PREVALENCE AND RISK FACTORS FOR INTESTINAL NEMATODE INFECTIONS IN CHILDREN AS ENVIRONMENTAL HEALTH INDICATORS FOR PREVENTION IN SUB-SAHARAN TROPICAL COMMUNITIES OF EBONYI STATE, NIGERIA

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ABSTRACT

A community-based cross-sectional study was conducted between November 2010 and February 2011 to assess the prevalence of intestinal nematode infections among children aged 1 – 14 years living in two communities of rural Ebonyi State, Nigeria, characterize the risk factors for infection and develop environmental health indicator for use for infection preventive activities. A pre-tested structured questionnaire was used to obtain information on sanitation, hygiene and socioeconomic variables. Stool samples were examined using existing standard protocols for parasitological detection and identification of nematode eggs/larvae. Results revealed that one or more nematodes infected the study population providing an overall prevalence of 57.9%. Dominant parasites encountered were A. lumbricoides (21.1%), hookworm (17.0%), T. trichiura (12.8%), and S. stercoralis (5.9%). One species of intestinal nematodes was detected in 26.2% of infected population whereas 14.5% and 2.5% harboured two and three nematode species respectively. Identified risk factors were environmental, sanitation, hygiene, socioeconomic, crowding in households and availability of washbasin with water in toilets. The environmental health indicator developed summarized the biological, environmental and social factors associated with risk infection. This could be incorporated into environmental and community-based health surveillance in line with the primary health-care delivery system initiative.

Keywords: Intestinal nematode, Prevalence, Intensity, Risk factor, Environment, Helminthiases

INTRODUCTION

Helminth infections especially those intestinal nematode infections caused by soil-transmitted helminths constitute major public health problems (WHO, 2002). Of particular worldwide importance are helminthiases caused by gastrointestinal nematodes including roundworms (*Ascaris lumbricoides*), hookworms (*Necator americanus, Ancylostoma duodenale*), whipworms (*Trichuris trichiura*), pinworms (*Enterobius vermicularis*) and threadworms (*Strongyloides stercoralis*). Adult stages of these nematode species are found in different locations of the human intestinal tract. *A. lumbricoides* parasitizes the entire small intestine, human hookworms of the genera *Necator* and *Ancylostoma* live in the upper part of the small intestine whereas *S. stercoralis, T. trichiura* and *E. vermicularis* are located in the large intestine, especially the caecum (Bethony *et al*., 2006; Cheesbrough, 2007). Infection with *A. lumbricoides, T. trichiura,* and *E. vermicularis* is direct by ingesting infective eggs in contaminated food or from contaminated fingers while human transmission of *S. stercoralis* and hookworm is primarily by active penetration of the skin (example feet) by infective filariform larvae especially when the individual is walking barefooted on contaminated soil (WHO, 2004, Cheesbrough, 2007). Infections with the intestinal nematodes thrive and persist in communities in need of better housing, clean water, appropriate sanitation, better access to health care, education and increased personal earnings (Crompton, 1999; Brooker *et al*., 2006; Ekundayo *et al*., 2007). This is typical of most rural communities and urban slums in many developing tropical and subtropical countries (WHO, 2002; Brooker *et al*., 2006). Intestinal nematode infections have been recognized as major courses of disease burden among children in developing countries (Chan *et al*., 1994; Forester *et al*., 1988), especially in sub-Saharan Africa (Crompton, 1999, Bethony *et al.,* 2006; Ekpeyong and Eyo, 2008; Edelduok *et al.,* 2013). Earlier estimates indicated that 4.5 billion individuals are at risk of intestinal nematode infections globally with estimated number of cases of *A. lumbricoides* as 807 million, *T. trichiura* as 604 million, hookworm (*N. americanus; A. duodenale*) as 576 million and *S. stercoralis* as 103 million (Bethony *et al.,* 2006; Hotez *et al*., 2008). Studies have also shown that intestinal nematode infections have profound effects on school performance, attendance and future economic productivity (Bleakley, 2003; Miguel and Kremer, 2003). Increased susceptibility of host to other infections such as HIV and malaria has been linked to intestinal nematode parasitism (Fincham *et al.,* 2003). Ascariasis in young children may substantially affect gastrointestinal function, lactose intolerance and mal-absorption of vitamin A (Taren *et al*., 1987). A substantial proportion of children infected with *E. vermicularis* showed loss of appetite, loss of weight, emotional instability (Cheesbrough, 2007). In young children, severe trichuriasis can contribute to chronic *Trichuris* dysentery syndrome, intestinal ulceration, iron deficiency anaemia and weight loss (Bundy and Cooper, 1989; WHO, 2002). Heavy infections with *S. stercoralis* can cause itchy dermatitis (especially in children) coupled with mal-absorption and dehydration (WHO, 2004; Brooker *et al*., 2006). The major pathology resulting from hookworm infection is blood loss due to invasion and attachment to the intestinal mucosa and submucosa (Lwambo *et al*., 1992; Hotez *et al*., 2004). It has been estimated that a single *N. americanus* ingests about 30µℓ (0.03 ml) of blood per day, while *A. duodenale* sucks up about 150 *µℓ* (0.15ml) from infected victims (WHO, 2002).

