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Scaling down of a deworming programme among school-age children after a thirty-years successful intervention in the Bolivian Chaco

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Abstract

Objective—Preventive chemotherapy (PC) is the World Health Organization (WHO) recommended control method for soil-transmitted helminthiases (STH). In the Bolivian Chaco, 6-monthly single-dose mebendazole delivery to school-age children (SAC) achieved a dramatic decrease in STH prevalence from 1987 to 2013. Consequently, in September 2016, PC delivery was interrupted in 9 rural communities. In compliance with WHO recommendations, we intensified surveillance to monitor STH prevalence and detect potential changes that would require interventions.

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Methods— We conducted two cross-sectional parasitology surveys 12 months apart (September 2016 – 2017) amongst SAC living in the communities where PC delivery had been halted. Study design, methods of sampling and sample analysis technique (direct microscopy, Kato-Katz technique) followed WHO recommendations, aiming to obtain data representative of the Bolivian Chaco ecological zone.

Results— Overall, 426 and 520 samples were collected in 2016 and 2017. STH prevalence was unremarkable: 0.7% (95%CI 0-1.5%) in 2016 and 0.8% (0-1.5%) in 2017. Conversely, the prevalence of tapeworms (13% in 2016, 12% in 2017) and intestinal protozoan infections (81% in 2016, 75% in 2017) continued to be high.

Conclusions— Our findings support the role of PC in the observed STH transmission reduction, as otherwise poor hygienic and health conditions persist in the Bolivian Chaco. A national survey, involving areas from all the ecological zones of Bolivia is now warranted.

Introduction

Soil-transmitted helminthiases (STH) are the most prevalent neglected tropical diseases (NTD) worldwide. In low- and middle-income tropical and subtropical countries they represent a significant public health problem intertwined with poor socio-economic conditions. STH are among the NTDs that are being controlled through preventive chemotherapy (PC), whereby anthelmintic drugs like albendazole or mebendazole are periodically administered to high-risk groups, such as school-age children (SAC) [1]. At global level, PC coverage for STH increased steadily in the last decade, reaching 69.5% of the target SAC, and 50.8% of preSAC population in 2016 [2].

The Bolivian Chaco is a semi-arid and sparsely-populated region, located in the south-east of the Plurinational State of Bolivia, between longitude 64°30' and 58°50' west of the Greenwich meridian and at latitude 17°58' and 22°20' south. Over the last three decades, since 1985 a mass-deworming program, based on 6-monthly single-dose mebendazole delivery to SAC was implemented in Bolivia, achieving impressive results at least in the Bolivian Chaco. Parasitological surveys conducted in this area 25 years apart documented a dramatic reduction of STH prevalence from 1987 to 2013: hookworm prevalence dropped from up to 50% to 0.4-1.3%, *Ascaris lumbricoides* from 19% to 0.9-1.5%, *Trichuris trichiura* from 19% to 0% [3] [4] [5]. The same studies showed no substantial change in the prevalence of tapeworms and protozoan intestinal infections during this lapse of time, suggesting that environmental fecal contamination caused by inadequate sanitation, poor hygiene, and unsafe drinking water still persist in the Bolivian Chaco. Since STH epidemiology is expected to change after several rounds of drug administration, a parasitological assessment should be periodically repeated in the areas of PC intervention and frequency of PC administration changed according to the STH prevalence [6]. Based on the recent findings documenting a low STH prevalence, and according to World Health Organization (WHO) recommendations, as of September 2016, local Departmental Health Services (SEDES) issued the interruption of PC delivery in the area of the Bolivian Chaco and a program of STH surveillance through annual cross-sectional parasitological surveys in sentinel sites was started, in order to monitor the effects of the PC scaling down on the STH transmission.

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Materials and Methods

Study design, methods of sampling and analysis technique were defined as per WHO recommendations, aiming to obtain data representative of the Bolivian Chaco ecological zone [6]. The sample size used (n = 50 individuals) is that recommended by WHO for cluster sampling, assuming a design effect equal to 2; this sample size allows estimates to be obtained with an absolute precision of 5% and a confidence level of 95% which is considered sufficient for monitoring purposes [6]–[8].

A first cross-sectional parasitological survey was conducted in September 2016, in 9 primary schools, randomly selected as sentinel sites, in the rural areas of the Cordillera Province (Department of Santa Cruz) and Gran Chaco Province (Department of Tarija) (Figure 1). In each school, a minimum of 50 children was enrolled among those attending the third-year class, usually age 8-9 years; children from higher classes were enrolled when the number of third-year pupils was less than 50. Demographic data were recorded through a questionnaire, filled at the presence of a parent or a legal guardian of the child. Each participant received a stool container, together with the instructions about the correct method to collect the specimen. Stool samples were analyzed for intestinal parasites by direct wet mount and Kato-Katz technique (one thick smear on a single stool sample from each individual). Twelve months later, we conducted a second cross-sectional study in the same 9 communities, using the same methodology.

