Trans R Soc Trop Med Hyg 2021; **0**: 1–8
https://doi.org/10.1093/trstmh/trab153 Advance Access publication 0 2021

ORIGINAL ARTICLE

Progress towards control and elimination of neglected tropical diseases targeted by preventive chemotherapy in São Tomé e Príncipe

Aisling Byrne [a], Alzira Rosário [b], Maria da Conceição Ferreira [c], Maria de Jesus Trovoada dos Santos [b], David Rollinson [d], and Susana Vaz Nery [a,*]

[a]Kirby Institute, University of New South Wales, Sydney, NSW 1466, Australia; [b]Programa de Controlo de Doenças Tropicais Negligenciadas, Ministério da Saúde, Rua Patrice Lumumba, São Tomé, São Tomé & Príncipe; [c]World Health Organization/European Society for Clinical Nutrition and Metabolism; [d]Global Schistosomiasis Alliance, Natural History Museum, London SW7 5BD, UK

*Corresponding author: Tel: +61 (2) 9385 0900; E-mail: snery@kirby.unsw.edu.au

Received 9 April 2021; revised 7 September 2021; accepted 13 September 2021

The São Tomé e Príncipe government is committed to achieving neglected tropical disease (NTD) control and elimination as a public health problem by 2025. In 2014, the Ministry of Health led a national survey to determine the prevalence of soil-transmitted helminths (STHs) and schistosomiasis across the country. Following this survey, a preventive chemotherapy (PC) campaign with mebendazole and praziquantel reached 31 501 school-age children in 2015. A follow-up 2017 survey to determine the impact of the intervention showed success in controlling schistosomiasis, as no infections were found, but limited impact on STHs, with prevalence similar to pretreatment levels. The survey also investigated the prevalence of a third NTD, lymphatic filariasis (LF), which was found to be endemic in the country. Since then the Ministry of Health has developed the Strategic Plan for the Fight Against Neglected Tropical Diseases 2019–2025 and identified gaps to be addressed. This narrative review systematises the existing literature reporting on the epidemiology of NTDs for which there are PC programs in São Tomé e Príncipe. PubMed was searched for relevant papers that measured the prevalence of LF, schistosomiasis and STHs. Additionally, data provided by the Ministry of Health surveys were analysed. Finally, we discuss current NTD control, including the impact of the coronavirus disease 2019 pandemic and identify priorities for program strengthening and operational research.

Keywords: lymphatic filariasis, neglected tropical diseases, preventive chemotherapy, schistosomiasis, soil-transmitted helminths

Introduction

There are an estimated 1 billion people affected by neglected tropical diseases (NTDs) worldwide. These diseases have mild to severe health, social and economic impacts. They disproportionately affect the poorest and marginalized populations in tropical and subtropical regions.[1] Since 2012, the World Health Organization (WHO) has prioritized the global scale-up of prevention and control, with the first NTD roadmap guiding implementation and progress.[2] Preventive chemotherapy (PC), regular administration of medications to populations at higher risk of morbidity, is the recommended and most cost-effective public health intervention used to control and eliminate several NTDs.[3] While significant progress has been made worldwide, not all targets set for 2020 were met. For example, according to the 2020 WHO NTD report, São Tomé e Príncipe did not meet the PC coverage goal of at least 75% of preschool and school-age children in need of STH treatment.[4]

São Tomé e Príncipe is a country of >219 000 people with a median age of 18.6 y. The country consists of two separate islands, São Tomé, with an area of 859 km^2, and Região Autónoma do Príncipe (RAP), formerly known as Pagué district, with an area of 142 km^2. The government has set a goal, aligning with the NTD roadmap, to control and eliminate target diseases as a public health problem by 2030.[5] Four NTDs have been identified as endemic in the country, including soil-transmitted helminths (STHs), schistosomiasis, lymphatic filariasis (LF) and leprosy. Leprosy is managed within the country's tuberculosis program. The national program to combat NTDs covers STHs, schistosomiasis and LF, which are amenable to PC programs and are the focus of this review (PC-NTDs).[5] In September 2018, the Ministry of Health, supported and guided by the WHO, among other partners, devised a national plan, the Strategic Plan for the Fight Against Neglected Tropical Diseases 2019–2025.[5] This document details the program priorities of an integrated approach for the control of NTDs and a scale-up of preventive chemotherapy. The Ministry of Health has also identified gaps in their NTD program and the measures necessary to improve control going forward. São Tomé e Príncipe intends to work towards the new

WHO 2030 targets and reduce or eliminate its burden of PC-NTDs, building on its past achievements considered here.[6]

Methods

The PubMed database was searched for relevant papers using the following search terms: Sao Tome and (e) Principe, neglected tropical disease(s), soil-transmitted helminths, deworming, lymphatic filariasis, schistosomiasis. Any papers that recorded a prevalence of STHs, LF and/or schistosomiasis were included, regardless of the year of publication. No exclusion criteria were considered. The Ministry of Health provided three documents: Plano Estratégico para a Luta Contra as Doenças Tropicals Negligenciadas 2019–2025 (The Strategic Plan for the Fight Against Neglected Tropical Diseases 2019–2025),[5] Plano Operacional (Operational Plan)[7] and Situation Epidemiologique des MTN a São Tomé e Príncipe (NTD Epidemiological Situation in São Tomé e Príncipe).[8] These documents were translated from Portuguese or French to English. Additionally, the Ministry of Health provided the raw data collected from the 2014 and 2017 national surveys. These data were used to create the tables, graphs and maps in this review.