In Nigeria, intestinal nematode infections have been recognized as major health issues at the national and state levels (Ola and Oyeledun, 1999; Holland *et al*., 1989; Ivoke, 2007; Ekpeyong and Eyo, 2008; Edelduok *et al.,* 2013). Reported prevalence indicated that *A. lumbricoides, T. trichiura* and hookworm species are the most common infections (Holland *et al*., 1989; Ivoke, 2007; Olaniyi *et al*., 2007; Ekpeyong and Eyo, 2008; Edelduok *et al.,* 2013). It has also been reported that the prevalence of these parasites especially *Ascaris* has not changed in the past half a millennium (Akogun, 1989), and poly-parasitism with these nematodes is a common recurrence (Ayanwale *et al*., 1982; Arene, 1984). Many researchers commented on the unhygienic but common practice of indiscriminate defaecating at farm lands and open fields (Nwosu, 1981; Adeyeba and Dipeolu, 1984; Ugbomoiko and Ofoezie, 2007) as a major predisposing factor to helminthiasis. The situation has not changed substantially, and there has been limited success in the introduction of latrines to rural villages in Nigeria (Holland and Asaolu, 1990). Despite the magnitude of these infections, policy-backed approach for intestinal helminth control is apparently lacking and data from epidemiological studies are seldom translated into useful health policies and management tools. A method of translating the results from epidemiological studies into health management tools is the development of environmental health indicators that incorporate health data obtained using scientifically based methods (Schwartz and Corvalan, 1996). This study therefore evaluated the prevalence and risks of intestinal nematode infections among children living in sub-Saharan tropical rural communities of Ebonyi State, Nigeria. Risk factors for the prevalence and intensity of infection were assessed and susceptible groups identified. An environmental health indicator that incorporated the most significant biological, environmental, behavioural and social factors associated with the risks of infection in the study population was developed using statistical methods. The objective of such an indicator was to guide community response to prevent intestinal nematode infection.

MATERIALS AND METHODS

Study Area and Demography: Ebonyi State is one of the six states created in 1996 within the Federal Republic of Nigeria. The study area comprises 10 agricultural villages located between 6^0 - 9^0 N, longitudes 6^0 – 8^0 E in southern Ebonyi State and covering a land area of 25,000 km^2. The topography varies from the sharp escarpment of Afikpo-North Local Government Area (LGA) to the gently undulating guinea-savannah mosaic landscapes of Ohaozara and Onicha LGAs. The climate is tropical and characterized by two distinct seasons, - the rainy season (April to October) and dry season (November to March). Annual precipitation ranges from 1200 to 2000 mm, while the temperature is typically tropical ranging from 24^0C to 32^0C and relative humidity 75.0 ± 3% in the rainy season (Oformata and Phil-Eze, 2001). The population of 410,000 (Nigeria Population Commission, 2006) with a population density of above 60 individuals per km^2 lives mostly in scattered village settlements. The population is homogenous with Igbo as the sole ethnic linguistic group and Christianity as the major religion. Agriculture is the dominant occupation of the inhabitants and rice, yam, cassava, peanut and pepper are produced in commercial quantities. The absence of pit latrines in many households has resulted in uncontrolled disposal of human faeces in farm land and rivers by children and young adults. The overflow of the pit latrines (where available) especially during the rainy reason favours nematode egg development and the transmission potential of intestinal nematode species. Each LGA has one general hospital, while each development centre is provided with a primary health clinic (PHC) where pregnant women and children routinely reported for minor health challenges. The area was selected for the study because it was representative of the filariasis-endemic part of Ebonyi State. Secondly, facilitated cooperation of the population was guaranteed as a consequence of the inauguration of the primary health-care delivery initiative campaign by the LGA chairpersons.

Ethical Clearance: The study protocol was approved by the Ethical Committee of Ebonyi State University Teaching Hospital, Abakaliki, Ebonyi State Ministry of Health (MOH) and the Primary Health Committees (PHC) of the study LGAs. Informed non-coercive consent of village leaders and heads of households were obtained prior to the commencement of the study. Free and informed consent formats were used in all interviews and examinations. All results were delivered individually and treatment of infections detected was carried out by the team physician assisted by LGAs health-care providers. Village meetings were held periodically to discuss issues, proffer solutions, deliver result and establish environmental health groups.

