MR. Wrote the final DAS. Elaborated, discussed and approved
37 429 the final version: GB, MR, AB, ABS, AO, FR, IA, CGO, and DAS.
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51 437 **Declaration of the conflict of interest**

52 438 The authors have no conflict of interest to declare.
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4 441 **Additional data sharing:** No additional data available.
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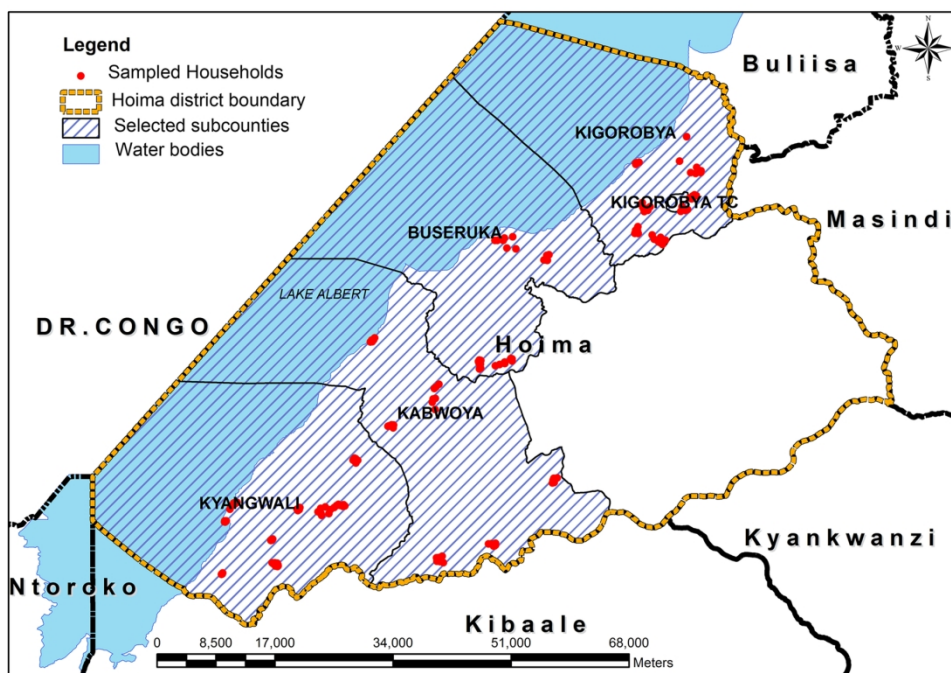
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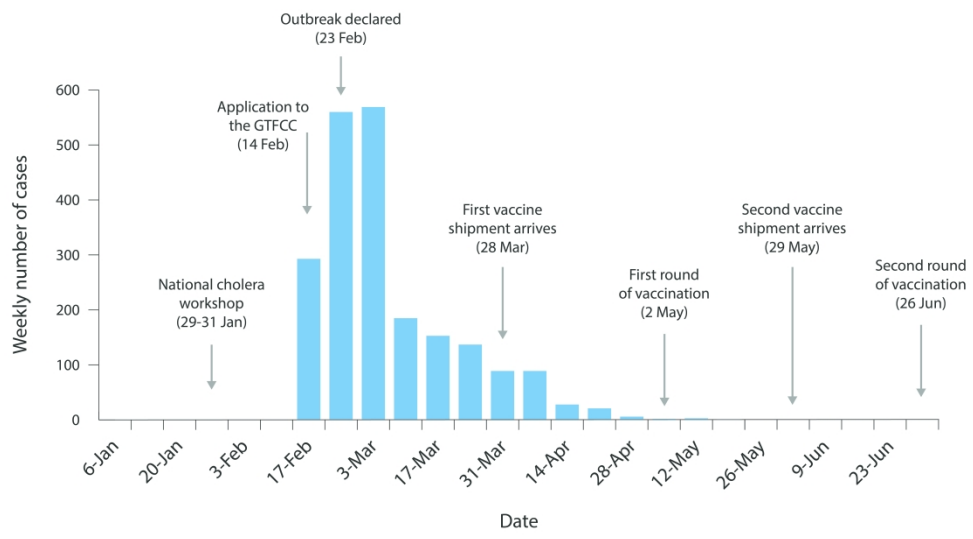
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3 1 **Evaluation of an integrated oral cholera vaccine campaign in response to a cholera outbreak**
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5 2 **in Hoima District, Uganda**

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43 31 oral cholera vaccine, Vaccine campaign
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3 32 **ABSTRACT**

4 33 **Objectives** To evaluate the quality and coverage of the campaign to distribute oral cholera
5 34 vaccine during a cholera outbreak in Hoima, Uganda to guide future campaigns of cholera
6 35 vaccine.

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9 36 **Design** Survey of communities targeted for vaccination to determine vaccine coverage rates
10 37 and perceptions of the vaccination campaign, and a separate survey of vaccine staff who
11 38 carried out the campaign.

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14 39 **Setting** Hoima District, Uganda.

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16 40 **Participants** Representative clusters of households residing in the communities targeted for
17 41 vaccination and staff members who conducted the vaccine campaign.

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19 42 **Results** Among 209 households (1,274 individuals) included in the coverage survey, 1193
20 43 (94%) reported receiving at least one OCV dose and 998 (78%) reported receiving two doses.
21 44 Among vaccinated individuals, minor complaints were reported by 71 persons (5.6%).
22 45 Individuals with 'some' education (primary school or above) were more knowledgeable
23 46 regarding the required OCV doses compared to non-educated (p value = 0.03). Factors
24 47 negatively associated with campaign implementation included community sensitisation time,
25 48 staff payment, and problems with field transport. Although the campaign was carried out quickly,
26 49 the outbreak was over before the campaign started. Most staff involved in the campaign (93%)
27 50 were knowledgeable about cholera control; however, 29% did not clearly understand how to
28 51 detect and manage adverse events following immunization.

29
30 52 **Conclusion** The campaign achieved high OCV coverage, but the surveys provided insights for
31 53 improvement. To achieve high vaccine coverage, more effort is needed for community
32 54 sensitisation, and additional resources for staff transportation and timely payment for campaign
33 55 staff is required. Pre and post-test assessment of staff training can identify and address
34 56 knowledge and skill gaps.

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3 **59 Strengths and limitations of this study**
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- 5 60 • The cluster survey of households in communities targeted for vaccination efficiently
6 61 documented actual coverage in the target population.
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8 62 • The household surveys were able to identify constraints to the campaign, especially in less
9 63 educated subgroups
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11 64 • The household surveys identified mild adverse events not detected by routine AEFI
12 65 surveillance (Adverse Events Following Immunization) during the campaign. Understanding
13 66 these perceived AEFIs should be recognized to ensure good communications between
14 67 communities and health officials.
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16 68 • Evaluation of the vaccination staff immediately following each round identified ways to
17 69 improve performance in the next round.
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19 70 • Monitoring and evaluation of the oral cholera vaccination campaign in Hoima district was
20 71 useful to guide future cholera prevention activities since the campaign was the first of its
21 72 kind. in Uganda.
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74 INTRODUCTION

75 Cholera, a preventable and treatable disease is characterized by profuse watery diarrhoea
76 caused by infection of the intestine with the bacterium *Vibrio cholerae*.¹ Cholera is a major
77 cause of morbidity and mortality in several countries in sub-Saharan Africa where cholera
78 outbreaks also negatively affect development due to associated high economic burden.^{2 3}
79 Between 2010 and 2016 an average 141,918 incident cases annually were reported from sub-
80 Saharan African countries, including Uganda.⁴ In Uganda, cholera outbreaks occurred as both
81 endemic and epidemic disease. Epidemic disease occurred in northern and eastern Uganda
82 districts⁵ and are thought to be worsened by contamination of water due to poor sanitation.⁶
83 Cholera outbreaks especially occur in districts along the international borders with the
84 Democratic Republic of the Congo (DR Congo), South Sudan and Kenya and along the Great
85 Lakes.^{5 7} These districts include Hoima, where cholera is endemic.^{5 8-10}

86
87 There has been debate in the public health community on best practices for endemic and
88 epidemic cholera disease control, with some preferring to focus on WASH interventions, and
89 others advocating for OCV for both endemic and epidemic disease control.¹¹ In part, this has
90 been facilitated by a relative lack of experience with OCV and concern that excess reliance on
91 vaccine might negatively affect essential infrastructural development and hygienic practices.
92 The World Health Organization (WHO) recommends an integrated approach to cholera
93 prevention where water, sanitation and hygiene (WaSH) interventions are complemented by
94 vaccine campaigns which provide oral cholera vaccine (OCV) to persons living in areas
95 considered high risk.^{2 12} These vaccine campaigns may be either preventive, in which the
96 vaccine is targeted to cholera hotspots, or reactive in which the campaign is implemented in
97 response to an outbreak or a humanitarian emergency.¹³

98
99 Two WHO-prequalified currently OCVs are available from the global stockpile: Shanchol
100 (Shantha Biotechnics Limited, India) and Euvichol (Eubiologics Co., Ltd., Korea).² The standard
101 immunization schedule consists of two doses given at an interval of at least two weeks to all
102 persons in the target area above one year of age. While there is increasing use of OCV to
103 control outbreaks, preventive use is constrained due to inadequate vaccine supply.¹⁴ Since
104 creation of a global OCV stockpile in July, 2013, several OCV campaigns had been successfully
105 implemented^{13 14} but it is still important to document national campaign experiences as well as
106 monitoring and evaluation activities, to continually improve the effectiveness and efficiency of
107 vaccine campaigns.

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3 108 The Ugandan Ministry of Health (MoH) had prepared plans for OCV campaigns in the areas
4 109 identified as cholera hotspots starting in the western districts of Uganda (including Hoima), near
5 110 the border with DR Congo and close to, or adjoining Lake Albert. These hotspot districts and
6 111 their specified sub-counties were confirmed during a national cholera workshop in Kampala on
7 112 29-31 January 2018. This workshop led to the development of an application for OCV to the
8 113 Global Taskforce for Cholera Control (GTFCC) which was submitted on 14 February 2018. The
9 114 application proposed providing OCV in these identified hotspots as a preventive strategy.
10 115 However, while preparations for these campaigns were underway, an outbreak was declared in
11 116 Hoima district on 23 February 2018. The earliest cases were identified among DR Congo
12 117 refugees, but then other cases were seen among the non-refugee Ugandan population. The
13 118 MoH responded to the outbreak with multisectoral interventions, including proper case
14 119 management, promotion of access to safe water and improved sanitation (WaSH), enhanced
15 120 cholera surveillance, as well as infection control and health education. These measures were
16 121 then supplemented with plans for an emergency OCV campaign. Thus, the original plans for a
17 122 preventive OCV campaign were shifted to an emergency response to control the outbreak. The
18 123 first doses of vaccine arrived on 28 March and the first round of vaccinations started on 2 May.
19 124 The doses for the second round arrived on 29 May and the second round started on 26 June. A
20 125 door-to-door strategy was used to deliver two doses of vaccine to an estimated 360,000 people,
21 126 including pregnant women, over the age of one year residing in the four targeted sub-counties.
22 127 To carry out the campaign, the MoH organized all activities including logistics, community
23 128 mobilisation and implementation, coordinating ground activities through an assigned point
24 129 person. Many stakeholders contributed to the campaign including the Hoima district local
25 130 government, WHO, UNICEF, UNHCR and Médecins sans Frontiers (MSF). Prior to the
26 131 campaign, the stakeholders met to define and coordinate their complementary tasks.
27 132 The epidemic curve based on a line list of cases and deaths by date and stated nationality is
28 133 shown on Figure 1. Over the course of the outbreak, 2,122 cases with 44 deaths (case fatality
29 134 rate, 2.1%) were reported. Sixty six percent (1,410) of the cases and 64% (28) of the deaths
30 135 occurred during the first two weeks of the outbreak. Many of the cases and deaths (1276 and
31 136 32, or 60% and 73%, respectively) occurred among persons who were from DR Congo, and the
32 137 refugees developed cholera symptoms soon after arrival in Uganda. Among the 44 deaths
33 138 reported, 25 (57%) occurred in the community, not in the health facility. Nineteen of the fatal
34 139 cases were treated at the health facility; the case fatality ratio (CFR) for facility-treated patients
35 140 was 0.9%. Although the emergency vaccination campaign intended to control the outbreak,

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3 141 because the outbreak was so sudden and so short-lived, the campaign could only be initiated
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5 142 after the outbreak had already declined.

6 143 *Rationale.* While vaccines are commonly used in Uganda, especially through the longstanding
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8 144 EPI program (Expanded Programme on Immunization), this was the first OCV use in Uganda,
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10 145 and there was no prior experience to guide responders and implementers. Thus, this study was
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12 146 carried out with the aim to document campaign activities and to monitor and evaluate its
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14 147 procedures and outcomes that could guide future OCV campaigns. The issues addressed
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16 148 during this study included the knowledge and practices of the campaign staff, vaccine coverage
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18 149 in the targeted areas, and the knowledge and practices of the community. After this initial
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20 150 campaign, the MoH continued its plans for preventive campaigns in the remaining cholera
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22 151 hotspot districts, informed by the lessons learned from this initial emergency use campaign. In
23
24 152 an effort to document the impact of OCV on an outbreak in a setting with endemic disease, we
25
26 153 undertook this monitoring and evaluation exercise, as described below.

25 154 26 155 **MATERIALS AND METHODS**

27 156 *Study setting.* Hoima district is located in western Uganda, across Lake Albert from DR Congo.
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29 157 It has a total area of 5735.5 square kilometres and a projected population of 630,000 persons
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31 158 (2018). The district consists of 13 administrative units as follows: 10 sub-counties
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33 159 (Kyabigambire, Buhimba, Kyangwali, Kabwoya, Bugambe, Kiziranfumbi, Kitoba, Kigorobyia,
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35 160 Buseruka and Buhanka), a municipality (Hoima municipality) and two town councils (Kigorobyia
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37 161 and Buhima town councils). The major economic activities of the population in Hoima are
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39 162 subsistence agriculture and fishing. Cholera is endemic in the district but the endemicity is
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41 163 localised in some specific sub-counties particularly those with fishing communities.¹⁵ The sub-
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43 164 counties targeted for OCV included Buseruka, Kabwoya, Kangwali, and Kigorobyia which
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45 165 together constitute the six administrative units of Kyangwali, Kigorobyia, Kabwoya Buseruka,
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47 166 Kigorobyia town council and Kyangwali refugee settlement (Old and New) as shown in Figure 2.

