Viewpoints

Extending Helminth Control beyond STH and Schistosomiasis: The Case of Human Hymenolepiasis

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The WHO recently produced updated guidelines for managers of helminth control programmes, specifically targeting soil-transmitted helminthiasis (STH) and schistosomiasis in school-age children [1]. In the case of schistosomiasis, this strategic document advocates treatment with praziquantel (PZQ) as the cornerstone of control, with the objective of reducing infection-associated morbidity, which is estimated to be 70 million disability-adjusted life years (DALYs). There are, however, other helminth infections currently absent from these guidelines that can result in important morbidity effects in children and are also treatable with PZQ. An important example is hymenolepiasis, which is caused by a cyclophyllidean tapeworm from the genus Hymenolepis.

Hymenolepiasis was first recognised in the small intestine of a boy in Cairo in 1851 by Bilharz [2]. The two species of Hymenolepis infecting man, namely H. nana and H. diminuta, are ubiquitous and H. nana is by far the most common of the two parasites. H. nana infections are considered to be the most prevalent human cestodiasis in the world [2–4]. Studies over the past 50 years documenting the prevalence of H. nana indicate that in some communities this infection can reach prevalence as high as 21% in children [see Text S1]. Cases of hymenolepiasis are often seen as clusters within a family and in institutions where children are crowded together (e.g., orphanages, childcare centres, and boarding schools) [2,5–7], suggesting a common source of exposure. The majority of infections occur as autoinfections as a result of contamination of food or water by humans, usually children, excreting viable eggs in their faeces [4]. While most H. nana infections are usually asymptomatic, numerous studies have documented that heavy infections with H. nana can cause severe morbidity in children, including severe diarrhoea, abdominal pain, decreased appetite, irritable behaviour, anal or nasal pruritus, and reduced growth [2,4,7–9].

Similarly to schistosomiasis, a single dose of PZQ eliminates the vast majority of Hymenolepis egg excretion [10–12]. However, it is likely that a PZQ gap exists in many communities being targeted by MDA in that the geographical location of Hymenolepis infections may not necessarily overlap with that of schistosomiasis. Guiding PZQ delivery solely on the basis of the distribution of schistosomiasis may miss communities endemic to Hymenolepis infection also in need of PZQ. This means that the populations at risk of hymenolepiasis may need to also be identified so that PZQ delivery can be extended to those areas.

In order to test our proposition, we have analysed data from a parasitic disease survey of 2,165 children aged ≤15 years, including 1,098 girls and 1,070 boys in the Dande municipality in Northern Angola. Previous analysis of this dataset revealed that children were at significantly increased risk of H. nana infection (prevalence of 6.2% [95% CI: 4.9–7.8%] in preschool children and 7.3% [95% CI: 5.8–9.0%] in school-age children) compared to adults (prevalence of 1.9% [95% CI: 1.1–3.1%]) [13]. Using these data, we aimed to describe the epidemiology of H. nana infection by quantifying the role of individual and household factors and the physical environment (land surface temperature, distance to irrigation canals and rivers) in H. nana infection; quantify the role of H. nana infection on morbidity outcomes such as anaemia, diarrhoea, abdominal pain, and growth; quantify the geographical variation in H. nana infection prevalence in children aged ≤15 years; generate the first high-resolution H. nana infection map; and compare this map with a preexisting S. haematobium map for the region [14] to identify the limitations of targeting PZQ distribution on the basis of urogenital schistosomiasis alone.

