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Elimination of morbidity due to soil-transmitted helminthiases among Afghan schoolchildren

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Abstract

Large sectors of the Afghan population have limited access to safe water and sanitation, which increases the risk of transmission of water- and food- borne diseases, including Soil-Transmitted Helminth (STH) infections. STHs interfere with the human host's health status, and their burden of disease is highest among children of school age.

Based on the results of a nationwide survey conducted in 2003, which showed an STH prevalence of 47.2%, and with the aim of reducing morbidity among school children, Afghanistan has been conducting nationwide deworming for preschool-age and school-age children since 2004.

In 2017, 14 years after the first baseline assessment, a follow-up survey was carried out among schoolchildren aged 8-10 years to provide an update on STH epidemiology and facilitate evidence-informed planning of future deworming campaigns.

Stool samples were collected from 2,263 pupils aged 8-10 years in five provinces representing the different ecological zones of the country - Kabul, Balkh, Herat, Nangarhar and Kandahar. Microscopic examination was carried out by the Kato-Katz thick smear technique, to assess the presence and the number of parasites and/or their eggs.

The survey revealed that 26.6% of the sample was infected with at least one of the STH, a marked decrease from the level registered in 2003. The most prevalent infection was the one with *A. lumbricoides* (25.7%), followed by *T. trichiura* (1.0%) and hookworms (0.1%). All positive children were noted to have light-intensity infections, compared to the previous survey where 9.7% of the sample had moderate-to-heavy intensity infections. Only 0.2% of the children had

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co-infection with two or more parasites. Meanwhile, 6.8% of the students were found infected with the dwarf tapeworm, *Hymenolepis nana*.

The absence of infections of moderate-to-heavy intensity after several yearly rounds of deworming and overall improvements in provision of safe water and sanitation, indicates successful control of morbidity due to STH and, overall, their elimination as a public-health problem from Afghanistan. Nevertheless, current levels of prevalence of infection still show persistence of active transmission of STHs, thus justifying the continued implementation of mass deworming interventions among children. The permanent elimination of STH transmission, however, will be possible only when the country reaches a sanitation level sufficient to impede fecal contamination of the environment with human excreta.

Keywords

Afghanistan; soil-transmitted helminth; worms; deworming; water; sanitation

Background

Soil-transmitted helminth (STH) infections are a group of parasitic diseases caused by nematode worms that are transmitted to humans by faecally-contaminated soil. The STH infections caused by *Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm), *Necator americanus* and *Ancylostoma duodenale* (hookworms) are among the most prevalent neglected tropical diseases (Hall et al., 2008; Brooker, 2010; WHO, 2013), and are widely distributed in tropical and subtropical areas where sanitation is inadequate and water supply is unsafe (WHO, 2012; Strunz et al., 2014).

STH infections interfere with the human host's health status, and their burden of disease is highest among children of school age (WHO, 2012; Oluwole et al., 2015). School-age children are an important high-risk group for STH infections, as they have been shown to impede physical growth and cognitive development, and to affect school attendance and performance (WHO, 2005; Liu et al., 2015; Ahmed et al, 2012).

More than 1.5 billion people, or 24% of the world's population, are estimated to be infected with STHs worldwide (WHO, 2018a). Over 267 million preschool-age children and over 568 million school-age children live in areas where these parasites are intensively transmitted, and are in need of treatment and other preventive interventions (WHO, 2018a). Morbidity due to STHs is proportionate to intensity of infection (WHO, 2017), and WHO considers that elimination of STHs as a public-health problem is achieved when prevalence of infections of moderate-to-heavy intensity is less than 1% (WHO, 2012).

In order to reduce the burden of STHs, preventive chemotherapy (deworming), using a single dose of albendazole (400 mg) or mebendazole (500 mg), is recommended as a public health intervention (WHO, 2006 and 2017). The main target population is represented by preschool-age and school-age children, although women of reproductive age and adults at high risk are also contemplated. Frequency of treatment is established for all target groups based on epidemiological assessments among children of school age (WHO, 2006 and

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2017). Preventive chemotherapy, the periodic large-scale administration of anthelminthic medicines to populations at risk, is an important component of a package that also includes health education for personal hygiene and the improvement of water and sanitation.