Study Design and Population: As part of the study, a house to house pre-survey census was conducted in the study area by two of the researchers along with Ohaozara and Onicha LGA officials to count children less than 14 years of age in households. The census was an integral part of the joint Ohaozara and Onicha LGA chairmen, primary health care delivery initiative. The traditional *Igbo* household includes a husband, wife/wives, their children, married sons and their wives, children and elderly widows. Another pilot survey was conducted in two communities of Okposi (Ohaozara LGA) and Isu (Onicha LGA) which represent two extremes of semiurban and rural environmental conditions respectively, to pre-test the questionnaire and train field data collectors. Soil samples were collected from damp and shady areas of 1000 household backyards (500 samples per community), placed in plastic bags and subsequently tested for presence of eggs of soil transmitted intestinal nematodes using the methods of Horn *et al.* (1990) and Cheesorough (2007). Seven hundred and twenty two (722) and 422 households were selected from Okposi and Isu communities, respectively by pooling all the households and drawing a sample using a table of random numbers. These 1144 households were pooled for all analyses because of their similar demographic and geographic characteristics. From each household two children were selected for the study by listing all children in the household by age and then using a table of random numbers to identify which children were to be included. Children were excluded from participating in the study if they did not have parental or guardian consent; if they did not provide stool sample; had recently emigrated to the study area from an area outside the study one, or had significant co-morbidities (e.g. severe diarrhoea, high fever, severe anaemia).

A cross-sectional survey was conducted from November, 2010 to February, 2011 using structured questionnaire to obtain information on sanitary facilities; hygiene, and socioeconomic status; structure of the home; source of drinking water and demographics of the household. House-to-house visits allowed structured observation as an aid in the evaluation of domestic conditions (condition of the backyard and toilet facilities, verification of presence of washbasin in toilet, etc.) as used in similar field investigation elsewhere (Kolsky and Bluementhal, 1995). The two researchers who took part in the pilot census also conducted and evaluated the condition of the houses and their surrounding and administered the questionnaire in *Igbo* language to the parents of the children. At least one parent of all selected children participated in the study by completing the questionnaire which took about 30 minutes to administer.

A single stool examination was conducted for each participant in a field laboratory by a trained technician from Ebonyi State Teaching Hospital, Abakaliki. Plastic stool containers with cover and label (for identification of each child) were distributed to a parent of a participating child for stool sample that was passed, collected and analyzed the following day within 6 hours of the sample being collected. Stool samples were first examined macroscopically using direct smear for general characteristics and worms. Stools were then examined microscopically using saline wet mounts for detection of eggs and larvae (WHO, 2002). Formalin-ether concentration technique was used for further identification of nematode eggs and larvae (Cheesbrough, 2007). Nematode eggs were quantified microscopically using Stoll's helminth counting technique (Cheesbrough, 2007). For quality control, different interviewers duplicated 10% of the interviews to check for inter-observer variability in the application of the questionnaires. A random sample of 10% of the smears prepared for the direct faecal smear was read by two different technicians (to evaluate the accuracy of the diagnosis). Slides were re-examined if the quality control showed >10% difference in egg count.

Statistical Analysis: Double entry programs (questionnaires and parasitological results) were employed to minimize error (Carneiro *et al.*, 2002). Data were entered and analyzed with Epi Info software (SS version 6.0, Texas, USA). Exploratory analysis was carried out to obtain descriptive statistics prior to fitting regression models. Socioeconomic sanitation and hygiene indices were constructed using principal component analysis, which selects the optimal linear combination of variables to summarize the information, incorporating the existing correlation between variables (the percentage of explained variance can be interpreted as a measure of index quality). A p-value ≤ 0.05 was defined as statistically significant using Chi-squared tests.

Socioeconomic indices for every child participant were determined individually, but as the indices were relatively homogeneous between households, a mean village index was calculated. Villages with index values were regrouped in three categories of "high", "middle" and "low", using the method of multiple comparisons of Kleinbaum *et al*. (1987). As the relationship between the risks of intestinal nematode infections and the sanitation and hygiene indices were not linear, these variables were also categorized. Cut-off points were based on inflection points detected in the diagnostic plots of the regression models. The percentile 20 was used as the cut-off point for the sanitation index. This separated 20% of children living in houses with better sanitary condition from the 80% with poorer sanitary conditions. For the hygiene index, the median was used.

Regression models were used to evaluate the best predictors of infections and intensity of intestinal nematode infections. Other variables included in the analysis were time of residence in the community, risk behaviour (playing in dust, no hand washing before eating and after using the toilet), crowding, socioeconomic and hygiene and sanitation indices. Finally, the logistic regression model for the infections was validated by the Hosmer and Lemeshow test for goodness of fit, and the Pearson chi square test (Hosmer and Lemeshow, 1989). By using this model, the estimated mean probability of infections was evaluated for each of the study communities. This environmental health indication allowed for the identification of high-risk villages in the study area.