Results

STHs and schistosomiasis

Our search found six cross-sectional studies surveying STHs and schistosomiasis before the first Ministry of Health national survey in 2014. Studies were community- or school-based and examined both stool and urine samples. STH species identified in stool samples included *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm. Schistosomiasis species included *Schistosoma haematobium*, identified in urine samples, and *Schistosoma intercalatum*, identified in stool samples. While original reports refer to *S. intercalatum*, in this article we use *Schistosoma guineensis* to reflect current terminology. All studies are summarised in Supplementary Material 1.

The earliest study was in 1983, when Pampiglione et al.[9] performed a community-based cross-sectional study including 1050 randomly selected healthy subjects from all regions of the country. Stool samples were analysed using the modified Ritchie technique. The prevalence of *A. lumbricoides* was 64.0%, *T. trichiura* 88.0%, hookworm 40.5% and *S. haematobium* 0.2%.

The first school-based study was in 1991, by Almeda et al.,[10] who performed a cross-sectional study of school-age children (5–15 y) in 28 schools across all districts (26 in São Tomé and 2 in Região Autónoma do Príncipe [RAP]). A total of 3030 stool samples were examined using the Kato–Katz technique and 782 urine samples were examined by filtration for *S. haematobium*. The prevalence of *S. guineensis* was 11.0%, *A. lumbricoides* 87.0%, *T. trichiura* 87.0%, hookworm 9.4% and *Schistosoma stercoralis* 0.1%. No schistosome eggs or gross haematuria were found in any of the urine samples. In 1992, an additional survey for *S. guineensis* was performed in the same 28 schools. They enrolled 2856 children who had not been included in the 1991 survey. Stool samples were analysed using the Kato–Katz technique. Urine samples from 332 children found infected with *S. guineensis* were also examined for *S. haematobium* by filtration. The prevalence of *S. guineensis* was 12.0%. No schistosome eggs or gross haematuria were found in any of the urine samples. In addition, a community-based survey for *S. guineensis* was conducted from 1991 to 1992 in 752 inhabitants of the village of São Marçal in the Mé-Zóchi/Água Grande district. Stool samples were analysed using the Kato–Katz technique and urine samples were examined by filtration. The prevalence of *S. guineensis* was 43.0% and the intensity of infection was 54.0% mild, 38.0% medium and 8.0% severe. No schistosome eggs or gross haematuria were found in any of the urine samples. In 1992, Ripert et al.[11] performed a cross-sectional study including 380 inhabitants of all ages in the town of Guadalupe, Lobata. The prevalence of *S. guineensis* was 25.5%, *A. lumbricoides* 73.7%, *T. trichiura* 73.7% and *Nector americanus* 35.5% measured in 380 stool samples using the Kato–Katz technique. Immunofluorescence found anti-bilharzia antibodies in 85.8% of 288 serum samples. An excreted schistosoma polysaccharide antigen was found in 49.1% of 397 urine samples by enzyme-linked immunosorbent assay.

It was 8 y before another study was published. In 2000, Belo et al.[12] performed a school-based study including 181 school-age children (5–15 y) from three primary schools in Guadalupe, São Marçal and Kilombo and a small town and localities of the Lobata and Água Grande districts, respectively. The prevalence of *S. guineensis* was 36.0%, *A. lumbricoides* 71.5%, *T. trichiura* 68.5% and hookworm 5.0% and was measured in 130 stool samples using the Kato–Katz and Teleman–Lima techniques. A total of 181 urine samples analysed by the sedimentation technique were negative for *S. haematobium*.

The first comparative study involving hospital and community surveys was in 2009 when Lobo et al.[13] performed a cross-sectional study in Lobata including 348 infants and children (214 attending the Ayres de Menezes Hospital [10 d–10 y old) and 134 from Agostinho Neto village (2 months–10 y old). The prevalence of *S. guineensis* was 0.9%, *A. lumbricoides* 10.3%, *T. trichiura* 6.5% and hookworm 0.5% in hospital samples. Village samples had a prevalence of *A. lumbricoides* of 27.6%, *T. trichiura* 4.5%, *S. stercoralis* 0.8% and hookworm 0.8%. Stool samples were analysed by a wet mount of stool prepared in saline and iodine solution and observed by light microscopy.