Deworming is regarded as a cost-effective intervention in reason of its high impact and low cost (Phommasack et al., 2008; Montresor et al., 2010, Boselli et al., 2011), while the side effects of the anthelminthics, which are very poorly absorbed by the intestinal tract, are normally mild and transitory (WHO, 2006; WHO, 2011). With regard to the potential disadvantages of large-scale deworming, the most serious seems to be the possible raise of resistance in the parasites (Vercruysse et al., 2011).

Afghanistan is a fragile and conflict-affected country. The proportion of the population aged 15 or below is 51.3%, making Afghanistan one of the youngest countries in Asia. Demographic pressure is exacerbated by significant numbers of returning internally displaced persons (IDPs) or refugees (World Bank, 2016).

The majority of the Afghan population have poor sanitation facilities (48% of urban and 75% of rural households have unimproved or no toilets) (CSO et al., 2017). Besides, 35% of overall households in Afghanistan do not have an improved source of drinking water (CSO et al., 2017). These facts increase the risk of transmission of water- and food- borne diseases, including STH infections, which are known to be prevalent in Afghanistan since long time (Buck et al., 1978). The most recent nationwide survey, a baseline parasitological assessment implemented in view of the establishment of a deworming control programme, was carried out in 2003 among children aged between 8 and 15 years old in four provinces of Afghanistan, with a similar methodology than the one reported here. The 2003 survey showed that 47.2% of the children were infected with at least one STH, mainly *A. lumbricoides* (Gabrielli et al., 2005).

To reduce the burden and morbidity associated with STHs among school children, Afghanistan has been conducting deworming with albendazole or mebendazole for both preschool-age children and school-age children.

The total number of children in need of deworming in Afghanistan was estimated between 12.2 million in 2010 to 13.5 million in 2017, of which approximately 35% were preschool-age children and 65% school-age children. Following official requests from the Ministry of Public Health (MoPH) of Afghanistan, a donation of the relevant quantities of albendazole (400 mg) tablets was made available by UNICEF and WHO every year.

Since 2010, preschool-age children aged 2-5 years have been covered by the deworming intervention during national immunization days (NID) organized by the MoPH with support from UNICEF; a single tablet of albendazole (400 mg) has been co-administered with vitamin A by health workers to each child attending the NID. Treatment has been carried out at annual intervals (2010-2012) and biannual intervals (2014-2017), with a gap in 2013. Coverage ranged from 96% to 100% (WHO, 2018b).

School-age children (6-15 years) were targeted by school-based, nationwide deworming campaigns. Anthelminthic tablets were administered by teachers to each child in the

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class. Deworming has been implemented at annual intervals from 2004 to 2010, in 2013, 2016 and 2017 by Ministries of Public Health and Education, with support from World Food Programme and World Health Organization. Although lower than with preschool-age children, the coverage was usually good, ranging from 62% to 81%; nevertheless, in 2009 a very low coverage of 0.41% was registered as logistics problems prevented the proper implementation of the campaign (WHO, 2018b).

As of end 2017, twelve rounds of deworming had been implemented for preschool-age children, and ten rounds of deworming had been implemented for school-age children. Both type of interventions have reached several million children at every round. Additional details on population treated and coverage achieved by year are available online (WHO, 2018b).

After several years of deworming, the country's national authorities and WHO decided that up-to-date information about the epidemiological situation of STH in the country was required. As such, in 2017, 14 years after the first baseline assessment, a follow-up survey was carried out among school children aged 8-10 years to determine the impact of the implemented interventions and measure the current prevalence and intensity of STH infections in Afghanistan. The ultimate objective of the survey was to facilitate evidence-informed planning of future deworming campaigns.

Method

The survey was conducted in five major provinces of Afghanistan: Kabul, Balkh, Herat, Nangarhar and Kandahar. These provinces are located in different parts (Centre, North, South, East and West) of the country representing various ecological/agro-climatic zones (Figure 1).

Kabul, Nangarhar and Kandahar are also three of the provinces where the 2003 survey was implemented; they were again selected with the aim of drawing a comparison between the results of the two surveys, even though for logistic and accessibility reasons it was not possible to visit the same localities and schools. In the west, Farah was replaced by Herat for logistic reasons, while an additional province, Balkh, was added with the aim of assessing the burden of STH in the northern part of the country, which could not be surveyed in 2003.

Available estimates indicate that around 40% of the total county population lived in the five surveyed provinces at the time of the survey (almost 17% in Kabul, 7% in Herat, 6% in Nangarhar, 5% in Balkh and 5% in Kandahar) (CSO, 2018). In addition to the residents, these provinces are subject to a considerable influx of people from neighboring provinces due to poor security and inadequate facilities prevailing.

