The SUKO Project: Control and Mapping of Schistosomiasis and Intestinal Helminthiasis in Sudan

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The SUKO Project, KOICA & KAHP

The SUKO Project

- **SUKO:** Sudan + Korea
- **Type:** **ODA program** for control of SCH & STH in Sudan supported by KOICA

Goals of the SUKO Project

- To help Sudanese construct **self-supported sustainable roadmap and system for NTD elimination** funded by KOICA
- Control of NTDs by Phase 1-3
- Elimination Program by the Phase 4 Project(SENSE)

History of the SUKO Project

- **Period:** 2009-2023
- **Four Phases:**
  - Phase 1: 2009-2011, Pilot survey and MDA in White Nile(WN)
  - Phase 2: 2012-2014, MDA + WASH in WN
  - Phase 3: 2014-2018, MDA + WASH in WN, Nationwide Mapping of SCH & STHs
  - Phase 4: 2019-2023, MDA + CLTS + Snail control in 3 States, 2nd Nationwide Mapping

* The project was suspended in 2020 by COVID-19 pandemic and cancelled by civil war due to military conflict in 2023.

Components of the SUKO Project

Component	Phase 1	Phase 2	Phase 3	Phase 4
Budget, US$	0.44m	1.1m	4.7m	6.6m
Site	WN	WN	WN, Nationwide	WN, Gezira, Kassala, Nationwide
MDA	O	O	O	O
WASH		O	O	
Mapping			O	O
Comm Health & Molluscicide				O
Microscopic dx	O	O	O	O + CCA
Sonographic dx		O	O	
SUKO Center Building			O	

Korean Embassy in Sudan September 03 2009
Embassador Mr. Byeong Kook Lee (red circle)

KOICA Center for Schistosomiasis Control, WN August 28, 2009
Mr. Gibril Nouman, Program Director of NTDs in Sudan(red circle)

Opening Ceremony of the SUKO Center, White Nile, 7 Feb. 2018

Egg Positive Rates of SCH in Sudan

	Phase 1	Phase 2	Phase 3	Phase 4
Year	2009-2011	2012-2014	2017	2023
Sites	WN	WN	Nationwide	WN, Gezira, Kassala
Baseline	2010 Sh 29.5% Sm 1.0%	2012 Sh Old 13.5% New 29.2%	Feb 2017 Sh 5.2% Sm 0.06%	WN Sh Sm Gezira Sh Sm Kassala Sh Sm
Endline	2011 Sh 13.5%	2014 Old 1.9% New 5.6%		
Reduction rate	53%	86% 81%		
				O

Children on the way with water


SUDAN
SOUTH KOREA

Project for Combating Schistosomiasis in Sudan
مشروع مكافحة البلهارسيا بالسودان بالتعاون مع منظمة الكويكا الكورية
THIS DRINKING WATER FACILITY WAS ESTABLISHED ON OCTOBER 30-2010
WITH AIR-TICKET SOLIDARITY CONTRIBUTION OF REPUBLIC OF KOREA
AIMING AT ERADICATING SCHISTOSOMIASIS IN SUDAN.


KOICA
Making a Better World Together
Second Phase of the Project for Combating Schistosomiasis in Sudan
Completion Ceremony of the Water Supply Facility
Jan 2012 ~ Mar 2014

Cha *et al. Parasites Vectors* (2019) 12:429
https://doi.org/10.1186/s13071-019-3689-z

Parasites & Vectors

RESEARCH Open Access

Epidemiological findings and policy implications from the nationwide schistosomiasis and intestinal helminthiasis survey in Sudan

Seungman Cha[1,2,3], Mousab Siddig Elhag[4], Young-Ha Lee[5], Dae-Seong Cho[2], Hassan Ahmed Hassan Ahmed Ismail[4] and Sung-Tae Hong[6*]

Abstract

Background: The World Health Assembly endorsed the WHO Neglected Tropical Disease (NTD) Roadmap in 2013, in which NTDs were suggested as tracers of equity in the assessment of progress towards the Sustainable Development Goals. Nationwide surveys were undertaken in all 18 states of Sudan to identify the geographical distribution and to estimate the prevalence and intensity of schistosomiasis and other intestinal helminthiases from December 2016 to March 2017.

Methods: We used two-stage random sampling. Each district was subdivided into one to three different ecological zones (EZs) based on proximity to water bodies. Probability-proportional-to-size sampling was used to select schools from each EZ. We estimated schistosomiasis and intestinal helminthiasis prevalence by the centrifugation method and Kato-Katz smears. Multi-level mixed-effect models were used to investigate the relationship between the prevalence of infections and risk factors, including improved water or latrine status at the household or school level. We estimated the cost-effectiveness of a one-time mass drug administration (MDA) intervention with 75% coverage at the district and EZ levels.

Results: A total of 105,167 students from 1772 schools were surveyed. The overall egg-positive rates were: *Schistosoma haematobium*, 5.2%; *S. mansoni*, 0.06%; and intestinal helminths, 5.47%. Severe endemic areas were concentrated in East and South Darfur States. Children living in a house or attending schools with an improved latrine were less likely to be infected with schistosomiasis than those without a latrine (adjusted odds ratio, aOR: 0.45, 95% confidence interval, CI: 0.41–0.51 and aOR: 0.75, 95% CI: 0.70–0.81 at the household or the school levels, respectively). Open defecation was strongly associated with schistosomiasis (aOR: 1.50, 95% CI: 1.35–1.66). In community-wide mass treatment at the district level with an 8% threshold for schistosomiasis, 2.2 million people would not benefit from MDA interventions with 75% coverage despite high endemicity, whilst 1.7 million people would receive the MDA intervention unnecessarily. EZ-level MDA was estimated to be more cost-effective than district-level administration under all circumstances.