Data were entered into Microsoft Excel 2010 software (Microsoft, Redmond, WA, USA); frequencies and percentages with 95% confidence intervals (CI) were calculated.

Ethics Consideration

The program was as part of the agreement between the Ministry of Health of the Plurinational State of Bolivia and the University of Florence, Italy, in collaboration with the SEDES of Santa Cruz and Tarija and with the support of the Guaraní political organization (Asamblea del Pueblo Guaraní). The study was approved by a local Ethic Committee (Colegio Médico de Santa Cruz, TDEM CITE No. 005/2016) and a written informed consent was obtained by a parent or a legal guardian of each enrolled child.

Results

The number of school-age children enrolled in the study was 519 in 2016 (50% females, mean age 9.4 years), and 581 in 2017 (51% females, mean age 9.8 years); the response rate was 82% (426/519) and 90% (520/581), respectively; only 3 STH infections were documented in 426 samples in 2016 (all by hookworm, prevalence 0.7%, 95% CI 0-1.5%), and 4 in 520 samples in 2017 (3 by hookworm and 1 by *A. lumbricoides*, prevalence 0.8%, 95% CI 0-1.5%). In all cases, the children were infected at light intensity (<2000 and <5000 eggs per gram of faeces for hookworm and *A. lumbricoides*, respectively) [9]; there were no cases of *T. trichiura* infection. In both surveys, *Hymenolepis nana* was the most frequent helminthic infection (13% in 2016, 12% in 2017). Conversely, we found high rates of intestinal protozoan infections (81% in 2016 and 75% in 2017), with *Blastocystis* sp. as the most common protozoan parasite (50% in 2016, 54% in 2017), followed by *E. coli* (27% in

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2016, 26% in 2017) and *E. nana* (26% in 2016, 22% in 2017). We also found that polyparasitism, defined as any two helminthic and/or protozoan and/or mixed infections, was frequent (58% in 2016, 43% in 2017, respectively). Details are shown in Table 1.

Discussion

Our results confirm that sustained reduction in STH prevalence has been achieved in the subnational area of the Bolivian Chaco, which warranted interruption of PC, as recommended by WHO. These data confirm the findings of two previous point-prevalence studies and are further corroborated by the low positivity rates found through routine copro-parasitological investigation from the main hospital laboratory services of this area (Hospitales Municipales de Camiri, Charagua Villa Montes, Yacuiba and Monteagudo) (Fernando Ramírez, Rosario Justiniano, Ana Liz Villagrán, Evelyn Illescas, Yuni Lara personal communications) [4], [5].

Figure 2 provides an overview of the changing prevalence of intestinal parasitic infections between 1987 and 2017. Infection rates might differ in different age categories. Direct comparisons can be made between 1987 and 2013 (all-age population), between 1990 and 2011 (pre-SAC and SAC), and between 2016 and 2017. Of note, prevalences in the general and paediatric population in 1987 and 1990 were roughly similar. All infections in 2016 and 2017 were light, while in 1990 moderate and heavy infections represented 1.1% and 5.6% of *A. lumbricoides* and hookworm infections, respectively [10]. It is remarkable the drop of *T. trichiura* prevalence from 20% in 1987 to the current 0%, given the considerable variation in the efficacy of single-dose benzimidazole reported across trials against this parasite. The mean baseline faecal egg count (FEC) resulted to highly affect the efficacy of single-dose PC for *T. trichiura*: in particular, up to 90% efficacy is expected in areas where mean FEC across infected subjects was low, like the Bolivian Chaco in 1990 [10], [11].

Reality seems to have exceeded expectations; a Bayesian geostatistical model, predicted for the Chaco region the STH prevalence to range 50%-63% in the different Provinces among 5-14 year-old children [12]. Possible reasons for such discrepancy are that the STH prevalence data used were limited in size and time, and that the possible impact of PC intervention was not considered amongst the model variables, due to uncertainties as to whether it was effectively implemented in Bolivia. While in the absence of empirical data, spatial modelling of STH epidemiology has become a popular way to inform decisions regarding the geographic areas and the size of the at-risk population to be targeted with mass drug administration, these findings stress the need for strengthening disease surveillance to reduce uncertainty in the models and better inform decision making [13].