In 2010 Chu et al.[14] and Liao et al.[15] conducted a cross-sectional school-based study including 252 school-age children from grades 4 and 5 (mean age 9.8 y [standard deviation 1.3]) in four primary schools in areas endemic for parasitic infections (São Marçal, Pantufo, Praia Gamboa and 1 de Junho, in Água Grande) and that had not participated in the annual routine deworming program that had been initiated in the country. Stool samples were analysed by the methiolate–iodine–formaldehyde concentration method. The combined prevalence of STHs (*A. lumbricoides, T. trichiura* and hookworm) was 64.7% and the prevalence of *S. guineensis* was 2.4%. *S. guineensis* was only detected in schoolchildren from São Marçal, with a prevalence of 8.2% in 73 stool samples. All 252 urine samples analysed for *S. haematobium* were found to be negative.

In 2011, Ferreira et al.[16] performed a cross-sectional study including 444 preschool-age children (1–5 y) from 11 schools across six health districts of São Tomé (Água Grande [four], Caué [one], Lobata [one], Cantagalo [one], Mé-Zóchi [three] and Lembá [one]). Stool samples were analysed by the formol–ether concentration method. The prevalence of *S. guineensis* was 3.0%, *A. lumbricoides* 56.0%, *T. trichiura* 52.5%, hookworm 3.0% and *S. stercoralis* 2.5%.

Two additional studies were conducted after the 2014 national survey led by the Ministry of Health. In 2017, Garzon et al.[17,18] conducted a birth cohort (n=388) and a nested cross-sectional (n=80) health-centre-based infant study in Água Grande, Lembá and Caué. Infants were followed from 3 to 24 months. Stool samples were analysed using the formol–ether concentration method. No schistosomiasis was found. In the birth cohort, the prevalence of *Giardia duodenalis* was 35.1% and any STH (*A. lumbricoides*, *T. trichiura* or both) was 30.4% at 24 months. In the nested cross-sectional study, the prevalence of *A. lumbricoides* was 10.0%, *T. trichiura* 2.5% and *G. duodenalis* 26.3%; 27.5% of infants had single or multiple infections with *A. lumbricoides* and/or *T. trichiura* at 24 months.

Finally, in 2018 and 2019, physicians reported two cases of *S. guineensis* in Portugal in people who had been living in São Tomé and Príncipe.[19,20]

LF

Our search found one LF study before the Ministry of Health mapping in 2016. In 1988, Ruiz et al.[21] led a community-based survey including 1200 people from households in Cantagalo and Lembá. The prevalence of LF was 1.6% in Cantagalo and 0.6% in Lembá and was measured by thick smear microscopy and examination of the interphase cellular serum of the microhaematocrit. Further diagnostics included the increase in volume in the lower extremities with thickened skin and loss of elasticity, as well as the presence of lymphatic oedema for >6 months.

Control efforts by the Ministry of Health

The first report of preventive chemotherapy came from the Instituto Marques de Valle Flor (IMVF), a non-governmental development organization that has been working in São Tomé e Príncipe since 1988.[22] As part of their Health For All plan, in 2007 they distributed 35 527 anthelminthic tablets in São Tomé e Príncipe covering 84.6% of children <9 y of age.[23] According to the IMVF, from 2008 to 2016 they carried out 301 000 child deworming treatments in the country.[22]

In 2014, the Ministry of Health conducted the first national prevalence survey of STHs and schistosomiasis using Kato–Katz microscopy of stool samples. It included 2020 children from 47 of the 224 schools in all districts of the country (Água Grande [seven schools, n=350], Mé-Zóchi [seven schools, n=350], Lobata [six schools, n=294], Cantagalo [six schools, n=225], Lembá [six schools, n=250], Caué [six schools, n=251] and RAP [nine schools, n=300]) (Figure 1 and Table 1). Schistosomiasis was detected, with an overall *S. guineensis* prevalence of 7.5% (Água Grande, 20.6%; Mé-Zóchi, 10.3%; Lobata, 4.4%; Cantagalo, 3.1%; Lembá, 4.8%; Caué, 3.2%; RAP, 1.0%). No *Schistosoma mansoni* was found (Figure 1 and Table 1). STH species detected included *A. lumbricoides* (32.8%), *T. trichiura* (57.0%) and hookworm (4.0%), with an overall prevalence of any STH infection of 70.7% (Água Grande, 75.7%; Mé-Zóchi, 62.0%; Lobata, 52.0%; Cantagalo, 66.2%; Lembá, 61.2%; Caué, 88.8%; RAP, 89.7%) (Figure 1 and Table 1).