Conclusions: Our findings provide updated prevalence figures to guide preventive chemotherapy programmes for schistosomiasis and intestinal helminthiasis in Sudan. Schistosomiasis was found to be common among the inhabitants of fragile and conflict-affected areas. In addition, we found that MDA interventions would be more cost-effective at the sub-district level than at the district level, and there was a strong association between schistosomiasis

Table 1 General characteristics of participants

State	Number of localities (districts)	No. of ecological zones	No. of schools	No. of students[a]					Mean age of students ± SD	
				Boys		Girls		Total	Boys	Girls
				n	%	*n*	%			
Red Sea	10	15	55	1922	57.5	1418	42.5	3340	10.01 ± 2.27	10.08 ± 2.08
River Nile	7	16	58	2076	56.2	1619	43.8	3695	10.42 ± 2.06	10.12 ± 2.02
Kassala	11	12	60	2184	60.8	1411	39.2	3595	11.02 ± 2.54	10.43 ± 2.09
Khartoum	7	20	95	3656	60.5	2385	39.5	6041	11.33 ± 2.97	9.88 ± 1.94
Al Jazirah	8	22	106	3391	53.8	2916	46.2	6307	10.59 ± 2.26	10.19 ± 2.06
Al Qadarif	12	21	103	2564	49.3	2640	50.7	5204	11.33 ± 2.43	10.79 ± 2.22
Sennar	7	14	51	1687	55.0	1378	45.0	3065	10.84 ± 2.10	10.53 ± 2.00
Blue Nile	7	15	68	2222	57.3	1657	42.7	3879	11.07 ± 2.37	11.01 ± 2.29
White Nile	9	25	121	3757	49.7	3805	50.3	7562	10.76 ± 2.13	10.43 ± 1.95
West Kordofan	14	38	183	6254	58.9	4371	41.1	10,625	11.31 ± 2.43	10.88 ± 2.27
North Kordofan	8	13	62	2159	59.3	1481	40.7	3640	11.12 ± 2.28	10.54 ± 2.13
South Kordofan	14	36	161	4846	51.2	4615	48.8	9461	10.92 ± 2.24	10.65 ± 2.12
Northern	7	14	65	1872	48.8	1968	51.2	3840	10.55 ± 2.11	10.08 ± 1.93
Central Darfur	6	21	74	2300	52.2	2109	47.8	4409	11.71 ± 2.69	11.30 ± 2.44
East Darfur	9	16	75	2570	54.6	2135	45.4	4705	11.60 ± 2.42	11.25 ± 2.24
West Darfur	8	15	72	2371	55.2	1928	44.8	4299	11.53 ± 2.26	11.17 ± 2.35
North Darfur	18	24	116	3854	56.7	2941	43.3	6795	11.09 ± 2.42	10.78 ± 2.29
South Darfur	21	53	247	8258	56.2	6447	43.8	14,705	11.42 ± 2.35	11.24 ± 2.28
Total	183	390	1772	57,943	55.1	47,224	44.9	105,167	11.10 ± 2.41	10.70 ± 2.21

[a] The number included all the children interviewed; hence, it is larger than the number of children whose stool or urine samples were examined