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49 168 *Population and design for the Monitoring and Evaluation of the OCV Campaign.* Two sub-
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51 169 studies were conducted to assess different aspects of the campaign. In sub-study one, a
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53 170 representative sample of the population that was targeted for vaccination was questioned to
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55 171 determine vaccine coverage rates, detect adverse events following immunization (AEFI) and
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57 172 collect additional information from the communities about the vaccine campaign. Sub-study two
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59 173 consisted of a survey among the campaign staff who participated in the OCV campaign after
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174 each round to assess their knowledge and practices.

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3 175 *Sub-study 1, community assessment.* Sub-study one was a survey conducted in the vaccine
4 176 target area, consisting of 31 clusters, each cluster consisting of 4 to 7 households per cluster.
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6 177 The study population included each person > one year of age who was living in the OCV
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8 178 targeted area at the time of the vaccination campaign. We assumed a household size of five
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10 179 persons based on estimates from a Demographic Health Survey conducted in 2016.¹⁶ The
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12 180 sample was increased in order to raise the analytical power and precision of the surveys and to
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14 181 allow for separate analysis by gender. The formula used for determining sample size was, $n =$
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16 182 $(z^2pq)/d^2$,¹⁷ where 'n' is the number of people desired for the survey, 'd' is the precision of the
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18 183 result, 'z' is the confidence limit, and 'p' and 'q' correspond to the proportion of persons in the
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20 184 population who are immunised and not immunised, respectively. We chose to use a low
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22 185 coverage of 50%. To identify the clusters, a list of villages was obtained from each of the four
23
24 186 sub-counties targeted for vaccination. From these lists, the Excel random number generator
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26 187 (=RANDBETWEENBETWEENBOTTOM, TOP) was used to select the 31 villages from which households
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28 188 were selected. From each selected village a list of households was obtained from village
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30 189 administrative leader (Local Council (LC) – 1: is the smallest recognised administrative unit in
31
32 190 Uganda. It is headed an elected leader called LC-1) and used to identify the household by
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34 191 random selection similar to that used to select the villages or clusters. The sub-county
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36 192 population was obtained from the district planning unit and used to compute the number of
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38 193 households for each sub county as indicated in Table 1. The number of villages selected in
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40 194 each sub-county was in proportion to the population of the sub-county.
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42 195

43 196 For the household interviews, data were collected through standardized questionnaires during
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45 197 face-to-face interviews conducted by trained research assistants using the local language.
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47 198 Within a selected household the questionnaires were administered to the key respondents
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49 199 (head of the HHs), who represented the entire household and provided information about each
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51 200 member of the household. If a suitable key respondent was absent, additional visits were
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53 201 scheduled. In two households, a person could not be located, and the household was dropped.
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55 202 For each vaccinated person, the research assistants assessed cholera immunization status.
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57 203 Vaccination status was ascertained in two ways: either the informant verbally indicated that the
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59 204 individual had received the dose of vaccine or the vaccination was recorded on the vaccine
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205 card. If the informant did not have a vaccine card, the reliability of the vaccination information
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was validated by asking about the details of the procedures of the vaccination (e.g. being given

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3 207 recently by mouth to all persons > 1 year of age). None of the residents who were approached
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5 208 refused to answer the survey.

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8 210 *Adverse Events Following Immunization (AEFI)*. The occurrence of AEFIs were assessed by
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10 211 asking for symptoms among the vaccine recipients following vaccination. As part of the
11 212 campaign itself, a routine system for AEFI detection was established in which the vaccine team
12 213 members advised vaccinees to report to a health worker or to seek care at a health facility if
13 214 they experienced symptoms following immunization. By contrast, the AEFI surveillance in this
14 215 sub-study asked the participants who participated in the cluster survey about symptoms they
15 216 may have experienced. This AEFI sub-study was thus, designed to enhance our understanding
16 217 of potential AEFIs which may not have been reported through the routine AEFI surveillance.
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23 219 AEFIs were categorised for each individual member of the household who received a dose of
24 220 OCV as follows. They were considered mild if the symptoms did not interfere with normal
25 221 activities; moderate if they interfered somewhat; and severe if the symptoms prevented the
26 222 individual from continuing normal activities.¹⁸ Persons who reported to be having ongoing
27 223 symptoms > 72 hours were advised to visit the nearest health facility for more care. Among
28 224 those reporting symptoms, information was recorded as to whether the person took any
29 225 medicine or received any treatment to lessen the symptoms.
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36 227 *Data collection and analysis*. Data from the community surveys were collected by tablet
37 228 computers using *Kobo Collect* (<https://www.kobotoolbox.org/>) installed to record the responses
38 229 in the field. Data were cleaned, coded, and stored in Stata Version 14. Data were analysed to
39 230 generate frequencies, percentages or proportions and means. Comparisons between groups
40 231 was done via logistic regression for the calculation of odds ratios and 95% confidence intervals.
41 232 The results of analysis were presented in the form of graphs, tables, charts, and means and
42 233 were included in interim and end of campaign reports.
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49 235 *Quality Assurance*. Research assistants were trained on data collection methods and were able
50 236 to consult field supervisors and the principal investigator on any issue that was not clear to
51 237 them. For quality assurance, the survey supervisors revisited about 10% of the households, not
52 238 to collect the data again, but to ensure that they were not skipped by the interviewers for eligible
53 239 respondents. The surveys were conducted about two weeks after completion of the second
54 240 round of the vaccination campaign to minimize recall bias.
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5 242 *Sub-study 2, staff assessment.* Staff were assessed on their level of knowledge on the cause of
6 243 cholera, the importance of safe water in cholera prevention, the target age group for cholera
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8 244 vaccination, and knowledge about AEFI and the procedures for care should subjects experience
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10 245 an AEFI. Staff were surveyed twice with each survey taking place within two weeks after
11 246 administration of the first and second OCV rounds, respectively. All staff who participated
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13 247 directly by administering the vaccines or indirectly through supervisory roles and who were
14 248 present at the workstation during the study period were enrolled in the survey. For the staff
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16 249 survey, structured questions were administered on paper questionnaires that allowed for adding
17 250 text to explain the answers (open-ended questions). Most of the vaccine staff had taken part in
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19 251 other public health campaigns, but none had participated earlier with a campaign to distribute
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21 252 OCV.

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23 253 *Ethical Considerations.* This study was conducted as part of the routine MoH operational
24 254 research for improvement of health services; however, ethical issues were considered and
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26 255 addressed. The proposal was approved by the Makerere University School of Public Health
27 256 Institutional Review Board (MaKSPH IRB) (no 610 in 2018) and Uganda National Council of
28
29 257 Science and Technology. Written informed consent was obtained from all participants in both
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31 258 sub-studies. Participation in the study was voluntary and respondents were free to opt out at
32
33 259 any stage of the interviews.

34 260 Confidentiality was observed at all stages of the study. No names or personal identifiers were
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36 261 included on the questionnaires. The research assistants underwent training on interview
37 262 techniques, neutrality, and research ethics. The benefits of the study to the staff included the
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39 263 ability to express themselves, provide feedback and observations that in turn might lead to
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41 264 improvements in supportive services for their training and work.

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44 266 *Patient and Public Involvement.* This research was done without research subject
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46 267 involvement. The time was inadequate to involve the subjects prior to the vaccine campaign.
47 268 They were also not invited to contribute to the writing or editing of this document for readability
48
49 269 or accuracy. However, the findings of the study were disseminated to the Hoima district
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51 270 administration, MoH and other policymakers to use them to strengthen health service
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53 271 interventions and future OCV campaigns.

54 272

55 273 **RESULTS**

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3 274 *Sub-study One, community survey results.* The community surveys were carried out in the four
4 275 sub-counties in Hoima districts of Buseruka, Kabwoya, Kyangwali and Kigorobyas as shown in
5 276 Figure 2 and Table 1. [Insert Figure 2 and Table 1] A total of 209 households, including 1,274
6 277 individuals, were surveyed. Most (96%) of the respondents were household heads or their
7 278 spouses. All respondents confirmed that they were living in the targeted OCV area at the time of
8 279 the campaign. Fifty-one (51%) of the respondents had primary education, 17% had secondary
9 280 education, 1% had tertiary education, and the remaining 31% had no education. The
10 281 respondents were aged 18 – 89 years with a mean age of 40 years. Both sexes were present,
11 282 with no statistically significant difference.

12 283 By verbal reports, 94% of the residents received at least one dose and 78% received two doses
13 284 of OCV. From verbal reporting, 91% of residents received vaccine during the first round and
14 285 81% received vaccine during the second round. For many of the households, a vaccine card
15 286 was available, and the vaccination card was used to confirm vaccination status. Using
16 287 information from the card only, coverage was 84% and 65% for round one and round two
17 288 respectively and the two-dose coverage was 62% (95%CI: 59.4-64.9). Coverage rates are
18 289 shown on Table 2. [Insert Table 2]

19 290
20 291 Among those who did not receive a dose of vaccine, over half of these missed doses (254 of the
21 292 357 missed doses during the two rounds) were because the person was not at home at the time
22 293 of vaccination or was out of town. In a few cases, the vaccine team missed the household,
23 294 accounting for 53 missed doses. Refusing to take vaccine was not reported.

24 295
25 296 *Reported AEFIs.* Overall, 71 individuals of 1,274 respondents (5.6%) reported an AEFI (Table
26 297 3). Determining a causal relation between the vaccination and the reported symptoms was not
27 298 attempted. [Insert Table 3]

28 299
29 300 Most AEFIs were considered mild or moderate, but 8 (0.6%) persons reported an AEFI as
30 301 severe. Most (60%) of the persons reporting an AEFI did not seek treatment including 60% of
31 302 those reporting a severe AEFI. 29.6% of the reported adverse events occurred in the first round,
32 303 40.9% in the second round and 29.6% in both rounds. The most common symptoms were
33 304 abdominal pain (15), diarrhoea, (9), fever, nausea, and headache (each 6) reports. Table 4
34 305 provides additional information on the AEFIs. The reported AEFIs were infrequent relative to the
35 306 number of doses distributed and there were no serious adverse events reported. [Insert Table4]

36 307

308 **Community knowledge of oral cholera vaccines.**

309 A majority (77%) of the respondents understood that vaccine was one of the ways to prevent
310 cholera. There was a statistically significant association between education level and knowledge
311 about OCV with those having at least a primary school education being almost twice as likely to
312 know the number of required doses as compared to those with no education (OR 1.90, 95% CI
313 1.06, 3.44 [P = 0.03].

314 *Sub-study Two, staff survey.* A total of 242 and 125 staff responded to the first and second
315 knowledge and practice (KP) surveys (KP1 and KP2). Most respondents were vaccination team
316 members (89% and 87% in vaccine rounds 1 and 2, respectively). Almost all the respondents
317 were knowledgeable about the cause of cholera, the importance of safe water in cholera
318 prevention and the vaccine target group, but were less knowledgeable regarding potential
319 adverse events following administration (AEFI) or how to advise vaccinees, with 29% and 16%
320 being less informed about AEFI during the first and second surveys.

321 When staff were asked to suggest areas that needed improvement in future OCV campaigns,
322 more than 10% suggested more timely payment of allowances, more time to sensitize and
323 inform the communities on the benefits of the vaccine, and better transportation and facilitation
324 allowances (payments to health workers to cover the cost they incurred when administering the
325 vaccines or conducting activities related to the OCV campaign). Other suggestions included
326 use of both static and mobile vaccination points, provision of gumboots, umbrellas, and more
327 areas for vaccine storage in sub-counties where vaccine would be more accessible, more
328 workers for hard to reach areas, and an increase in the number of vaccine days to complete the
329 vaccinations and increase coverage.

330

331 **DISCUSSION**

332 The results of this monitoring and evaluation exercise documented important findings on the
333 OCV campaign, the knowledge and practices of both the community and the health staff
334 involved in the campaign and implications for the conduct of future OCV campaigns as part of
335 an integrated cholera control strategy. These findings suggest that the OCV campaign in Hoima
336 successfully provided the vaccine to a very large proportion of the target population in Hoima
337 district, western Uganda. Approximately 93.6% of respondents reported receiving at least one
338 dose and 78.3% reported receiving two doses among residents. Given the mobile and transient
339 nature of this population, this was noteworthy, and suggests that even better coverage may be
340 possible for more settled populations in Uganda.

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3 341 Since this was the first such campaign with OCV, there was concern that the population might
4 342 be reluctant to accept it. This is a vaccine with which they were not familiar, it was given orally
5 343 to all ages rather by injection to children, and two doses were required. Despite these potential
6 344 constraints, we found that most people accepted taking the vaccine readily; however, some
7 345 were not at home resulting in missed vaccinations.

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11 347 High vaccination coverage is especially important when one is attempting to achieve herd
12 348 protection. Since it is estimated that herd protection can be achieved with a coverage even
13 349 lower than 90%;¹⁹ the high coverage achieved in this campaign would be expected to induce
14 350 significant indirect protection even among those who did not receive vaccine.^{19 20}

15 351
16 352 It was noted in the administrative report from the MoH and during a stakeholder's meeting that
17 353 one of the reasons for the reduction in the coverage during the second OCV dose was the
18 354 unpredictable campaign dates for the second round. The vaccine for the second round had to
19 355 be shipped and cleared through customs, and the timing for this was not certain. To avoid this
20 356 problem in the future, a mechanism needs to be established to provide a better timeline for
21 357 receipt of the vaccine shipments.

22 358
23 359 *Community Reception to OCV.* As with previous OCV campaigns outside Uganda, very few
24 360 AEFI were reported.^{21 22} Most of adverse events were considered mild or moderate and were
25 361 self-limited. Despite the low prevalence of AEFI, the survey exposed the need to better inform
26 362 the community about seeking treatment for more severe adverse events or for those that do not
27 363 quickly resolve. This was especially true for families with little education who were less likely to
28 364 seek medical attention for severe AEFI (data not shown). Notably, members in the community
29 365 demonstrated good understanding of the rationale for the vaccine; however, a key takeaway
30 366 from the survey was a need to better communicate the number of required doses, given that
31 367 those with more education were twice as likely than those with no education to know the
32 368 number of doses needed.