H. nana transmission is known to be facilitated by contact with environments contaminated with human faeces, use of inadequate drinking sources, the absence of proper sanitation and ineffective treatment of excreta or waste, deficient personal hygiene, and the presence of another infected person in the household [5,7,15–17]. In line with previous studies, we found that bathing in irrigation canals is an important risk factor for H. nana infection. The irrigation canals are a legacy of the sugar plantation industry set up in the 1950s and surround the provincial capital of Caxito and neighbouring communities. While the sugar mill is no longer in production, the irrigation canals are used by the population for their daily necessities including clothes washing, recreation, and in some instances as a source of drinking water.
Figure 1. Observed and predicted prevalence of *Hymenolepis nana* infection (A) and predicted prevalence of *S. haematobium* (B) in the Dande municipality in Angola.
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coinfected children are associated with previous history of abdominal pain and acute malnutrition is a reasonable argument to advocate the delivery of PZQ to the communities with the aim of reducing helminth-associated morbidity in the study area. While albendazole may be made available to this population due to the high endemicity of STHs (≤30%), the high spatial heterogeneity of S. haematobium endemicity in the area means that PZQ will not be made available to all communities on an annual basis [13]. The results of our study show that guiding delivery of PZQ solely on schistoosomiasis in integrated programmes that also include albendazole is likely to overlook the important interaction of STH with other parasites such as H. nana, which should be the focus of interventions even in areas of low endemicity.

The prevalence of hymenolepiasis in a community can be a useful indicator of the degree of faecal contamination of an environment and/or the level of hygiene practice. Because WASH coverage in sub-Saharan Africa shows considerable regional disparities [22–24], the disease burden due to H. nana infection is likely to be highly geographically variable. Modern geographical risk prediction methods using model-based geostatistics (MBG) provide an extensive set of spatial modeling tools for assessing the geographical overlap of multiple parasite infections and are being used as control tools for targeting helminth interventions [25]. One approach is overlaying prevalence of infection maps for multiple parasites (i.e., coendemiCity mapping). To that regard, our predictive map of H. nana infection showed an area of high H. nana risk (prevalence >8%) associated with more populated areas near and around Caxito and a large cluster predicted to the commune of Mabubas that is unrelated to the endemicity of schistoosomiasis (Figure 1). The fact that areas likely to receive PZQ annually or biannually (due to high to moderate S. haematobium infection, respectively) do not completely overlap with areas of high H. nana prevalence of infection may pose an import gap in PZQ delivery needs (Figure 1). Furthermore, PZQ may not be sufficiently efficacious to eliminate H. nana infection, as effective treatment sometimes requires prolonged therapy with niclosamide (5–7 days) to eliminate emerging adult worms and to eradicate the infection [31].

The results highlight the need for WASH improvements to be delivered to communities concomitantly with antihelminth therapy if resources are available. The impact of autoinfection is unlikely to change unless WASH interventions are put in place. More importantly, in this study we show for the first time that H. nana infection is an important contributor to infection-associated morbidity, particularly in children aged <5 years, and that the delivery of PZQ to control schistosomiasis and hymenolepiasis should take into consideration their coendemiCity. If delivery of PZQ is based solely on schistoosomiasis endemicity thresholds, areas in need of PZQ to treat H. nana infections will be reached at very low frequencies or not at all. However, it remains to be demonstrated whether targeting of communities for PZQ distribution on the basis of H. nana disease burden is likely to be cost-effective, and further economic analysis needs to be conducted. To improve visibility and enhance advocacy for the control of hymenolepiasis, it may be warranted to include this infection in the list of neglected tropical diseases.

Supporting Information

Text S1 Technical information. (DOC)