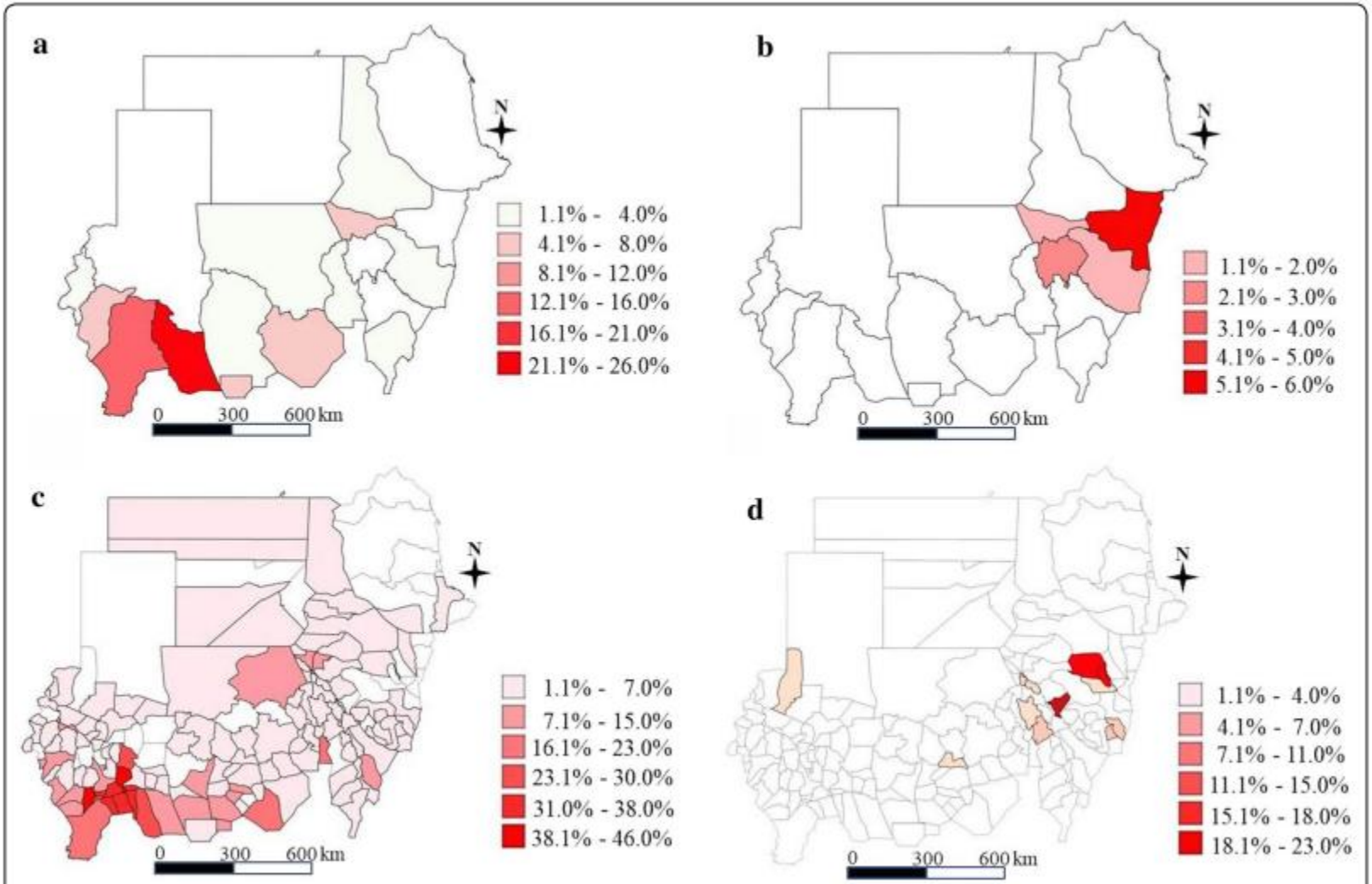


Fig. 1 Schistosomiasis prevalence. **a** *Schistosoma haematobium* at state level. **b** *Schistosoma mansoni* at state level. **c** *Schistosoma haematobium* at district level. **d** *Schistosoma mansoni* at district level

Table 3 Prevalence of *Schistosoma haematobium* and *Schistosoma mansoni* by intensity

State	*S. haematobium*				*S. mansoni*					
	Light infection (< 50 eggs/10 ml)		Heavy infection (≥ 50 eggs/10 ml)		Light infection (< 100 epg)		Moderate infection (100–399 epg)		Heavy infection (≥ 400 epg)	
	n/*N*[a]	%	*n*/*N*[a]	%	*n*/*N*[a]	%	*n*/*N*[a]	%	*n*/*N*[a]	%
Red Sea	2/2944	0.07	1/2944	0.03	0/2425	0.00	0/2425	0.00	0/2425	0.00
River Nile	42/3216	1.31	8/3216	0.25	2/2986	0.07	4/2986	0.13	2/2986	0.07
Kassala	4/3480	0.11	2/3480	0.06	161/3244	4.96	202/3244	6.23	5/3244	0.15
Khartoum	228/5730	3.98	71/5730	0.12	72/5434	1.32	84/5434	1.55	4/5434	0.07
Al Jazirah	27/5904	0.46	3/5904	0.05	126/5563	2.26	151/5563	2.71	4/5563	0.07
Al Qadarif	49/6114	0.80	33/6114	0.54	82/5736	1.43	85/5736	1.48	0/5736	0.00
Sennar	17/2787	0.61	0/2787	0.00	16/2745	0.58	18/2745	0.66	0/2745	0.00
Blue Nile	88/3715	2.37	11/3715	0.30	9/3699	0.24	10/3699	0.27	0/3699	0.00
White Nile	331/6933	4.77	49/6933	0.71	5/6574	0.08	5/6574	0.08	0/6574	0.00
West Kordofan	386/10,073	3.83	33/10,073	0.33	2/10,188	0.02	2/10,188	0.02	0/10,188	0.00
North Kordofan	94/3532	2.66	1/3532	0.03	1/3577	0.03	0/3577	0.00	0/3577	0.00
South Kordofan	435/8173	5.35	34/8137	0.42	3/8399	0.04	3/8399	0.04	0/8399	0.00
Northern	11/3751	0.29	6/3751	0.16	1/3532	0.03	0/3532	0.00	0/3532	0.00
Central Darfur	152/3166	4.80	0/3166	0.00	1/3174	0.03	0/3174	0.00	0/3174	0.00
East Darfur	485/3863	12.56	312/3863	8.08	13/4238	0.31	14/4238	0.33	0/4238	0.00
West Darfur	46/4017	1.15	16/4017	0.40	6/3936	0.15	12/3936	0.30	4/3936	0.10
North Darfur	77/6524	1.18	3/6524	0.05	17/6545	0.26	17/6545	0.26	0/6545	0.00
South Darfur	933/13,084	7.13	1282/13,084	9.79	3/14,045	0.02	3/14,045	0.02	0/14,045	0.00
Total	3407/96,970	3.51	1865/96,970	1.92	520/96,040	0.54	613/96,040	0.64	19/96,040	0.02