33 369
34 370 *Staff Reception to OCV.* Inclusion of staff KP survey contributed to the success of the project
35 371 by identifying gaps among the staff knowledge and performance. Questioning the vaccine staff
36 372 about their training and their experience in the field is not a common activity when conducting
37 373 monitoring and evaluation activities during OCV campaigns. Many people had to be mobilized
38 374 quickly and these were the key people who interacted with the communities. It was important

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3 375 that the staff accurately represent the campaign as an integrated cholera prevention program,
4 376 but this was the first time these people carried out this role. The MoH felt it important to monitor
5 377 their knowledge and behaviors as well as any constraints they felt in carrying out their functions.
6 378 While they were generally knowledgeable about the disease and about the vaccine, these staff
7 379 needed additional training regarding recognizing and managing AEFIs. They also faced
8 380 challenges regarding logistical support. After the first staff KP survey, these gaps were
9 381 communicated to the MoH so that appropriate actions could be taken to ensure that these gaps
10 382 were addressed prior to the second round.
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16 383
17 384 Most other OCV campaigns have also reported high coverage rates. These have included
18 385 reports from Bangladesh^{23 24}, Malawi^{25 26}, Mozambique²¹, Democratic Republic of Congo ²⁷,
19 386 Zambia ²⁸, South Sudan ^{29 30}, Iraq³¹, Haiti³², and Guinea ³³. Clearly, OCV is well accepted
20 387 among these very diverse population groups where the vaccine campaigns have been carried
21 388 out.
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26 389
27 390 Important limitations of this study need to be mentioned. Ideally, one would prefer to conduct
28 391 community studies prior to a campaign to understand knowledge and attitudes about cholera to
29 392 improve communications regarding the upcoming campaign as part of an integrated strategy to
30 393 control cholera. However, since the campaign was carried out on an emergency basis during an
31 394 outbreak, a study prior to the campaign was not possible. Secondly, a community survey
32 395 immediately after the first round might have provided feedback to the teams that would have
33 396 improved the coverage for the second round. It should also be noted that a single informant
34 397 provided information about receipt of the vaccine for all members of the household, so this
35 398 informant might have incorrect information concerning one or more members of the household;
36 399 however, since the vaccine was directly given to the household members together, it seems that
37 400 inaccuracies would be minimal. The community KP survey did not include questions on attitudes
38 401 regarding cholera. Since the survey had to be carried out very quickly following the campaign,
39 402 and since the survey was targeted to identify issues that would be immediately relevant to
40 403 campaign performance, it was felt that understanding attitudes regarding cholera, even though
41 404 important, would have required other qualitative methods requiring more time than was
42 405 available. Similarly, direct observation of the training and coordination meetings would have
43 406 been useful to independently assess the efficiency and effectiveness of these training and
44 407 coordination meetings. Furthermore, there was no list of all workers in the campaign and many
45 408 of the workers who participated in the second round had left prior to administering the
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3 409 questionnaire; thus, there were fewer respondents in the second round and the proportion of all
4 410 workers who participated could not be determined precisely. Finally, it was not possible, given
5 411 the time constraints, to fully integrate WASH interventions together with the OCV campaign, or
6 412 to monitor and evaluate community and staff responsiveness to such integration.
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10 413
11 414 In this outbreak 2,122 cholera cases and 44 deaths were reported, nearly all before the OCV
12 415 campaign and over half occurred in the first two weeks of the outbreak. Of note, the outbreak
13 416 started in February 2018 at about the same time the application for preventive use of OCV was
14 417 being submitted. The original application proposed a series of preventive campaigns over
15 418 the next year, and Hoima, as well as neighbouring districts in western Uganda, were targeted
16 419 for vaccination in the first round of these preventive campaigns. However, when the outbreak
17 420 was identified, plans were quickly shifted so that an emergency campaign could be
18 421 implemented to control the outbreak. Even though this emergency response was planned as
19 422 quickly as possible, in fact, the outbreak was essentially over before the vaccine campaign
20 423 could start, so it had no impact on the outbreak itself, but likely reduced the risk for future
21 424 outbreaks.
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30 426 Though the outbreak started with the influx of the refugees from DRC into Uganda, it quickly
31 427 spread to the refugee host communities in Hoima. Therefore, to prevent rapid spread,
32 428 improvement of cholera prevention measures for both the refugees and the host communities is
33 429 paramount during resettlement.
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37 430

38 431 **CONCLUSION**

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40 432 This study suggests that the OCV campaign in Hoima district to prevent cholera was successful
41 433 and achieved a high level of coverage in this population that was targeted to be at risk.
42 434 However, there was need to devote more effort on community sensitisation on the benefits of
43 435 vaccination, as well as improving some logistic support during the campaign.
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47 436
48 437 While a rapid response to this outbreak was appropriate, in fact, even with a rapidly organized
49 438 campaign, the outbreak was over before the vaccine could be given; thus, the vaccine had no
50 439 impact on this outbreak. Nevertheless, this area had already been identified as a hotspot, and it
51 440 would have been targeted if the planned preventive campaign had proceeded as originally
52 441 planned. Planners must realize that an area identified as a hotspot might experience an
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3 442 outbreak while preparations are underway for a preventive campaign and take this into account
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5 443 when allocating vaccine for preventive vs emergency campaigns. Since these are areas where
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7 444 cholera risk is high, outbreaks are likely to occur in these areas if there are delays in
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9 445 implementing preventive campaigns.
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For peer review only

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3 447 **FIGURE LEGENDS**

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6 449 **Figure 1. Epicurve of the Hoima Outbreak, 2018 with events identified in response**

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9 450 **to the outbreak**

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11 451 **Figure 2: Map of Hoima District, showing sub-counties that received OCV and**

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13 452 **households where interviews were conducted (red dots)**

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Table 1. Age and Sex Breakdown of the Participants in the Cluster Survey

Age Group (years)	Male	Female	Total
1 to 4	98	93	191
5 to 14	236	207	443
15 to 44	210	285	495
45+	80	65	145
Total	625	650	1274

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Table 2: Vaccination coverage post OCV campaign, Hoima District, Uganda, 2018.

Total surveyed = 1274	Round 1	Round 2	Received only one dose	Received two doses	Received at least one dose
Reported number (%)	1,164 (91.4)	1,027 (80.6)	195 (15.3)	998 (78.3)	1193 (93.6)
(95% CI)	(89.7-92.8)	(78.3-82.7)	(13.4-17.4)	(76.0-80.5)	(92.2-94.9)
Confirmed by availability of the vaccination card (%)	1,065 (83.6)	823 (64.6)	142 (11.1)	792 (62.2)	934 (73.3)
(95% CI)	(81.5-85.5)	(61.9-67.2)	(9.5-13.0)	(59.5-64.8)	(70.8-75.7)

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Table 3: Treatment and Resolution of Adverse Events Following Immunization in Hoima District, Uganda, 2018.

Symptoms	Treatment		Status		
	No treatment (%)	Treated (%)	Recovered (%)	Ongoing (%)	Improved, not to baseline (%)
Mild	24(80.0)	6(20.0)	29(96.7)	1(3.3)	0(0.0)
Moderate	11(39.3)	17(60.7)	23(82.1)	3(10.7)	2(7.1)
Severe	8(61.5)	5(38.5)	10(76.9)	0(0.0)	3(23.1)

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460

461 **Table 4. Onset and frequency of symptoms reported as adverse events**

	<6 hours	6-12 hours	12-24 hours	1-7 days	8-14 days	Total
462						
463	3	2	2	2	0	9
464	3	0	0	2	0	5
465	6	0	0	0	0	6
466	15*	0	0	0	0	15
467	0	3	0	1	0	4
468	0	0	0	0	1	1
469	1	1	0	3	1	6
470	1	1	0	6	1	9
471	1	0	0	0	0	1
472	0	3	0	0	0	3
473	0	1	0	0	0	1
474	0	0	0	0	1	1
475	0	0	0	1	0	1
476	3	0	2	1	0	6
477	1	0	0	2	0	3
478	34	11	4	18	4	71

- 480 • Three persons reported abdominal pain in one household

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495 **Footnotes**

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497 Discussed, critically revised and approved the study protocol: GB, MR, WAB, CGO, DAS.

498 Performed the research: GB, MR, WAB, AO, FR, IA. Analysed the data: GB, MR, WAB, AO,
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507 **Declaration of the conflict of interest**

508 The authors have no conflict of interest to declare.

509
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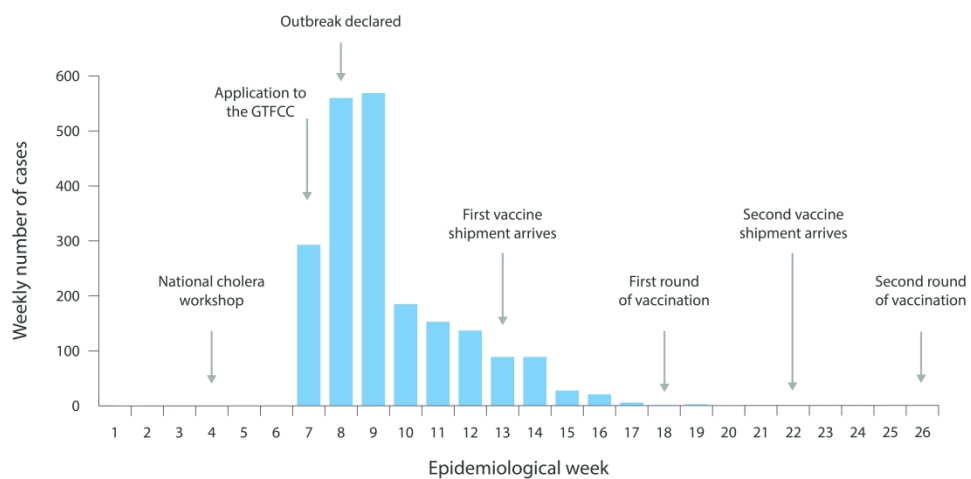


Figure 1. Epicurve of the Hoima Outbreak, 2018 with events identified in response to the outbreak

542x305mm (300 x 300 DPI)

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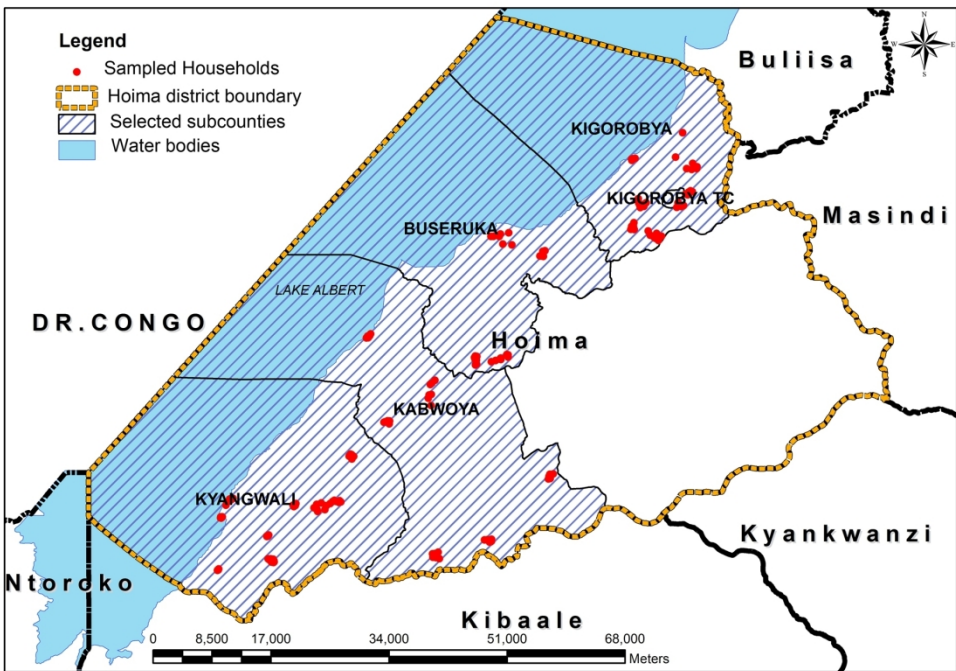


Figure 2: Map of Hoima District, showing sub-counties that received OCV and households where interviews were conducted (red dots)

170x119mm (300 x 300 DPI)

BMJ Open

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3 1 **Use of surveys to evaluate an integrated oral cholera vaccine campaign in response to a**
4
5 2 **cholera outbreak in Hoima District, Uganda**

6
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3 32 **ABSTRACT**

4 33 **Objectives** To evaluate the quality and coverage of the campaign to distribute oral cholera
5 34 vaccine during a cholera outbreak in Hoima, Uganda to guide future campaigns of cholera
6 35 vaccine.

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9 36 **Design** Survey of communities targeted for vaccination to determine vaccine coverage rates
10 37 and perceptions of the vaccination campaign, and a separate survey of vaccine staff who
11 38 carried out the campaign.

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13
14 39 **Setting** Hoima District, Uganda.

15
16 40 **Participants** Representative clusters of households residing in the communities targeted for
17 41 vaccination and staff members who conducted the vaccine campaign.

18
19 42 **Results** Among 209 households (1,274 individuals) included in the coverage survey, 1193
20 43 (94%; 95% CI: 92-95%) reported receiving at least one OCV dose and 998 (78%; 95% CI: 76-
21 44 81%) reported receiving two doses. Among vaccinated individuals, minor complaints were
22 45 reported by 71 persons (5.6%). Individuals with 'some' education (primary school or above)
23 46 were more knowledgeable regarding the required OCV doses compared to non-educated (p
24 47 value = 0.03). Factors negatively associated with campaign implementation included community
25 48 sensitisation time, staff payment, and problems with field transport. Although the campaign was
26 49 carried out quickly, the outbreak was over before the campaign started. Most staff involved in
27 50 the campaign (93%) were knowledgeable about cholera control; however, 29% did not clearly
28 51 understand how to detect and manage adverse events following immunization.

29
30 52 **Conclusion** The campaign achieved high OCV coverage, but the surveys provided insights for
31 53 improvement. To achieve high vaccine coverage, more effort is needed for community
32 54 sensitisation, and additional resources for staff transportation and timely payment for campaign
33 55 staff is required. Pre and post-test assessment of staff training can identify and address
34 56 knowledge and skill gaps.