Kabul province (estimated population 4.5 million) hosts the capital and the largest city of Afghanistan, and is situated in the central region of the country. Almost all ethnic groups of the country such as Pashtun, Tajik, Hazara, Uzbeks, Turkmens, Baluch, Sikhs and Hindus live in Kabul city (Naval Postgraduate School, 2018), which serves as the nation's political and cultural center (CSO, 2018).

Herat province (estimated population 1.9 million) is located in the south-western region of Afghanistan. The population is multi-ethnic and Pashtuns, Tajik, Hazara, Turkmen, Uzbek and Aimaq are the known tribes of this province (Naval Postgraduate School, 2018).

Nangarhar province (estimated population 1.5 million) is located in the east of Afghanistan. The population is also multi-ethnic, although largely Pashtun (Naval Postgraduate School, 2018). Balkh province (estimated population 1.3 million) is situated in the northern part of the country and is ethnically diverse, including substantial Tajik, Hazara, Pashtuns, Arab, Uzbek and Turkmen populations (Naval Postgraduate School, 2018).

Kandahar province (estimated population 1.2 million) is located in southern Afghanistan. The inhabitants are mainly Pashtuns, although smaller communities of Tajiks, Hazaras, Uzbeks and Baloch are also found in parts of the city of Kandahar (Naval Postgraduate School, 2018).

The study population were school children aged 8 to 10 years, attending schools in the selected 5 provinces. As recommended by WHO (WHO, 2006; WHO, 2011), the survey was conducted in school-age children (as the group with the highest levels of prevalence and intensity of infection); prevalence in other age groups can be extrapolated from collected data.

The sample size of the survey was calculated through the calculation formula for the estimated population proportion. Taking into account 5% precision of the estimate, 95% confidence level and 50% expected population proportion with infinite population, the sample turned out to be 385 individuals per province, or 1,925 for the five provinces. Considering 20% non-response rate at the provincial level, the final sample turned out to be 2,310 individuals (pupils). We did not include a design effect because we considered a class to be a random sample of school children in the area and not a cluster.

Inclusion criteria of the study sample were: schoolchildren in the age group of 8-10 years, who had not received any anthelmintic drugs during the last 6 months. Children younger than 8 years, older than 10 years, and who had received any anthelmintic drugs during the last 6 months were excluded.

We used a two-stage sampling method. In the first stage, eight primary schools were randomly selected (using random generate command in Excel) from the list of all primary schools in each province. In the second stage, all classes having the target age group were identified and then an equal number of target age children were randomly selected from attendance sheets of each class to obtain the total of 55 children per school.

The children were selected from 40 schools (8 in each of the 5 provinces).

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of the Ministry of Public Health (MoPH), Afghanistan. Permission was taken from the head of each school. Before enrolment of a pupil in the study, the objectives of the study were explained, and written consent was obtained from the parents or guardians of children one day before the actual data collection. Anyone who was not willing to take part in the study

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was excluded. Only the study participants who were diagnosed positive for STH received one tablet of albendazole 400 mg (anthelmintic drug).

The specimen collection and examination, as well as the recording and reporting of survey data was done by a team of two trained lab-technicians in each province who were regularly supervised by a senior lab-technologist. The lab-technicians distributed plastic containers, collected stool samples from the pupils and stored them in a plastic container that was sent to the designated laboratory in each province.

Microscopic examination of all stool samples was carried out in the designated laboratory by the Kato-Katz thick smear technique within a few hours (4–6 h) from collection, as per WHO recommendations (WHO, 2011). For each specimen analyzed, the presence of STH parasites was recorded separately and the number of eggs per gram of faeces was calculated for each species. The senior lab-technologist in each team was responsible for re-analyzing 10 % of the slide as quality control.

The data related to each individual, including test results, were recorded in the purposely designed sheet. Recorded data were submitted to central level for statistical analysis.

Main variables considered in the survey were the following:

- Age: age of the children (8 to 10 years)
- Sex: Male or female
- Province and district: Kabul, Balkh, Herat, Nangarhar, Kandahar and relevant districts
- Results of the test: Positive for STH parasites and their eggs, negative for STH parasites and their eggs, and count of the eggs

Collected data were recorded into a Microsoft Excel spreadsheet and analyzed by SPSS version 20.

