A review of soil transmitted helminthiasis in Nigeria

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1. Introduction

Soil transmitted helminthiasis (STH) are parasitic infection caused mainly by *Ascaris lumbricoides* (common roundworms), *Trichuris trichiura* (whipworms), and the hookworms *Necator americanus* and *Ancylostoma duodenale*. Of the 1.5 billion infected, about 270 million and 600 million are preschool and school-aged children, respectively. Conditions relating to the epidemiology of STH are mostly linked to poverty as sufferers are mainly from the world’s most impoverished regions[1]. The Americas, China, East Asia and sub-Saharan Africa account for over 56% of the STH infection globally[2].

The developmental stages of the nematodes causing STH are partly in the soil and in vertebrate host(s). In worse case scenarios, STH may impact on the mental health of children as well as bring about malnutrition leading to growth retardation[3,4]. Among neglected tropical diseases, STH accounts for the highest disability adjusted life years (DALYs) among parasitic diseases in the world. Nigeria is endemic to STH and control programmes/efforts have been ongoing. Here, data on the burden of STH infections in Nigeria in form of years of life lost due to mortality (YLLs), the distribution of the infection in the six geopolitical zones and the prevalence pattern over a 37-year period are presented. The prevalence data showed reduction in *Ascaris lumbricoides* and *Trichuris trichiura* infections; while infections with hookworm and *Strongyloides* showed irregular pattern with no significant differences. Notably, YLD for *A. lumbricoides* infection was the highest in the south-west; and the factors possibly impacting on the burden of STH in Nigeria were highlighted.

2. Methodology

Literature search was done on Google Scholar and PubMed databases using relevant keywords. Studies on the prevalence of STH (*Ascaris*, hookworm, *Trichuris* and *Strongyloides*) in Nigeria were selected and reviewed. Prevalence data from the surveyed States categorised under the six geopolitical zones were analysed.
Rural to urban ratio, STH prevalence and YLD were estimated. Statistical analyses using One-way ANOVA were applied with GraphPad Prism version 5.01 (GraphPad software, San Diego, CA, USA). Mean differences are significant at $P < 0.005$.

3. Study on STH infection in Nigeria: the limitation

STH investigation in Nigeria spans over nine decades[7]. Historically till date, there are little or no changes regarding the tools/methods used for STH study as microscopy remains in-use. In some cases, geographic information systems have been applied in order to gather supporting data for risk mapping and predictive studies[8]. However, molecular techniques in relation to identification and prevalence studies of species of STH are yet to be applied in epidemiological surveys in Nigeria. This is due to its relatively high cost and the requirement of specially trained technical staff. The molecular technique is now becoming an unavoidable method because it is capable of overcoming the challenges of misidentification as it is highly sensitive and specific. A case in point is the difficulty in differentiating hookworm species for which data in Nigeria are largely speculative. In addition, the possibility of other Trichuris species to be responsible for trichuriasis is considerably high but has not been investigated using more species-specific methods. Meanwhile, elsewhere, there is the growing use of molecular techniques[9], and recently, Necator americanus was the dominant hookworm species among children[9]. Similarly, a relatively high prevalence of STH across some endemic countries was confirmed by using PCR-restriction fragment length polymorphisms and Trichuris vulpi was identified in some of the children[10]. The prospect and potential of PCR-based detection methods using next-generation sequencing approach is seriously gaining attention globally[11,12].

4. Prevalence and distribution of STH infection

In Nigeria, STH studies have been focused mostly on children (preschool and school-age) (69%) than adults (31%); and mostly in rural (68.9%) than urban areas (31.1%) (Figure 1). Age group of 4–10 years is the high risk group and most infected[13-15]. Children within this age group are highly active with frequent soil contact during play hours both at home and in school. Infection in relation to sex is often linked to external/environmental factors with males indulging more in risk behaviour than their female counterparts[16,17].