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3 59 **Strengths and limitations of this study**
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- 5 60 • The cluster survey of households in communities targeted for vaccination efficiently
6 61 documented actual vaccine coverage in the target population.
7
8 62 • The cluster surveys of households identified mild adverse events not identified during the
9 63 campaign and identified the emphasize the second dose, especially among less educated
10 64 groups.
11
12 65 • Surveys of the vaccination staff immediately following each round identified certain
13 66 weaknesses in staff orientation as well as constraints to their job performance in the field.
14
15 67 • The household surveys obtained data from a single spokesperson for the household rather
16 68 than from each individual which might have introduced some uncertainty in the household
17 69 data.
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19 70 • Evaluation of the vaccination staff was carried through surveys and would have benefited by
20 71 direct observation of the training and the field performance.
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73 INTRODUCTION

74 Cholera, a preventable and treatable disease is characterized by profuse watery diarrhoea
75 caused by infection of the intestine with the bacterium *Vibrio cholerae*.¹ Cholera is a major
76 cause of morbidity and mortality in several countries in sub-Saharan Africa where cholera
77 outbreaks also negatively affect development due to associated high economic burden.^{2 3}
78 Between 2010 and 2016 an average 141,918 incident cases annually were reported from sub-
79 Saharan African countries, including Uganda.⁴ In Uganda, cholera outbreaks occurred as both
80 endemic and epidemic disease. Epidemic disease occurred in northern and eastern Uganda
81 districts⁵ and are thought to be worsened by contamination of water due to poor sanitation.⁶
82 Cholera outbreaks especially occur in districts along the international borders with the
83 Democratic Republic of the Congo (DR Congo), South Sudan and Kenya and along the Great
84 Lakes.^{5 7} These districts include Hoima, where cholera is endemic.^{5 8-10}

85
86 There has been debate in the public health community on best practices for endemic and
87 epidemic cholera disease control, with some preferring to focus on WASH interventions, and
88 others advocating for OCV for both endemic and epidemic disease control.¹¹ In part, this has
89 been facilitated by a relative lack of experience with OCV and concern that excess reliance on
90 vaccine might negatively affect essential infrastructural development and hygienic practices.
91 The World Health Organization (WHO) recommends an integrated approach to cholera
92 prevention where water, sanitation and hygiene (WaSH) interventions are complemented by
93 vaccine campaigns which provide oral cholera vaccine (OCV) to persons living in areas
94 considered high risk.^{2 12} These vaccine campaigns may be either preventive, in which the
95 vaccine is targeted to cholera hotspots, or reactive in which the campaign is implemented in
96 response to an outbreak or a humanitarian emergency.¹³

97
98 Two WHO-prequalified currently OCVs are available from the global stockpile: Shanchol
99 (Shantha Biotechnics Limited, India) and Euvichol (Eubiologics Co., Ltd., Korea).² The standard
100 immunization schedule consists of two doses given at an interval of at least two weeks to all
101 persons in the target area above one year of age. While there is increasing use of OCV to
102 control outbreaks, preventive use is constrained due to inadequate vaccine supply.¹⁴ Since
103 creation of a global OCV stockpile in July, 2013, several OCV campaigns had been successfully
104 implemented^{13 14} but it is still important to document national campaign experiences as well as
105 monitoring and evaluation activities, to continually improve the effectiveness and efficiency of
106 vaccine campaigns.

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3 107 The Ugandan Ministry of Health (MoH) had prepared plans for OCV campaigns in the areas
4 108 identified as cholera hotspots starting in the western districts of Uganda (including Hoima), near
5 109 the border with DR Congo and close to, or adjoining Lake Albert. These hotspot districts and
6 110 their specified sub-counties were confirmed during a national cholera workshop in Kampala on
7 111 29-31 January 2018. This workshop led to the development of an application for OCV to the
8 112 Global Taskforce for Cholera Control (GTFCC) which was submitted on 14 February 2018. The
9 113 application proposed providing OCV in these identified hotspots as a preventive strategy.
10 114 However, while preparations for these campaigns were underway, an outbreak was declared in
11 115 Hoima district on 23 February 2018. The earliest cases were identified among DR Congo
12 116 refugees, but then other cases were seen among the non-refugee Ugandan population. The
13 117 MoH responded to the outbreak with multisectoral interventions, including proper case
14 118 management, promotion of access to safe water and improved sanitation (WaSH), enhanced
15 119 cholera surveillance, as well as infection control and health education. These measures were
16 120 then supplemented with plans for an emergency OCV campaign. Thus, the original plans for a
17 121 preventive OCV campaign were shifted to an emergency response to control the outbreak. The
18 122 first doses of vaccine arrived on 28 March and the first round of vaccinations started on 2 May.
19 123 The doses for the second round arrived on 29 May and the second round started on 26 June. A
20 124 door-to-door strategy was used to deliver two doses of vaccine to an estimated 360,000 people,
21 125 including pregnant women, over the age of one year residing in the four targeted sub-counties.
22 126 To carry out the campaign, the MoH organized all activities including logistics, community
23 127 mobilisation and implementation, coordinating ground activities through an assigned point
24 128 person. Many stakeholders contributed to the campaign including the Hoima district local
25 129 government, WHO, UNICEF, UNHCR and Médecins sans Frontiers (MSF). Prior to the
26 130 campaign, the stakeholders met to define and coordinate their complementary tasks.
27 131 The epidemic curve based on a line list of cases and deaths by date and stated nationality is
28 132 shown on Figure 1. Over the course of the outbreak, 2,122 cases with 44 deaths (case fatality
29 133 rate, 2.1%) were reported. Sixty six percent (1,410) of the cases and 64% (28) of the deaths
30 134 occurred during the first two weeks of the outbreak. Many of the cases and deaths (1276 and
31 135 32, or 60% and 73%, respectively) occurred among persons who were from DR Congo, and the
32 136 refugees developed cholera symptoms soon after arrival in Uganda. Among the 44 deaths
33 137 reported, 25 (57%) occurred in the community, not in the health facility. Nineteen of the fatal
34 138 cases were treated at the health facility; the case fatality ratio (CFR) for facility-treated patients
35 139 was 0.9%. Although the emergency vaccination campaign intended to control the outbreak,

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3 140 because the outbreak was so sudden and so short-lived, the campaign could only be initiated
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5 141 after the outbreak had already declined.

6 142 *Rationale.* While vaccines are commonly used in Uganda, especially through the longstanding
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8 143 EPI program (Expanded Programme on Immunization), this was the first OCV use in Uganda,
9
10 144 and there was no prior experience to guide responders and implementers. Thus, this study was
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12 145 carried out with the aim to document campaign activities and to monitor and evaluate its
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14 146 procedures and outcomes that could guide future OCV campaigns. The issues addressed
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16 147 during this study included the knowledge and practices of the campaign staff, vaccine coverage
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18 148 in the targeted areas, and the knowledge and practices of the community. After this initial
19
20 149 campaign, the MoH continued its plans for preventive campaigns in the remaining cholera
21
22 150 hotspot districts, informed by the lessons learned from this initial emergency use campaign. In
23
24 151 an effort to document the impact of OCV on an outbreak in a setting with endemic disease, we
25
26 152 undertook this monitoring and evaluation exercise, as described below.
27
28 153

25 154 **MATERIALS AND METHODS**

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27 155 *Study setting.* Hoima district is located in western Uganda, across Lake Albert from DR Congo.
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29 156 It has a total area of 5735.5 square kilometres and a projected population of 630,000 persons
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31 157 (2018). The district consists of 13 administrative units as follows: 10 sub-counties
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33 158 (Kyabigambire, Buhimba, Kyangwali, Kabwoya, Bugambe, Kiziranfumbi, Kitoba, Kigorobyia,
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35 159 Buseruka and Buhanika), a municipality (Hoima municipality) and two town councils (Kigorobyia
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37 160 and Buhima town councils). The major economic activities of the population in Hoima are
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39 161 subsistence agriculture and fishing. Cholera is endemic in the district but the endemicity is
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41 162 localised in some specific sub-counties particularly those with fishing communities.¹⁵ The sub-
42
43 163 counties targeted for OCV included Buseruka, Kabwoya, Kangwali, and Kigorobyia which
44
45 164 together constitute the six administrative units of Kyangwali, Kigorobyia, Kabwoya Buseruka,
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47 165 Kigorobyia town council and Kyangwali refugee settlement (Old and New) as shown in Figure 2.
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46 167 *Population and design for the Monitoring and Evaluation of the OCV Campaign.* Two sub-
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48 168 studies were conducted to assess different aspects of the campaign. In sub-study one, a
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50 169 representative sample of the population that was targeted for vaccination was questioned to
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52 170 determine vaccine coverage rates, detect adverse events following immunization (AEFI) and
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54 171 collect additional information from the communities about the vaccine campaign. Sub-study two
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56 172 consisted of a survey among the campaign staff who participated in the OCV campaign after
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58 173 each round to assess their knowledge and practices.

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3 174 *Sub-study 1, community assessment.* Sub-study one was a two-stage, cluster survey
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5 175 conducted in the vaccine target area, consisting of 31 clusters, each cluster consisting of 4 to 7
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7 176 households per cluster. The study population included each person > one year of age who was
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9 177 living in the OCV targeted area at the time of the vaccination campaign. We assumed a
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11 178 household size of five persons based on estimates from a Demographic Health Survey
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13 179 conducted in 2016.¹⁶ The sample was increased in order to raise the analytical power and
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15 180 precision of the surveys and to allow for separate analysis by gender. The formula used for
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17 181 determining sample size was, $n = (z^2pq)/d^2$,¹⁷ where 'n' is the number of people desired for the
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19 182 survey, 'd' is the precision of the result, 'z' is the confidence limit, and 'p' and 'q' correspond to
20
21 183 the proportion of persons in the population who are immunised and not immunised, respectively.
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23 184 We chose to use a low coverage of 50%.

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25 185
26
27 186 To identify the clusters, a list of villages was obtained from each of the four sub-counties
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29 187 targeted for vaccination. From these lists, the Excel random number generator
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31 188 (=RANDBETWEENBOTTOM, TOP) was used to select the 31 villages from which households
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33 189 were selected. The number of villages per sub-county was proportionate to the population of
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35 190 the sub-county. The sub-county populations were obtained from the district planning unit.
36
37 191 From each selected village a list of households was obtained from the village administrative
38
39 192 leader (Local Council (LC) – 1. This is the smallest recognised administrative unit in Uganda. It
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41 193 is headed an elected leader called LC-1) who provided a list of households from which we
42
43 194 randomly selected households to interview.

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45 195
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47 196 For the household interviews, data were collected through standardized questionnaires during
48
49 197 face-to-face interviews conducted by trained research assistants using the local language.
50
51 198 Within a selected household the questionnaires were administered to the key respondents
52
53 199 (head of the HHs), who represented the entire household and provided information about each
54
55 200 member of the household. If a suitable key respondent was absent, additional visits were
56
57 201 scheduled. In two households, a person could not be located, and the household was dropped.
58
59 202 For each vaccinated person, the research assistants assessed cholera immunization status.
60
61 203 Vaccination status was ascertained in two ways: either the informant verbally indicated
62
63 204 that the individual had received the dose of vaccine or the vaccination was recorded on
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65 205 the vaccine card. If the informant did not have a vaccine card, the reliability of the
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67 206 vaccination information was validated by asking about the details of the procedures of

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3 207 the vaccination (e.g. being given recently by mouth to all persons > 1 year of age). None
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5 208 of the residents who were approached refused to answer the survey. The age and sex of the
6
7 209 participants in the survey is shown in Table 1.

8
9 210
10 211 *Adverse Events Following Immunization (AEFI)*. The occurrence of AEFIs were assessed by
11 212 asking for symptoms among the vaccine recipients following vaccination. As part of the
12 213 campaign itself, a routine system for AEFI detection was established in which the vaccine team
13 214 members advised vaccinees to report to a health worker or to seek care at a health facility if
14 215 they experienced symptoms following immunization. By contrast, the AEFI surveillance in this
15 216 sub-study asked the participants who participated in the cluster survey about symptoms they
16 217 may have experienced. This AEFI sub-study was thus, designed to enhance our understanding
17 218 of potential AEFIs which may not have been reported through the routine AEFI surveillance.

18 219
19 220 AEFIs were categorised for each individual member of the household who received a dose of
20 221 OCV as follows. They were considered mild if the symptoms did not interfere with normal
21 222 activities; moderate if they interfered somewhat; and severe if the symptoms prevented the
22 223 individual from continuing normal activities.¹⁸ Persons who reported to be having ongoing
23 224 symptoms > 72 hours were advised to visit the nearest health facility for more care. Among
24 225 those reporting symptoms, information was recorded as to whether the person took any
25 226 medicine or received any treatment to lessen the symptoms.

26 227
27 228 *Data collection and analysis*. Data from the community surveys were collected by tablet
28 229 computers using *Kobo Collect* (<https://www.kobotoolbox.org/>) installed to record the responses
29 230 in the field. Data were cleaned, coded, and stored in Stata Version 14. Data were analysed to
30 231 generate frequencies, percentages or proportions and means. Comparisons between groups
31 232 was done via logistic regression for the calculation of odds ratios and 95% confidence intervals.
32 233 The results of analysis were presented in the form of graphs, tables, charts, and means and
33 234 were included in interim and end of campaign reports.

34 235
35 236 *Quality Assurance*. Research assistants were trained on data collection methods and were able
36 237 to consult field supervisors and the principal investigator on any issue that was not clear to
37 238 them. For quality assurance, the survey supervisors revisited about 10% of the households, not
38 239 to collect the data again, but to ensure that they were not skipped by the interviewers for eligible

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3 240 respondents. The surveys were conducted about two weeks after completion of the second
4 241 round of the vaccination campaign to minimize recall bias.

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8 243 *Sub-study 2, staff assessment.* Staff were assessed on their level of knowledge on the cause of
9 244 cholera, the importance of safe water in cholera prevention, the target age group for cholera
10 245 vaccination, and knowledge about AEFI and the procedures for care should subjects experience
11 246 an AEFI. Staff were surveyed twice with each survey taking place within two weeks after
12 247 administration of the first and second OCV rounds, respectively. All staff who participated
13 248 directly by administering the vaccines or indirectly through supervisory roles and who were
14 249 present at the workstation during the study period were enrolled in the survey. For the staff
15 250 survey, structured questions were administered on paper questionnaires that allowed for adding
16 251 text to explain the answers (open-ended questions). Most of the vaccine staff had taken part in
17 252 other public health campaigns, but none had participated earlier with a campaign to distribute
18 253 OCV.

19 254 *Ethical Considerations.* This study was conducted as part of the routine MoH operational
20 255 research for improvement of health services; however, ethical issues were considered and
21 256 addressed. The proposal was approved by the Makerere University School of Public Health
22 257 Institutional Review Board (MaKSPH IRB) (no 610 in 2018) and Uganda National Council of
23 258 Science and Technology. Written informed consent was obtained from all participants in both
24 259 sub-studies. Participation in the study was voluntary and respondents were free to opt out at
25 260 any stage of the interviews.