[a] *n*, number of children infected; *N*, number of children examined (the *N* in this table is different from that in Table 2 because the parasite count was missing for some infected children

Table 4 Association between risk factors and schistosomiasis prevalence (*S. haematobium* or *S. mansoni*)

Risk factors		% (*n*/*N*)	Adjusted OR[a] (95% CI)	*P*-value
Latrine (household level)	Improved	2.9 (470/16,111)	0.45 (0.41–0.51)	<0.001
	Unimproved	6.1 (3805/62,507)	0.88 (0.82–0.93)	<0.001
	No latrine	7.2 (1495/20,779)	ref	
Latrine (school level)	Improved	4.9 (2307/46,813)	0.75 (0.70–0.81)	<0.001
	Unimproved	5.8 (1701/29,180)	0.82 (0.77–0.89)	<0.001
	No latrine	7.3 (1825/25,090)	ref	
Open defecation	Yes	7.4 (1394/18,796)	1.50 (1.35–1.66)	<0.001
	No	5.4 (4439/82,287)	ref	
Water (household level)	Improved	5.7 (5139/90,444)	0.92 (0.84–1.02)	0.13
	Unimproved	6.5 (694/10,639)	ref	
Water (school level)	Improved	5.6 (4727/84,912)	1.05 (0.96–1.14)	0.29
	Unimproved	6.8 (1106/16,171)	ref	
Sex	Female	4.3 (1944/45,280)	0.63 (0.58–0.69)	<0.001
	Male	7.1 (3826/54,117)	ref	
Routine water contact (contact with water bodies more than 2 times a week[b])	Yes	10.1 (3866/38,445)	2.96 (2.79–3.15)	<0.001
	No	3.1 (1904/60,952)	ref	
Water contact type	Fetching water	9.9 (1355/13,718)	1.35 (1.26–1.44)	<0.001
	Bathing	13.3 (1700/12,770)	1.70 (1.59–1.81)	<0.001
	Washing clothes	14.3 (1013/7060)	1.94 (1.80–2.10)	<0.001
	Farming	10.2 (241/2362)	1.11 (0.96–1.28)	<0.001
	Swimming	11.9 (1909/16,034)	1.82 (1.71–1.94)	<0.001
	Watering livestock	20.0 (1068/5348)	2.32 (2.14–2.51)	<0.001
	Fishing	11.2 (62/552)	0.89 (0.67–1.18)	0.42
	No routine water contact	3.1 (1904/60,952)	ref	

[a] Latrine (household/school): adjusted for age, sex, water (household, school), latrine (school/household); water (household/school): adjusted for age, sex, latrine (household, school), water (school/household); open defecation: adjusted for age, sex, water (household, school), latrine (school); sex: adjusted for water (household, school), latrine (household, school); water contact: adjusted for age, sex, water (household, school), latrine (household, school)