Intensity of infection was analysed in the sub-sample of infected individuals using the negative of binomial regression, performed in the light of the results of the egg counts (per gram of faeces which showed a Poisson pattern with an over dispersion component (Anderson, 1986; Guyatt and Bundy, 1991).

RESULTS

The pre-study census showed that a total of 2338 children (54% males; 46% females) aged 0 – 14 years lived in the area within the study period. This sample population was distributed in 10 villages as follows: Ohadoro (246), Akanu (141), Odege (449), Isiovia (301) and Izuogu (217) all in Okposi community; Nkwoegu (220), Obiegu (205), Egueke (236), Mgbalaeze (198) and Amanato (126) all in Isu community. From the study population of 2288 drawn from 1144 households, full information was provided for 74% (n = 1693) of the children, including stool samples for parasitological examination. In 25% of the households visited, the occupants were tenants and in 62% they owned no land of their own. Most (86%) of the dwellings were constructed on ancestral land. About 69% of the parents/guardians were literate. For 70% of the population, the water supply consisted of borehole water sources; 57% of households depended on rivers/streams. In the pilot study, 24% of the 1000 soil samples examined tested positive for soil transmitted nematode eggs and larvae.

The cross-sectional survey showed that one or more intestinal nematodes infected the study population providing an overall prevalence of 57.9%. The most prevalent parasites identified were *A. lumbricoides* (21.1%), followed by hookworm (17.0%), *T. trichiura* (12.8%) and *S. stercoralis* (5.9%). One species of the nematode parasites was detected in 26.2% of infected children, while 14.5% and 2.5% of the infected children harboured two, and three or more nematode species, respectively (Table 1).

The prevalence of each nematode species by age and gender shows that males generally had significantly higher prevalence of *A. lumbricoides, T. trichiura,* hookworm and *S. stercoralis* than females among children in the 0-4 years age group ($p<0.05$). Similar patterns of infection prevalence were observed in infected children in the 5 – 9 and 10 – 14 years age categories (Table 2). The infections were not age-dependent but over dispersed with children in the 5-9 years age group harbouring more parasites than those in other age groups.

Risk factors for intestinal nematode infection are presented in Tables 3 and 4. Children from households with high sanitation and hygiene indices had lower risks of infection than those from households in the low categories (odds ratio (OR) = 0.52; 95% confidence interval (CI) 0.30 - 0.92 and OR = 0.52, 95% (CI) 0.30 = 0.90), respectively.

Children >5 years of age had higher risk of intestinal nematode infection than younger ones (OR = 3.50, 95% (CI) 1.81 - 6.70).

Table 1: Prevalence of intestinal nematode infections in 1693 children aged 0 – 14 in southern Ebonyi State, Nigeria

Intestinal nematode infections	Number (%) of children infected
Any intestinal nematode species	980 (57.9)
No intestinal nematode infection	713 (42.1)
Number of nematode infections per child	
1	257 (26.2)
2	142(14.5)
≥3	25(2.5)
Specific nematode parasites	
Ascaris Lumbricoides	357(21.1)
Hookworm (*Necator americanus*)	288(17.0)
Trichuris trichiura	217(12.8)
Strongyloides stercoralis	100(5.9)

An inverse relation between socioeconomic status and the risk of infection by intestinal nematodes was observed; the risk was estimated to be 2.5 times greater among children from households with low socioeconomic index, when compared to children from middle socioeconomic group. The risk in the middle socioeconomic category was twice that in those children from households with a high socioeconomic status. An interaction was established between crowding in households and availability of water in washbasins in toilets. This model stipulated that the risk of intestinal nematode infections was greater among children from overcrowded households without water in the toilet washbasins, when compared to those having water even after adjusting for socioeconomic, sanitation and hygiene factors and children's age (OR for crowding without water = 6.82; OR for crowding with water = 1.48).

The intensity of the intestinal nematode infections, analyzed for infected children showed that children from crowded household had a higher risk of intense infection than those living in non-crowded dwellings (Risk ratio [RR] = 2.13; 95% CI 1.00 - 4.32). This risk was lower in children with access to water in the toilet washbasin than in those without it (RR = 0.42; 95% CI 0.21 - 0.88). A similar association was observed in children from households with better hygiene status (RR = 0.42; 95% CI 0.18-1.00), and in those with; longer residence time in their villages (RR = 0.20; 95% CI 0.08 - 0.81) that had higher risk of intense infection. Similarly children who spent more than 4 year at school showed a lower risk of infections than those with less years at school (RR = 0.015; 95% CI 0.08 - 0.37) (Table 5).