26 261 Confidentiality was observed at all stages of the study. No names or personal identifiers were
27 262 included on the questionnaires. The research assistants underwent training on interview
28 263 techniques, neutrality, and research ethics. The benefits of the study to the staff included the
29 264 ability to express themselves, provide feedback and observations that in turn might lead to
30 265 improvements in supportive services for their training and work.

31 266
32 267 *Patient and Public Involvement.* This research was done without research subject
33 268 involvement. The time was inadequate to involve the subjects prior to the vaccine campaign.
34 269 They were also not invited to contribute to the writing or editing of this document for readability
35 270 or accuracy. However, the findings of the study were disseminated to the Hoima district
36 271 administration, MoH and other policymakers to use them to strengthen health service
37 272 interventions and future OCV campaigns.

273

274 RESULTS

275 *Sub-study One, community survey results.* The community surveys were carried out in the four
276 sub-counties in Hoima districts of Buseruka, Kabwoya, Kyangwali and Kigoroby as shown in
277 Figure 2 and Table 1. [Insert Figure 2 and Table 1] A total of 209 households, including 1,274
278 individuals, were surveyed. Most (96%) of the respondents were household heads or their
279 spouses. All respondents confirmed that they were living in the targeted OCV area at the time of
280 the campaign. Fifty-one (51%) of the respondents had primary education, 17% had secondary
281 education, 1% had tertiary education, and the remaining 31% had no education. The
282 respondents were aged 18 – 89 years with a mean age of 40 years. Both sexes were present,
283 with no statistically significant difference.

284 By verbal reports, 94% (95% CI: 92-95%) of the residents received at least one dose and 78%
285 (95% CI: 76-81%) received two doses of OCV. From verbal reporting, 91% (95% CI: 90-93%) of
286 residents received vaccine during the first round and 81% (95% CI: 78-83%) received vaccine
287 during the second round. For many of the households, a vaccine card was available, and the
288 vaccination card was used to confirm vaccination status. Using information from the card only,
289 coverage was 84% (95% CI: 82-86%) and 65% (95% CI: 62-67%) for round one and round two
290 respectively and the two-dose coverage was 62% (95% CI: 60-65%). Coverage rates are
291 shown on Table 2. [Insert Table 2]

292
293 Among those who did not receive a dose of vaccine, over half of these missed doses (254 of the
294 357 missed doses during the two rounds) were because the person was not at home at the time
295 of vaccination or was out of town. In a few cases, the vaccine team missed the household,
296 accounting for 53 missed doses. Refusing to take vaccine was not reported.

297
298 *Reported AEFIs.* Overall, 71 individuals of 1,274 respondents (5.6%) reported an AEFI (Table
299 3). Determining a causal relation between the vaccination and the reported symptoms was not
300 attempted. [Insert Table 3]

301
302 Most AEFIs were considered mild or moderate, but 8 (0.6%) persons reported an AEFI as
303 severe. Most (60%) of the persons reporting an AEFI did not seek treatment including 60% of
304 those reporting a severe AEFI. 29.6% of the reported adverse events occurred in the first round,
305 40.9% in the second round and 29.6% in both rounds. The most common symptoms were
306 abdominal pain (15), diarrhoea, (9), fever, nausea, and headache (each 6) reports. Table 4

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3 307 provides additional information on the AEFIs. The reported AEFIs were infrequent relative to the
4 308 number of doses distributed and there were no serious adverse events reported. [Insert Table4]

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8 310 ***Community knowledge of oral cholera vaccines.***

9 311 A majority (77%) of the respondents understood that vaccine was one of the ways to prevent
10 312 cholera. There was a statistically significant association between education level and knowledge
11 313 about OCV with those having at least a primary school education being almost twice as likely to
12 314 know the number of required doses as compared to those with no education (OR 1.90, 95% CI
13 315 1.06, 3.44 (P = 0.03).

14 316 *Sub-study Two, staff survey.* A total of 242 and 125 staff responded to the first and second
15 317 knowledge and practice (KP) surveys (KP1 and KP2). Most respondents were vaccination team
16 318 members (89% and 87% in vaccine rounds 1 and 2, respectively). Almost all the respondents
17 319 were knowledgeable about the cause of cholera, the importance of safe water in cholera
18 320 prevention and the vaccine target group, but were less knowledgeable regarding potential
19 321 adverse events following administration (AEFI) or how to advise vaccinees, with 29% and 16%
20 322 being less informed about AEFI during the first and second surveys.

21 323 When staff were asked to suggest areas that needed improvement in future OCV campaigns,
22 324 more than 10% suggested more timely payment of allowances, more time to sensitize and
23 325 inform the communities on the benefits of the vaccine, and better transportation and facilitation
24 326 allowances (payments to health workers to cover the cost they incurred when administering the
25 327 vaccines or conducting activities related to the OCV campaign). Other suggestions included
26 328 use of both static and mobile vaccination points, provision of gumboots, umbrellas, and more
27 329 areas for vaccine storage in sub-counties where vaccine would be more accessible, more
28 330 workers for hard to reach areas, and an increase in the number of vaccine days to complete the
29 331 vaccinations and increase coverage.

30 332

31 333 **DISCUSSION**

32 334 The results of this monitoring and evaluation exercise documented important findings on the
33 335 OCV campaign, the knowledge and practices of both the community and the health staff
34 336 involved in the campaign and implications for the conduct of future OCV campaigns as part of
35 337 an integrated cholera control strategy. These findings suggest that the OCV campaign in Hoima
36 338 successfully provided the vaccine to a very large proportion of the target population in Hoima
37 339 district, western Uganda. Approximately 93.6% of respondents reported receiving at least one

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3 340 dose and 78.3% reported receiving two doses among residents. Given the mobile and transient
4 341 nature of this population, this was noteworthy, and suggests that even better coverage may be
5 342 possible for more settled populations in Uganda.
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9 344 Since this was the first such campaign with OCV, there was concern that the population might
10 345 be reluctant to accept it. This is a vaccine with which they were not familiar, it was given orally
11 346 to all ages rather by injection to children, and two doses were required. Despite these potential
12 347 constraints, we found that most people accepted taking the vaccine readily; however, some
13 348 were not at home resulting in missed vaccinations.
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19 350 High vaccination coverage is especially important when one is attempting to achieve herd
20 351 protection. Since it is estimated that herd protection can be achieved with a coverage even
21 352 lower than 90%;¹⁹ the high coverage achieved in this campaign would be expected to induce
22 353 significant indirect protection even among those who did not receive vaccine.^{19 20}
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26 354
27 355 It was noted in the administrative report from the MoH and during a stakeholder's meeting that
28 356 one of the reasons for the reduction in the coverage during the second OCV dose was the
29 357 unpredictable campaign dates for the second round. The vaccine for the second round had to
30 358 be shipped and cleared through customs, and the timing for this was not certain. To avoid this
31 359 problem in the future, a mechanism needs to be established to provide a better timeline for
32 360 receipt of the vaccine shipments.
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38 362 *Community Reception to OCV.* As with previous OCV campaigns outside Uganda, very few
39 363 AEFI were reported.^{21 22} Most of adverse events were considered mild or moderate and were
40 364 self-limited. Despite the low prevalence of AEFI, the survey exposed the need to better inform
41 365 the community about seeking treatment for more severe adverse events or for those that do not
42 366 quickly resolve. This was especially true for families with little education who were less likely to
43 367 seek medical attention for severe AEFI (data not shown). Notably, members in the community
44 368 demonstrated good understanding of the rationale for the vaccine; however, a key takeaway
45 369 from the survey was a need to better communicate the number of required doses, given that
46 370 those with more education were twice as likely than those with no education to know the
47 371 number of doses needed.
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3 373 *Staff Reception to OCV.* Inclusion of staff KP survey contributed to the success of the project
4 374 by identifying gaps among the staff knowledge and performance. Questioning the vaccine staff
5 375 about their training and their experience in the field is not a common activity when conducting
6 376 monitoring and evaluation activities during OCV campaigns. Many people had to be mobilized
7 377 quickly and these were the key people who interacted with the communities. It was important
8 378 that the staff accurately represent the campaign as an integrated cholera prevention program,
9 379 but this was the first time these people carried out this role. The MoH felt it important to monitor
10 380 their knowledge and behaviors as well as any constraints they felt in carrying out their functions.
11 381 While they were generally knowledgeable about the disease and about the vaccine, these staff
12 382 needed additional training regarding recognizing and managing AEFIs. They also faced
13 383 challenges regarding logistical support. After the first staff KP survey, these gaps were
14 384 communicated to the MoH so that appropriate actions could be taken to ensure that these gaps
15 385 were addressed prior to the second round.
16 386

17 387 Most other OCV campaigns have also reported high coverage rates. These have included
18 388 reports from Bangladesh^{23 24}, Malawi^{25 26}, Mozambique²¹, Democratic Republic of Congo ²⁷,
19 389 Zambia ²⁸, South Sudan ^{29 30}, Iraq³¹, Haiti³², and Guinea ³³. Clearly, OCV is well accepted
20 390 among these very diverse population groups where the vaccine campaigns have been carried
21 391 out.
22 392

23 393 Important limitations of this study need to be mentioned. Ideally, one would prefer to conduct
24 394 community studies prior to a campaign to understand knowledge and attitudes about cholera to
25 395 improve communications regarding the upcoming campaign as part of an integrated strategy to
26 396 control cholera. However, since the campaign was carried out on an emergency basis during an
27 397 outbreak, a study prior to the campaign was not possible. Secondly, a community survey
28 398 immediately after the first round might have provided feedback to the teams that would have
29 399 improved the coverage for the second round. It should also be noted that a single informant
30 400 provided information about receipt of the vaccine for all members of the household, so this
31 401 informant might have incorrect information concerning one or more members of the household;
32 402 however, since the vaccine was directly given to the household members together, it seems that
33 403 inaccuracies would be minimal. The community KP survey did not include questions on attitudes
34 404 regarding cholera. Since the survey had to be carried out very quickly following the campaign,
35 405 and since the survey was targeted to identify issues that would be immediately relevant to
36 406 campaign performance, it was felt that understanding attitudes regarding cholera, even though

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3 407 important, would have required other qualitative methods requiring more time than was
4 408 available. Similarly, direct observation of the training and coordination meetings would have
5 409 been useful to independently assess the efficiency and effectiveness of these training and
6 410 coordination meetings. Furthermore, there was no list of all workers in the campaign and many
7 411 of the workers who participated in the second round had left prior to administering the
8 412 questionnaire; thus, there were fewer respondents in the second round and the proportion of all
9 413 workers who participated could not be determined precisely. Finally, it was not possible, given
10 414 the time constraints, to fully integrate WASH interventions together with the OCV campaign, or
11 415 to monitor and evaluate community and staff responsiveness to such integration.
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19 417 In this outbreak 2,122 cholera cases and 44 deaths were reported, nearly all before the OCV
20 418 campaign and over half occurred in the first two weeks of the outbreak. Of note, the outbreak
21 419 started in February 2018 at about the same time the application for preventive use of OCV was
22 420 being submitted. The original application proposed a series of preventive campaigns over
23 421 the next year, and Hoima, as well as neighbouring districts in western Uganda, were targeted
24 422 for vaccination in the first round of these preventive campaigns. However, when the outbreak
25 423 was identified, plans were quickly shifted so that an emergency campaign could be
26 424 implemented to control the outbreak. Even though this emergency response was planned as
27 425 quickly as possible, in fact, the outbreak was essentially over before the vaccine campaign
28 426 could start, so it had no impact on the outbreak itself, but likely reduced the risk for future
29 427 outbreaks.
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38 429 Though the outbreak started with the influx of the refugees from DRC into Uganda, it quickly
39 430 spread to the refugee host communities in Hoima. Therefore, to prevent rapid spread,
40 431 improvement of cholera prevention measures for both the refugees and the host communities is
41 432 paramount during resettlement.
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46 434 **CONCLUSION**

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48 435 This study suggests that the OCV campaign in Hoima district to prevent cholera was successful
49 436 and achieved a high level of coverage in this population at high risk. However, there was need
50 437 to devote more effort on community sensitisation on the benefits of vaccination, as well as
51 438 improving some logistic support during the campaign.
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3 440 While a rapid response to this outbreak was appropriate, in fact, even with a rapidly organized
4 441 campaign, the outbreak was over before the vaccine could be given; thus, the vaccine had no
5 442 impact on this outbreak. Nevertheless, this area had already been identified as a hotspot, and it
6 443 would have been targeted if the planned preventive campaign had proceeded as originally
7 444 planned. Planners must realize that an area identified as a hotspot might experience an
8 445 outbreak while preparations are underway for a preventive campaign and take this into account
9 446 when allocating vaccine for preventive vs emergency campaigns. Since these are areas where
10 447 cholera risk is high, outbreaks are likely to occur in these areas if there are delays in
11 448 implementing preventive campaigns.
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450 **FIGURE LEGENDS**

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452 **Figure 1. Epicurve of the Hoima Outbreak, 2018 with events identified in response to the**
453 **outbreak**

454 **Figure 2: Map of Hoima District, showing sub-counties that received OCV and**
455 **households where interviews were conducted (red dots)**

456

For peer review only

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Table 1. Age and Sex Breakdown of the Participants in the Cluster Survey

Age Group (years)	Male	Female	Total
1 to 4	98	93	191
5 to 14	236	207	443
15 to 44	210	285	495
45+	80	65	145
Total	625	650	1274

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Table 2: Vaccination coverage post OCV campaign, Hoima District, Uganda, 2018.

Total surveyed = 1274	Round 1	Round 2	Received only one dose	Received two doses	Received at least one dose
Reported number (%) (95% CI)	1,164 (91.4) (89.7-92.8)	1,027 (80.6) (78.3-82.7)	195 (15.3) (13.4-17.4)	998 (78.3) (76.0-80.5)	1193 (93.6) (92.2-94.9)
Confirmed by availability of the vaccination card (%) (95% CI)	1,065 (83.6) (81.5-85.5)	823 (64.6) (61.9-67.2)	142 (11.1) (9.5-13.0)	792 (62.2) (59.5-64.8)	934 (73.3) (70.8-75.7)

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Table 3: Treatment and Resolution of Adverse Events Following Immunization in Hoima District, Uganda, 2018.