According to the WHO estimates used to determine the critical cut-off for transmission assessment surveys (TAS), data obtained in the Bolivian Chaco would correspond to a true STH prevalence ranging between 2% and 10%, maintained for 12 months after PC suspension [8]. As there is as yet little experience about frequency reduction or suspension of mass drug administration, it is not possible to predict whether this condition will be permanent or whether and when STH prevalence will gradually revert to its original levels. Suspending PC must be accompanied by strengthened STH surveillance to detect any change in infection prevalence and institute adequate response measures, such as restoring PC. Accordingly, annual cross-sectional surveys in the Bolivian Chaco sentinel sites have been planned for the next years. According to WHO recommendations, PC frequency should now be reduced to every other year, but it could be further deferred should the next surveys show unchanged low prevalence [6], [14].

Several factors, other than PC, could have influenced the drop in STH prevalence. In Bolivia, the human development index (HDI) and the infant mortality rate (IMR) – two proxies for social and health conditions –, showed a steady improvement in the last quarter of century [15]. Furthermore, Bolivia has recently experienced more than a decade of economic growth, leading to a poverty reduction from 63% to 39% of the population, between 2004 and 2015 [16]. On the other hand, in rural areas of Bolivia the access to improved sanitation facilities is still low (33%), safely managed services are lacking, and 40% of people still practice open defecation [17]. The persisting high prevalence of protozoan parasite intestinal infections (*Entamoeba coli, Giardia intestinalis* and *Blastocystis* spp.) as well as other fecal-oral infections, confirm that hygienic and sanitary conditions continue to be inadequate in the Bolivian Chaco [18]. Moreover, the analysis of the major climate indicators (temperature, annual precipitation), potentially affecting STH transmission dynamics, did not show significant changes during the last 30 years (Fabbri C, Messeri A, Orlandini S, unpublished data).

Therefore, along with the programmed STH surveillance activities, a health education intervention, inspired to the WAter, Sanitation and Hygiene (WASH) principles, will now be implemented in the same areas of the Bolivian Chaco, in order to promote healthy behaviors and to reduce the transmission of feco-oral infections.

Finally, as recommended by WHO/PAHO in recent years, a national survey, involving areas from all the ecological zones of the Plurinational State of Bolivia is now warranted, to provide solid epidemiological data about STH distribution and the size of the population at risk of infection, in order to update the PC intervention strategy at national level [19].

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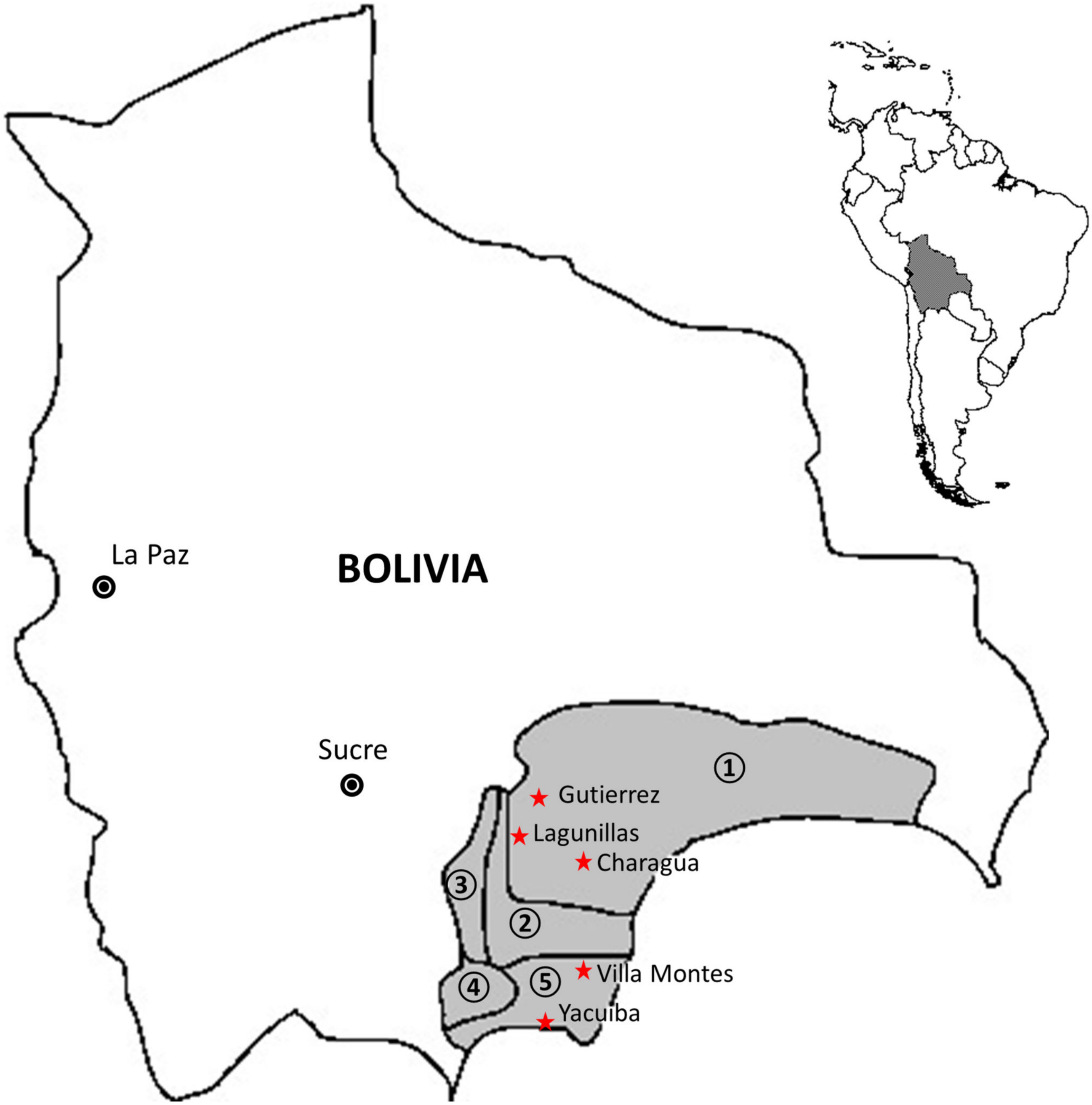