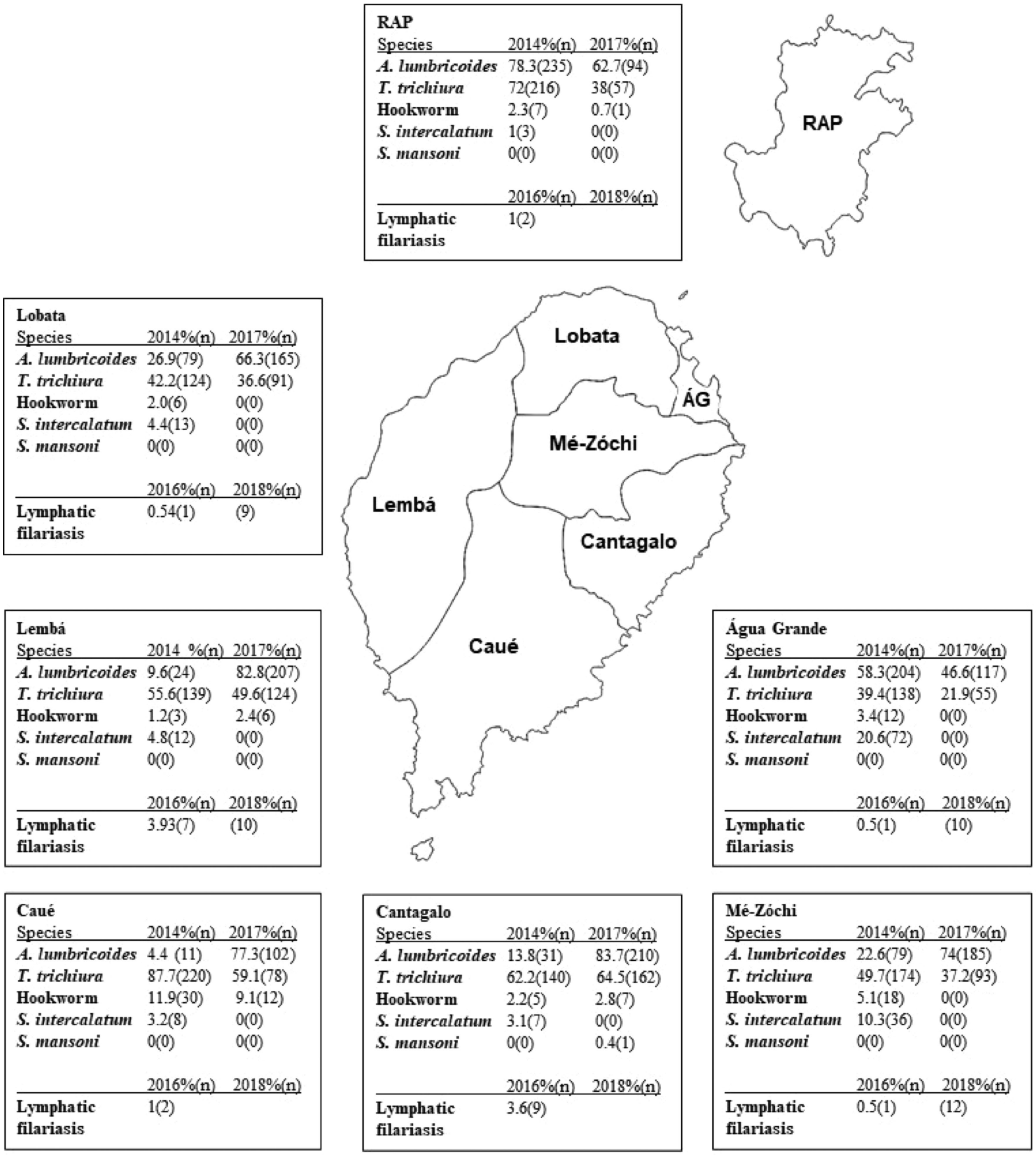
Following this survey, from November 2014 to March 2015, the Ministry of Health led a PC campaign with mebendazole and praziquantel targeting school-age children, reaching a total therapeutic coverage of 87.2% (31 501/36 113 school-age children).[5]

In 2017 the Ministry of Health conducted an additional national survey to determine the impact of the 2014–2015 intervention on the prevalence of STHs and schistosomiasis.[5] This survey used Kato–Katz stool microscopy and included 1533 children from 33 of the 224 schools in all seven districts of the country (Água Grande [five schools, n=251], Mé-Zóchi [five schools, n=250], Lobata [five schools, n=249], Cantagalo [five schools, n=251], Lembá [five schools, n=250], Caué [five schools, n=132] and RAP [three schools, n=150]). Only one participant was found with *S. mansoni* and no *S. guineensis* was found. STH species detected included *A. lumbricoides* (70.5%), *T. trichiura* (43.0%) and hookworm (1.7%). the prevalence of any STH infection was 73.8% (Água Grande, 51.0%; Mé-Zóchi, 70.0%; Lobata, 68.7%; Cantagalo, 86.5%; Lembá, 87.2%; Caué, 87.9%; RAP, 71.3%) (Figure 1 and Table 1).