Symptoms	Treatment		Status		
	No treatment (%)	Treated (%)	Recovered (%)	Ongoing (%)	Improved, not to baseline (%)
Mild	24(80.0)	6(20.0)	29(96.7)	1(3.3)	0(0.0)
Moderate	11(39.3)	17(60.7)	23(82.1)	3(10.7)	2(7.1)
Severe	8(61.5)	5(38.5)	10(76.9)	0(0.0)	3(23.1)

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464 **Table 4. Onset and frequency of symptoms reported as**
465 **adverse events**

	<6 hours	6-12 hours	12-24 hours	1-7 days	8-14 days	Total
Diarrhoea	3	2	2	2	0	9
Vomiting	3	0	0	2	0	5
Nausea	6	0	0	0	0	6
Abdominal pain	15*	0	0	0	0	15
Stomach gurgling	0	3	0	1	0	4
Mouth ulcers	0	0	0	0	1	1
Cough	1	1	0	3	1	6
Felt feverish	1	1	0	6	1	9
Poor appetite	1	0	0	0	0	1
Dizziness	0	3	0	0	0	3
Fainted	0	1	0	0	0	1
Itching	0	0	0	0	1	1
Weakness	0	0	0	1	0	1
Headache	3	0	2	1	0	6
Other	1	0	0	2	0	3
Total	34	11	4	18	4	71

484 • Three persons reported abdominal pain in one household

485

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493
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498 **Footnotes**

499 **Contributors:** Conceived and designed the study: GB, MR, WAB, ABS, CGO, DAS.
500 Discussed, critically revised and approved the study protocol: GB, MR, WAB, CGO, DAS.
501 Performed the research: GB, MR, WAB, AO, FR, IA. Analysed the data: GB, MR, WAB, AO,
502 DAS. Wrote the first draft: GB, MR. Wrote the final DAS. Elaborated, discussed and approved
503 the final version: GB, MR, AB, ABS, AO, FR, IA, CGO, and DAS.

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510 **Declaration of the conflict of interest**

511 The authors have no conflict of interest to declare.

512

513 **Additional data sharing:** Data are available upon reasonable request

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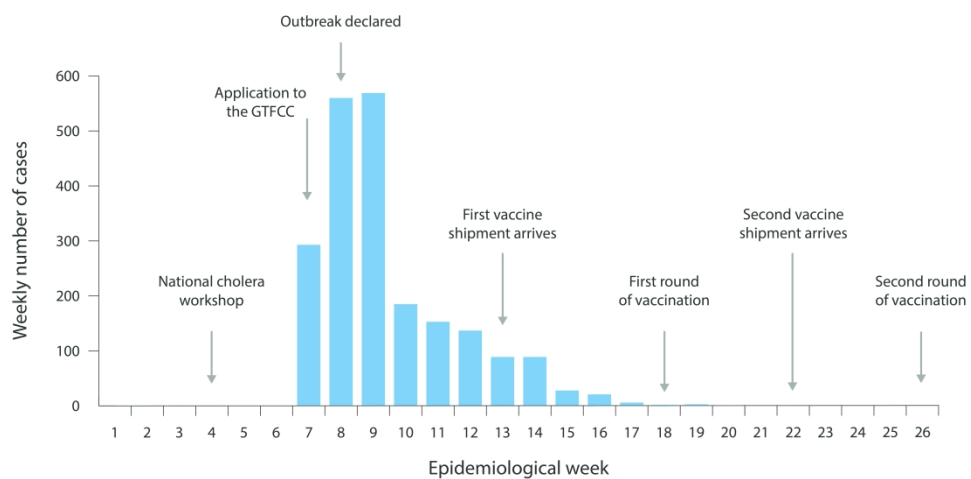


Figure 1. Epicurve of the Hoima Outbreak, 2018 with events identified in response to the outbreak

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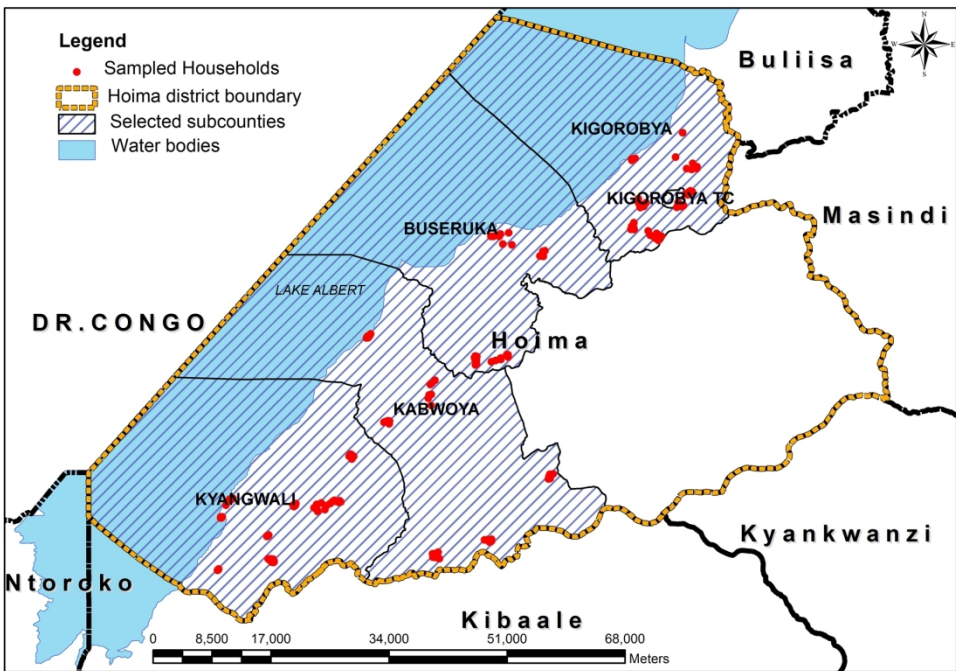


Figure 2: Map of Hoima District, showing sub-counties that received OCV and households where interviews were conducted (red dots)

170x119mm (300 x 300 DPI)

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3 1 **Use of surveys to evaluate an integrated oral cholera vaccine campaign in response to a**
4
5 2 **cholera outbreak in Hoima District, Uganda**

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3 32 **ABSTRACT**

4 33 **Objectives** To evaluate the quality and coverage of the campaign to distribute oral cholera
5 34 vaccine during a cholera outbreak in Hoima, Uganda to guide future campaigns of cholera
6 35 vaccine.

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9 36 **Design** Survey of communities targeted for vaccination to determine vaccine coverage rates
10 37 and perceptions of the vaccination campaign, and a separate survey of vaccine staff who
11 38 carried out the campaign.

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14 39 **Setting** Hoima District, Uganda.

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16 40 **Participants** Representative clusters of households residing in the communities targeted for
17 41 vaccination and staff members who conducted the vaccine campaign.

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19 42 **Results** Among 209 households (1,274 individuals) included in the coverage survey, 1193
20 43 (94%; 95% CI: 92-95%) reported receiving at least one OCV dose and 998 (78%; 95% CI: 76-
21 44 81%) reported receiving two doses. Among vaccinated individuals, minor complaints were
22 45 reported by 71 persons (5.6%). Individuals with 'some' education (primary school or above)
23 46 were more knowledgeable regarding the required OCV doses compared to non-educated (p
24 47 value = 0.03). Factors negatively associated with campaign implementation included community
25 48 sensitisation time, staff payment, and problems with field transport. Although the campaign was
26 49 carried out quickly, the outbreak was over before the campaign started. Most staff involved in
27 50 the campaign (93%) were knowledgeable about cholera control; however, 29% did not clearly
28 51 understand how to detect and manage adverse events following immunization.

29
30 52 **Conclusion** The campaign achieved high OCV coverage, but the surveys provided insights for
31 53 improvement. To achieve high vaccine coverage, more effort is needed for community
32 54 sensitisation, and additional resources for staff transportation and timely payment for campaign
33 55 staff is required. Pre and post-test assessment of staff training can identify and address
34 56 knowledge and skill gaps.

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3 59 **Strengths and limitations of this study**
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- 5 60 • The cluster survey of households in communities targeted for vaccination efficiently
6 61 documented actual vaccine coverage in the target population.
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8 62 • The cluster surveys of households identified mild adverse events not identified during the
9 63 campaign and identified the emphasize the second dose, especially among less educated
10 64 groups.
11
12 65 • Surveys of the vaccination staff immediately following each round identified certain
13 66 weaknesses in staff orientation as well as constraints to their job performance in the field.
14
15 67 • The household surveys obtained data from a single spokesperson for the household rather
16 68 than from each individual which might have introduced some uncertainty in the household
17 69 data.
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19 70 • Evaluation of the vaccination staff was carried through surveys and would have benefited by
20 71 direct observation of the training and the field performance.
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73 INTRODUCTION

74 Cholera, a preventable and treatable disease is characterized by profuse watery diarrhoea
75 caused by infection of the intestine with the bacterium *Vibrio cholerae*.¹ Cholera is a major
76 cause of morbidity and mortality in several countries in sub-Saharan Africa where cholera
77 outbreaks also negatively affect development due to associated high economic burden.^{2 3}
78 Between 2010 and 2016 an average 141,918 incident cases annually were reported from sub-
79 Saharan African countries, including Uganda.⁴ In Uganda, cholera outbreaks occurred as both
80 endemic and epidemic disease. Epidemic disease occurred in northern and eastern Uganda
81 districts⁵ and are thought to be worsened by contamination of water due to poor sanitation.⁶
82 Cholera outbreaks especially occur in districts along the international borders with the
83 Democratic Republic of the Congo (DR Congo), South Sudan and Kenya and along the Great
84 Lakes.^{5 7} These districts include Hoima, where cholera is endemic.^{5 8-10}

85
86 There has been debate in the public health community on best practices for endemic and
87 epidemic cholera disease control, with some preferring to focus on WASH interventions, and
88 others advocating for OCV for both endemic and epidemic disease control.¹¹ In part, this has
89 been facilitated by a relative lack of experience with OCV and concern that excess reliance on
90 vaccine might negatively affect essential infrastructural development and hygienic practices.
91 The World Health Organization (WHO) recommends an integrated approach to cholera
92 prevention where water, sanitation and hygiene (WaSH) interventions are complemented by
93 vaccine campaigns which provide oral cholera vaccine (OCV) to persons living in areas
94 considered high risk.^{2 12} These vaccine campaigns may be either preventive, in which the
95 vaccine is targeted to cholera hotspots, or reactive in which the campaign is implemented in
96 response to an outbreak or a humanitarian emergency.¹³

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98 Two WHO-prequalified currently OCVs are available from the global stockpile: Shanchol
99 (Shantha Biotechnics Limited, India) and Euvichol (Eubiologics Co., Ltd., Korea).² The standard
100 immunization schedule consists of two doses given at an interval of at least two weeks to all
101 persons in the target area above one year of age. While there is increasing use of OCV to
102 control outbreaks, preventive use is constrained due to inadequate vaccine supply.¹⁴ Since
103 creation of a global OCV stockpile in July, 2013, several OCV campaigns had been successfully
104 implemented^{13 14} but it is still important to document national campaign experiences as well as
105 monitoring and evaluation activities, to continually improve the effectiveness and efficiency of
106 vaccine campaigns.

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3 107 The Ugandan Ministry of Health (MoH) had prepared plans for OCV campaigns in the areas
4 108 identified as cholera hotspots starting in the western districts of Uganda (including Hoima), near
5 109 the border with DR Congo and close to, or adjoining Lake Albert. These hotspot districts and
6 110 their specified sub-counties were confirmed during a national cholera workshop in Kampala on
7 111 29-31 January 2018. This workshop led to the development of an application for OCV to the
8 112 Global Taskforce for Cholera Control (GTFCC) which was submitted on 14 February 2018. The
9 113 application proposed providing OCV in these identified hotspots as a preventive strategy.
10 114 However, while preparations for these campaigns were underway, an outbreak was declared in
11 115 Hoima district on 23 February 2018. The earliest cases were identified among DR Congo
12 116 refugees, but then other cases were seen among the non-refugee Ugandan population. The
13 117 MoH responded to the outbreak with multisectoral interventions, including proper case
14 118 management, promotion of access to safe water and improved sanitation (WaSH), enhanced
15 119 cholera surveillance, as well as infection control and health education. These measures were
16 120 then supplemented with plans for an emergency OCV campaign. Thus, the original plans for a
17 121 preventive OCV campaign were shifted to an emergency response to control the outbreak. The
18 122 first doses of vaccine arrived on 28 March and the first round of vaccinations started on 2 May.
19 123 The doses for the second round arrived on 29 May and the second round started on 26 June. A
20 124 door-to-door strategy was used to deliver two doses of vaccine to an estimated 360,000 people,
21 125 including pregnant women, over the age of one year residing in the four targeted sub-counties.
22 126 To carry out the campaign, the MoH organized all activities including logistics, community
23 127 mobilisation and implementation, coordinating ground activities through an assigned point
24 128 person. Many stakeholders contributed to the campaign including the Hoima district local
25 129 government, WHO, UNICEF, UNHCR and Médecins sans Frontiers (MSF). Prior to the
26 130 campaign, the stakeholders met to define and coordinate their complementary tasks.
27 131 The epidemic curve based on a line list of cases and deaths by date and stated nationality is
28 132 shown on Figure 1. Over the course of the outbreak, 2,122 cases with 44 deaths (case fatality
29 133 rate, 2.1%) were reported. Sixty six percent (1,410) of the cases and 64% (28) of the deaths
30 134 occurred during the first two weeks of the outbreak. Many of the cases and deaths (1276 and
31 135 32, or 60% and 73%, respectively) occurred among persons who were from DR Congo, and the
32 136 refugees developed cholera symptoms soon after arrival in Uganda. Among the 44 deaths
33 137 reported, 25 (57%) occurred in the community, not in the health facility. Nineteen of the fatal
34 138 cases were treated at the health facility; the case fatality ratio (CFR) for facility-treated patients
35 139 was 0.9%. Although the emergency vaccination campaign intended to control the outbreak,

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3 140 because the outbreak was so sudden and so short-lived, the campaign could only be initiated
4 141 after the outbreak had already declined.
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6 142 *Rationale.* While vaccines are commonly used in Uganda, especially through the longstanding
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8 143 EPI program (Expanded Programme on Immunization), this was the first OCV use in Uganda,
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10 144 and there was no prior experience to guide responders and implementers. Thus, this study was
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12 145 carried out with the aim to document campaign activities and to monitor and evaluate its
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14 146 procedures and outcomes that could guide future OCV campaigns. The issues addressed
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16 147 during this study included the knowledge and practices of the campaign staff, vaccine coverage
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18 148 in the targeted areas, and the knowledge and practices of the community. After this initial
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20 149 campaign, the MoH continued its plans for preventive campaigns in the remaining cholera
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22 150 hotspot districts, informed by the lessons learned from this initial emergency use campaign. In
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24 151 an effort to document the impact of OCV on an outbreak in a setting with endemic disease, we
25
26 152 undertook this monitoring and evaluation exercise, as described below.
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28 153