Figure 1. The study area of the Bolivian Chaco: municipalities of the surveyed communities.
The Bolivian Chaco includes 5 Provinces: 1) Cordillera; 2) Luis Calvo; 3) Hernando Siles; 4) Burdett O'Connor; 5) Gran Chaco. The surveyed communities are located in the rural areas surrounding the municipalities of Gutierrez (communities of Palmarito and Ivamirapinta), Lagunillas (Teta Piau/Kurupaity) and Charagua (San Antonio del Parapetí) in the Cordillera Province; Villa Montes (Tarairí; Chimeo; Capirendita; San Antonio) and Yacuiba (Palmar Chico) in the Gran Chaco Province.

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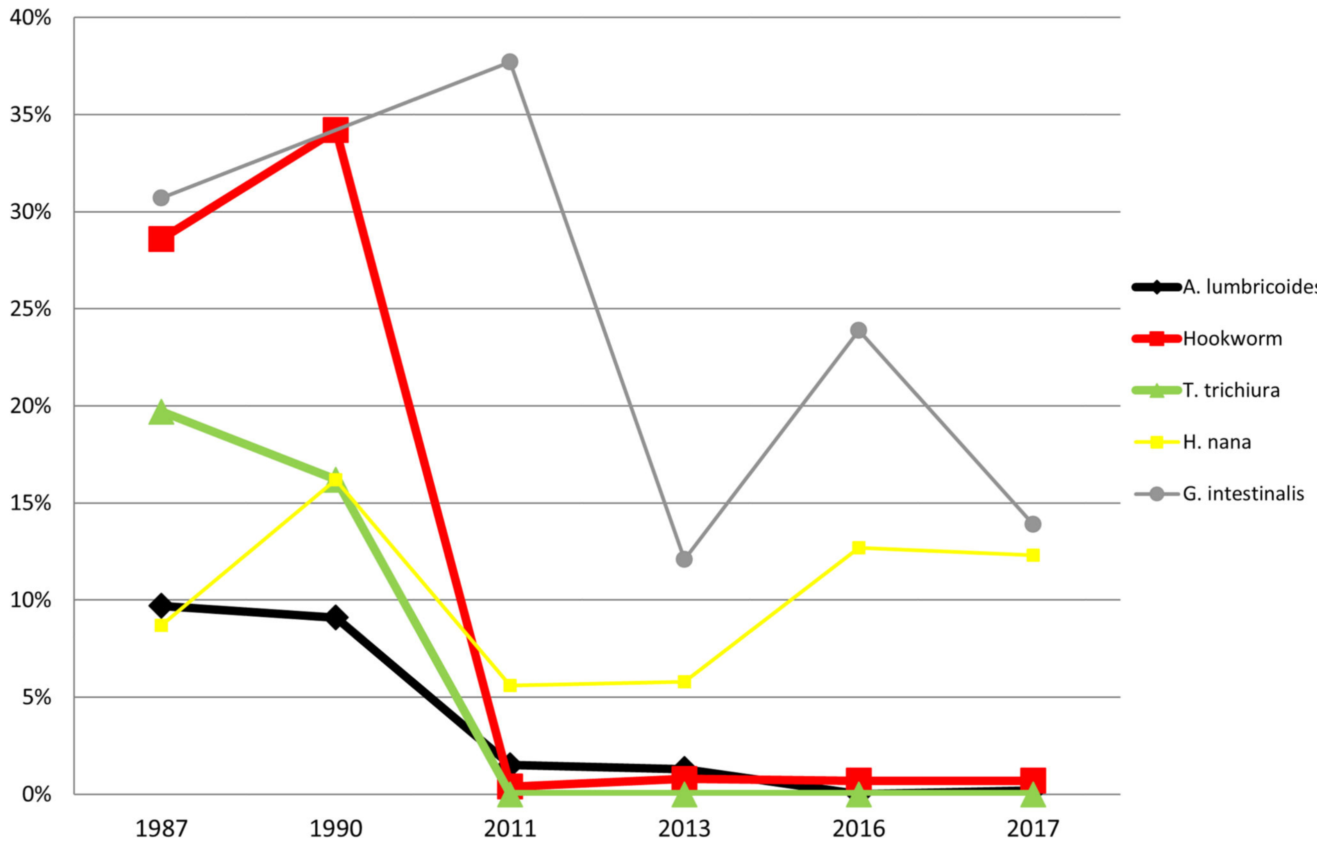