DISCUSSION

The results obtained from this study provide probably the first population based quantitative and qualitative estimates of the prevalence of intestinal nematode infections in association with the biological, environmental and social risk variables in rural areas of Ebonyi State, Nigeria. The higher prevalence of geohelminths (*A. lumbricoides, T. trichiura,* hookworm and *S. stercoralis)* observed among males than females in children aged 0 – 14 years indicate that in rural Nigeria children especially the more active males are exposed early to acquire the soil-transmitted intestinal nematodes by the faecal-oral route while playing in the contaminated soil of their immediate environment. This result was authenticated in the study by the detection of the ova of intestinal nematodes in some soil samples collected from the study area. This pattern of intestinal nematode parasitism with respect to the age and gender of the children coupled with the sanitation/hygiene of the surrounding indicated that these indices were risk factors for infection with orally acquired soil-transmitted intestinal nematodes including *A. lumbricoides, T. trichiura* and probably for parasites that infect primarily by skin penetration, such as hookworm and *S. stercoralis.* The findings of this study are in agreement with similar studies of schooling and teenage children elsewhere in Africa (Akweley *et al*., 1986; Glickman *et al*., 1999; Ivoke, 2007; Ekpeyong and Eyo, 2008; Edelduok *et al.,* 2013).

Table 2: Prevalence of intestinal nematode infections by age and gender of 1693 children in southern Ebonyi state, Nigeria

Age (years)	Gender	Number Examined	Number (%) Positive	Nematode Parasite Infection (%) *Ascaris Lumbricoides*	*Trichuris trichiura*	Hookworm	*Strongyloides stercoralis*
1 - 5	Male	284	177(62.2)	68(38.6)	58(33.0)	23(13.07)	20(11.4)
	Female	155	62(40.3)	17(27.4)	11(17.7)	2(3.2)	4(6.5)
	Total	439	239(54.5)	85(35.7)	71(29.8)	25(10.5)	24(10.11)
6 - 10	Male	374	269(72.0)	113(42.2)	56(20.9)	108(40.3)	48(17.9)
	Female	319	185(57.9)	66(35.7)	29(15.8)	66(35.9)	17(9.2)
	Total	693	454(65.5)	180(39.6)	85(18.8)	174(38.3)	65(14.4)
11 - 14	Male	314	183(58.3)	62(34.1)	47(25.8)	55(30.2)	7(3.8)
	Female	247	104(42.0)	30(29.1)	15(14.6)	33(32.0)	4(3.9)
	Total	561	287(51.2)	93(32.3)	62(21.8)	88(30.7)	11(3.9)
Overall	Male	972	629(64.7)	243(38.8)	161(25.7)	186(29.6)	75(11.9)
	Female	721	351(48.7)	113(32.4)	55(15.8)	101(28.8)	25(7.1)
	Total	1693	980(57.9)	356(36.3)	216(22.0)	287(29.3)	100(10.2)

Table 3: Multivariate model-logistic regression analysis of risk factors for intestinal nematode infections in southern Ebonyi state, Nigeria, 2010*

Co-variable	Responses	Number (%)	Coefficient	Odds ratio	95% Confidence interval
Sanitation index	High	225 (13.3)	-0.63	0.52	0.30-0.92
	Low	1468 (86.7)	-	-	-
Hygiene index	High	748 (44.2)	-0.62	0.52	0.30-0.90
	Low	945 (55.8)	-	-	-
Age (child>5yrs)	Yes	1226 (72.4)	1.25	3.50	1.81-6.70
	No	467 (27.6)	-	-	-
Socioeconomic index	High	711 (42.0)	-0.68	0.50	0.25-0.92
	Middle	677 (40.0)	-	-	-
	Low	305 (18.0)	0.89	2.43	1.35 – 4.35
Crowding	Yes	508 (30.0)	1.42	6.82	2.25 -18.6
	No	1185 (70.0)	-	-	-
Water in wash basin	Yes	1558 (92.0)	-0.62	0.51	0.21 - 1.20
	No	135 (8.0)	-	-	-

**Total number of observations = 1693*

Table 4 General characteristics of the study population of children in southwestern Ebonyi state, Nigeria, 2010

Characteristics of the study population	Socioeconomic group High	Middle	Low
Prevalence of intestinal nematode infection	32 (9.2%)	47 (14.30%)	45 (29.30%)
Hygiene index (High)	259 (60.20%)	191 (46.07%)	87 (39.10%)
Washbasin with water	449 (97.95%)	339 (93.43%)	204 (85.41%)
Crowding	132 (28.17%)	136 (31.01%)	94 (37.46%)

Number in parenthesis is the percentage prevalence

Although *A. lumbricoides, T. trichiura,* hookworm and *S. stercoralis* were detected either alone or in mixed infections, variable significant differences were detected in the prevalence of the parasites according to gender those studies. In developing countries, intestinal parasitic infections have been associated with substandard sanitations, poor personal hygiene, lack of convenient, safe water supply, over crowding and socioeconomic standard (Forester *et al*., 1988; Kightlinger *et al*, 1998; Hotez and Kamath, 2009).

