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LESSONS FROM THE FIELD

Accelerating onchocerciasis elimination in humanitarian settings: lessons from South Sudan

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There is persistent meso- and hyperendemicity of onchocerciasis (river blindness) in South Sudan, a country that has endured armed conflict for many years. In 2018, Amref Health Africa, in collaboration with local communities, the South Sudan Ministry of Health and other stakeholders, initiated some interventions, among which was Innovative Approaches to Reduce the Burden of Disease Caused by Onchocerciasis (IARDO) project. This project implemented several strategies, including identifying areas where onchocerciasis elimination programs need strengthening, switching from annual to biannual community-directed treatment with ivermectin (CDTI), additional ivermectin administration to postpartum women and school children and a community-based 'slash and clear' vector control strategy. These measures resulted in increased CDTI coverage, fewer bites from blackfly vectors and decreased onchocerciasis-related morbidity. The feasibility of these interventions, low cost, national government support and community ownership suggest their long-term sustainability.

Introduction

The neglected tropical disease (NTD) onchocerciasis (river blindness), caused by the filarial parasite *Onchocerca volvulus*, is currently endemic in 31 African countries, Yemen and Latin America, where it inflicts skin and eye disease.[1] It is estimated that 99% of the 20.9 million *O. volvulus*–infected individuals live in Africa. National onchocerciasis programs mainly rely on community-directed treatment with ivermectin (CDTI),[1] through which the disease has been eliminated as a public health problem in several African countries. However, many onchocerciasis-endemic areas in Africa, particularly those that have experienced periods of insecurity and where CDTI coverage has been suboptimal or interrupted, still experience high onchocerciasis transmission. This is the case in South Sudan, which remains among the most endemic countries for onchocerciasis.[2] If no concerted action is taken in such settings, it might be impossible to eliminate onchocerciasis in the coming decades.

In Maridi County (Western Equatoria State, South Sudan), we documented high levels of *O. volvulus* transmission in 2019 despite the initiation of annual CDTI since the early 2000s.[2] Due to frequent conflicts and other challenges, CDTI rounds were inconsistent and coverage remained low. Furthermore, the Maridi dam was identified as the sole blackfly breeding site in the Maridi Central area, with monthly biting rates reaching 6039 bites/person in 2019.[2] As a contribution to the fight against onchocerciasis in South Sudan, Amref Health Africa obtained Research for Health in Humanitarian Crises (R2HC) funding to conduct the project Innovative Approaches to Reduce the Burden of Disease Caused by Onchocerciasis (IARDO), consisting of a community-based prevention program to decrease the disease burden caused by *O. volvulus*. In collaboration with the Ministry of Health (MOH) of South Sudan, local communities and other stakeholders, a series of innovative interventions were implemented (Table 1). These interventions were initiated and have been evaluated in Maridi and are being extended to other onchocerciasis-endemic areas including Mundri East and West, Mvolo, Wulu and Raga Counties.

Implementation and impact of the interventions

Identifying areas where onchocerciasis elimination programs need strengthening

Using house-to-house surveys in Maridi, Mundri East and West and Mvolo Counties, a very high onchocerciasis disease

Table 1. Interventions to accelerate onchocerciasis elimination in South Sudan.

Interventions	Brief description	Observations/recommendations
Identifying the areas or hotspots where onchocerciasis elimination programs need to be strengthened	Conducting house-to-house surveys to determine the prevalence of persons suspected of having epilepsy and blindness and to determine the proportion of people who took ivermectin during the last CDTI round.	Community drug distributors (CDDs) can be trained to identify persons suspected of having epilepsy[3] by using simple screening questions that reflect the operational definition of epilepsy: having experienced two or more seizures (including nodding) without fever, ≥24 h apart. Since 2022, Maridi CDDs have been using this approach to screen for epilepsy (among other disabilities) during the CDTI census.
	Testing children ages 3–9 y with the OV16 RDT to estimate the level of ongoing *O. volvulus* transmission, particularly in communities where high onchocerciasis morbidity is observed.[4]	Communication of the OV16 RDT results of the children to the parents was found to raise their interest and awareness about onchocerciasis in their community. This is expected to further motivate the population to take ivermectin during CDTI.
Biannual CDTI	Community-based approach to provide ivermectin to every eligible community member every 6 months rather than once a year. Implemented since 2022 in Maridi, Mundri East and West, Mvolo, and Raga Counties. Increased coverage and frequency of ivermectin intake will accelerate onchocerciasis elimination.	To encourage adherence to CDTI, it is important to explain that the intake of ivermectin can protect children from developing OAE.[5] To increase ivermectin uptake, CDTI rounds should be organised during the dry seasons when there is minimal farming activity and little or no rainfall to disrupt distribution plans.
School-based ivermectin distribution	Providing ivermectin directly in schools to treat children 5–14 y of age, as the younger children often have low coverage during conventional CDTI.[6] Especially indicated when community-wide biannual treatment is not provided. Pilot project initiated in Wulu County in April 2024 to distribute ivermectin in schools.	To be done ideally 6 months after the previous/before the next CDTI. This can be integrated with other school-based NTD preventive programs, e.g. albendazole or praziquantel. This requires proper planning and a strong multisectoral collaboration between health and education at the county and state levels.
Postnatal ivermectin treatment	Providing ivermectin at maternal and child health units and/or vaccination units of health facilities, where it can be given to nursing mothers and other community members who require the drug. This contributes to closing the treatment gap observed among young women, as ivermectin is contraindicated during pregnancy. Implemented in 2023 in Maridi County.	Although ivermectin is deemed unsafe during pregnancy, it can be given to postpartum women after the first week of breastfeeding. This can be done all year round. Pregnant women encountered during routine CDTI or antenatal visits should be encouraged to take ivermectin from the second week after childbirth.
S&C intervention	The first step is to identify blackfly breeding sites along fast-flowing river segments. Thereafter, trained community volunteers actively engage in thoroughly cleaning and cutting off all organic substrates (trailing vegetation, leaves, algae, tree branches, etc.) at the identified breeding sites, as these can act as supports for blackfly breeding.	It is important to conduct community meetings and formative research to explain the benefits of the intervention and to motivate the community to conduct it using its own funds. The S&C activity should preferentially be carried out during the 2–3 weeks preceding the rainy season, as increased rains allow blackflies to thrive.