Figure 2. Soil-transmitted helminths trend 1987-2017 in the Bolivian Chaco.

Hymenolepis nana and *Giardia intestinalis* trends were also showed as examples of feco-oral transmitted parasites. Study population was constituted by general population in 1987 (n=381) [3] and 2013 (n=223) [5], pre-school- and school-age children (SAC) in 1990 (n=179) [10] and 2011 (n=268) [4], only SAC in 2016 (n=426) and 2017 (n=520). In 1987 and 2011 the surveyed areas included both rural and urban areas, while other surveys were limited to rural areas.

Table 1

Prevalence of intestinal parasitic infection in school-age children living in two Department of the Bolivian Chaco.

	TOTAL		SANTA CRUZ DEPARTAMENT		TARIJA DEPARTAMENT	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**
Samples - n	426	520	203	255	223	265
Parasitism rate* - % (n)	81.9% (349)	78.1% (406)	87.2% (177)	76.5 (195)	77.1% (172)	79.6% (211)
Polyparasitism rate**	57.5% (245)	43.3% (225)	65.5% (133)	44.3% (113)	50.2% (112)	42.3% (112)
SOIL-TRANSMITTED HELMINTHS AND OTHER INTESTINAL HELMINTHIC INFECTIONS						
A. lumbricoides	0% (0)	0.2% (1)	0% (0)	0.4% (1)	0% (0)	0% (0)
Hookworms	0.7% (3)	0.6% (3)	0% (0)	0% (0)	1.4%(3)	1.1% (3)
S. stercoralis	0% (0)	0.8% (4)	0% (0)	0.4% (1)	0% (0)	1.1%(3)
E. vermicularis	0.7% (3)	0.6% (3)	0.5% (1)	1.2% (3)	0.9% (2)	0% (0)
H. nana	12.7% (54)	12.3% (64)	15.3% (31)	14.9% (38)	10.3% (23)	9.8% (26)
INTESTINAL PROTOZOAN INFECTIONS						
Blastocystis	49.8%(212)	54.2% (282)	59.1% (120)	52.2% (133)	41.3%(92)	56.2% (149)
C. mesnili	0.5% (2)	1.9% (10)	0.5% (1)	1.2% (3)	0.5% (1)	2.6% (7)
E. coli	26.5%(113)	26.2% (136)	23.7% (48)	24.7% (63)	29.2%(65)	27.6% (73)
E. hartmanni	27.9%(119)	10.2% (53)	31.5% (64)	3.5% (9)	24.7%(55)	16.6% (44)
E. histolytica complex	7.0% (30)	0.4% (2)	4.9% (10)	0% (0)	9.0%(20)	0.8% (2)
E. nana	26.1%(111)	21.7% (113)	35.0% (71)	27.5% (70)	17.9%(40)	16.2% (43)
G. intestinalis	23.9%(102)	13.9% (72)	28.6% (58)	13.7% (35)	19.7%(44)	14% (37)
I. bütschlii	5.6% (24)	5% (26)	8.4% (17)	9.4% (24)	3.1%(7)	0.8% (2)

*Any helminthic or protozoan infection

**any two helminthic and/or protozoan and/or mixed infections