Proportions were compared using Chi-squared test. Proportions of individuals infected by one or more helminth species were calculated considering 95%confidence intervals (CIs).

Results

The survey was implemented in September and October 2017, about 10 months after the latest round of deworming among the school-age population.

In total 2263 children, out of 2310 sampled, participated in the survey (98% response rate). Approximately 38% of the study population were girls.

In total, 602 of 2263 students under study were infected with at least one of the STH, showing the overall STH prevalence of 26.6% (95% CI: 24.8-28.4). *Ascaris lumbricoides* was the most prevalent STH, recorded in 25.7% of study population (95% CI: 23.9-27.5), followed by *T. trichiura* affecting only 1.0% (95% CI: 0.6-1.4) and by hookworms with 0.1% (95% CI: 0.0-0.2). All positive children were noted to have light-intensity infections

and no moderate-to-heavy intensity infection was recorded. Mean of STH egg count was 57.75 eggs per gram of faeces (epg) among positive participants. Only 0.2% (95% CI: 0.02-0.38) of the children were co-infected with two or more STHs.

Details on the prevalence of infection by province are presented in table 1.

Among the total STH-positive population, 39.2% were girl and 60.8% boy students, while the prevalence of STHs was slightly higher among girl than boy students: 27.4% (236/862) and 26.1% (366/1401), respectively. No significant association was found between gender and STH prevalence ($X^2 = 0.430$, $p = 0.512$).

The survey also found that 6.7% (95% CI: X.X-X.X) of the students were infected with the dwarf tapeworm, *Hymenolepis nana*. In spite of comparable modes of transmission (ingestion of eggs dispersed in the environment through faecal contamination by infected individuals), hymenolepiasis is not usually grouped together with the STH infections, and as such was excluded from cumulative calculations in our analysis.

Discussion and conclusion

The survey revealed that overall prevalence of STHs at national level was 26.6%, which marks a major decrease from the level (47.2%) reported in the baseline assessment survey in 2003. More importantly, all the infections identified were of light intensity, and as such not responsible for causing morbidity in the human host.

The impact documented in Afghanistan is in line with the one obtained in countries implementing STH control for long time, such as Cambodia (Sinuon et al., 2006), Vietnam (Casey et al., 2017) or Zanzibar, Tanzania (Knopp et al., 2010).

As mentioned, several rounds of deworming have been implemented in Afghanistan between 2004 and 2017, and millions of children have been targeted and treated every year.

Moreover, the general life and sanitation conditions have also improved, which is likely to have contributed to reducing the STH burden. Notably, as per the 2005 National Risk and Vulnerability Assessment (NRVA), only 7% of households in Afghanistan had access to safe toilet facilities (MoRD and CSO, 2007), while the Afghanistan Demographic and Health Survey in 2015 (ADHS-2015) reported that one-fourth (25%) of Afghan households had access to improved toilet facilities (CSO et al., 2017). NRVA-2005 reported that 31% of the households had access to safe drinking water whereas ADHS-2015 reported that overall, 65% of households in Afghanistan have access to an improved source of drinking water.

Province-wise results show some disparities, and there was a significant association between provinces and prevalence of STHs ($X^2 = 193.4$, $p < .001$).

Balkh, Herat and Kabul had lower prevalence of STH infections compared to Nangarhar and Kandahar. This is probably due to the relatively good security situation enjoyed by the three provinces, which allows for proper implementation of deworming interventions, improved sanitation, access to safe drinking water, and the implementation of hand-washing practices (EASO, 2017). Notably, ADHS-2015 reported that households with a place for

hand washing were most frequent in Balkh (98.2%), Herat (82.1%), and Kabul (86.5%), and much less common in Kandahar (35.7%) and Nangarhar (60%) (CSO, 2017).

Conversely, the higher prevalence of STHs in Nangarhar and Kandahar can be attributed to local deterioration of the security situation (UN, 2017), which not only challenged proper implementation of deworming campaigns, but also caused large population displacement and affected the general social development. Besides, Nangarhar and Kandahar provinces have open border with neighboring Pakistan; and both provinces have received large number of returnees from Pakistan in the last few years (IOM, 2017; MoRR, 2018). This fact may play a role in increasing the burden of STH in the mentioned provinces, considering that to the date of the survey no large-scale deworming targeting school-age children had been implemented in Pakistan (WHO, 2018b).