This survey also investigated LF in 2016 across all districts of the country and included 1413 people of all ages.[5] All districts were found to be endemic for LF, with a total of 23 cases (Água Grande, 0.5%; Mé-Zóchi, 0.5%; Lobata, 0.5%; Cantagalo, 3.6%; Lembá, 3.9%; Caué, 1.0%; RAP, 1.0%) (Figure 1 and Table 1).[5] Following these results, between March and April 2018, the Ministry of Health led the first mass drug administration with diethylcarbamazine citrate (100 mg) and albendazole (400 mg), which included 162 512 people corresponding to a therapeutic coverage of 84.8%.[5] During the campaign, 52 cases of elephantiasis were identified.[5]

From the robust observations made by the Ministry of Health during the national surveys and intervention campaigns, a plan for future progress was developed. The Strategic Plan for the Fight Against Neglected Tropical Diseases 2019–2025 outlines the commitment of the Ministry of Health to PC-NTD control and elimination and outlines the schedule and periodicity of preventive chemotherapy for STHs, schistosomiasis and LF (Table 2A).[5] In each district there will be two rounds of preventive chemotherapy per year, in May and November, alternating between mass drug administration for LF elimination using a triple drug combination of ivermectin (IVM; 200 mg/kg), diethylcarbamazine citrate (DEC; 6 mg/kg) and albendazole (ABZ; 400 mg), commonly known as IDA, and a second round of PC targeting school children either with mebendazole (MBZ) or albendazole (ABZ) for STH control or a combination of albendazole/mebendazole and praziquantel for STH and schistosomiasis control (Table 2A). An initial pre-transmission assessment survey (TAS) using Kato–Katz diagnostics was planned for 2020 with subsequent TASs in 2021, 2023 and 2025 to assess LF elimination (Table 2A).[5]

While the plan was followed in 2019, the global coronavirus disease 2019 (COVID-19) pandemic meant that only one round of PC could be done in 2020. As a result, all districts received the planned mass drug administration for LF (that also included ALB for STHs) but did not receive the school PC for schistosomiasis (Table 2B). Plans for the TAS were also disrupted and consequently the pre-TAS has been delayed to June 2021 and TASs 1–3 will be carried out annually from 2022 (Table 2B). An external evaluation will be performed in 2025 to assess whether LF has been eliminated as a public health problem.[5]



RAP

Species	2014%(n)	2017%(n)
A. lumbricoides	78.3(235)	62.7(94)
T. trichiura	72(216)	38(57)
Hookworm	2.3(7)	0.7(1)
S. intercalatum	1(3)	0(0)
S. mansoni	0(0)	0(0)
	2016%(n)	2018%(n)
Lymphatic filariasis	1(2)	

Lobata

Species	2014%(n)	2017%(n)
A. lumbricoides	26.9(79)	66.3(165)
T. trichiura	42.2(124)	36.6(91)
Hookworm	2.0(6)	0(0)
S. intercalatum	4.4(13)	0(0)
S. mansoni	0(0)	0(0)
	2016%(n)	2018%(n)
Lymphatic filariasis	0.54(1)	(9)

Lembá

Species	2014 %(n)	2017%(n)
A. lumbricoides	9.6(24)	82.8(207)
T. trichiura	55.6(139)	49.6(124)
Hookworm	1.2(3)	2.4(6)
S. intercalatum	4.8(12)	0(0)
S. mansoni	0(0)	0(0)
	2016%(n)	2018%(n)
Lymphatic filariasis	3.93(7)	(10)

Água Grande

Species	2014%(n)	2017%(n)
A. lumbricoides	58.3(204)	46.6(117)
T. trichiura	39.4(138)	21.9(55)
Hookworm	3.4(12)	0(0)
S. intercalatum	20.6(72)	0(0)
S. mansoni	0(0)	0(0)
	2016%(n)	2018%(n)
Lymphatic filariasis	0.5(1)	(10)

Caué

Species	2014%(n)	2017%(n)
A. lumbricoides	4.4 (11)	77.3(102)
T. trichiura	87.7(220)	59.1(78)
Hookworm	11.9(30)	9.1(12)
S. intercalatum	3.2(8)	0(0)
S. mansoni	0(0)	0(0)
	2016%(n)	2018%(n)
Lymphatic filariasis	1(2)	

Cantagalo

Species	2014%(n)	2017%(n)
A. lumbricoides	13.8(31)	83.7(210)
T. trichiura	62.2(140)	64.5(162)
Hookworm	2.2(5)	2.8(7)
S. intercalatum	3.1(7)	0(0)
S. mansoni	0(0)	0.4(1)
	2016%(n)	2018%(n)
Lymphatic filariasis	3.6(9)	

Mé-Zóchi

Species	2014%(n)	2017%(n)
A. lumbricoides	22.6(79)	74(185)
T. trichiura	49.7(174)	37.2(93)
Hookworm	5.1(18)	0(0)
S. intercalatum	10.3(36)	0(0)
S. mansoni	0(0)	0(0)
	2016%(n)	2018%(n)
Lymphatic filariasis	0.5(1)	(12)

Figure 1. Map of prevalence recorded in 2014/2016 STH and schistosomiasis surveys and 2016/2018 LF surveys. Data are from the strategic report and the data sets were provided by the Ministry of Health. The 2014 national survey included 47 of 224 schools and 2020 samples were analysed (Água Grande [7 schools, n=350], Mé-Zóchi [7 schools, n=350], Lobata [6 schools, n=294], Cantagalo [6 schools, n=225], Lembá [6 schools, n=250], Caué [6 schools, n=251] and RAP (formerly Pagué district; 9 schools, n=300]). The 2017 national survey included 33 of 224 schools and 1533 samples were analysed (Água Grande [5 schools, n=251], Mé-Zóchi [5 schools, n=250], Lobata [5 schools, n=249], Cantagalo [5 schools, n=251], Lembá [5 schools, n=250], Caué [5 schools, n=132] and RAP [3 schools, n=150]). The 2014 and 2017 survey had 15 schools in common (Água Grande, 2; Mé-Zóchi, 1; Lobata, 2; Cantagalo, 2; Lembá, 3; Caué, 4; RAP, 3).