Survey data (1980 to early 2017) from the six geopolitical zones showed a decreasing trend in prevalence for A. lumbricoides ($F = 3.89; P = 0.012$) and T. trichiura ($F = 3.44; P = 0.021$) (Figure 2). Meanwhile, hookworm ($F = 1.506; P = 0.220$) and Strongyloides ($F = 0.705; P = 0.555$) showed irregular prevalence pattern. Drugs against hookworm are most times ineffective because of the drug resistance[18-20].

Across the geopolitical zones of the country, STH burden was the highest in the southern region (south-west, south-east, and south-south) compared to the northern region (Table 1). This could be attributed partly to the climatic conditions in the south where helminths thrive more in these conditions than in dry and arid conditions in the north. STH prevalence for the north-eastern region, however, could not be estimated due to limited available data.

| Table 1 | Mean prevalence and estimated YLD according to geopolitical zones (2005–2017). |
|---------|--------------------------------------------------------------------------------|
| Region  | Ascaris | Hookworm | Trichuris | Strongyloides |
|         | Mean ± SD (%) | YLD per 10000 | Mean ± SD (%) | YLD per 10000 | Mean ± SD (%) | YLD per 10000 | Mean ± SD (%) | YLD per 10000 |
| South-west | 31.9 ± 18.6 | 86.0 | 12.0 ± 13.5 | 32.5 | 8.5 ± 9.6 | 23.0 | 8.8 ± 10.1 | 23.8 |
| South-south | 23.7 ± 19.9 | 63.9 | 12.4 ± 10.2 | 33.4 | 8.5 ± 11.9 | 23.1 | 1.2 ± 0.5 | 3.0 |
| South-east | 18.1 ± 14.1 | 48.9 | 23.4 ± 26.9 | 63.3 | 7.0 ± 6.0 | 19.0 | 3.7 ± 4.9 | 10.0 |
| North-central | 6.6 ± 4.5 | 17.7 | 14.9 ± 12.6 | 40.2 | 6.3 ± 2.8 | 17.0 | 6.7 ± 8.4 | 18.2 |
| North-west | 9.1 ± 7.5 | 24.6 | 9.1 ± 8.5 | 24.7 | 3.2 ± 4.6 | 8.6 | 7.9 ± 10.9 | 21.3 |
| North-east | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

N/A: Not available.
5. Risk factors

Environmental factors and conditions influencing STH transmission are similar to those existing elsewhere in the tropics and other sub-Saharan African countries. Meanwhile, habits known to impact on STH infection and prevalence include open bush defecation[21-23], walking barefooted, geophagy and onychophagy[21,24]. Other risk factors have been linked to occupation of parents, sources of drinking water and poor personal hygiene[21,22,25-30]. The role of the soil as reservoir in maintaining the transmission cycle cannot be overstated[31].

The burden of infection in relation to the immune status of individuals has demonstrated higher prevalence among HIV positives than HIV negatives. Prevalence of STH in HIV sero-positive group could be twice the prevalence in HIV sero-negative group[32-35].

6. DALYs and infection burden

DALYs have become a fast growing metric measurement to assessing disease burden[36]. A lot of reports on STH from Nigeria have been documented, especially from rural communities and in children but reports of infection burden measured in DALYs are unavailable. Here we provide an estimated value of YLD based on available prevalence data and morbidity of infection[37].

YLD due to STH in this review was estimated using the formula below[38]:

\[ YLD = P \times DW \]

where, P = number of prevalent cases, DW = disability weight.

Here, prevalence was used rather than incidence[38] because in Nigeria, surveys are widely reported in prevalence (Table 2).