[b] River, stream, lake, irrigation canal, reservoir

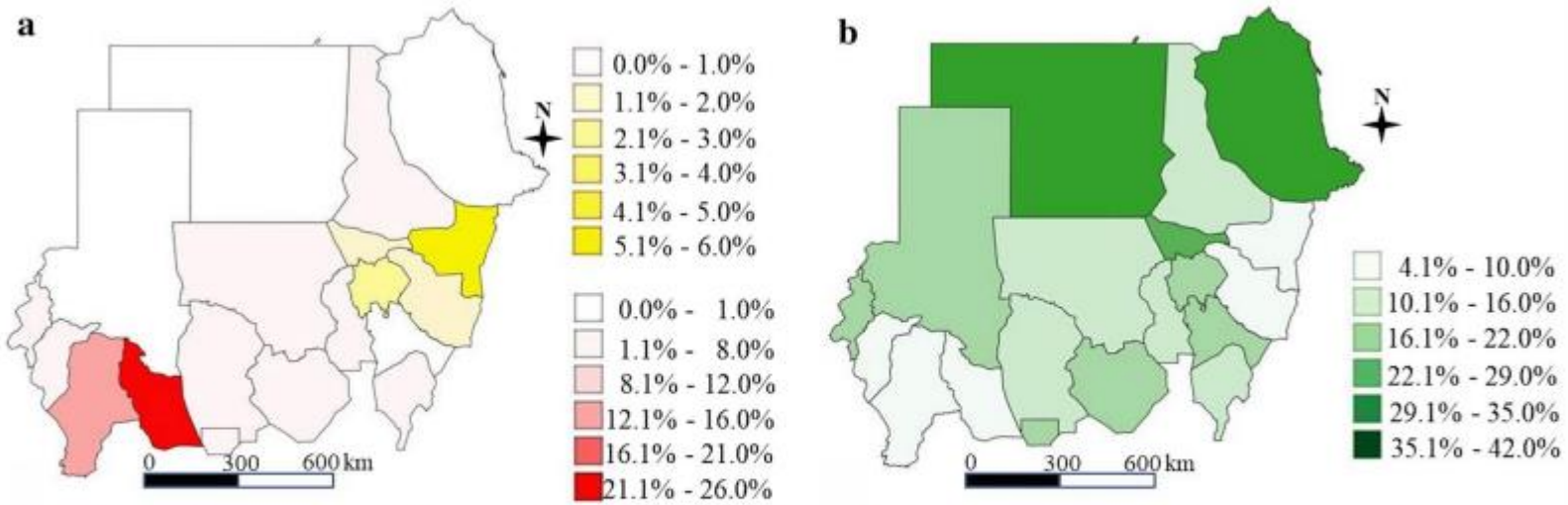


Fig. 2 Schistosomiasis prevalence and improved latrine coverage. **a** Schistosomiasis prevalence (red: *S. haematobium* prevalence; yellow: *S. mansoni* prevalence). **b** Improved latrine coverage (green: improved latrine coverage). An improved latrine was defined as a plush toilet or ventilated improved pit latrine

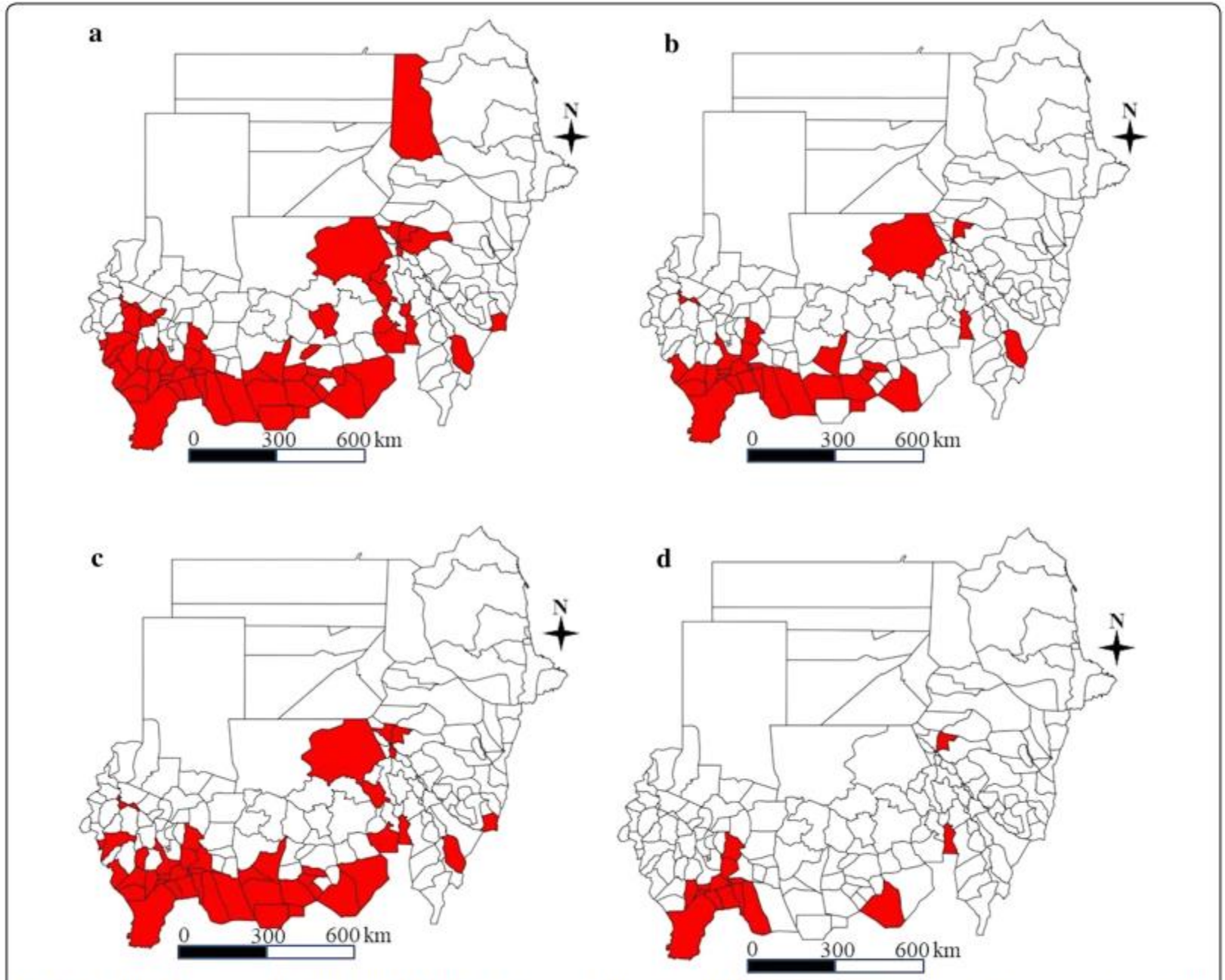


Fig. 3 MDA target areas by a different threshold. **a** MDA target areas for school-aged children at 3% prevalence threshold. **b** MDA target areas for all community people at 8% prevalence threshold. **c** MDA target areas for school-aged children at 5% prevalence threshold. **d** MDA target areas for all community people at 15% prevalence threshold (red color: MDA target area)