The environmental health indicator developed as a result of this study provided the basis to set up specific protection strategies against intestinal nematode infections. For instance, if children are at a higher risk of infection in a rural area than in a semiurban setting (because they spend more time at home engaged in risky behaviour such as playing in

Table 5 Intensity of intestinal nematode infections (eggs/grams of faeces)[a] in children of southern Ebonyi state, Nigeria, 2010[a]

Covariable	Responses	Number (%)	Risk ratio	95% Confidence interval
Crowding	Yes	434 (44.31)	2.13	1.00 - 4.32
	No	546 (55. 69)	-	-
Water in washbasin	Yes	677 (69.13)	0.42	0.21 - 0.88
	No	303 (30.87)	-	-
Hygiene index	High	239 (24.41)	0.42	0.18 - 1.00
	Low	741 (75.59)	-	-
Residence in community	>1 year	941 (96.00)	0.20	0.08 - 0.81
	<1 year	39 (4.00)	-	-
Years of schooling	>4 years	221 (22.56)	0.15	0.08 - 0.37
	<4 years	759 (77.44)	-	-

[a]*Negative binomial regression, total number of observations = 980; Number in parenthesis is the percentage prevalence.*

dusty and dirty surroundings), domestic sanitation and hygiene are targeted as priorities for preventive action. The indicator summarized the most significant biological, environmental and social factors associated with intestinal nematode infection in the studied population. Infections occur as a result of ingestion of infective nematode eggs, deposited by infected humans on humid and shady soil, and that overcrowding in human dwellings increase the likelihood of faecal-oral transmission of the infections (Schulz and Kroeger, 1992; Asaolu and Ofoezie, 2003; Raso *et al*., 2005). It has been suggested from earlier studies that the intensity of intestinal nematode infections is influenced by several variables including cultural, genetic, hygiene, environmental and socioeconomic factors (Forester *et al.,* 1988; Kightlinger *et al.,* 1998; WHO 2002; Hotez and Kamath, 2009). The model of intensity of intestinal nematode infections illustrates the importance of crowding as a significant risk factor of infection in households; the proximity of infective and susceptible persons promotes transmission of infection (Forester *et al*., 1988; Kightlinger *et al*., 1998; Raso *et al*., 2005). As observed in this study, and other studies (Carneiro *et al.,* 2002; Raso *et al*., 2005), children with less intense infection were from households with higher school profiles. Additionally, children living in households with longer time of residence in the study villages had lower counts of intestinal nematode eggs in faeces than children from families that migrated between communities who had fewer possibilities of improving their dwelling conditions. Given the array of environmental factors influencing health risks, a practical definition of what constitutes unhealthy dwelling becomes necessary. As water quantity and quality is a major issue in the study area, provision and promotion of personal use of water (for example through provision of subsidized washbasins and soap as incentives for hand washing may be a cost benefit health intervention strategy).

Conclusion: The present study confirmed strong associations between nematode linked intestinal helminthiasis, environmental and other risk factors operating in rural communities of Ebonyi State, Nigeria. Data obtained could provide the basis for environmental and community based health surveillance in line with the primary health-care delivery initiative of the local governments. Additional evaluations of these and other potential risk factors, in other epidemiological settings may be required before effective and sustainable preventive measures for control can be developed in Ebonyi State, Nigeria.

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REFERENCES

ADEYEBA, O. A. and DIPEOLU, O. O. (1984). A survey of gastrointestinal parasites in a local government area of south-west Nigeria. *International Journal of Zoonoses,* 11: 105 – 110.

AKOGUN, O. B. (1989). Some social aspects of helminthiasis among the people of Gumau district, Bauchi State, Nigeria. *Journal of Tropical Medicine and Hygiene*, 92: 193 – 196.

AKWALEY, A., CROMPTON, D. W. T., WALTERS, D. E. and ARNOLD, S. E. (1986). An investigation of the prevalence of intestinal parasites in pre-school children in Ghana. *Parasitology,* 92: 209 – 217.

ANDERSON, R. M. (1986). The population dynamics and epidemiology of intestinal nematode infections. *Transactions of the Royal Society of Tropical Medicine and Hygiene,* 80: 86 – 96.

ARENE, F. O. (1984). Preliminary parasitological survey of intestinal parasites among inhabitants of Okrika Island in the Niger Delta. *The Journal of Infection*, 9: 309 – 310.

ASAOLU, S. O. and OFOEZIE, I. E. (2003). The role of health education and sanitation in the control of helminth infections. *Acta Tropica*, 86: 283 – 294.

AYANWALE, F. O., ESURUOSO, G. O. and DIPEOLU, O. O. (1982). The epidemiology of human intestinal helminthiasis in Ibadan, South Western Nigeria. *International Journal of Zoonoses,* 9: 69 – 72.