Discussion

São Tomé e Príncipe is committed to the control and elimination of PC-NTDs in the country, with set plans to achieve and verify LF elimination by 2025 and continuing PC for schistosomiasis until 2024 and for STHs beyond that.

The 2017 national survey suggests that schistosomiasis in São Tomé e Príncipe has been successfully controlled and supports that by 2024 it may be eliminated. We recommend that additional schistosomiasis surveys be conducted to monitor whether zero prevalence has been achieved and is sustained and indeed can confirm that this NTD has been eliminated. Future surveys

Table 1. Prevalence of STHs and schistosomiasis recorded in each district by the 2014 and 2017 national surveys[a]

District	*A. lumbricoides*, % (n)		*T. trichiura*, % (n)		Hookworm, % (n)		*S. mansoni*, % (n)		*S. guineensis*, % (n)		Any STH infection, % (n)	
	2014[b]	2017[c]	2014	2017	2014	2017	2014	2017	2014	2017	2014	2017
Água Grande	58.29 (204)	46.61 (117)	39.43 (138)	21.91 (55)	3.43 (12)	0.00 (0)	0.00 (0)	0.00 (0)	20.57 (72)	0.00 (0)	75.71 (265)	51.00 (128)
Mé-Zóchi	22.57 (79)	74.00 (185)	49.71 (174)	37.20 (93)	5.14 (18)	0.00 (0)	0.00 (0)	0.00 (0)	10.29 (36)	0.00 (0)	62.00 (217)	70.00 (175)
Lobata	26.87 (79)	66.27 (165)	42.18 (124)	36.55 (91)	2.04 (6)	0.00 (0)	0.00 (0)	0.00 (0)	4.42 (13)	0.00 (0)	52.04 (153)	68.67 (171)
Cantagalo	13.78 (31)	83.67 (210)	62.22 (140)	64.54 (162)	2.22 (5)	2.79 (7)	0.00 (0)	0.40 (1)	3.11 (7)	0.00 (0)	66.22 (149)	86.45 (217)
Lembá	9.60 (24)	82.80 (207)	55.60 (139)	49.60(124)	1.20 (3)	2.40 (6)	0.00 (0)	0.00 (0)	4.80 (12)	0.00 (0)	61.20 (153)	87.20 (218)
Caué	4.38 (11)	77.27 (102)	87.65 (220)	59.09 (78)	11.95 (30)	9.09 (12)	0.00 (0)	0.00 (0)	3.19 (8)	0.00 (0)	88.84 (223)	87.88 (116)
RAP	78.33 (235)	62.67 (94)	72.00 (216)	38.00 (57)	2.33 (7)	0.67 (1)	0.00 (0)	0.00 (0)	1.00 (3)	0.00 (0)	89.67 (269)	71.33 (107)
Total	32.82 (663)	70.45 (1080)	56.98 (1151)	43.05 (660)	4.01 (81)	1.70 (26)	0.00 (0)	0.40 (1)	7.48 (151)	0.00 (0)	70.74 (1429)	73.84 (1132)

[a]Data come from the data set provided by the Ministry of Health.
[b]The 2014 national survey included 47 of 224 schools and 2020 samples were analysed (Água Grande [7 schools, n=350], Mé-Zóchi [7 schools, n=350], Lobata [6 schools, n=294], Cantagalo [6 schools, n=225], Lembá [6 schools, n=250], Caué [6 schools, n=251] and RAP [9 schools, n=300]).
[c]The 2017 national survey included 33 of 224 schools and 1533 samples were analysed (Água Grande [5 schools, n=251], Mé-Zóchi [5 schools, n=250], Lobata [5 schools, n=249], Cantagalo [5 schools, n=251], Lembá [5 schools, n=250], Caué [5 schools, n=132] and RAP [3 schools, n=150]). The 2014 and 2017 survey had 15 schools in common (Água Grande, 2; Mé-Zóchi, 1; Lobata, 2; Cantagalo, 2; Lembá, 3; Caué, 4; RAP, 3).

should include an increased number of schools and communities historically associated with known transmission sites for suitable intermediate snail hosts so possible hot spots are not ignored. Furthermore, the future verification of interruption of transmission will require studies to determine whether infections are still occurring in snails and whether potential reservoir hosts are still present. New diagnostic approaches such as molecular techniques will also be beneficial, as detecting eggs by the Kato–Katz method may miss low-intensity infections. The planned TAS could offer a platform to integrate surveys targeting multiple NTDs.

