

(Continued from previous page)

Key findings For the five NTDs, between 26 and 41 countries required PC, 69.2–212.7 million people were treated with coverage between 54.8–71.4%. In total 15,273 conflict events were reported including high rates of violence against civilians (29.4%), protests (28.8%), and battles (18.1%). The decision tree process included four main steps including i) information gathering ii) determine a disease mapping strategy iii) determine an MDA implementation strategy and iv) create a disease and conflict database. Based on these steps, risk maps were created. The South Sudan case study on onchocerciasis found the majority of the districts requiring mapping or MDA had a conflict event, and required specialised methods adapted to context and risk, with support from implementation partners in selected areas.

Conclusions The paper presents a new methodological approach for implementing safe and effective mapping and intervention strategies in NTD endemic countries with ongoing complex emergencies, which will help to address challenges and make progress toward the NTD Roadmap targets of 2030.

Keywords Neglected tropical diseases, NTDs, Sub-Saharan Africa, Conflict, Crisis, Complex emergencies, Mapping,

for Elimination of NTDs (ESPEN) data portal [23] allow health ministries and stakeholders to share programme data, and provide important starting points for this information in African NTD-endemic countries. This information can be used together with data on complex emergencies available from data portals such as the Armed Conflict Location and Event Data Project (ACLED) [24, 25], to help make informative programmatic decisions.

The NTD NGO Network (NNN) has a Conflict and Humanitarian Emergency (C&HE) Cross-Cutting Group comprising a diverse range of NTD experts [26]. It acknowledges that the implementation of NTD mapping and interventions in complex emergencies is difficult and made more challenging given that there are no current guidelines to support endemic

determine an MDA implementation strategy and iv) create a disease and conflict database.

Using this methodological approach, South Sudan is presented as a case study as it has one of the highest burdens of NTDs [10] and lowest levels of peace with a ranking of 161 out of 163 on the global peace index [19]. Due to widespread conflict since 2013, more

requiring PC ranged between 110 and 342 million; number of countries that implemented and reported activities between 18 and 30, percentage of districts that implemented PC between 7.3–86.4% (excluding pre-school aged children (PAC) for STH and trachoma); percentage of districts achieving effective coverage between 47.1–90.3% (excluding PAC for STH and trachoma); number of people in need and treated (millions) between 69.2–212.7 and overall coverage between 54.8–71.4% (Table 1).

The WHO Global Health Observatory PC data for AFR countries requiring PC in 2018 were summarised for each country (available in Additional Table 2). The mean coverage rates for each of the five PC NTDs in the

Information gathering of NTD programmatic data

LF, onchocerciasis, schistosomiasis, STH and trachoma were reported in South Sudan, which has a population of 9,991,337 (2016), with PC required for each of these NTDs. The mean MDA coverage rate for each disease in 2018 was low with LF reporting 17.4%, onchocerciasis 25.4%, schistosomiasis 0%, STH (SAC only) 40.7% and

trachoma 13.5%. The WHO ESPEN portal provided data on endemicity programmatic requirements in 2017 and were summarised as the number of districts in each state requiring mapping or MDA implementation (Table 4). Of the 79 districts, the endemicity was known for LF in 78 districts (98.7%), onchocerciasis in 48 districts (60.8%), schistosomiasis in 39 districts (49.4%)

mapping still required for the latter three diseases. The Global Trachoma Atlas showed that trachoma endemicity was known in 29 districts (36%). Two implementing partners were reported in the ESPEN data portal including The MENTOR Initiative (10 districts for onchocerciasis) and The Carter Centre (5 districts for trachoma), and a further two reported by co-author (JW), including the WHO (4 districts for onchocerciasis) and CBM (4 districts for onchocerciasis). Overall, these implementing partners were supporting the NTD programme in 21 districts (details available in the Additional Table 3).

Simulation of conflict

There was a total of 673 conflict events reported in South Sudan between September 2018 to August 2019 and the distribution of event types is shown in Fig. 4a-f. The highest proportion of conflict events occurred in the Central Equatorial region (39.4%), and the lowest proportion in the Northern Bahr el Ghazal region (0.7%). In total 68 (86.1%) of the 79 districts recorded at least one conflict event and 11 districts (13.9%) recorded no conflict event, as shown in Fig. 4g. The most common conflict type was violence against civilians (51.0%), followed by battles (36.6%) and the least common was explosion/remote violence (1.5%) (Table 5).

Onchocerciasis mapping and MDA

The combination of disease, conflict and implementing partner data was used to create maps to inform the mapping and MDA implementation strategies (Fig. 5a-d). Onchocerciasis elimination mapping was required in 31 districts across the states of Eastern Equatoria, Jonglei, Northern Bahr el Ghazal, Unity and Upper Nile (Fig. 5a). Of the 31 districts requiring mapping, most districts (*n*

methodology was assessed by placing participants into groups of 5

endemic countries experiencing complex emergencies
[26]. The NNN C&HE Group used an international

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