BETHONG, J., BROOKER, S., ALBONICO, M., GEIGER, S. M., LAIKAS, A., DIEMERT, D. and HOTEZ, P. J. (2006). Soil-transmitted helminth infections: ascariasis, trichuriasis and hookworm. *Lancet*, 367: 1521 – 1532.

BLEAKLEY, H. (2003). Disease and development: evidence from hookworm eradication in American South. *Journal of European Economic Association,* 1: 376 – 386.

BROOKER, S., CLEMENTS, A. and BUNDY, D. A. P. (2006). Global epidemiology, ecology and control of soil-transmitted helminth infections. *Advances in Parasitology*, 62: 223 – 265.

BUNDY, D. A. P. and COOPER, E. S. (1989). Trichuris and trichuriasis in humans. *Advances in Parasitology*, 28: 107 – 173.

CARNEIRO, F. F., CIFUENTES, E., TELLEZ-ROJO, M. M. and ROMIEU, I. (2002). The risk of *Ascaris lumbricoides* infection in children as an environmental health indicator to guide preventive activities in Caparao and Alto Caparao, Brazil. *Bulletin of the World Health Organization,* 80(1): 40 – 46.

CHAN, L., BUNDY, D. A. P. and KAN, S. P. (1994). Aggregation and predisposition to *Ascaris lumbricoides* and *Trichuris trichiura* at the familial level. *Transactions of the Royal Society of Tropical Medicine and Hygiene,* 88: 46 – 48.

CHEESBROUGH, M. (2007). *District Laboratory Practice in Tropical Countries,* (Part 1). 2nd Edition, Cambridge University Press, Cambridge.

CROMPTON, D. W. (1999). How much human helminthiasis in there in the world? *Journal of Parasitology*, 85: 397 – 403.

EDELDUOK, E., EYO, J. and EKPE, E. (2013). Soil-transmitted helminth infections in relation to the knowledge and practice of preventive measures among school children in rural communities in South-Eastern Nigeria. *IOSR Journal of Pharmacy and Biological Sciences,* 5(6): 33 – 37.

EKPENYONG, E. A. and EYO, J. E. (2008). Prevalence of intestinal helminths infections among schooling children in tropical semi urban communities. *Animal Research International*, 5(1): 804 – 810.

EKUNDAYO, O. J., ALIYU, M. H. and JOLLY, P. E. (2007). A review of intestinal helminthiasis in Nigeria and the need for school-based intervention. *Journal of Rural and Tropical Public Health, 6:* 33 – 39.

FINCHAM, J. E., MARKUS, M. B. and ADAMS, V. J. (2003). Could control of soil-transmitted helminthic infection influence the HIV/AIDS pandemic? *Acta Tropica*, 86: 315 – 333.

FORESTER, J. E., SCOTT, M. E., BUNDY, D. A. P. and GOLDEN, M. H. N. (1988). Clustering of *Ascaris lumbricoides* and *Trichuris trichiura* infections within households. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 82: 282 – 288.

GLICKMAN, L. T., CAMARA, A. O., GLICKMAN, N. W. and MCCABE, G. P. (1999). Nematode intestinal parasites of children in rural Guinea, Africa: prevalence and relationship to geophagia. *International Journal of Epidemiology,* 28: 169 – 174.

GUYATT, H. L. and BUNDY, D. A. P. (1991). Estimating prevalence of community morbidity due to intestinal helminths: prevalence of infection as an indicator of the prevalence of disease. *Transactions of the Royal Society of Tropical Medicine and Hygiene,* 85: 778 – 782.

HOLLAND, C. V. and ASAOLU, S. O. (1990). Ascariasis in Nigeria. *Parasitology Today*, 6: 143 – 147.

HOLLAND, C. V., ASAOLU, S. O., CROMPTON, D. W., STODDART, R. C., MACDONALD, R. and TORIMIRO, S. E. (1989). The epidemiology of *Ascaris lumbricoides* and other soil-transmitted helminths in primary school children from Ile-Ife, Nigeria, *Parasitology,* 99(part 2): 275 – 285.

HORN, K., SCHNEIDER, T. and STOYE, M. (1990). Quantitative comparison of methods for detecting eggs of *Toxocara canis* in sand samples. *Journal of Veterinary Medicine*, 837: 241 – 250.

HOSMER, D. W. AND LEMESHOW, S. (1989). *Applied Logistic Regression*. John Wiley and Sons, New York, USA.

HOTEZ, P. J. and KAMATH, A. (2009). Neglected tropical diseases in sub-Saharan Africa: review of their prevalence, distribution, and disease burden. *PLOS Neglected Tropical disease*, 3: e412. doi: 10.1371/journal .pntd.0000412.