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References

1. WHO (2011) Helminth control in school age children: a guide for managers of control programmes. Geneva: World Health Organization.
2. Hawn TR, Jong EC (2001) Hymenolepis nana. In: Gillespie S, Pearson RD, editors. Principles and practice of clinical parasitology. Chichester, England: Wiley. pp. 627–629.
3. King CH (2010) Cestodes (tapeworms). In: Mandell GL, Bennett JE, Dolin R, editors. Mandell, Douglas and Bennett’s principles and practice of infectious disease. 7th edition. Philadelphia: Churchhill Livingstone Elsevier. pp. 3699–3610.
4. Acha PN, Sfyres B (2003) Hymenolepis. In: Barriga OO, editor. Zoonoses and communicable diseases common to man and animals. 3rd edition. Washington, D.C.: Pan American Health Organization. pp. 199–204.
5. Mason PR, Patterson BA (1994) Epidemiology of Hymenolepis nana infections in primary school children in urban and rural communities in Zimbabwe. J Parasitol 80: 245–250.
6. Feachem RG, Guy MW, Harrison S, Iwugo KO, Marshall T, et al. (1983) Excreta disposal facilities and intestinal parasitism in urban Africa: preliminary studies in Botswana, Ghana and Zambia. Trans R Soc Trop Med Hyg 77: 515–521.
7. Mirilla BR, Samantray JC (2002) Hymenolepis nana: a common cause of paediatric diarrhoea in urban slum dwellers in India. J Trop Pediatr 48: 331–334.
8. Romero-Cabello R, Godinez-Hana L, Gutierrez-Quroz M (1991) Clinical aspects of hymenolepiasis in pediatrics. Bol Med Hosp Infant Mex 48: 101–105.
9. Suarez Hernandez M, Bonet Couce E, Díaz Gonzalez M, Ocampo Ruiz I, Vidal Garcia I (1998) Epidemiological study on Hymenolepis nana infection in Ciego de Avila Province, Cuba. Bol Chil Parasitol 53: 31–34.
10. Cook GC (1986) The clinical significance of gastrointestinal helminths–a review. Trans R Soc Trop Med Hyg 80: 675–685.
11. Schenone H (1980) Praziquantel in the treatment of Hymenolepis nana infections in children. Am J Trop Med Hyg 29: 320–321.
12. Farid Z, Ayad El-Masry N, Wallace CK (1984) Treatment of Hymenolepis nana with a single oral dose of praziquantel. Trans R Soc Trop Med Hyg 78: 280–281.
13. Sousa-Figueiredo JC, Gamboa D, Pedro JM, Fauconn C, Langa AJ, et al. (2012) Epidemiology of malaria, schistosomiasis, geohelminths, anemia and malnutrition in the context of a demographic surveillance system in Northern Angola. PLoS ONE 7: e33189. doi:10.1371/journal.pone.0033189.
14. Soares Magalhães RJ, Langa A, Pedro JM, Sousa-Figueiredo JC, Clements ACA, et al. (2013) Role of malnutrition and parasite infections in the spatial variation in children’s anaemia risk in northern Angola. Geospat Health 7: 341–354.
15. Kaminsky RG (1993) Parasitism and diarrhoea in children from two rural communities and marginal barrio in Honduras. Trans R Soc Trop Med Hyg 85: 70–73.
16. Mara DD, Feachem RGA (1999) Water- and excreta-related diseases: unitary environmental classification. J Environ Eng 125: 334–339.
17. Kosoff P, Hernandez F, Pardo V, Visconti M, Zimmerman M (1989) Urban helminthiasis in two socioeconomically distinct Costa Rican communities. Rev Biol Trop 37: 181–186.
18. Costa MJ, Rosario E, Langa A, António G, Bendíss A, et al. (2012) Setting up a demographic surveillance system in Northern Angola. African Population Studies 26.
19. Shahnazi M, Jafari-Sabet M (2010) Prevalence of parasitic contamination of raw vegetables in villages of Qazvin Province, Iran. Foodborne Pathog Dis 7: 1025–1030.
20. Else KJ (2005) Have gastrointestinal nematodes outwitted the immune system? Parasite Immunol 27: 407–415.
21. Lunn PG, Northrop-Clewes CA, Dosnes RM (1991) Intestinal permeability, mucosal injury, and growth faltering in Gambian infants. Lancet 338: 907–910.
22. Soares Magalhães RJ, Barnett AG, Clements AC (2011) Geographical analysis of the role of water supply and sanitation in the risk of helminth infections of children in West Africa. Proc Natl Acad Sci U S A 108: 20004–20009.
23. WHO (2010) Progress on sanitation and drinking-water. Geneva, Switzerland: World Health Organization.
24. Pruss A, Kay D,Fewtrell L, Bartram J (2002) Estimating the burden of disease from water, sanitation, and hygiene at a global level. Environ Health Perspect 110: 537–542.
25. Soares Magalhães RJ, Clements AC, Patil AP, Gething PW, Brooker S (2011) The applications of model-based geostatistics in helminth epidemiology and control. Adv Parasitol 74: 267–296.