25 154 **MATERIALS AND METHODS**

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27 155 *Study setting.* Hoima district is located in western Uganda, across Lake Albert from DR Congo.
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29 156 It has a total area of 5735.5 square kilometres and a projected population of 630,000 persons
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31 157 (2018). The district consists of 13 administrative units as follows: 10 sub-counties
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33 158 (Kyabigambire, Buhimba, Kyangwali, Kabwoya, Bugambe, Kiziranfumbi, Kitoba, Kigorobyia,
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35 159 Buseruka and Buhanika), a municipality (Hoima municipality) and two town councils (Kigorobyia
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37 160 and Buhima town councils). The major economic activities of the population in Hoima are
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39 161 subsistence agriculture and fishing. Cholera is endemic in the district but the endemicity is
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41 162 localised in some specific sub-counties particularly those with fishing communities.¹⁵ The sub-
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43 163 counties targeted for OCV included Buseruka, Kabwoya, Kangwali, and Kigorobyia which
44
45 164 together constitute the six administrative units of Kyangwali, Kigorobyia, Kabwoya Buseruka,
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47 165 Kigorobyia town council and Kyangwali refugee settlement (Old and New) as shown in Figure 2.
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49 166

46 167 *Population and design for the Monitoring and Evaluation of the OCV Campaign.* Two sub-
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48 168 studies were conducted to assess different aspects of the campaign. In sub-study one, a
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50 169 representative sample of the population that was targeted for vaccination was questioned to
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52 170 determine vaccine coverage rates, detect adverse events following immunization (AEFI) and
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54 171 collect additional information from the communities about the vaccine campaign. Sub-study two
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56 172 consisted of a survey among the campaign staff who participated in the OCV campaign after
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58 173 each round to assess their knowledge and practices.

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3 174 *Sub-study 1, community assessment.* Sub-study one was a two-stage, cluster survey
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5 175 conducted in the vaccine target area, consisting of 31 clusters, each cluster consisting of 4 to 7
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7 176 households per cluster. The study population included each person > one year of age who was
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9 177 living in the OCV targeted area at the time of the vaccination campaign. We assumed a
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11 178 household size of five persons based on estimates from a Demographic Health Survey
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13 179 conducted in 2016.¹⁶ The sample was increased in order to raise the analytical power and
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15 180 precision of the surveys and to allow for separate analysis by gender. The formula used for
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17 181 determining sample size was, $n = (z^2pq)/d^2$,¹⁷ where 'n' is the number of people desired for the
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19 182 survey, 'd' is the precision of the result, 'z' is the confidence limit, and 'p' and 'q' correspond to
20
21 183 the proportion of persons in the population who are immunised and not immunised, respectively.
22
23 184 We chose to use a low coverage of 50%.

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26
27 186 To identify the clusters, a list of villages was obtained from each of the four sub-counties
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29 187 targeted for vaccination. From these lists, the Excel random number generator
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31 188 (=RANDBETWEENBOTTOM, TOP) was used to select the 31 villages from which households
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33 189 were selected. The number of villages per sub-county was proportionate to the population of
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35 190 the sub-county. The sub-county populations were obtained from the district planning unit.
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37 191 From each selected village a list of households was obtained from the village administrative
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39 192 leader (Local Council (LC) – 1. This is the smallest recognised administrative unit in Uganda. It
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41 193 is headed an elected leader called LC-1) who provided a list of households from which we
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43 194 randomly selected households to interview.

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47 196 For the household interviews, data were collected through standardized questionnaires during
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49 197 face-to-face interviews conducted by trained research assistants using the local language.
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51 198 Within a selected household the questionnaires were administered to the key respondents
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53 199 (head of the HHs), who represented the entire household and provided information about each
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55 200 member of the household. If a suitable key respondent was absent, additional visits were
56
57 201 scheduled. In two households, a person could not be located, and the household was dropped.
58
59 202 For each vaccinated person, the research assistants assessed cholera immunization status.
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61 203 Vaccination status was ascertained in two ways: either the informant verbally indicated
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63 204 that the individual had received the dose of vaccine or the vaccination was recorded on
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65 205 the vaccine card. If the informant did not have a vaccine card, the reliability of the
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67 206 vaccination information was validated by asking about the details of the procedures of

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3 207 the vaccination (e.g. being given recently by mouth to all persons > 1 year of age). None
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5 208 of the residents who were approached refused to answer the survey. The age and sex of the
6
7 209 participants in the survey is shown in Table 1.

8
9 210
10 211 *Adverse Events Following Immunization (AEFI)*. The occurrence of AEFIs were assessed by
11 212 asking for symptoms among the vaccine recipients following vaccination. As part of the
12 213 campaign itself, a routine system for AEFI detection was established in which the vaccine team
13 214 members advised vaccinees to report to a health worker or to seek care at a health facility if
14 215 they experienced symptoms following immunization. By contrast, the AEFI surveillance in this
15 216 sub-study asked the participants who participated in the cluster survey about symptoms they
16 217 may have experienced. This AEFI sub-study was thus, designed to enhance our understanding
17 218 of potential AEFIs which may not have been reported through the routine AEFI surveillance.

18 219
19 220 AEFIs were categorised for each individual member of the household who received a dose of
20 221 OCV as follows. They were considered mild if the symptoms did not interfere with normal
21 222 activities; moderate if they interfered somewhat; and severe if the symptoms prevented the
22 223 individual from continuing normal activities.¹⁸ Persons who reported to be having ongoing
23 224 symptoms > 72 hours were advised to visit the nearest health facility for more care. Among
24 225 those reporting symptoms, information was recorded as to whether the person took any
25 226 medicine or received any treatment to lessen the symptoms.

26 227
27 228 *Data collection and analysis*. Data from the community surveys were collected by tablet
28 229 computers using *Kobo Collect* (<https://www.kobotoolbox.org/>) installed to record the responses
29 230 in the field. Data were cleaned, coded, and stored in Stata Version 14. Data were analysed to
30 231 generate frequencies, percentages or proportions and means. Comparisons between groups
31 232 was done via logistic regression for the calculation of odds ratios and 95% confidence intervals.
32 233 The results of analysis were presented in the form of graphs, tables, charts, and means and
33 234 were included in interim and end of campaign reports.

34 235
35 236 *Quality Assurance*. Research assistants were trained on data collection methods and were able
36 237 to consult field supervisors and the principal investigator on any issue that was not clear to
37 238 them. For quality assurance, the survey supervisors revisited about 10% of the households, not
38 239 to collect the data again, but to ensure that they were not skipped by the interviewers for eligible

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3 240 respondents. The surveys were conducted about two weeks after completion of the second
4 241 round of the vaccination campaign to minimize recall bias.

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8 243 *Sub-study 2, staff assessment.* Staff were assessed on their level of knowledge on the cause of
9 244 cholera, the importance of safe water in cholera prevention, the target age group for cholera
10 245 vaccination, and knowledge about AEFI and the procedures for care should subjects experience
11 246 an AEFI. Staff were surveyed twice with each survey taking place within two weeks after
12 247 administration of the first and second OCV rounds, respectively. All staff who participated
13 248 directly by administering the vaccines or indirectly through supervisory roles and who were
14 249 present at the workstation during the study period were enrolled in the survey. For the staff
15 250 survey, structured questions were administered on paper questionnaires that allowed for adding
16 251 text to explain the answers (open-ended questions). Most of the vaccine staff had taken part in
17 252 other public health campaigns, but none had participated earlier with a campaign to distribute
18 253 OCV.

19 254 *Ethical Considerations.* This study was conducted as part of the routine MoH operational
20 255 research for improvement of health services; however, ethical issues were considered and
21 256 addressed. The proposal was approved by the Makerere University School of Public Health
22 257 Institutional Review Board (MaKSPH IRB) (no 610 in 2018) and Uganda National Council of
23 258 Science and Technology. Written informed consent was obtained from all participants in both
24 259 sub-studies. Participation in the study was voluntary and respondents were free to opt out at
25 260 any stage of the interviews.

26 261 Confidentiality was observed at all stages of the study. No names or personal identifiers were
27 262 included on the questionnaires. The research assistants underwent training on interview
28 263 techniques, neutrality, and research ethics. The benefits of the study to the staff included the
29 264 ability to express themselves, provide feedback and observations that in turn might lead to
30 265 improvements in supportive services for their training and work.

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34 267 *Patient and Public Involvement.* This research was done without research subject
35 268 involvement. The time was inadequate to involve the subjects prior to the vaccine campaign.
36 269 They were also not invited to contribute to the writing or editing of this document for readability
37 270 or accuracy. However, the findings of the study were disseminated to the Hoima district
38 271 administration, MoH and other policymakers to use them to strengthen health service
39 272 interventions and future OCV campaigns.

273

274 **RESULTS**

275 *Sub-study One, community survey results.* The community surveys were carried out in the four
276 sub-counties in Hoima districts of Buseruka, Kabwoya, Kyangwali and Kigoroby as shown in
277 Figure 2 and Table 1. [Insert Figure 2 and Table 1] A total of 209 households, including 1,274
278 individuals, were surveyed. Most (96%) of the respondents were household heads or their
279 spouses. All respondents confirmed that they were living in the targeted OCV area at the time of
280 the campaign. Fifty-one (51%) of the respondents had primary education, 17% had secondary
281 education, 1% had tertiary education, and the remaining 31% had no education. The
282 respondents were aged 18 – 89 years with a mean age of 40 years. Both sexes were present,
283 with no statistically significant difference.

284 By verbal reports, 94% (95% CI: 92-95%) of the residents received at least one dose and 78%
285 (95% CI: 76-81%) received two doses of OCV. From verbal reporting, 91% (95% CI: 90-93%) of
286 residents received vaccine during the first round and 81% (95% CI: 78-83%) received vaccine
287 during the second round. For many of the households, a vaccine card was available, and the
288 vaccination card was used to confirm vaccination status. Using information from the card only,
289 coverage was 84% (95% CI: 82-86%) and 65% (95% CI: 62-67%) for round one and round two
290 respectively and the two-dose coverage was 62% (95% CI: 60-65%). Coverage rates are
291 shown on Table 2. [Insert Table 2]

292
293 Among those who did not receive a dose of vaccine, over half of these missed doses (254 of the
294 357 missed doses during the two rounds) were because the person was not at home at the time
295 of vaccination or was out of town. In a few cases, the vaccine team missed the household,
296 accounting for 53 missed doses. Refusing to take vaccine was not reported.

297
298 *Reported AEFIs.* Overall, 71 individuals of 1,274 respondents (5.6%) reported an AEFI (Table
299 3). Determining a causal relation between the vaccination and the reported symptoms was not
300 attempted. [Insert Table 3]

301
302 Most AEFIs were considered mild or moderate, but 8 (0.6%) persons reported an AEFI as
303 severe. Most (60%) of the persons reporting an AEFI did not seek treatment including 60% of
304 those reporting a severe AEFI. 29.6% of the reported adverse events occurred in the first round,
305 40.9% in the second round and 29.6% in both rounds. The most common symptoms were
306 abdominal pain (15), diarrhoea, (9), fever, nausea, and headache (each 6) reports. Table 4

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3 307 provides additional information on the AEFIs. The reported AEFIs were infrequent relative to the
4 308 number of doses distributed and there were no serious adverse events reported. [Insert Table4]

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8 310 ***Community knowledge of oral cholera vaccines.***

9 311 A majority (77%) of the respondents understood that vaccine was one of the ways to prevent
10 312 cholera. There was a statistically significant association between education level and knowledge
11 313 about OCV with those having at least a primary school education being almost twice as likely to
12 314 know the number of required doses as compared to those with no education (OR 1.90, 95% CI
13 315 1.06, 3.44 (P = 0.03).

14 316 *Sub-study Two, staff survey.* A total of 242 and 125 staff responded to the first and second
15 317 knowledge and practice (KP) surveys (KP1 and KP2). Most respondents were vaccination team
16 318 members (89% and 87% in vaccine rounds 1 and 2, respectively). Almost all the respondents
17 319 were knowledgeable about the cause of cholera, the importance of safe water in cholera
18 320 prevention and the vaccine target group, but were less knowledgeable regarding potential
19 321 adverse events following administration (AEFI) or how to advise vaccinees, with 29% and 16%
20 322 being less informed about AEFI during the first and second surveys.

21 323 When staff were asked to suggest areas that needed improvement in future OCV campaigns,
22 324 more than 10% suggested more timely payment of allowances, more time to sensitize and
23 325 inform the communities on the benefits of the vaccine, and better transportation and facilitation
24 326 allowances (payments to health workers to cover the cost they incurred when administering the
25 327 vaccines or conducting activities related to the OCV campaign). Other suggestions included
26 328 use of both static and mobile vaccination points, provision of gumboots, umbrellas, and more
27 329 areas for vaccine storage in sub-counties where vaccine would be more accessible, more
28 330 workers for hard to reach areas, and an increase in the number of vaccine days to complete the
29 331 vaccinations and increase coverage.