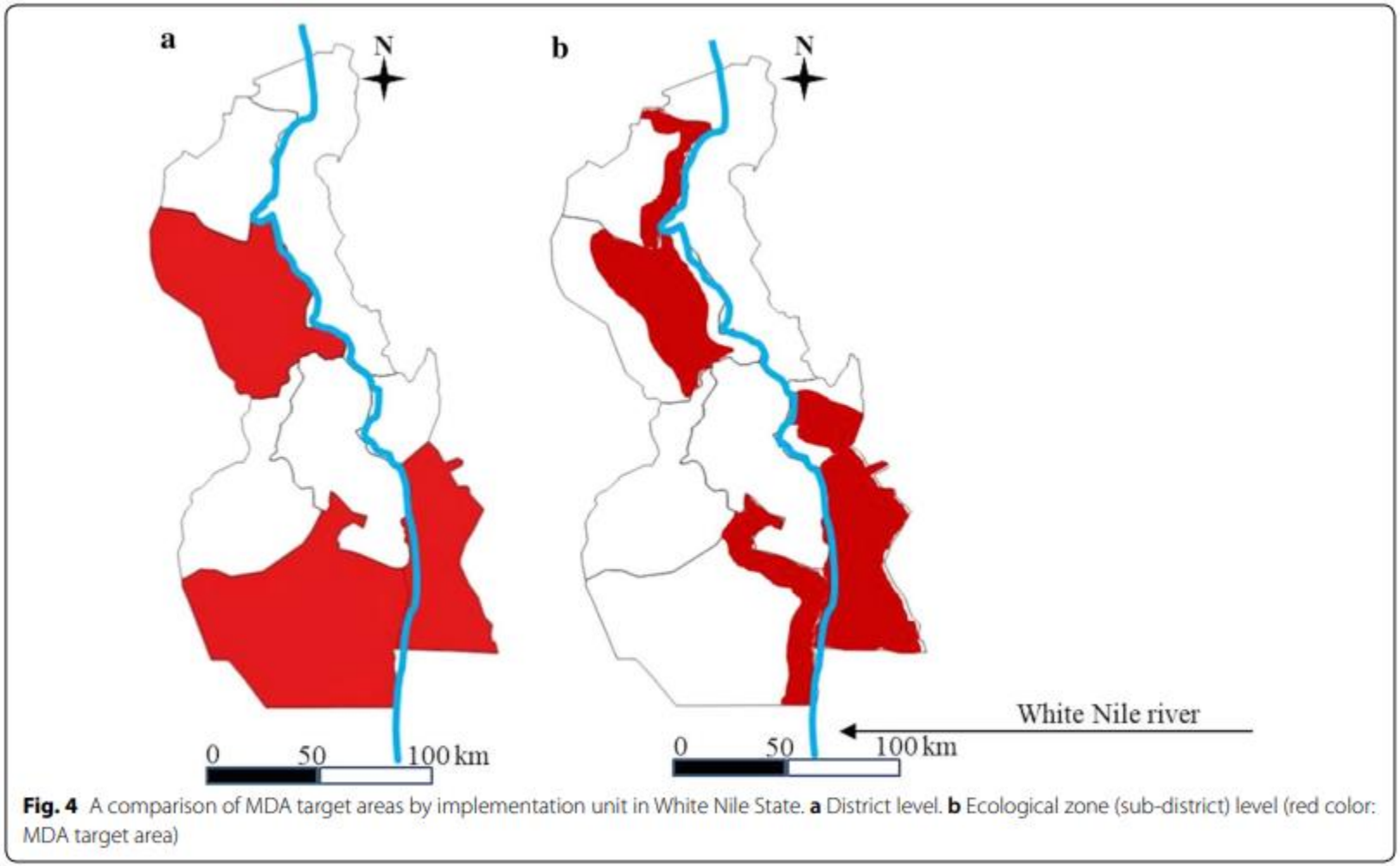


Fig. 4 A comparison of MDA target areas by implementation unit in White Nile State. **a** District level. **b** Ecological zone (sub-district) level (red color: MDA target area)

Table 6 Cost-effectiveness of a one-time MDA intervention at the district and ecological zone levels (75% coverage)

MDA strategy	Level of MDA	Cost[a] (US$)	DALY[b] (averted)	ICER (US$ per DALY averted)
Community-wide at 15%	Ecological zone	3,482,808	9057	385
	District	2,620,471	6784	386
Community-wide at 8%	Ecological zone	8,022,345	13,684	586
	District	7,305,368	10,323	708
SAC only (school-aged children) at 5%	Ecological zone	3,350,078	4338	772
	District	3,425,714	3755	912
SAC only (school-aged children) at 3%	Ecological zone	3,962,109	4506	879
	District	4,872,481	3950	1234

[a] Cost of community-based treatment and delivery, US$1.74; cost of school-based treatment and delivery, US$0.74

[b] Disability was calculated on the basis of updated disability weights. An equal disability weight was applied to all infection intensities

Abbreviations: DALY, disability-adjusted life-years; ICER, incremental cost-effectiveness ratio

Supplementary information

Supplementary information accompanies this paper at https://doi.org/10.1186/s13071-019-3689-z.

Additional file 1: Table S1. Prevalence of schistosomiasis by grade. **Table S2.** Other helminthiases prevalence. **Table S3.** Schistosomiasis haematobium prevalence by state, locality and ecological zone. **Table S4.** Schistosomiasis mansoni prevalence by state, locality and ecological zone. **Table S5.** MDA target areas (community-wide at 8% a threshold). **Table S6.** MDA target areas (community-wide at a 15% threshold). **Table S7.** MDA target areas (school-aged children at a 3% threshold). **Table S8.** MDA target areas (school-aged children at a 5% threshold).