On the other hand, it appears that the control of STHs is further away from the target of elimination as a public health problem. Despite the STH preventive chemotherapy that began in 2015, the prevalence of STHs remained high and even increased in some districts between the initial national survey and the 2017 follow-up. One contributing factor may be the use of mebendazole in the school deworming campaigns, which is less efficacious against hookworm and *T. trichiura* than albendazole.[24] The IDA for LF elimination, which includes albendazole and ivermectin, provides an opportunity for an additional impact on STHs, given that this combination is known to be more efficacious against *T. trichiura*. Ivermectin is also efficacious against *Strongyloides stercoralis*, known to be present in the country.[25] As with schistosomiasis, there is the need to conduct impact assessments that can adequately reflect the impact of the existing deworming campaigns and the use of diagnostic techniques such as polymerase chain reaction that can detect all the potential existing species, including *S. stercoralis*. Expanding the current school-based deworming program to include entire communities, similar to the recommended LF mass drug administration, would also accelerate STH control efforts.[26]

The strategic plan also recognises the need to strengthen several aspects of the existing NTD control program. From an operational perspective, there is recognition of the need to improve planning of the PC campaigns and strengthen resource mobilisation and sustainability of funding. There is also interest in improving monitoring, evaluation and surveillance and therefore, conducting integrated NTD surveys in addition to the planned TAS could represent an opportunity to strengthen the program and provide additional evidence for future planning.

Finally, those running the NTD control program are supportive of developing partnerships and collaborations with other programs of the Ministry of Health and other sectors that could also contribute to the control and elimination of NTDs in the country. One example is integrated vector control for LF and malaria. For example, in areas where *Anopheles* is the primary vector for both malaria and filariasis, promoting the use of insecticide-treated nets or conducting indoor residual spraying during and after LF mass drug administration can enhance the impact on LF transmission.[27] An integrated vector management strategy may also reveal whether podoconiosis (non-filarial elephantiasis) is a problem or not. Additionally there is a need to improve the standard of water, sanitation and hygiene (WASH) access and use throughout the country. According to the Ministry of Health, access to clean water is a problem in São Tomé e Príncipe. This may impact the degree of water contact with natural freshwater bodies that are potential schistosomiasis reservoirs, and limit appropriate handwashing practices that are effective in reducing exposure to STHs. Despite some latrine construction programs,

Table 2. The Ministry of Health preventive chemotherapy schedule (A) before COVID-19 and (B) with COVID-19 disruptions for each district for 2019–2025 and expected years of TASs