The above considerations are also confirmed by the longitudinal comparison of 2003 and 2017 data from the three provinces that were surveyed in both years. While in Kabul the reduction in prevalence of STH infections was substantial, levels remained the same in Nangarhar and Kandahar (Table 1).

In addition, our survey also confirmed that *H. nana* is prevalent among Afghan populations, as indicated by other recent investigations (Maassen et al., 2017; Korzeniewski, 2016; Korzeniewski et al., 2016). In our opinion the presence of *H. nana*, a parasite that is responsible for minimal morbidity, is associated with poor sanitation and is not sensitive to the drugs used for STH control (albendazole or mebendazole), could be a useful indicator, in areas where the prevalence of STH has been significantly reduced by pharmacological intervention, of the environmental contamination with human excreta and therefore of the need to continue large scale interventions with albendazole or mebendazole to avoid recrudescence of STH transmission and morbidity.

One of the limits of our study lies in the fact that sampling of the provinces to be surveyed was not randomized at national level but rather excluded areas where security conditions were not allowing safe collection of data in schools. Nevertheless, efforts were made to include relatively unsafe and less-developed provinces such as Nangarhar and Kandahar, so as to have a fair representation of the country as a whole. A second limit is that the survey was school-based, thus the sample was represented by children attending schools, in a country where primary school enrolment rate is still suboptimal (CSO et al., 2017; UNESCO, 2018). Although non-enrolled children benefited from a series of interventions (including deworming during their preschool-age childhood, improvements in water and sanitation and implementation of hand-washing practices), they were excluded from school-based deworming. Finally, the fact that only 38.1% of the study population were girls, rather than being a sampling bias, is a reflection of persisting gender imbalances in primary school enrolment in the country (CSO et al., 2017; UNESCO, 2018).

The sensitivity of the Kato-Katz method performed on a single specimen has been reported to be limited for infections of low intensity, and as such it may not be considered a suitable tool for individual-level diagnosis in clinical settings. Nevertheless, it is the WHO-

recommended tool for community assessments and the one based on which public-health action is recommended (WHO, 2006; WHO, 2011).

In conclusion, the marked decrease in prevalence and intensity of STH infections among schoolchildren between 2003 and 2017 indicates successful control of associated morbidity, and, because of absence of infections of moderate-to-heavy intensity, their elimination as a public-health problem in all surveyed provinces (WHO, 2012).

Although it is clear that the permanent elimination of STH transmission will be possible only when the country reaches a level of sanitation sufficiently high to impede fecal contamination with human excreta, the fact that Afghanistan, which endures a protracted complex emergency, has been able to achieve elimination of STH infections as a public-health problem indicates the feasibility of large-scale deworming in challenging environments and sets an example for other countries. Nevertheless, current levels of prevalence of infection still show persistence of active transmission of STHs. This fact, coupled with the consideration that elimination as a public-health problem is a reversible status requiring sustained interventions to be maintained, the still precarious conditions of access to water and sanitation, and the large displacement of populations across the country, justifies the continuation of STH control interventions including mass deworming campaigns among school-age children in Afghanistan.