Additional file 2: Figure S1. The prevalence of other intestinal helminthiasis at state level.

Stool microscopy: 5.5% egg positive rate, 4.9% of *Hymenolepis nana*

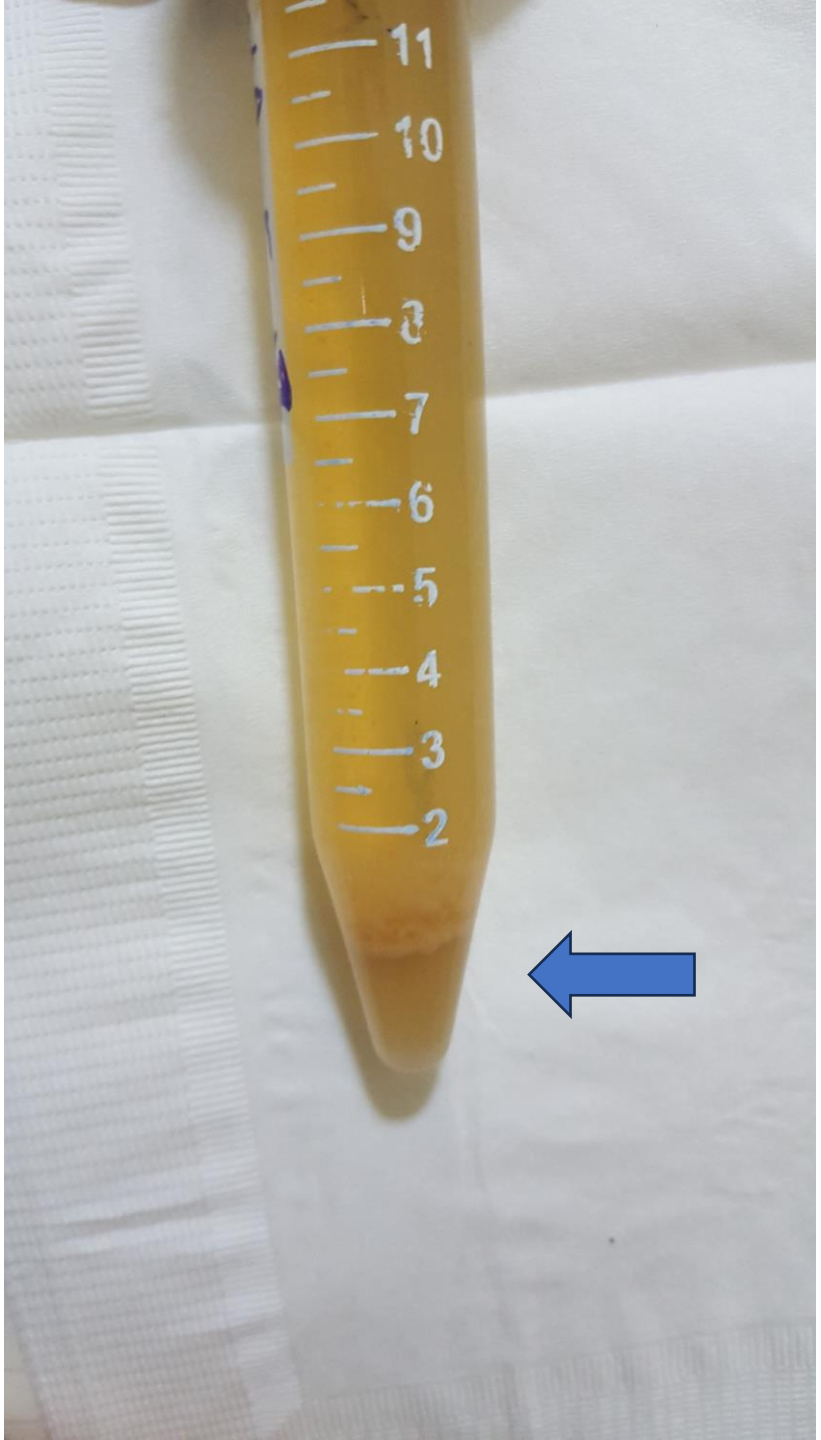
Lessons of the Mapping

- **Capacity building of nationwide cross-sectional survey in Sudan** ⟹ **WE CAN DO!**
  - ✓ Statistical sampling
  - ✓ Lab examination & QA
  - ✓ MDA
  - ✓ Community education
- International attention for global donors
- The SUKO Network for NTDs in 18 states and Networking in East Africa

Summary of the SUKO Project

- National NTD Control Program in Sudan: Delivery of donated anthelmintics, active intervention based on mapping data
- Community in Sudan: Self-neglect
- Sustainability solely depends on overseas donors: Funding for NTDs elimination supported by domestic vs. overseas
- Low coverage rates of MDA
- Low attendance at school of SAC
- Manpowers: Well-trained experts (600 persons) through the SUKO Project
- Major risk factors: open defecation, water contact
- Political unstability, armed conflicts: No sustainable elimination programmes of NTDs in Sudan
- SCH: Persistently prevalent, resurged at the project areas