30 332

31 333 **DISCUSSION**

32 334 The results of this monitoring and evaluation exercise documented important findings on the
33 335 OCV campaign, the knowledge and practices of both the community and the health staff
34 336 involved in the campaign and implications for the conduct of future OCV campaigns as part of
35 337 an integrated cholera control strategy. These findings suggest that the OCV campaign in Hoima
36 338 successfully provided the vaccine to a very large proportion of the target population in Hoima
37 339 district, western Uganda. Approximately 93.6% of respondents reported receiving at least one

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3 340 dose and 78.3% reported receiving two doses among residents. Given the mobile and transient
4 341 nature of this population, this was noteworthy, and suggests that even better coverage may be
5 342 possible for more settled populations in Uganda.
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9 344 Since this was the first such campaign with OCV, there was concern that the population might
10 345 be reluctant to accept it. This is a vaccine with which they were not familiar, it was given orally
11 346 to all ages rather by injection to children, and two doses were required. Despite these potential
12 347 constraints, we found that most people accepted taking the vaccine readily; however, some
13 348 were not at home resulting in missed vaccinations.
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19 350 High vaccination coverage is especially important when one is attempting to achieve herd
20 351 protection. Since it is estimated that herd protection can be achieved with a coverage even
21 352 lower than 90%;¹⁹ the high coverage achieved in this campaign would be expected to induce
22 353 significant indirect protection even among those who did not receive vaccine.^{19 20}
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26 354
27 355 It was noted in the administrative report from the MoH and during a stakeholder's meeting that
28 356 one of the reasons for the reduction in the coverage during the second OCV dose was the
29 357 unpredictable campaign dates for the second round. The vaccine for the second round had to
30 358 be shipped and cleared through customs, and the timing for this was not certain. To avoid this
31 359 problem in the future, a mechanism needs to be established to provide a better timeline for
32 360 receipt of the vaccine shipments.
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38 362 *Community Reception to OCV.* As with previous OCV campaigns outside Uganda, very few
39 363 AEFI were reported.^{21 22} Most of adverse events were considered mild or moderate and were
40 364 self-limited. Despite the low prevalence of AEFI, the survey exposed the need to better inform
41 365 the community about seeking treatment for more severe adverse events or for those that do not
42 366 quickly resolve. This was especially true for families with little education who were less likely to
43 367 seek medical attention for severe AEFI (data not shown). Notably, members in the community
44 368 demonstrated good understanding of the rationale for the vaccine; however, a key takeaway
45 369 from the survey was a need to better communicate the number of required doses, given that
46 370 those with more education were twice as likely than those with no education to know the
47 371 number of doses needed.
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3 373 *Staff Reception to OCV.* Inclusion of staff KP survey contributed to the success of the project
4 374 by identifying gaps among the staff knowledge and performance. Questioning the vaccine staff
5 375 about their training and their experience in the field is not a common activity when conducting
6 376 monitoring and evaluation activities during OCV campaigns. Many people had to be mobilized
7 377 quickly and these were the key people who interacted with the communities. It was important
8 378 that the staff accurately represent the campaign as an integrated cholera prevention program,
9 379 but this was the first time these people carried out this role. The MoH felt it important to monitor
10 380 their knowledge and behaviors as well as any constraints they felt in carrying out their functions.
11 381 While they were generally knowledgeable about the disease and about the vaccine, these staff
12 382 needed additional training regarding recognizing and managing AEFIs. They also faced
13 383 challenges regarding logistical support. After the first staff KP survey, these gaps were
14 384 communicated to the MoH so that appropriate actions could be taken to ensure that these gaps
15 385 were addressed prior to the second round.
16 386

17 387 Most other OCV campaigns have also reported high coverage rates. These have included
18 388 reports from Bangladesh^{23 24}, Malawi^{25 26}, Mozambique²¹, Democratic Republic of Congo ²⁷,
19 389 Zambia ²⁸, South Sudan ^{29 30}, Iraq³¹, Haiti³², and Guinea ³³. Clearly, OCV is well accepted
20 390 among these very diverse population groups where the vaccine campaigns have been carried
21 391 out.
22 392

23 393 Important limitations of this study need to be mentioned. Ideally, one would prefer to conduct
24 394 community studies prior to a campaign to understand knowledge and attitudes about cholera to
25 395 improve communications regarding the upcoming campaign as part of an integrated strategy to
26 396 control cholera. However, since the campaign was carried out on an emergency basis during an
27 397 outbreak, a study prior to the campaign was not possible. Secondly, a community survey
28 398 immediately after the first round might have provided feedback to the teams that would have
29 399 improved the coverage for the second round. It should also be noted that a single informant
30 400 provided information about receipt of the vaccine for all members of the household, so this
31 401 informant might have incorrect information concerning one or more members of the household;
32 402 however, since the vaccine was directly given to the household members together, it seems that
33 403 inaccuracies would be minimal. It should be noted that we were not able to adjust for cluster
34 404 sampling in the community surveys. If we have adjusted for cluster effect, it would have
35 405 increased the variance slightly, but it would not affect the means.³⁴ The community KP survey
36 406 did not include questions on attitudes regarding cholera. Since the survey had to be carried out

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3 407 very quickly following the campaign, and since the survey was targeted to identify issues that
4 408 would be immediately relevant to campaign performance, it was felt that understanding attitudes
5 409 regarding cholera, even though important, would have required other qualitative methods
6 410 requiring more time than was available. Similarly, direct observation of the training and
7 411 coordination meetings would have been useful to independently assess the efficiency and
8 412 effectiveness of these training and coordination meetings. Furthermore, there was no list of all
9 413 workers in the campaign and many of the workers who participated in the second round had left
10 414 prior to administering the questionnaire; thus, there were fewer respondents in the second
11 415 round and the proportion of all workers who participated could not be determined precisely.
12 416 Finally, it was not possible, given the time constraints, to fully integrate WASH interventions
13 417 together with the OCV campaign, or to monitor and evaluate community and staff
14 418 responsiveness to such integration.

15 419
16 420 In this outbreak 2,122 cholera cases and 44 deaths were reported, nearly all before the OCV
17 421 campaign and over half occurred in the first two weeks of the outbreak. Of note, the outbreak
18 422 started in February 2018 at about the same time the application for preventive use of OCV was
19 423 being submitted. The original application proposed a series of preventive campaigns over
20 424 the next year, and Hoima, as well as neighbouring districts in western Uganda, were targeted
21 425 for vaccination in the first round of these preventive campaigns. However, when the outbreak
22 426 was identified, plans were quickly shifted so that an emergency campaign could be
23 427 implemented to control the outbreak. Even though this emergency response was planned as
24 428 quickly as possible, in fact, the outbreak was essentially over before the vaccine campaign
25 429 could start, so it had no impact on the outbreak itself, but likely reduced the risk for future
26 430 outbreaks.

27 431
28 432 Though the outbreak started with the influx of the refugees from DRC into Uganda, it quickly
29 433 spread to the refugee host communities in Hoima. Therefore, to prevent rapid spread,
30 434 improvement of cholera prevention measures for both the refugees and the host communities is
31 435 paramount during resettlement.

32 436

33 437 **CONCLUSION**

34 438 This study suggests that the OCV campaign in Hoima district to prevent cholera was successful
35 439 and achieved a high level of coverage in this population at high risk. However, there was need

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3 440 to devote more effort on community sensitisation on the benefits of vaccination, as well as
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5 441 improving some logistic support during the campaign.

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8 443 While a rapid response to this outbreak was appropriate, in fact, even with a rapidly organized
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10 444 campaign, the outbreak was over before the vaccine could be given; thus, the vaccine had no
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12 445 impact on this outbreak. Nevertheless, this area had already been identified as a hotspot, and it
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14 446 would have been targeted if the planned preventive campaign had proceeded as originally
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16 447 planned. Planners must realize that an area identified as a hotspot might experience an
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18 448 outbreak while preparations are underway for a preventive campaign and take this into account
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20 449 when allocating vaccine for preventive vs emergency campaigns. Since these are areas where
21
22 450 cholera risk is high, outbreaks are likely to occur in these areas if there are delays in
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24 451 implementing preventive campaigns.
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453 **FIGURE LEGENDS**

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455 **Figure 1. Epicurve of the Hoima Outbreak, 2018 with events identified in response to the**
456 **outbreak**

457 **Figure 2: Map of Hoima District, showing sub-counties that received OCV and**
458 **households where interviews were conducted (red dots)**

459

For peer review only

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Table 1. Age and Sex Breakdown of the Participants in the Cluster Survey

Age Group (years)	Male	Female	Total
1 to 4	98	93	191
5 to 14	236	207	443
15 to 44	210	285	495
45+	80	65	145
Total	625	650	1274

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Table 2: Vaccination coverage post OCV campaign, Hoima District, Uganda, 2018.

Total surveyed = 1274	Round 1	Round 2	Received only one dose	Received two doses	Received at least one dose
Reported number (%) (95% CI)	1,164 (91.4) (89.7-92.8)	1,027 (80.6) (78.3-82.7)	195 (15.3) (13.4-17.4)	998 (78.3) (76.0-80.5)	1193 (93.6) (92.2-94.9)
Confirmed by availability of the vaccination card (%) (95% CI)	1,065 (83.6) (81.5-85.5)	823 (64.6) (61.9-67.2)	142 (11.1) (9.5-13.0)	792 (62.2) (59.5-64.8)	934 (73.3) (70.8-75.7)

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Table 3: Treatment and Resolution of Adverse Events Following Immunization in Hoima District, Uganda, 2018.

Symptoms	Treatment		Status		
	No treatment (%)	Treated (%)	Recovered (%)	Ongoing (%)	Improved, not to baseline (%)
Mild	24(80.0)	6(20.0)	29(96.7)	1(3.3)	0(0.0)
Moderate	11(39.3)	17(60.7)	23(82.1)	3(10.7)	2(7.1)
Severe	8(61.5)	5(38.5)	10(76.9)	0(0.0)	3(23.1)

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466

467 **Table 4. Onset and frequency of symptoms reported as**
 468 **adverse events**

	<6 hours	6-12 hours	12-24 hours	1-7 days	8-14 days	Total
469 Diarrhoea	3	2	2	2	0	9
470 Vomiting	3	0	0	2	0	5
471 Nausea	6	0	0	0	0	6
472 Abdominal pain	15*	0	0	0	0	15
473 Stomach gurgling	0	3	0	1	0	4
474 Mouth ulcers	0	0	0	0	1	1
475 Cough	1	1	0	3	1	6
476 Felt feverish	1	1	0	6	1	9
477 Poor appetite	1	0	0	0	0	1
478 Dizziness	0	3	0	0	0	3
479 Fainted	0	1	0	0	0	1
480 Itching	0	0	0	0	1	1
481 Weakness	0	0	0	1	0	1
482 Headache	3	0	2	1	0	6
483 Other	1	0	0	2	0	3
484 Total	34	11	4	18	4	71

485 • Three persons reported abdominal pain in one household

488

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496

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501 **Footnotes**

502 **Contributors:** Conceived and designed the study: GB, MR, WAB, ABS, CGO, DAS.

503 Discussed, critically revised and approved the study protocol: GB, MR, WAB, CGO, DAS.

504 Performed the research: GB, MR, WAB, AO, FR, IA. Analysed the data: GB, MR, WAB, AO,
505 DAS. Wrote the first draft: GB, MR. Wrote the final DAS. Elaborated, discussed and approved
506 the final version: GB, MR, AB, ABS, AO, FR, IA, CGO, and DAS.

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512

513 **Declaration of the conflict of interest**

514 The authors have no conflict of interest to declare.

515

516 **Additional data sharing:** Data are available upon reasonable request

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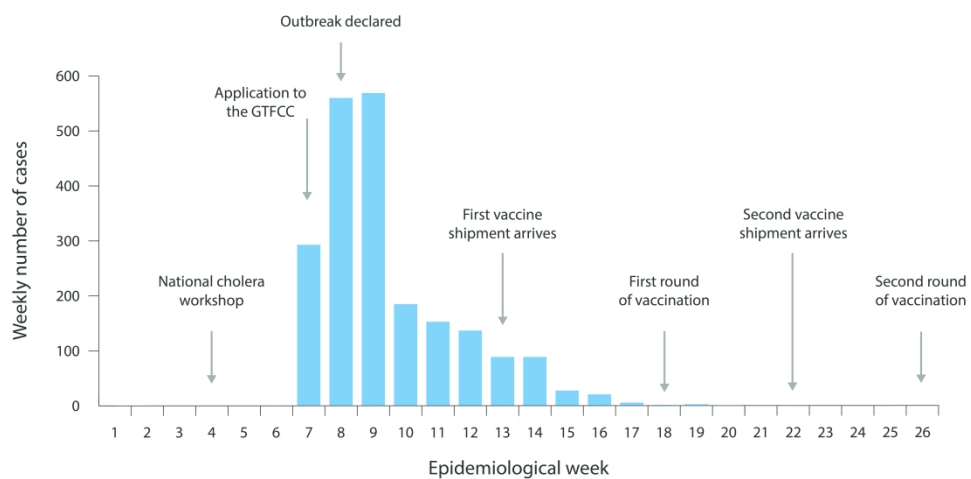


Figure 1. Epicurve of the Hoima Outbreak, 2018 with events identified in response to the outbreak

542x305mm (300 x 300 DPI)

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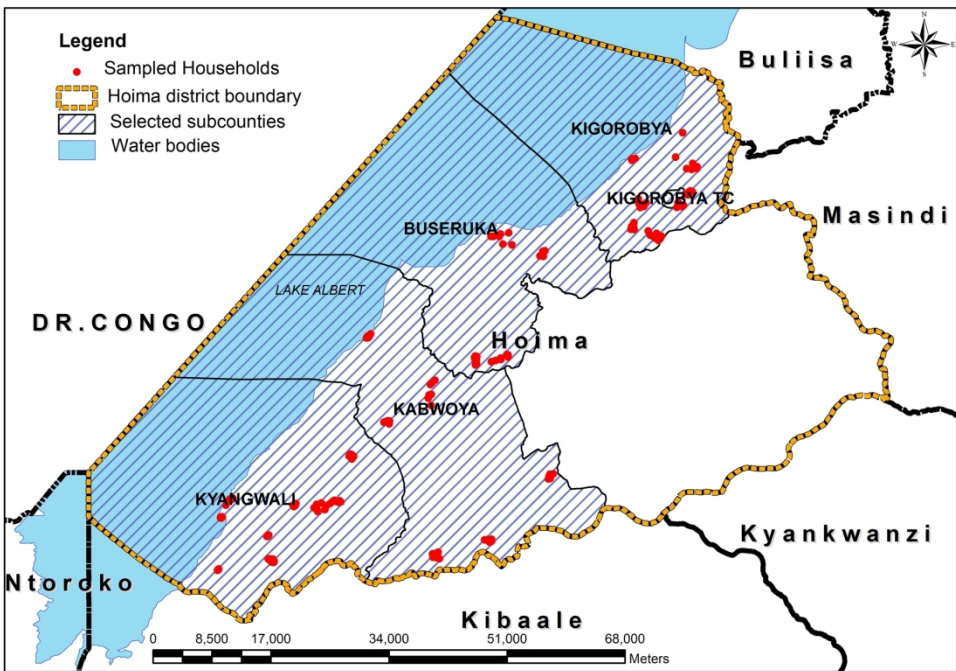


Figure 2: Map of Hoima District, showing sub-counties that received OCV and households where interviews were conducted (red dots)

170x119mm (300 x 300 DPI)