Table 2

| State               | No. Sampled | Ascaris (%) | Hookworm (%) | Trichuris (%) | Strongyloides (%) | Study population                          | Ref   |
|---------------------|-------------|-------------|--------------|---------------|-------------------|-------------------------------------------|-------|
| Abia                | 338         | 36.60       | 26.00        | 13.00         | -                 | Primary school children                   | [39]  |
| Akwa Ibom           | 316         | 18.00       | 21.50        | 13.30         | 2.80              | Primary school pupils                      | [40]  |
| Akwa Ibom           | 405         | 24.20       | 41.70        | 4.70          | -                 | School-aged children                       | [41]  |
| Anambra             | 1536        | 20.80       | 13.00        | 15.30         | 1.30              | School-aged children                       | [42]  |
| Bauchi              | 1037        | 22.50       | 4.40         | 1.50          | -                 | Rural dwellers                             | [43]  |
| Benue               | 418         | -           | 35.40        | 3.80          | -                 | Pre-school children                        | [44]  |
| Benue               | 580         | 11.89       | 18.62        | 4.65          | 1.89              | Primary school children                    | [45]  |
| Borno               | 257         | 19.10       | N/A          | 3.50          | N/A               | Almajiris                                  | [46]  |
| Cross River         | 350         | 64.40       | 10.90        | 1.10          | -                 | Preschool children                         | [47]  |
| Delta               | 194         | 42.78       | 28.35        | 11.34         | 1                 | School-age children                        | [48]  |
| Delta               | 1351        | 48.41       | 29.76        | 17.39         | -                 | School-age children                        | [49]  |
| Delta               | 211         | 45.97       | 13.27        | 20.38         | -                 | School children                            | [50]  |
| Ebonyi              | 576         | 10.90       | 7.50         | 4.20          | -                 | School-aged children                       | [51]  |
| Ebonyi              | 510         | 10.80       | 4.30         | 1.20          | 0.60              | Primary school children                    | [52]  |
| Edo                 | 1166        | 10.80       | 9.20         | 1.70          | -                 | Rural dwellers                             | [53]  |
| Edo                 | 200         | 4.00        | 15.00        | 0.50          | 1.00              | Primary school children                    | [54]  |
| Edo                 | 192         | 25.00       | 13.02        | -             | 1.00              | School-age children                        | [48]  |
| Edo                 | 3601        | 6.50        | 2.80         | 1.40          | -                 | Randomly selected individuals from the state | [55]  |
| Edo                 | 6213        | 19.50       | 16.90        | 5.90          | -                 | Hospital patients                          | [56]  |
| Edo                 | 207         | 11.10       | 5.80         | 3.80          | 0.50              | Outpatient children                        | [57]  |
| Edo                 | 2000        | 6.00        | 3.70         | 0.90          | 1.20              | HIV infected individuals                   | [32]  |
| Edo                 | 500         | 4.20        | 1.40         | -             | -                 | HIV control individuals                    | [32]  |
| Edo                 | 496         | 6.90        | 2.40         | 0.20          | -                 | Out-patient children                       | [30]  |
| Edo                 | 862         | 38.20       | 29.40        | 27.30         | -                 | Individual from 3 geographic zones of the Defunct Bendel State | [58]  |
| Edo                 | 140         | 18.60       | -            | 2.10          | -                 | Children from orphanages                   | [59]  |
| Enugu               | 6842        | 20.60       | 71.10        | 7.90          | 0.40              | Rural dwellers                             | [60]  |
| Enugu               | 407         | 22.90       | 32.40        | 2.50          | 1.00              | School children                            | [13]  |
| Enugu               | 1296        | 4.90        | 2.50         | 0.70          | -                 | School children                            | [23]  |
| Enugu               | 255         | 46.00       | 23.00        | 9.00          | 11.00             | Primary school children                    | [14]  |
| Enugu               | 1269        | -           | -            | -             | -                 | Children and adults                        | [61]  |
| Enugu               | 242         | 12.40       | 29.30        | 16.50         | 0.40              | Primary school pupils                      | [62]  |
| Enugu               | 13385       | 7.40        | 14.30        | 2.20          | 0.90              | Outpatients individuals                    | [63]  |
| Enugu               | 1296        | 4.90        | 2.50         | 0.70          | -                 | School children                            | [64]  |
| Kano                | 284         | 2.30        | 94.20        | -             | -                 | Primary school pupils                      | [65]  |
| Kano                | 96          | 28.10       | 5.20         | -             | -                 | School-aged children                       | [66]  |
| Kano, Abia, Enugu and Ebonyi | 231 | 2.26 | 3.90 | - | 1.70 | Nomads                                    | [67]  |
| Kano                | 570         | 7.90        | 5.30         | 3.50          | -                 | Apparently healthy children                | [68]  |
| Kano                | 105         | -           | 3.80         | -             | -                 | HIV infected individuals                   | [34]  |
| Kebbi               | 1357        | 9.95        | 13.63        | 0.29          | -                 | Inhabitants of Bagudo, Dandi and Zuru L.G.A | [69]  |
| Kwara               | 90          | 6.70        | 7.80         | 10.00         | 18.90             | HIV positive individuals                   | [33]  |
| Kwara               | 90          | 6.70        | 7.80         | 6.70          | 5.60              | HIV negative individual                    | [33]  |