Mass & Snow in UB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Significance of Echogenic Snow Sign as an Ultrasonography Finding for Diagnosis of Urogenital Schistosomiasis

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Abstract. Urogenital schistosomiasis (UGS) is one of the important neglected tropical diseases, which requires global elimination programs. It is primarily diagnosed by urine microscopy (UM), but its sensitivity is not satisfactory. Ultrasonography (US) is an alternative screening method of UGS. The present study investigated the diagnostic feasibility of new criteria including echogenic snow sign, innumerable scattered small echogenic foci floating in bladder lumen, for UGS in White Nile State, Republic of Sudan, 2013–2014. A total of 1,462 participants were screened by US or UM, and 948 by both. The 948 subjects were 1–80 years of age, 485 (51.2%) of them were boys or men, and 648 (68.4%) were less than 15 years of age. Eggs were detected from 133 (14.0%) by UM. The US findings of bladder wall thickening, polypoid mass, and ureter dilatation were regarded as positive for UGS following the World Health Organization (WHO) guidelines. Of the 948 subjects, 155 (16.4%) were positive for US by the WHO criteria. The echogenic snow sign was detected in 75 participants, and was most frequently observed in age group of 10–14. It was more commonly observed in UM-positive participants (35/133; 26.3%) than in UM-negative participants (40/815; 4.9%), and the difference was statistically significant with an odds ratio of 6.92 (4.20–11.41). When the echogenic snow was added to the WHO criteria, 42 participants were additionally revealed to have UGS-related morbidity, reaching a total of 198 (20.9%) participants. The echogenic snow sign can be suggested as a new finding to the criteria of US for UGS.

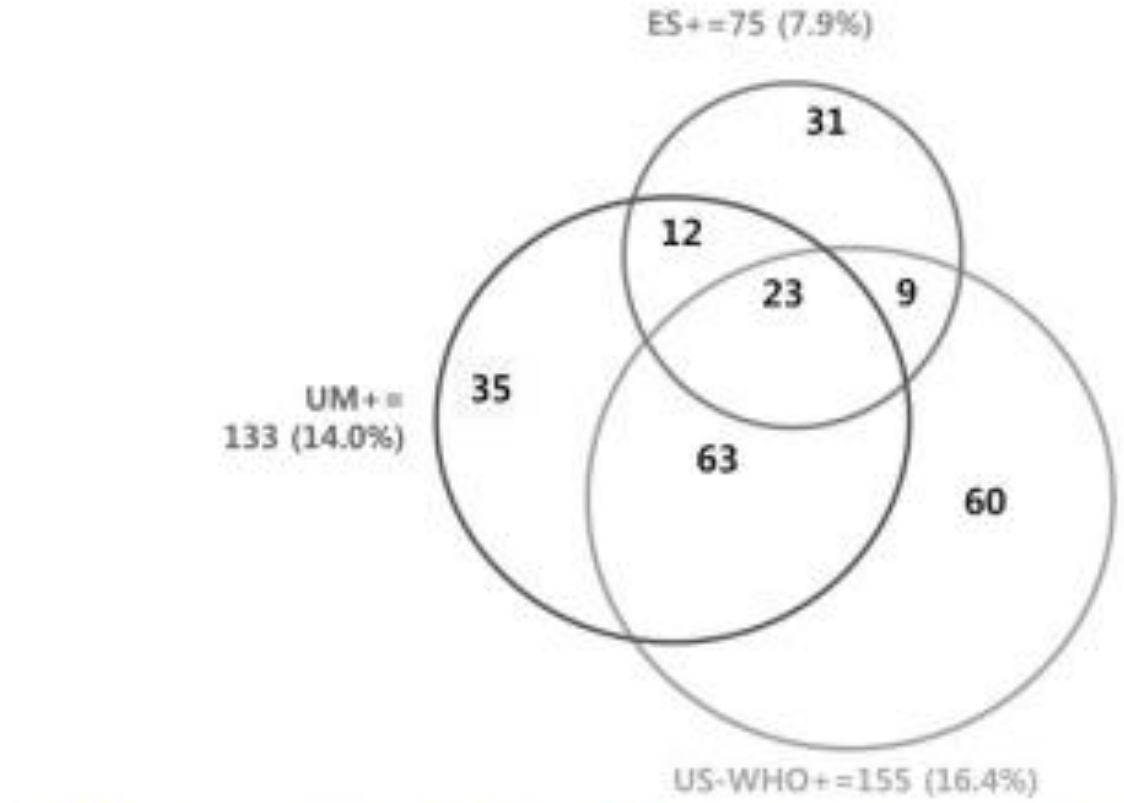

FIGURE 3. Composition of the participants tested positive by urine microscopy (UM+), ultrasonography by WHO criteria (US−WHO+) and echogenic snow sign (ES+).

Comparing diagnostic values by US criteria under various gold standard

Diagnostic measure	Gold Standard		
	UM Positivity N=133	UM + Old Crit N=202	UM + New Crit N=233
UM Sensitivity	100%(133/133)	65.8%(133/202)	57.1%(133/233)
Old Crit Sensitivity	64.7%(86/133)	76.7%(155/202)	66.5%(155/233)
New Crit Sensitivity	73.7%(98/133)	-	93.9%(198/233)

Challenges for NTDs in Sudan

- Overcome self-neglect
- Sustainable system and funding