HOTEZ, P. J., BRINDLEY, P., BETHONY, J. M., KING, C. H., PEARCE, E. J. and JACOBSON, J. (2008). Helminth infections: the great neglected tropical diseases. *Journal of Clinical Investigation*, 118: 1311 – 1321.

HOTEZ, P. J., BROOKER, S., BETHONY, J. M., BOTTAZZI, M. E., LOUKAS, A. and XIAO, S. (2004). Hookworm infection. *New England Journal of Medicine*, 351: 799 – 807.

IVOKE, N. (2007). A coprological survey of geohelminth infections among school children in rural Ebonyi state, Nigeria. *Animal Research International*, 4(2): 653 – 661.

KLEINBAUM, D. G., KUPPER, L. L. and MULLER, K. E. (1987). *Applied Regression Analysis and other Multivariate Methods.* 2nd Edition, PWS-Kent Publishing Company, Boston (MA), USA.

KNIGHTLINGER, L. K., SEED, J. R. and KIGHTLINGER, M. B. (1998). *Ascaris lumbricoides* intensity in relation to environmental, socioeconomic, and behavioural determinants of exposure to infection in children from southeast Madagascar. *Journal of Parasitology,* 84: 480 – 484.

KOLSKY, P. J. and BLUEMENTHAL, U. J. (1995). Environmental health indicators and sanitation-related disease in developing countries: limitation to the use of routine data sources. *World Health Statistics Quarterly*. 48: 132 – 139.

LWAMBO, N. J., BUNDY, D. A. P. and MEDLEY, G. F. (1992). A new approach to morbidity risk assessment in hookworm endemic communities. *Epidemiology and Infections*, 108: 469 – 481.

MIGUEL, E.A. and KREMER, M. (2003). Worms: identifying impacts on education and health in the presence of treatment externalities. *Econometrics,* 72: 157 – 217.

NIGERIA POPULATION COMMISSION (NPC). (2006). *Report of the 2006 National Census Exercise.* National Population Commission Bulletin, Abuja, Nigeria.

NWOSU, A. B. C. (1981). The community ecology of soil-transmitted helminth infections of humans in a hyper-endemic area of southern Nigeria. *Annals of Tropical Medicine and Parasitology*, 75: 197 – 203.

OFORMATA, G. E. K. and PHIL-EZE, P. O. (2001). *Geographical Perspective on Environmental Problems and Management in Nigeria*, 4th Edition, Jamoe Enterprises, Enugu, Nigeria.

OLA, J. A. and OYELEDUN, B. (1999). School Health in Nigeria. National Strategies. Pages: 81 – 84. *In:* World Health Organization (Ed.), Improving Health through Schools. National and International Strategies. World Health Organization, Geneva, Switzerland.

RASO, G., UTZINGER, J., SILUE, K. D., OUATTARA, M., YAPI, A., TOTY, A., MATTHYS, B., VOUNATSUO, P., TANNER, M. and N'GORAN, E. K. (2005). Disparities in parasitic infections, perceived ill health and access to health care among poorer and less poor schoolchildren of rural Cote d'Ivoire. *Tropical Medicine and International Health,* 10: 42 – 57.

SCHULZ, S. and KROEGER, A. (1992). Soil contamination with *Ascaris lumbricoides* eggs as an indicator of environmental hygiene in urban areas of north-east Brazil. *Journal of Tropical Medicine and Hygiene,* 95: 95 – 103.

SCHWARTZ, E. and CORVALAN, C. (1996). Decision-making in environmental health. In: Briggs, D., Corvalan, C., Nurminen, M. editors. *Linkage Methods for Environmental Health Analysis: General Guidelines*. Pages: 121 – 35. Office of Global and Integrated Environmental Health; Document WHO/EHG/95.24 , UNEP-EPA-WHO, Geneva, Switzerland.

TAREN, D. L., NESHEIM, M. C., CROMPTON, D. W., HOLLAND, C. V., BARBEAU, I., RIVERA, G., SANJUR, D., TIFFANY, J. and TUCKER, K. (1987). Contributions of ascariasis in poor nutritional status in children from Chiriqui province, Republic of Panama. *Parasitology,* 95: 603 – 613.

UGBOMOIKO, U. S. and OFOEZIE, I. E. (2007). Multiple infection diagnosis of intestinal helminthiasis in the assessment of health and environmental effect of developmental projects in Nigeria. *Journal of Helminthology*, 81: 227 – 231.

WORLD HEALTH ORGANIZATION (2002). *Prevention and control of schistosomiasis and soil-transmitted helminthiasis.* Report of a WHO Expert Committee. World Health Organization, Technical Report Series, 912: 1 - 63.

WORLD HEALTH ORGANIZATION (2004). Preventable and control of schistosomiasis and soil-transmitted helminthiasis. World Health Organization, Geneva, Switzerland.