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scale of 0–1 (0 = perfect health; 1 = death), was adopted\[104\]. YLDs due to STH according to the geopolitical zones are shown in Table 1.

7. Control efforts

The achievement of control and elimination relies largely on chemotherapy through mass drug administration (MDA). Drugs commonly administered against STH in Nigeria are albendazole, pyrantel and levamisole. These drugs have demonstrated varying egg reduction and curative rates (Table 3). There are increasing reports of mass deworming programme across the country\[69,109,110\], and studies have suggested that sustainable decrease in infection burden is a result of continuous use of antihelminthics\[69,78\].

The previously high and recently decreased rate of infection in communities may be due to MDA, increased community awareness and other control efforts\[78\]. Other practices largely responsible for decreasing STH prevalence across the country include improving and socio-economic status of parents/caregivers\[25,26,30\] with an increasing percentage of children now using foot wears both at home and in school\[26\]. Clearly, integrated control methods have been responsible for the observed trend in STH prevalence\[111\].

8. Conclusion

This review presents the limitations of the present tools used for STH investigation in Nigeria, and highlights the need to apply a more sensitive and specific diagnostic tool in epidemiological studies. Meanwhile, the mean prevalence of the pooled survey data over four
decades across the country shows a decreasing trend for Ascaris and Trichuris infection. However, the need to regularly update the national prevalence and DALYs would be helpful in tracking the progress of control efforts. In addition, the government has to live up to its responsibility by ensuring it abides by the recommendation of the World Health Assembly of 100% target-treatment of school-age children annually in places with > 50% STH prevalence. It is also imperative to engage research in determining the level of drug resistance with the view to applying the most effective chemotherapy regimen. Ultimately, an approach for elimination is to identify risk factors peculiar to different communities/regions in Nigeria.

Conflict of interest statement

We declare that we have no conflict of interest.

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Table 3
Outcomes of chemotherapeutic studies in some states in Nigeria.

| States     | Drug type                  | Sampled population | Egg/worm reduction rate (%) | Cure rate (%) | Age group (years) | References |
|------------|----------------------------|--------------------|-----------------------------|--------------|------------------|------------|
| Ondo       | Albendazole (200 mg)       | 1076               | N/A                         | 49.7%–94.4%  | 4–16             | [3]        |
| Delta      | Albendazole (200 mg)       | 905                | 56.1–95.6                   | 55.8         | 4–16             | [105]      |
| Osun       | Albendazole (200–400 mg)   | 625                | 89                           | 33           | 1–4              | [78]       |
| Rivers     | Pyrantel pamoate           | > 24000            | > 70                        | NA           | 2–12             | [106]      |
| Ebonyi     | Albendazole                | 576                | 100                          | > 90.6       | 6–17             | [51]       |
| Enugu      | Levamisole (50 mg)         | 242                | 82.5                         | > 80         | 5–13             | [62]       |
| Akwa Ibom  | Pyrantel                   | 316                | 78.9                         | 80.2         | 5–13             | [40]       |
| Enugu      | Albendazole (400 mg)       | 1296               | 18.8                         | > 15.1       | 4–15             | [107]      |
| Edo        | Albendazole, mebendazole, pyrantel pamoate | 31 | 95.4 | NA | 1–5 | [108] |

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