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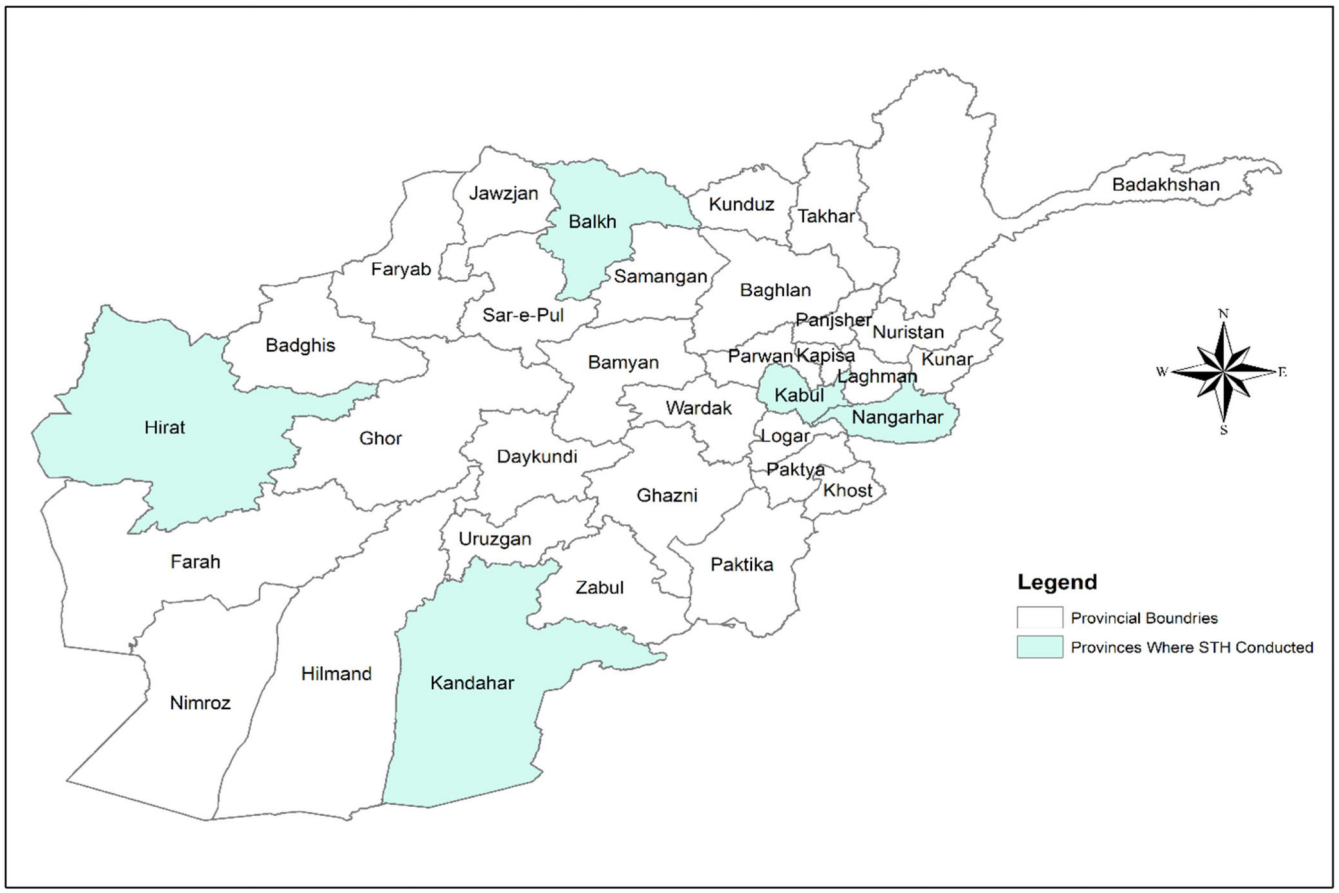

Figure 1. Map of Afghanistan showing the 5 provinces where the survey was implemented

Table 1

Prevalence of soil-transmitted helminth infections by Province (%), in 2003 and 2017*

	Province											
	Kabul		Balkh		Herat		Nangarhar		Kandahar		Total	
	2003	2017	2003	2017	2003	2017	2003	2017	2003	2017	2003	2017
Any STH												
-Prevalence of infection	*61.9*	*23.4*	*N/A*	*12.6*	*N/A*	*14.8*	*34.8*	*35.7*	*42.8*	*46.8*	*47.3*	*26.6*
-Prevalence of moderate-to-heavy intensity infection	*26.4*	*0*	*N/A*	*0*	*N/A*	*0*	*3.1*	*0*	*7.2*	*0*	*9.7*	*0*
A. lumbricoides prevalence	*57.3*	*23.4*	*N/A*	*12.6*	*N/A*	*14.1*	*27*	*33.1*	*37.4*	*45.5*	*40.9*	*25.7*
T. trichiura prevalence	*13*	*0.4*	*N/A*	*0*	*N/A*	*0.7*	*6.3*	*2.6*	*7.8*	*1.4*	*9.9*	*1*
Hookworms prevalence	*0*	*0*	*N/A*	*0*	*N/A*	*0*	*2.7*	*0*	*0*	*0.5*	*0.7*	*0.1*
H. nana prevalence	*N/A*	*4.9*	*N/A*	*4.2*	*N/A*	*3.5*	*N/A*	*19.6*	*N/A*	*1.3*	*N/A*	*6.7*

* Balkh and Herat were not surveyed in 2003; H. nana data were not collected in 2003; surveyed children were aged 8-15 years in 2003 and 8-10 years in 2017