Districts	2019	2020	2021	2022	2023	2024	2025
(A)							
Água Grande	(ABZ1+DEC+IVM)[a]	(PZQ+ABZ1)[c]	(MEB1)	(PZQ+MEB1)	(ABZ1)	(PZQ+ABZ1)	(MEB1)
	(MEB)[b]	(DEC+IVM+ABZ2)	(MEB2)	(MEB2)	(ABZ2)	(ABZ2)	(MEB2)
Mé-Zóchi	(ABZ1+DEC+IVM)	(PZQ+MEB1)	(MEB1)	(PZQ+MEB1)	(ABZ1)	(PZQ+ABZ1)	(MEB1)
	(MEB)	(DEC+IVM+ABZ2)	(MEB2)	(MEB2)	(ABZ2)	(ABZ2)	(MEB2)
Lobata	(ABZ1+DEC+IVM)	(PZQ+MEB1)	(MEB1)	(MEB1)	(PZQ+ABZ1)	(ABZ1)	(MEB1)
	(MEB)	(DEC+IVM+ABZ2)	(MEB2)	(MEB2)	(ABZ2)	(ABZ2)	(MEB2)
Cantagalo	(ABZ1+DEC+IVM)	(PZQ+MEB1)	(MEB1)	(MEB1)	(PZQ+ABZ1)	(ABZ1)	(MEB1)
	(MEB)	(DEC+IVM+ABZ2)	(MEB2)	(MEB2)	(ABZ2)	(ABZ2)	(MEB2)
Lembá	(ABZ1+DEC+IVM)	(PZQ+MEB1)	(MEB1)	(ABZ1)	(PZQ+ABZ1)	(ABZ1)	(MEB1)
	(MEB)	(DEC+IVM+ABZ2)	(MEB2)	(MEB2)	(ABZ2)	(ABZ2)	(MEB2)
Caué	(ABZ1+DEC+IVM)	(PZQ+MEB1)	(MEB1)	(MEB1)	(PZQ+ABZ1)	(ABZ1)	(MEB1)
	(MEB)	(DEC+IVM+ABZ2)	(MEB2)	(MEB2)	(ABZ2)	(ABZ2)	(MEB2)
RAP	(ABZ1+DEC+IVM)	(PZQ+MEB1)	(MEB1)	(MEB1)	(PZQ+ABZ1)	(ABZ1)	(MEB1)
	(MEB)	(DEC+IVM+ABZ2)	(MEB2)	(MEB2)	(ABZ2)	(ABZ2)	(MEB2)
		Pre-TAS	TAS 1	TAS 2	TAS 3		External evaluation
(B)							
Água Grande	(ABZ1+DEC+IVM)		(PZQ+MEB1)	(PZQ+MEB1)	(PZQ+ABZ1)	(PZQ+ABZ1)	(MEB1)
	(MEB)	(DEC+IVM+ABZ2)	(MEB2)	(MEB2)	(MEB)	(ABZ2)	(MEB2)
Mé-Zóchi	(ABZ1+DEC+IVM)		(PZQ+MEB1)	(PZQ+MEB1)	(ABZ1)	(PZQ+ABZ1)	(MEB1)
	(MEB)	(DEC+IVM+ABZ2)	(MEB2)	(MEB2)	(ABZ2)	(ABZ2)	(MEB2)
Lobata	(ABZ1+DEC+IVM)		(PZQ+MEB1)	(MEB1)	(ABZ1)	(PZQ+ABZ1)	(MEB1)
	(MEB)	(DEC+IVM+ABZ2)	(MEB2)	(MEB2)	(ABZ2)	(ABZ2)	(MEB2)
Cantagalo	(ABZ1+DEC+IVM)		(PZQ+MEB1)	(MEB1)	(ABZ1)	(PZQ+ABZ1)	(MEB1)
	(MEB)	(DEC+IVM+ABZ2)	(MEB2)	(MEB2)	(ABZ2)	(ABZ2)	(MEB2)
Lembá	(ABZ1+DEC+IVM)		(PZQ+MEB1)	(MEB1)	(ABZ1)	(PZQ+ABZ1)	(MEB1)
	(MEB)	(DEC+IVM+ABZ2)	(MEB2)	(MEB2)	(ABZ2)	(ABZ2)	(MEB2)
Caué	(ABZ1+DEC+IVM)		(PZQ+MEB1)	(MEB1)	(ABZ1)	(PZQ+ABZ1)	(MEB1)
	(MEB)	(DEC+IVM+ABZ2)	(MEB2)	(MEB2)	(ABZ2)	(ABZ2)	(MEB2)
RAP	(ABZ1+DEC+IVM)		(PZQ+MEB1)	(MEB1)	(ABZ1)	(PZQ+ABZ1)	(MEB1)
	(MEB)	(DEC+IVM+ABZ2)	(MEB2)	(MEB2)	(ABZ2)	(ABZ2)	(MEB2)
			Pre-TAS	TAS 1	TAS 2	TAS 3	External evaluation

Data provided by the Ministry of Health (Round 1 and Round 2).
[a]ABZ+DEC+IVM: combination of preventive chemotherapy for LF.
[b]MBZ: preventive chemotherapy for STHs.
[c]PZQ+MBZ: preventive chemotherapy for schistosomiasis and STHs, respectively.

open defecation and urination is widespread, therefore strategies to increase access to improved sanitation will be needed to help prevent transmission of both STHs and schistosomiaisis.[28] The Ministry of Health is aware of the need for WASH programs with a strong education and behavioural change component to sustain STH and schistosomiasis control and elimination efforts in the longer term.[29] Increased coordination between the NTD program and the WASH sector could overcome existing funding shortfalls.

Conclusions

The Ministry of Health has made great efforts towards the development and implementation of a comprehensive NTD control program. Despite the disruptions caused by the COVID-19 pandemic, the program has adapted and should still be on target. The relatively small population and size of this archipelago country is an advantage in NTD elimination. The 2017 survey suggests that there is the potential for São Tomé e Príncipe to be one of the first countries to eliminate schistosomiasis. The LF elimination program is likely to be successful and may also impact STH control, including *T. trichiura* and *S. stercoralis* (post-LF) elimination, as additional rounds of ivermectin and albendazole in a community-wide STH control program could potentially achieve STH elimination. Given the 2030 NTD Road Map recommends ivermectin for *Strongyloides* control, this would be another justification for additional rounds of ivermectin.[6] Sustainable long-term interruption of NTD transmission will depend on future collaboration with the WASH sector as well as strong surveillance plans. With monitoring and evaluation, São Tomé e Príncipe could serve as a model for other countries with similar epidemiological characteristics.

Supplementary data

Supplementary data are available at *Transactions* online.

Authors' contributions: SVN conceptualized the manuscript and interpreted the data. AB wrote the first draft of the manuscript and analysed the data. MdCF, AR and MdJTdS provided the raw data collected from the national surveys. SVN, DR, MdCF, AR and MdJTdS critically revised the manuscript for intellectual content. All authors read and approved the final manuscript. AB and SVN are guarantors of the paper.

Acknowledgements: The authors would like to acknowledge the Ministry of Health of São Tomé e Príncipe for their collaboration and contribution to this article, particularly those involved in the national prevalence surveys. The authors would also like to acknowledge Marta Palmeirim for contributing to an early draft of the manuscript.

Funding: None.

Competing interests: None.

Ethical approval: Not required.

Data availability: Data available on request from the authors.

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