burden (skin, eye and epileptic disorders), low ivermectin coverage and high seroprevalence of *O. volvulus* antibody by OV16 rapid diagnostic tests (RDTs) among children ages 6–9 y were documented.[5,7,8] The high OV16 seroprevalence (range 10.3–27.3%), indicative of ongoing onchocerciasis transmission in all the sites, was associated with a high prevalence of epilepsy (range 3.3–5.1%) and/or blindness (range 2.7–2.8%).[5,7,8] In endemic settings, these clinical conditions could serve as proxies for poor/non-existent onchocerciasis control measures, warranting a strengthening of the onchocerciasis elimination program.

This is particularly relevant in places where state-of-the-art onchocerciasis investigations are very difficult or not feasible.

Strengthening onchocerciasis elimination measures in endemic sites

Following implementation of the preventive measures outlined in Table 1, *O. volvulus* transmission in Maridi has been on a downward trend, although the reduction in OV16 seroprevalence was not yet significant after 3 y of intervention.[5] It is worth noting that all the interventions were feasible, acceptable to the local communities and implemented with the full involvement of the county health authorities and the national MOH. Official government data showed a reduction in ivermectin treatment refusals among those ≥5 y of age in Maridi, from 1107/107 544 (1.0%) in 2021 to 38/103 698 (0.04%) in 2023. This could be due (at least in part) to increased onchocerciasis awareness (including communication of OV16 RDT results). The impact of each intervention is summarised below and sustainability prospects are briefly discussed.

Additional ivermectin administration

To increase ivermectin uptake, alternative approaches must be adopted for ivermectin delivery since annual CDTI alone hardly achieves optimal coverage in humanitarian settings like South Sudan. Suggested strategies include:

- Switching from annual to biannual CDTI: A 6-month treatment strategy increases the proportion of the population that receives ivermectin during a calendar year, with many getting the drug twice. Implementing CDTI twice a year will not double the cost of the intervention, as some costs would be incurred only once (for instance, training and community census). Therefore, this approach is cost-effective in settings where it can significantly improve the therapeutic coverage of ivermectin. Biannual CDTI was successfully initiated in Maridi County and resulted in increased ivermectin treatment coverage from 40.8% in 2017 to 56.6% in 2022.[5]
- Adopting school-based distribution of ivermectin: Given that treatment coverage was reportedly low for the 5–14 y age group,[6] and considering their susceptibility to onchocerciasis-associated epilepsy (OAE),[9] school-aged children must be prioritised for ivermectin delivery. The safety and programmatic feasibility of co-administering ivermectin with albendazole and praziquantel during school-based interventions could be leveraged to improve treatment coverage among children in a cost-effective manner.[10] Ivermectin distribution to school children, when combined with other school-based chemoprophylaxis schemes, is a low-cost strategy to achieve biannual ivermectin treatment of school-aged children if biannual CDTI is difficult to organise for logistical and/or financial reasons. This intervention is currently being pilot tested in South Sudan in Wulu County, an onchocerciasis-endemic area where, so far, biannual CDTI has not yet been implemented because information concerning the onchocerciasis disease burden is not available. In a house-to-house study conducted in February 2024, our team documented an epilepsy prevalence of 4.1% in Wulu County (unpublished data). In a coordinated action conducted in 10 schools (April 2024), 2037 pupils were treated with ivermectin in a single day; the cost of this intervention at the county level totalled US$291, mainly for personnel costs (incentives for school and health authorities involved in implementation). Excluding the costs for state/national preparatory meetings and ivermectin supply, both funded by the onchocerciasis program during annual CDTI, brings the cost for treating a child using the school-based approach to US$0.14 (see the Supplementary material).
- Post-natal administration of ivermectin: Due to limited safety data, pregnant women are not eligible to receive ivermectin during CDTI until day 8 post-delivery. This has resulted in many women missing out on ivermectin treatment during consecutive years, possibly creating parasitic reservoirs in the community. To address this issue in Maridi, we instituted a postpartum ivermectin treatment scheme whereby breastfeeding mothers are encouraged to take the drug when they come to vaccinate their children. Under the supervision of the county NTD coordinator, we pilot tested this strategy at the Maridi Hospital (catchment population 21 834 people), resulting in the treatment of 506 persons in 6 months (482 breastfeeding mothers and 24 accompanying fathers who had also missed the previous CDTI). Assuming an ivermectin coverage of 56.6% in this community as recently documented in Maridi,[5] an estimated 43.4% (9476 persons) were not treated during the last CDTI. The postnatal ivermectin distribution strategy was thus able to recover 5.3% (506/9476) of this untreated population at no additional cost. Importantly, the sensitised mothers went home to also sensitise their peers to report to the health facility for free ivermectin treatment. Furthermore, pregnant women coming to the hospital for antenatal visits are informed that the drug is available after they have given birth. As this strategy entails no additional costs (the drugs are provided for free by the onchocerciasis program), it is highly feasible and reproducible in other settings. The Maridi County Health Department has adopted this strategy and intends to expand it to other health facilities. Currently, postnatal ivermectin treatment has also been rolled out at the Mundri Primary Health Care Centre.

Community-based vector control using 'slash and clear' (S&C)

Depleting the vector population represents another important arm in the fight against onchocerciasis. Hitherto, this was achieved using chemical larvicides, which are expensive, ecologically dangerous and require skilled personnel for administration in the river.[11] The community-based S&C strategy provides an environmentally friendly and non-technical alternative that has been shown to significantly reduce blackfly biting rates in Maridi[5] (see Figure 1). After training village volunteers and providing the necessary basic equipment (machetes, boots, gloves), the research team supervised two rounds of S&C at the Maridi dam (2019 and 2020). Two additional S&C rounds were done in 2021 with reduced supervision. Since 2022, the villagers have demonstrated community ownership by conducting S&C without the help of the research team. Focus group discussions conducted among the S&C volunteers showed their willingness to continue implementing this strategy, as they experienced great benefits in terms of reduced blackfly nuisance in their homes and farms. In January 2024, we returned to Maridi to measure

Figure 1. Village volunteers performing S&C for blackfly control at the Maridi dam, South Sudan.

blackfly biting rates and found them to be at 403 bites/person/month, down from 6039 bites/person/month at baseline,[5] representing a 93% decrease. In addition to the postnatal ivermectin treatment strategy, the Maridi County Health Department has also guaranteed continuous implementation of S&C at the Maridi dam. The long-term plan is for the current volunteers to train other villagers in S&C, such that the intervention can be perpetuated. A second S&C program has also been initiated on the Naam River in Mvolo County since November 2023 and is well accepted by the communities there.

Conclusions

The collaboration between Amref Health Africa, the South Sudan MOH, local communities and stakeholders has resulted in successful implementation of several potentially sustainable interventions to reduce onchocerciasis transmission and associated morbidity in South Sudan.[12] Moreover, the scientific collaboration within this project has resulted in increased international awareness about onchocerciasis-associated morbidities, including OAE as an important public health problem that urgently needs to be addressed. The impact of the additional ivermectin distribution strategies on the overall coverage will need to be evaluated via a pre- and post-intervention community-wide survey.

However, to achieve the 2030 onchocerciasis elimination goal in the post-conflict and poverty-stricken onchocerciasis-endemic areas of South Sudan, annual CDTI alone will not suffice. As recommended by mathematical models of onchocerciasis transmission dynamics, implementing a panoply of strategies simultaneously would be most efficient in achieving elimination of transmission within optimal timelines. Therefore, additional strategies that are context-specific must be developed and transferred to the affected communities for sustainable implementation. Strong leadership, stable long-term funding, operational research and strategic interventions must be deployed to sustainably accelerate elimination prospects and decrease the disease burden caused by onchocerciasis in South Sudan. These lessons can serve as a foundation for adapting onchocerciasis responses in other humanitarian settings confronted with similar challenges.

Supplementary material

Supplementary data are available at *International Health* online (http://inthealth.oxfordjournals.org).

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subsequent versions of the manuscript and approved the final version for submission.

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Data availability: Most of the data presented in this article are available in previous scientific publications cited in the text. Unpublished data can be obtained from the corresponding author upon reasonable request.

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